CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE OLIFANTS WATER MANAGEMENT AREA: (WMA 4) - WP 10383

EVALUATION OF SCENARIOS REPORT

FINAL

REPORT NO.: **RDM/WMA04/00/CON/CLA/0212**

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Private Bag X313
Pretoria, 0001
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Tel: (012) 336 7500/ +27 12 336 7500
Fax: (012) 336 6731/ +27 12 336 6731

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Prepared by:

Golder Associates Africa, Prime Africa and Retha Stassen

Title: *Evaluation of Scenarios Report*

Authors: *Golder Associates Africa, Prime Africa and Retha Stassen*

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Approved for the Professional Service Providers by:

………………………………………..

Trevor Coleman

Study Manager

DEPARTMENT OF WATER AFFAIRS (DWA)

Directorate Water Resource Classification

Approved for DWA by:

………………………………………..

Chief Director: Water Ecosystems

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LIST OF ABBREVIATIONS AND ACRONYMS

CD: RDM	Chief Directorate: Resource Directed Measures
DBSA	Development Bank of South Africa
DWA	Department of Water Affairs
EEAs	Environmental Economic Accounting
EIS	Ecological Importance and Sensitivity
ESBC	Ecologically Sustainable Base Configuration
ERE	Environmental and Resource Economics
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
HN	Hydro-node
IUA	Integrated Unit of analysis
IWRM	Integrated Water Resource Management
MC	Management Class
MEA	Millennium Ecosystems Assessment
NWA	National Water Act
PES	Present Ecological State
PGM	Platinum Group Metals
PSC	Project Steering Committee
REC	Recommended Ecological Category
RDM	Resource Directed Measures
RQOs	Resource Quality Objectives
RWQOs	Resource Water Quality Objectives
SAM	Social Accounting Matrix
SAWQGs	South African Water Quality Guidelines
SEEAW	System of Environmental Economic Accounting for Water
SNA	System of National Accounts
TWQR	Target Water Quality Range
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WRC	Water Research Commission
WRCS	Water Resource Classification System
WRYM	Water Resources Yield model

GLOSSARY

Some key terms and definitions as for Water Resource Classification as applied in the study:

Ecological Importance and Sensitivity (EIS)	Key indicators in the ecological classification of water resources. Ecological importance relates to the presence, representativeness and diversity of species of biota and habitat. Ecological sensitivity relates to the vulnerability of the habitat and biota to modifications that may occur in flows, water levels, physico-chemical conditions, etc.
Ecological Water Requirements (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
Ecological Water Requirement Sites	Specific points on the river as determined through the site selection process. An EWR site consists of a length of river which may consist of various cross-sections for both hydraulic and ecological purposes. These sites provide sufficient indicators to assess environmental flows and assess the condition of biophysical components (drivers such as hydrology, geomorphology and physico-chemical) and biological responses (*viz*. fish, invertebrates, riparian vegetation).
Integrated unit of analysis (IUAs)	The basic unit of assessment for the classification of water resources. The IUAs incorporates socio-economic zones and are defined by catchment area boundaries.
Management Class (MC)	The MC is representative of those attributes that the DWA (as the custodian) and society require of different water resources (consultative process). The process requires a wide range of trade-offs to assessed and evaluated at a number of scales. Final outcome of the process is a set of desired characteristics for use and ecological condition each of the water resources in a given catchment. The WRCS defines three management classes, Class I, II, and III based on extent of use and alteration of ecological condition from the predevelopment condition.
Present Ecological State (PES)	The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses *viz*. fish, invertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions.
Recommended Ecological	The Recommended Ecological Category is the future ecological state (Ecological Categories A to D) that can be recommended for a resource

Category (REC)	unit depending on the EIS and PES. The REC is determined based on ecological criteria and considers the EIS, the restoration potential of the system and attainability there-of.
River Node (Hydro-node)	These are modelling point's representative of an upstream reach or area of an aquatic eco-system (rivers, wetlands, estuaries and groundwater) for which a suite of relationships apply.
Scenario	Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. Each scenario represents an alternative future condition, generally reflecting a change to the present condition.
Significant Water Resources	Water resources that are deemed to be significant from a water resource use perspective, and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in their quality and quantity of water. Water resources are deemed to be significant based on factors such as, but not limited to, aquatic importance, aquatic ecosystems to protect and socio-economic value.
Sub-nodes	Finer scale of modelling points defined within a particular IUA at which flows and water qualities will be set to protect a particular ecological subarea that is identified as important and sensitive.
Sub-quaternary catchments	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments). The update of the PES and EIS (2010) status has been determined per sub-quaternary.
Trade-offs	Balancing of all factors in relation to the water resource and/or and IUA(s) that are not necessarily attainable at the same which may involve a giving up of one benefit, advantage, etc. in order to gain another regarded as more desirable. This may include balancing of those factors between use and protection (which may or may not be conflicting), between downstream impacts and upstream uses and vice versa, between possible use of resources within a catchment and between catchments, and between possible resource uses between different parts of the country. Decisions on these trade-offs will have different implications for different stakeholders at local, regional and national levels.
Water Resource	The WRYM is a yield model, developed by the Department of Water

Yield Model (WRYM)	Affairs, to assess system yield. In terms of the WRCS process it has been used to assess the yield per IUA for the different catchment configuration scenarios based on the water demands specified in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011).

EXECUTIVE SUMMARY

Background

Chapter 3 of the National Water Act (NWA, Act 106 of 1998) provides for the protection of water resources through the implementation of resource directed measures which includes the classification of water resources, setting the Reserve and resource quality objectives. In 2010, the Department of Water Affairs (DWA) identified the need to undertake the classification of significant water resources in the Olifants Water Management Area (WMA) in accordance with the Water Resource Classification System (WRCS).

To classify a water resource, the WRCS lays out a set of procedures grouped together in 7 steps that when applied to a specific catchment will result in the determination of a Management Class (MC). Determining the class of a water resource requires that the costs and benefits associated with utilisation versus protection of a water resource is assessed, taking into account the social, economic and ecological landscape in a catchment.

The ultimate goal of the study is the implementation of the WRCS which has as its final product the selection of one of three MCs for the 13 Integrated Units of Analysis (IUAs) that were identified in the Olifants WMA study area. The MCs will essentially describe the desired condition of the resource, and conversely, the degree to which it can be utilised. The MCs will, therefore, ensure that a balance is maintained between the need to protect and sustain water resources on one hand and the need to develop and use them on the other. This process will specify one of three MCs for each IUA, which will then be translated into Resource Quality Objectives (RQOs) that will specify the actual targets and ranges for maintenance of a specific class of water resource. The RQO development process is a separate process that has recently been initiated by the DWA and will run on based on the outcome of the classification study.

As such, classification is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use. The basis for determining the MC is the determination of an ecological sustainable level of protection that is required for water resources and integrating this with the economic and social goals. Once appropriate levels of ecological protection are established for the water resources; the measures required to achieve these protection levels, can then be assessed in terms of the overall implications to the IUAs and the WMA. This forms the scenario evaluation component of the WRCS process. The study process is now in its final stages in terms of the WRCS process, the evaluation of scenarios.

Approach

A scenario can be defined as “a story of what could happened in the future”, and is used to understand different ways that future events might unfold. Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

Each scenario represents an alternative future condition, generally reflecting a change to the present condition. Analysis thereof gives the ability to compare the implications of one scenario against another, with the ultimate aim to make a selection of the preferred scenario.

Establishment of MCs for the IUAs of the Olifants WMA requires integration of the following suite of components into scenario analysis:

- Water availability in the catchment (water quantity)
- Ecological water requirements (protection of a sustainable level of ecology)
- Economic and social drivers
- Ecosystem services
- Water quality

In terms of the classification, a range of scenarios were established in order to understand what the result would be in terms of system yield by implementing a certain level of ecological protection required to ensure sustainable use of the catchment water resources (consideration of ecological, water quality and quantity needs).

Each scenario defines a certain ecological condition (Ecological Category [EC] of A, B, C or D) for each water resource; and the water requirement to maintain that category.

To facilitate the classification decision making process for the Olifants WMA, six scenarios have now been evaluated (5 initial scenarios plus one additional). These are as follows:

- Scenario 1: The Present Ecological State (PES) was used as the ecological protection level at the EWR sites. The water required to maintain the PES ecological category was implemented. The 2010 Water Requirements per water use sector for the Olifants WMA as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) was implemented. This scenario formed the base scenario against which the additional scenarios were compared.
- Scenario 2: Same configuration as Scenario 1, however, the Recommended Ecological Category (REC) was implemented as the ecological protection level.
- Scenario 3: Same configuration as Scenario 1, except, an ecological category of D was implemented at all EWR sites to understand the implications of the maximum use of the water resources.
- Scenario 4: The PES was used as the ecological protection level at the EWR sites. The water required to maintain the PES ecological level was implemented. However, the 2035 projected water requirements per water use sector for the Olifants WMA as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were implemented.
- Scenario 5: Same configuration as Scenario 4, however, the REC was implemented as the ecological protection level.
- Scenario 6: The use of excess mine water in the Upper Olifants Catchment to meet the water

requirements was identified in the reconciliation strategy as a source of water to achieve reconciliation. The mine water has been used in the first 5 scenarios as a source of water. However, the impact on in-stream flow and quality of releasing the excess treated mine water to the river system to supply the water requirements in the Middle Olifants was not considered. In this scenario, the 2035 water requirements were used together with the PES EWR. The excess mine water not required to meet the water requirements in the Upper Olifants Catchment was released to the river to supply the water requirements in the Middle Olifants. The resulting increase in the flow and water quality in the main stem Olifants through IUA 3, 5 and 7 were assessed to see if an improved ecological category can be achieved with the releases. The PES and REC ecological category in IUA 5 and 7 is a D. The use of the river to transport the water in improving the ecological category in these IUA's was assessed.

Results

Scenario evaluation included assessment of different ecological categories and water user requirements, in different configurations to obtain results that reflect:

- A water balance (yield required to maintain ecological protection level and water use requirements – results in water surplus or deficit in the IUA)
- Ecological consequences, and
- An economic implication (cost-benefit analysis of the regional economy and social well-being).

Where there is a water deficit, the various interventions identified in the Olifants Reconciliation Strategy to achieve the required water supply were applied in the economic analysis. The summary of the results is shown in Table E1 below. All scenarios result in a deficit in terms of the water balance for the Olifants WMA.

Table E1: Results of the water balance and implication of scenario analysis

Scenario	Description	Water Balance	Cost/Implication of implementation
1	**ESBC (PES) Scenario**	60 million m^3/a deficit	An additional 60 million m^3/a of water is required in the Olifants WMA to ensure improved ecosystem health. Water quality increases across the WMA. The additional water comes from water savings achieved within the upper and lower parts of the WMA, and 22 million m^3 acid mine drainage is treated. GDP of the WMA decreases by R100m per year (0.07%) to pay for the additional water. It is possible that water prices increase somewhat to pay for some components of the water addition.
2	**REC Scenario (Recommended Ecological Reserve)**	171 million m^3/a deficit (60 +111 additional water to meet REC)	An additional 171 million m^3/a of water is required in the Olifants WMA to ensure a higher level of improved ecosystem health. Water quality improves across the WMA, more so than in Scenario 1, especially in the coal mining areas and in the Kruger National Park. The additional water comes from extensive water savings achieved across the whole WMA, 58 million m^3 acid mine drainage is treated, and a water transfer is required. GDP of the WMA decreases by R380m per year (0.27%) to pay for the additional water. Water prices are likely to increase about three times more than in Scenario 1 to pay for some components of the water

Scenario	Description	Water Balance	Cost/Implication of implementation
			addition.
3	**Maximum use scenario**	9 million m^3/a deficit (60 - 51 due to reduction in EWR requirements)	An additional 9 million m^3/a of water is required in the Olifants to ensure improved ecosystem health (this provides a very low level of ecosystem protection and lowest level of ecosystem services of all the scenarios). Water quality improves in coal mining areas, but deterirates in other parts of the WMA and the Kruger National Park. The additional water comes from water savings achieved within the upper parts of the WMA, and 22 million m^3 acid mine drainage is treated. GDP of the WMA decreases by R110m per year (0.07%) to pay for the additional water. There is a low likelihood that water prices would increase to pay for the water addition.
4	**Future growth PES scenario**	219 million m^3/a deficit (60+159 future water requirements)	An additional 219 million m^3/a of water is required in the Olifants WMA to ensure improved ecosystem health, and long term ecosystem achieved health is similar to that of Scenario 1. Water quality improves across the WMA. The additional water comes from water savings achieved within the WMA, and 27 million m^3 acid mine drainage is treated. GDP of the WMA grows as a result of general economic growth, although embedded within this growth is a GDP decreases to pay for the additional water. Water prices are likely to increase about three times more than in Scenario 1 to pay for some components of the water addition.
5	**Future growth REC Scenario**	330 million m^3/a deficit (171+159 future water requirements)	In Scenario 5 (2035), an additional 330 million m^3/a of water is required in the Olifants WMA to ensure improved ecosystem health, and long term ecosystem achieved health is similar to that of Scenario 2. Water quality improves across the WMA, more so than in Scenario 4, especially in the coal mining areas and in the Kruger National Park. This water comes from extensive water savings achieved across the whole WMA, 58 million m^3 acid mine drainage is treated, and a water transfer is required. GDP of the WMA grows as a result of general economic growth, although embedded within this growth is a GDP decrease to pay for the additional water. Water prices are likely to increase about four times more than in Scenario 1 to pay for some components of the water addition.
6	**Scenario 4 plus release of excess treated mine water to river system**	219 million m^3/a of Scenario 4	As in Scenario 4, an additional 219 million m^3/a is still required to meet the deficit for the scenario. The additional 219 million m^3/a of water is required in the Olifants WMA to ensure improved ecosystem health, and long term ecosystem achieved health is similar to that of Scenario 1. Water quality improves across the WMA. The additional water comes from water savings achieved within the WMA, and 55 million m^3/a acid mine drainage is treated. GDP of the WMA grows as a result of general economic growth, although embedded within this growth is a GDP decreases to pay for the additional water. Water prices are likely to increase about three times more than in Scenario 1 to pay for some components of the water addition.

The results and implications as detailed in Table E1 above mean the following:

- The ecological consequences evaluation show that the EWR sites in general meet the Present Ecological State (PES) Ecological category (EC) and/or Recommended Ecological Category (REC). However, the flow requirements for some components at EWR sites 4 (Wilge River) and 16 (Olifants in Kruger National Park) could not be met. The best that can be achieved at EWR 4 is an EC of a D where the PES is a C and the REC is a B. At EWR 16 although the REC is a B, the best that could be achieved was a B/C.

- Reconciliation options for ecological water requirements (PES and REC) incur implementation costs.
- On the one hand these costs reduce Gross Domestic Product (GDP) through reduced company profits. However, the reconciliation options also generate revenues in the economy.
- Most important, they ensure the constant delivery of aquatic ecosystem services. In Scenarios 1, 2, 4 and 5, the ecosystem service benefits increases across the WMA.
- Where GDP decreases this is because company profits have been taken out (out of GDP) to pay for new water infrastructure.
- Ecosystem service changes are directly proportional to changes in flow.
- Scenario 1: Requires R 284 million / year (URV)
- Scenario 2: Requires nearly R 0.6 bn more (R 947 million / year) to increase ecosystem services by R 160 million
- Scenario 4/5: Platinum group mining grows significantly, the rest of the economy grows by 1%.
- Scenario 6: The increase in flows and the improvement in water quality in the middle reaches of the Olifants resulted in the potential of the ecological category meeting a C/D if the option of releasing water to the river system is followed and the necessary management measures are put in place to ensure that the water reaches the middle Olifants.

Conclusion and Recommendations

The scenarios and evaluation results were presented to the PSC at a meeting held on the 24 October 2012 with the aim of describing and understanding Scenario 6, the overall scenario evaluation results and selecting recommended scenarios for proposal to the Minister. Based on the technical evaluation and assessment of the identified criteria, the 6 scenarios were assessed in terms of EWR implementation, water quality implications, WMA water balance and economic and social implications to determine the most likely go forward options:

In terms of the assessment scenarios 1,2,3 and 5 were 'eliminated' based on the following reasoning:

- Scenario 3: Water resources cannot be sustained in this scenario. Ecological condition and water quality deteriorates.
- Scenario 5: Availability of water is a constraint. Scenarios 5 has a high deficit which means water may have to be transferred into the catchment. The reconciliation strategy for the Olifants WMA showed that there is limited water available for transfer and the stand point of DWA is that the deficits in the Olifants WMA must be met with augmentation actions taken within the Olifants WMA. Water prices could potentially be very high.
- Scenarios 1 and 2: These scenarios do not cater for future growth in water requirements.

Based on the above assessment and on recommendation from the PSC, the go forward options are Scenario 4 and 6 which supply the PES ecological categories and meet the future growth in water requirements in the WMA. In Scenario 6 additional treated mine water released from the Upper Olifants to meet the water requirements of the Middle Olifants.

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1 INTRODUCTION

1.1 BACKGROUND

Chapter 3 of the National Water Act (NWA, Act 106 of 1998) provides for the protection of water resources through the implementation of Resource Directed Measures (RDM) which includes the Classification of water resources, setting the Reserve and Resource Quality Objectives (RQOs). Classification of water resources aims to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other.

In 2010, the Department of Water Affairs (DWA) identified the need to undertake the classification of significant water resources in the Olifants Water Management Area (WMA) in accordance with the Water Resource Classification System (WRCS).

The Regulations define three water resource Management Classes:

- Class I - minimally used and configuration of ecological categories of that water resource minimally altered from its pre-development condition;
- Class II - moderately used and configuration of ecological categories of that water resource moderately altered from its pre-development condition; and
- Class III - heavily used and configuration of ecological categories of that water resource significantly altered from its pre-development condition.

The Olifants WMA is a highly utilised and regulated catchment and like many other WMAs in South Africa its water resources are becoming more stressed due to an accelerated rate of development and the scarcity of water resources. There is an urgency to ensure that water resources in the Olifants WMA are able to sustain their level of uses and be maintained at their desired states. The determination of the Management Classes (MC) of the significant water resources in Olifants River System 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 and the catchment. The ultimate goal of the study is the implementation of the WRCS in the Olifants WMA in order to determine the management class (MC). The purpose of the MC once set, is to establish clear goals relating to the quantity and quality of the relevant water resource in order to facilitate a balance between protection and use of water resources.

To classify a water resource, the WRCS lays out a set of procedures grouped together in 7 steps that when applied to a specific catchment will result in the determination of a MC. The study process is now in the final stages WRCS (finalised Step 5 based on the feedback of Step 6) (Figure 1), ‘the evaluation of scenarios within the integrated water resource management process’, and recommendation scenarios towards MCs.

1.2 SPATIAL EXTENT OF STUDY

The spatial extent for the classification study includes secondary drainage regions B1 to B7, the catchment area of the Olifants WMA. This includes the Upper, Middle and Lower Olifants and

Steelpoort river sub-catchment areas within the Olifants WMA (see Figure 2).

The Olifants WMA corresponds with the South African portion of the Olifants River catchment but excludes the Letaba River catchment. The WMA falls within three provinces *viz*. Gauteng, Mpumalanga and the Limpopo Provinces and it covers approximately 54 550 km^2. The main tributaries of the Olifants River are the Wilge, Elands and Ga-Selati Rivers on the left bank and the Klein Olifants, Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank. The Olifants River is a tributary of the Limpopo River which is shared by South Africa, Botswana, Zimbabwe and Mozambique.

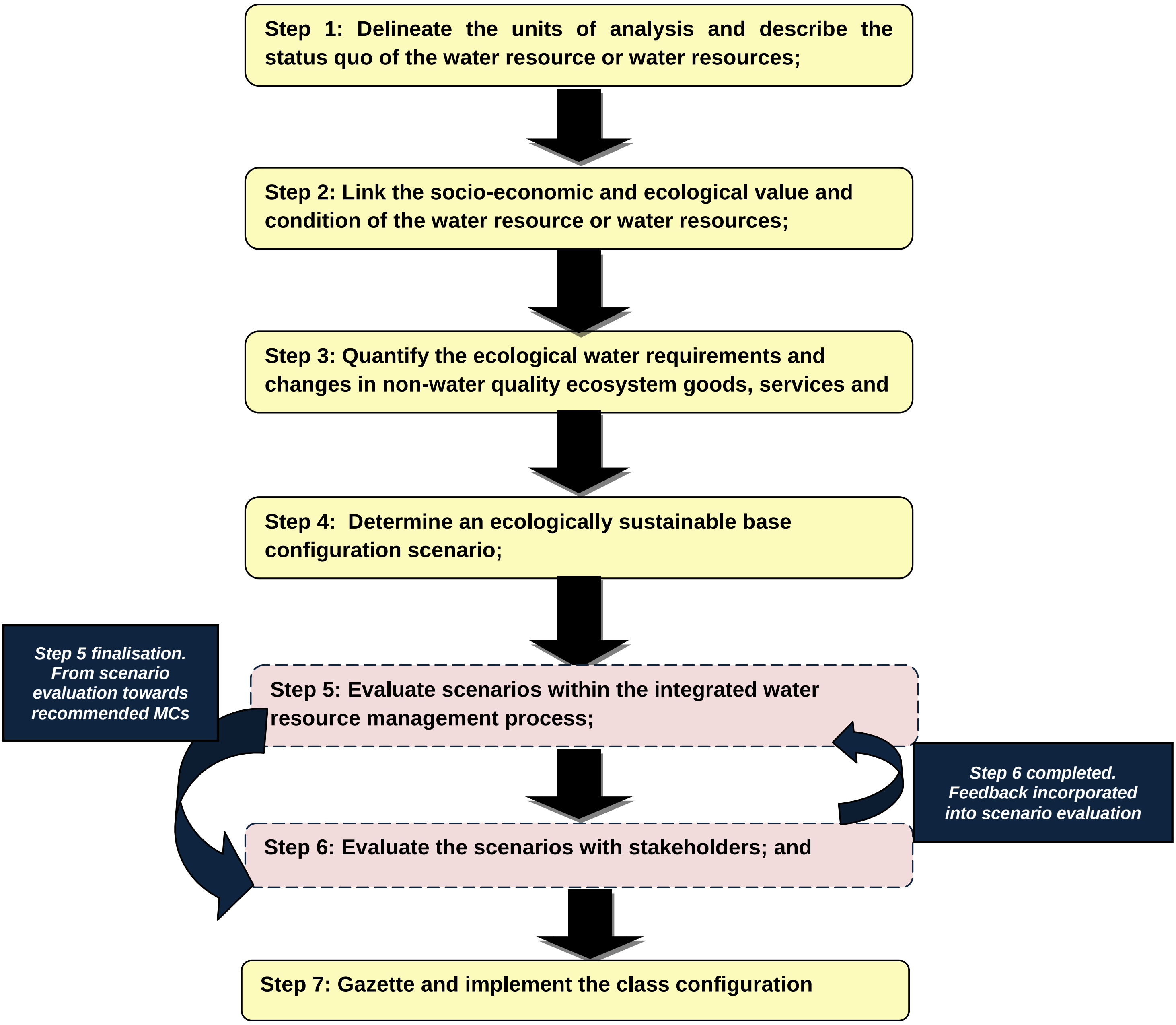


Figure 1: 7 Step WRC Process in the Olifants WMA

Figure 2: Study area – the Olifants WMA

2 THE STUDY PROCESS

This study is primarily of a technical nature being guided by stakeholder participation and engagement. The WRCS is being applied taking account of the local conditions, socio-economic imperatives and dynamics within the Olifants River system.

The main components that are being addressed through the study process (Figure 3) include the:

- Study scope definition and water resource information and data gathering.
- Definition of the Integrated units of analysis (IUAs) and significant water resources.
- Status quo assessment of the WMA (assessment of present state water resource quality, identification of water resource issues, determination of the institutional environment, assessment of the socio-economic) etc.
- The application of the WRCS, *i.e.* establishing the MC by integration of the economic, social and ecological goals through a suitable analytical decision-making system (trade-offs).
- Stakeholder engagement and consultation processes, and
- Population of the classification templates.

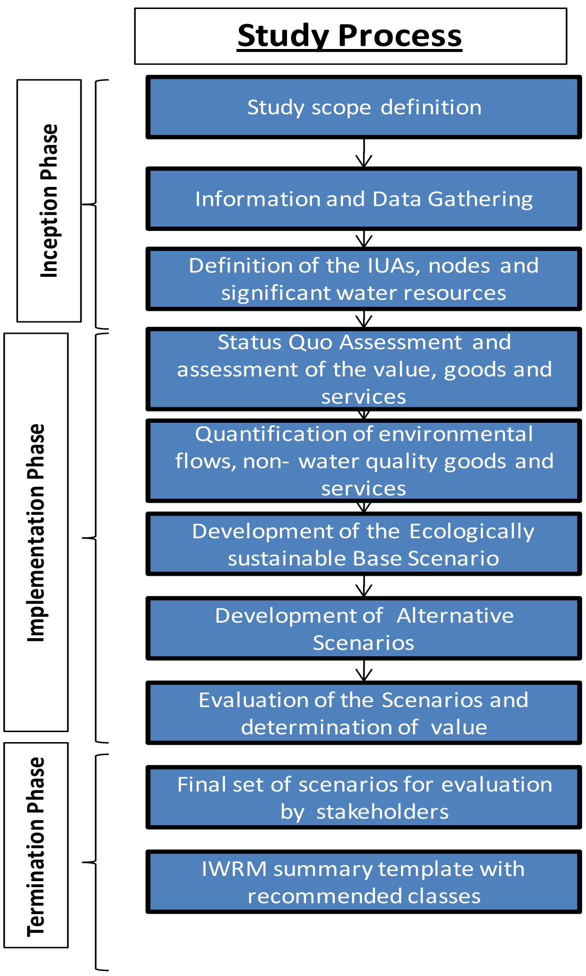


Figure 3: Study process followed for classification of water resources in the Olifants WMA

In terms of the process defined above, the approach undertaken by the study team in terms of the implementation and application is outlined in Figure 4 below.

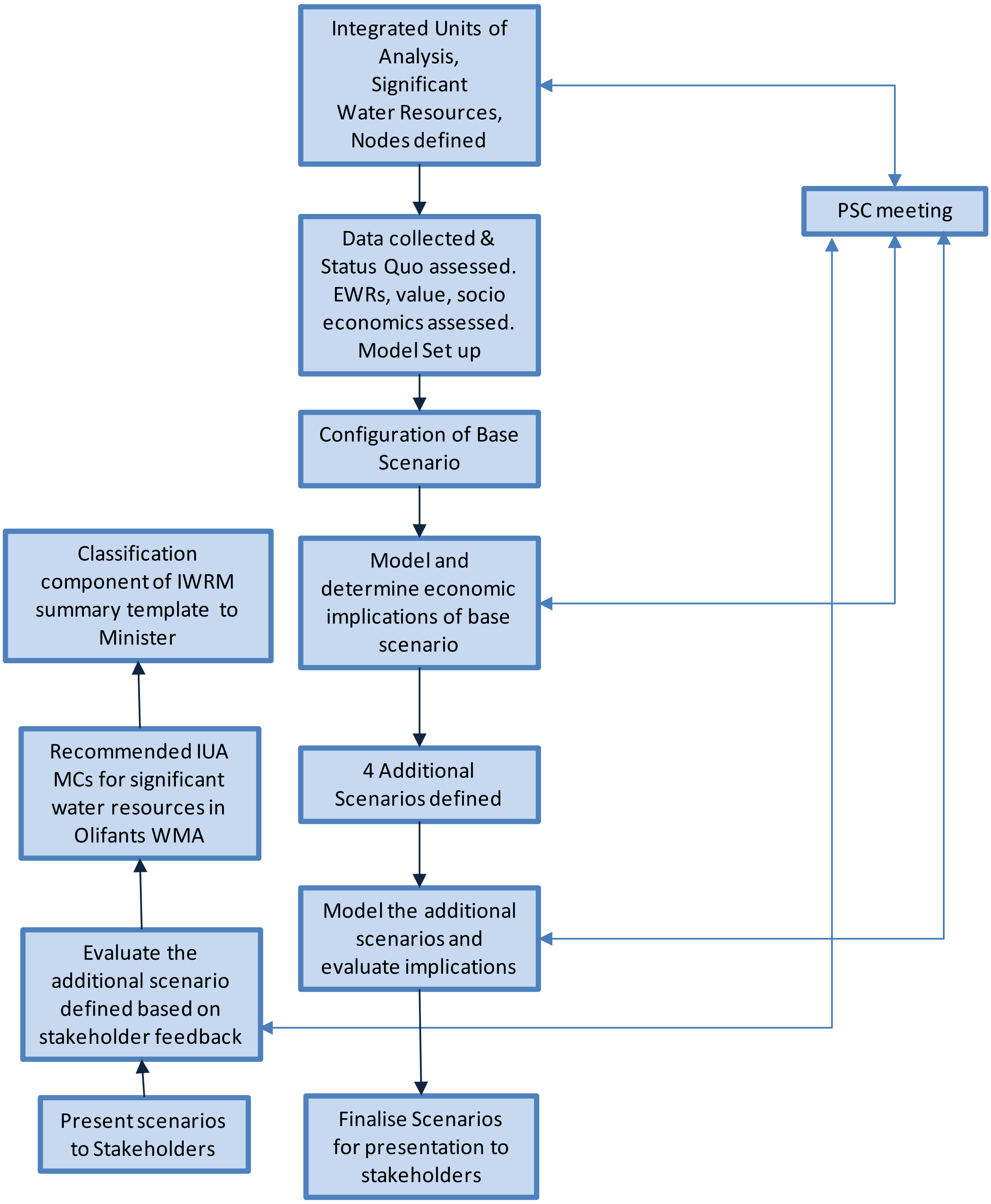


Figure 4: Approach undertaken in terms of implementation of study process

In terms of Figure 4:

- At the inception phase, the IUAs, nodes and significant network of water resources were finalised (June 2011) once confirmed with Project Steering Committee (PSC) members at the first meeting in February 2011. The feedback obtained was incorporated into IUA delineation.

- The status quo assessment of the WMA, valuation of water resources, and ecological water requirements (EWR) quantification and related flows at each node was completed by September 2011. The updated Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the water resources (2010) was obtained from a recently completed DWA study (DWA, 2010).
- A base scenario with a set of the EWRs at each EWR site was then established. The ecological categories used as the base scenario was based on the 2001 Reserve determination and where changes observed on the 2010 PES of the water resources in the Olifants WMA. The water resources yield model (WRYM) was run based on these EWRs and water balance outputs were fed into the economic modelling assessment (November 2011). This formed the ecologically sustainable base configuration scenario (ESBC).
- The base scenario was then proposed to the PSC in November 2011. This scenario with the proposed ecological categories per IUA was accepted by the PSC members. At the meeting a further four alternate catchment scenarios were confirmed.
- The four alternate scenarios were subsequently taken forward through the modelling processes and the ecological consequences and economic implications of each were assessed. The ecological assessment of responses to various flow scenarios were based on the approach developed by Kleynhans for application in the Habitat Flow Stressor Response Model (Kleynhans, pers. comm., 2012).The scenarios were evaluated to determine if they are sustainable, economically viable and meet the requirements of the users in the catchment. The evaluation of the scenario results were reported back to the PSC at a meeting held on 15 May 2012.
- Further to this meeting, the scenarios were refined and additional and supporting information was added to elaborate on the explanation and understanding. This information was appropriately packaged for stakeholder consultation (June-July 2012).
- The final set of scenarios was evaluated by consultation with stakeholders through step 6 of the process (broader stakeholder groups – three meetings to be held in July 2012. An additional scenario was identified during this stakeholder engagement process. The comments captured at these meetings and throughout the study have been included in the study Issues and Response report.
- The additional scenario identified was formulated and evaluated and report back on the final scenario evaluation (all 6 scenarios) was provided to the PSC at its final meeting in October 2012.
- The outcome of this process has resulted in the recommendation of scenarios and proposed MCs for each of the thirteen IUAs in the Olifants WMA. These scenarios and associated MCs were based on what is practical and achievable; while at the same time ensuring the water resources of the WMA are not degraded.
- The classification component of the Integrated Water Resources Management (IWRM) summary template with recommended scenarios, proposed classes and supporting information will be completed by December 2012.
- The recommended scenarios and proposed MCs will be submitted to the Minister for

consideration. The final proposed MCs together with the established Resource Water Quality Objectives (RQOs) for the Olifants WMA will be gazetted by November 2013, which includes a 60 day public comment period.

The above has been conducted in terms of the prescribed steps of the WRCS as outlined in the DWA guidelines (DWA, 2007) as best suited to circumstances and conditions that prevailed.

3 THE EVALUATION OF SCENARIOS WITHIN THE INTEGRATED WATER RESOURCE MANAGEMENT PROCESS (STEP 5 FINALISATION)

An integral component of the water resource classification process is the scenario configuration and evaluation, which is an iterative process that assesses the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible for the WMA, to support the recommended management class options.

This task has been undertaken in compliance with the requirements of the study terms of reference that specifies that the classification process is required to build from existing and current initiatives within the framework of the integrated water resource management processes in the WMA. The study process is now in the final stages of the WRC process, 'finalised Step 5 based on the feedback of Step 6'. The scenario evaluation has been finalised and recommended scenarios are proposed.

3.1 OBJECTIVES OF STEP 5 OF THE WRCS

The objective of step 5 of the WRCS was to evaluate scenarios configured as part of Step 4. This was completed in May 2012. Following the stakeholder workshops held as part of step 6 of the process an additional scenario was proposed. Scenario evaluation was then re-visited and the feedback from Step 6 was incorporated within the integrated water resource management process so that a subset of catchment scenarios can be recommended towards proposed MCs.

The following activities have been undertaken as part of finalisation of Step 5 of the WRCS process:

- Inclusion of the additional scenario proposed as part of Step 6
- Yield model analysis and adjustment
- Reporting of ecological consequences and IUA- level ecological condition
- Assessment of water quality implications
- Description of the macro-economic implications
- Evaluation of the overall scenario implications for the WMA, and
- Selection of a subset of recommended scenarios.

The process followed is that described in the WRCS Guidelines, Volumes 1, 2, 3 and 4 (Overview and the 7-step classification procedure; Ecological, hydrological and water quality guidelines for the 7-step classification procedure; Socio-economic guidelines for the 7-step classification procedure, and Decision analysis (including the stakeholder engagement process for 7–step Classification Procedure) (DWA, 2007a, 2007b, 2007c and 2007d).

3.2 PURPOSE OF THE REPORT

The purpose of this report is to provide the details of the final assessment and the results of the scenario analysis and evaluation of all scenarios for the Olifants WMA. This is related to the following:

- Description of the catchment scenarios assessed as part of the scenario analysis;

- Presentation of the yield analysis per scenario (results of the water balance per IUA per scenario);
- Presentation of the results of the socio-economic assessment and evaluation;
- Description of water quality implications and ecological consequences;
- Summary of the scenario analysis (proposed implications per scenario);
- The recommended scenarios and proposed MCs for consideration by the Minister.

4 SUPPORTING INPUTS TO SCENARIO EVALUATION

In terms of the components of the study process the following outputs have been defined/ determined to date or used as key input as support to the evaluation of scenarios:

- Limited Visioning exercise
- Water resource information and data gathering assessment
- Determination of the integrated units of analysis
- Socio-economic: Evaluation and the decision-analysis framework and method summary
- Ecological Water Requirements quantification
- Present Ecological Status (external to classification process – used as input)(DWA, 2010)
- Ecological Base Scenario Configuration determination
- Alternate Catchment Configuration Scenarios definition

The key elements of the above inputs are described briefly below. The individual study reports are available on request from the study public participation office or on the DWA website at http://www.dwa.gov.za/rdm/WRCS.

4.1 LIMITED VISIONING EXERCISE

Visioning is a process of articulating society's aspirations for the future – in this case, the 'basket' of benefits to be derived from aquatic ecosystem services and the costs associated with their use." A limited visioning exercise was undertaken at the first PSC meeting of the study in February 2011 in an attempt to understand the stakeholders issues and concerns in the areas in which they live, work or have interests in the Olifants WMA, and to determine their societal values and management objectives. The aim of the exercise was to also obtain some indication of what the stakeholders required in terms of the level of protection of water resources in the Olifants WMA (extent use of the water resources). This was undertaken through a brief questionnaire that was distributed to members (Appendix A). The limited feedback obtained (11 completed questionnaires) was reviewed and the input provided some insight into the protection level required for some water resources.

Of the stakeholders that filled in the visioning questionnaire:

- 100% said the conservation of biodiversity was important.
- 55% supported the promotion and development of recreation and tourism.
- 82% said that we should aim for water conservative uses.
- Approximately 70% supported economic development and social upliftment.
- Sector growth was supported as follows:
    - 55% commercial agriculture,
    - 82% eco-tourism, and
    - 27% Subsistence farming. This sector will receive further support provided that it is done in a responsible way with good management support.

- 73% of respondents said that they would like to see an improvement in the overall present ecological status of the entire catchment or IUA.
- 73% also did not want to see a deterioration in the present ecological status of the entire catchment or IUA for purposes of development.
- 82% supported the protection of certain areas where the ecological status needed to be maintained or improved.
- 55% said that deterioration of the present ecological status of certain areas for the purpose of development may be allowed.

While the above response represents a limited number of the total stakeholder groups in the Olifants WMA, it did provide some direction in terms of the management objectives and the desired state for water resources in the catchment area. In summary the combined vision would be to allow responsible development to achieve social upliftment while maintaining the present ecological status and improving ecological important areas of the WMA.

4.2 WATER RESOURCE INFORMATION AND DATA GATHERING

Numerous studies have been and are currently being undertaken on the Olifants River System and task 2 of this study focused on gathering data and collecting information from a wide variety of sources such as the Department of Water Affairs, other government departments, the Water Research Commission, provincial departments, Statistics South Africa, research and academic organisations and other study groups. An assessment and review of all the existing information and data was undertaken and summaries of the available information were compiled and the information availability was assessed. The above was used to identify any gaps and outstanding information. Specific recommendations have been made as to the collection of additional data and/or the extrapolation of existing data. For parallel studies ongoing liaison has been established with other study teams and has been maintained to ensure that the transfer of information, data and reports has taken place. More detailed information is available in study Information Analysis report (DWA, 2011, Report No. RDM/WMA04/00/CON/CLA/0211).

4.3 INTEGRATED UNITS OF ANALYSIS

Thirteen IUAs have been defined for the Olifants WMA (Figure 5). The process followed in terms of IUA delineation was that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWA, February 2007).

Delineation of units of analysis is required as it would not be appropriate to set the same MC for all water resources in a catchment. The delineation of a WMA into IUAs for the purpose of determining the MC for significant rivers is done primarily according to a number of socio-economic criteria and drainage region (catchment area) boundaries. IUAs are thus a combination of socio-economic zones and watershed boundaries (DWA, 2007). Ecological information also plays a role in the delineation.

The following was considered for delineation of IUAs within the Olifants WMA:

- Socio-economic zones (SEZs)
- Catchment area boundaries (drainage regions and water resource systems)

- Similar land use characteristics/land based activities
- Eco-regions and Geomorphology
- Ecological information
- Present status of water resources
- Stakeholder input

The IUA delineation is indicated in Table 1 below and illustrated in Figure 5.

Table 1: Catchment areas of the thirteen IUAs defined for the Olifants WMA

IUA	Delineation	Quaternary Catchment
1	Upper Olifants River catchment	B11A, B11B, B11C, B11D, B11E, B11F, B11G, B11H, B11J, B11K, B11L, B12A, B12B, B12C, B12D
2	Wilge River catchment area	B20A, B20B, B20C, B20D, B20E, B20F, B20G, B20H, B20J
3	Selons River area including Loskop Dam	B12E, B32A, B32B, B32C
4	Elands River catchment area	B31A, B31B, B31C, B31D, B31E, B31F, B31G
5	Middle Olifants up to Flag Boshielo Dam	B32D, B31H, B31J, B32E, B32F, B32G, B32H, B32J, B51A, B51B, B51C, B51D, B51E
6	Steelpoort River catchment	B41A, B41B, B41C, B41D, B41E, B41F B41G, B41H, B41J, B41K
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	B51F, B51G, B51H, B52A, B52B, B52C, B52D, B52E, B52F, B52G, B52H, B52J
8	Spekboom catchment	B42A, B42B, B42C, B42D, B42E, B42F B42G, B42H
9	Ohrigstad River catchment area	B60E, B60F, B60G,B60H
10	Lower Olifants	B60J, B71A, B71B, B71C, B71D, B71E, B71F, B71G, B71H, B71J, B72A, B72B, B72C
11	Ga-Selati River area	B72E, B72F,B72G, B72H, B72J, B72K
12	Lower Olifants within Kruger National Park	B72D, B73A, B73B, B73C, B73D, B73E B73F, B73G, B73H, B73J
13	Blyde River catchment area	B60A,B60B, B60C, B60D

Biophysical and Management Hydro-nodes

Biophysical hydro-nodes are established to serve as points that account for interactions between ecosystems and management hydro-nodes are established to account for water quality or flow impacts in the catchment. Allocation nodes are also selected to serve as modelling points for the Classification process in a catchment. These allocation nodes are located at the outlet of an IUA. The establishment of biophysical and management hydro-nodes are guided by a number of considerations. The key considerations are:

- Significant water resources
- Biophysical and eco-regional characteristics;

- Location of Ecological Water Requirement (EWR) sites and ecological information;
- Ecological Importance and Sensitivity categories of water resources;
- Present ecological state;
- Broad-scale hydrological and geomorphological characters;
- Water infrastructure;
- Water management, planning and allocation information.

Based on the above considerations proposed biophysical and management hydro-nodes have been established in each of the IUAs delineated for the Olifants WMA. An initial list of hyro-nodes were proposed during the IUA delineation process and confirmed on completion of the EWR quantification step of the WRCS process (Step 3). The hydro-nodes and quaternary catchments within each IUA are listed in Table 2 below and indicated on Figure 5. Allocation hydro-nodes and EWR sites are also indicated on the map.

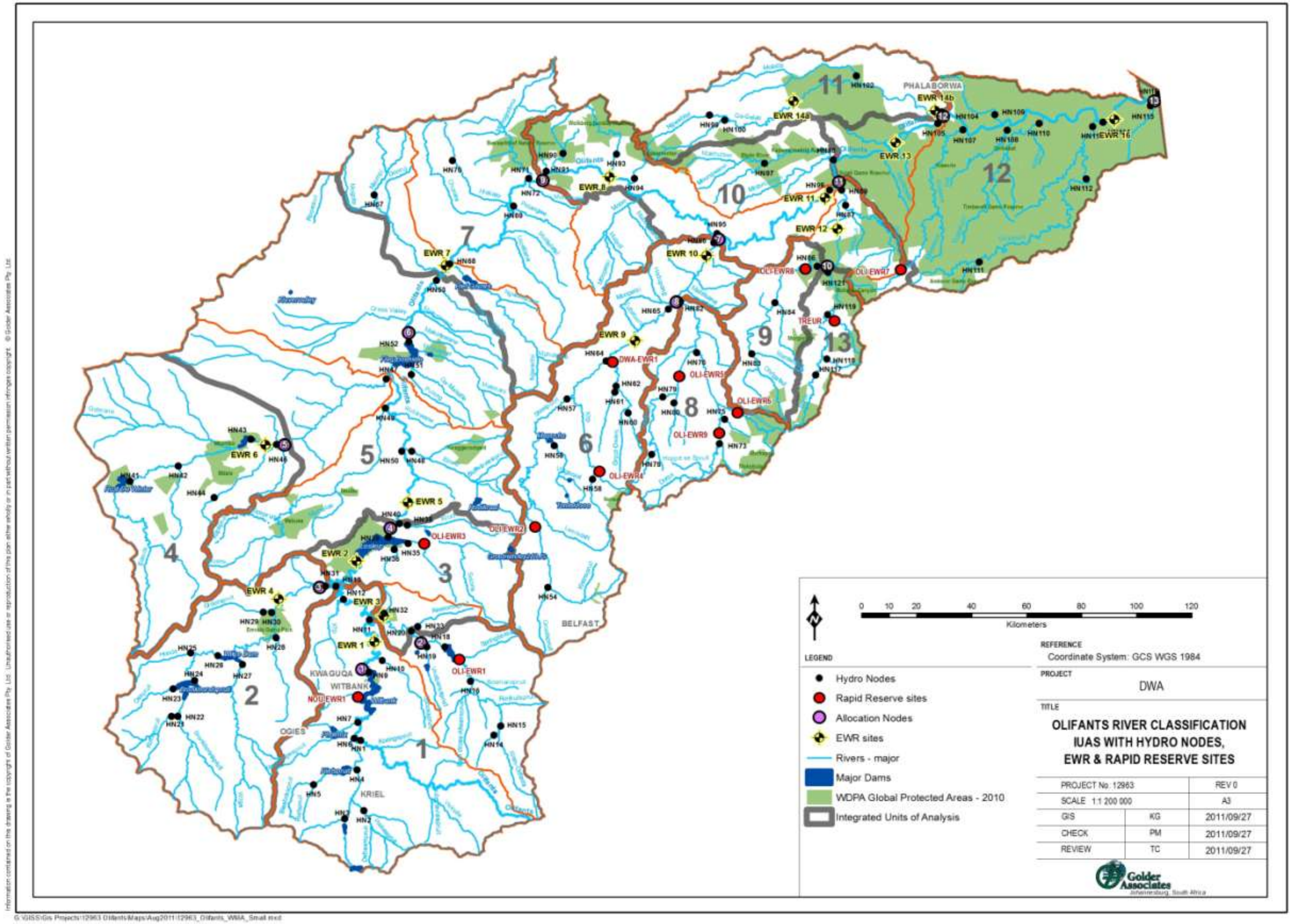


Figure 5 : Integrated Units of Analysis, hydro nodes and EWR sites within Olifants WMA

Table 2: Hydro nodes for the Olifants WMA (per IUA)

IUA	Node no	Quaternary catchment	Hydro-Nodes
1	HN1	B11A, B11B	Olifants (confluence with Steenkoolspruit)
	HN2	B11C	Piekespruit (confluence with Steenkoolspruit)
	HN3	B11D	Dwars-indie-Wegspruit (confluence with Trichardtspruit)
	HN4	B11D	Steenkoolspruit (outlet of quaternary)
	HN5	B11E	Blesbokspruit (confluence with Rietspruit)
	HN6	B11E	Steenkoolspruit (confluence with Olifants)
	HN7	B11F	Olifants (outlet of quaternary)
	HN8	B11G	Noupoortspruit (EWR site – NOU-EWR1)
	HN9	B11G	Olifants (releases from Witbank Dam)
	HN10	B11H	Spookspruit (confluence with Olifants)
	HN11	B11J	Olifants (EWR site 1 – EWR1)
	HN12	B11K, B11L	Klipspruit (confluence with Olifants)
	HN14	B12A	Boschmansfontein (confluence with Klein Olifants)
	HN15	B12A	Klein Olifants (outlet of quaternary)
	HN16	B12B	Klein Olifants (outlet of quaternary)
	HN17	B12C	Klein Olifants (EWR site – OLI-EWR1)
	HN18	B12C	Klein Olifants (releases from Middelburg Dam)
	HN19	B12D	Vaalbankspruit (confluence with Klein Olifants)
	HN20	B12D	Klein Olifants (outlet of quaternary)
2	HN21	B20A	Bronkhorstpruit (outlet of quaternary)
	HN22	B20B	Koffiespruit (confluence with Bronkhorstspruit)
	HN23	B20C	Osspruit (inflow to Bronkhorstspruit Dam)
	HN24	B20C	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)
	HN25	B20D	Hondespruit (confluence with Bronkhorstspruit)
	HN26	B20D	Bronkhorstpruit (confluence with Wilge)
	HN27	B20E, B20F	Wilge (confluence with Bronkhorstspruit
	HN28	B20G	Saalboomspruit (confluence with Wilge)
	HN29	B20H	Grootspruit (confluence with Wilge)
	HN30	B20H	Wilge (outlet of quaternary)
	HN31	B20J	Wilge (EWR site – EWR4, outlet of IUA2)
3	HN32	B12E	Doringboomspruit (confluence with Klein Olifants)
	HN33	B12E	Keeromspruit (confluence with Klein Olifants)
	HN34	B12E	Klein Olifants (EWR site – EWR3)
	HN35	B32A	Kranspoortspruit (EWR site – OLI-EWR3)
	HN36	B32A	Boekenhoutloop (inflow to Loskop Dam)
	HN37	B32A	Olifants (EWR site – EWR2)
	HN38	B32B, B32C	One node at confluence of Selons with Olifants in B32C.

IUA	Node no	Quaternary catchment	Hydro-Nodes
			Included: Klipspruit (confluence with Selons) Kruis (confluence with Selons) Selons (confluence with Olifants)
	HN39	B32C	Olifants (releases from Loskop Dam)
	HN40	B32C	Olifants (outlet of quaternary – outlet of IUA3)
4	HN41	B31A, B, C	One node at outlet of B31C, releases from Rust de Winter Dam. Included: B31A (Elands) B31B (Hartbeesspruit) B31C (Elands)
	HN42	B31D	Enkeldoringspruit (confluence with Elands)
	HN43	B31F	Elands (releases from Makhombe Dam)
	HN44	B31G	Kameel (upper part only
	HN45	B31G	Elands (EWR site – EWR6)
	HN46	B31G	Elands (outlet of quaternary – outlet of IUA4)
5	HN47	B31H, B31J	Elands (outlet of quaternary, confluence with Olifants))
	HN48	B32E, B32F	One node at confluence with Olifants in B32F Included: B32E (Bloed) B32F (Doringpoortloop, Diepkloof and Bloed)
	HN49	B32G, H	One node at outlet of B32H, confluence with Olifants Included: B32G (Moses) B32H (Mametse and Moses)
	HN50	B32D	Olifants (EWR site – EWR5)
	HN51	B51B	Puleng (upper part only)
	HN52	B51B	Olifants (releases from Flag Boshielo Dam)
	HN53	B51D, B51E	Olifants (outlet of quaternary– outlet of IUA5)
6	HN54	B41A	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit
	HN55	B41B	Steelpoort (EWR site – OLI-EWR2)
	HN56	B41C	Masala (confluence with Steelpoort), including Tonteldoos and Vlugkraal)
	HN57	B41D, B41E	Steelpoort (inflow to De Hoop Dam)
	HN58	B41F	Draaikraalspruit (confluence with Klip)
	HN59	B41F	Klip (EWR site – OLI-EWR4)
	HN60	B41G	Kraalspruit (confluence with Groot Dwars)
	HN61	B41G	Klein Dwars (Confluence with Groot Dwars)
	HN62	B41G	Upper reaches of Dwars (before mining impacts)
	HN63	B41H	Dwars (EWR site – DWA-EWR1)

IUA	Node no	Quaternary catchment	Hydro-Nodes
	HN64	B41H	Steelpoort
	HN65	B41J	Steelpoort (EWR site – EWR9)
	HN66	B41J, B41K	Steelpoort (EWR site – EWR10) (confluence with Olifants – outlet of IUA6)
7	HN67	B51F	Nkumpi (outlet of quaternary)
	HN68	B51G	Olifants (EWR site – EWR7)
	HN69	B52E	Palangwe (confluence with Olifants)
	HN70	B52F	Hlakaro (outlet)
	HN71	B52J	Mphogodima (confluence with Olifants)
	HN72	B52A, E, G, J	Olifants (outlet of quaternary – outlet of IUA7)
8	HN73	B42A, B42B	One node for Dorpspruit at outlet of B42B. Included: Hoppe se Spruit (confluence) Doringbergspruit (confluence)
	HN74	B42B	Dorpspruit (EWR site – OLI-EWR9)
	HN75	B42C	Potloodspruit (confluence with Dorps)
	HN76	B42D, B42E	Dorps (confluence with Spekboom) Spekboom (confluence with Dorps)
	HN77	B42D	Spekboom (EWR site – OLI-EWR6)
	HN78	B42F	Potspruit (confluence with Watervals)
	HN79	B42F	Watervals (releases from Buffelskloof Dam)
	HN80	B42G	Rooiwalhoek-se-Loop (confluence with Watervals)
	HN81	B42G	Watervals (EWR site – OLI-EWR5)
	HN82	B42H	Spekboom (outlet of quaternary – outlet of IUA 8)
9	HN83	B60E, B60F	One node at outlet of B60F. Included: Kranskloofspruit (confluence with Ohrigstad) Mantshibi (confluence with Ohrigstad) Ohrigstad (outlet of quaternary)
	HN84	B60G	Vyehoek (confluence with Ohrigstad)
	HN85	B60H	Ohrigstad (EWR site – OLI-EWR8)
	HN86	B60H	Ohrigstad (outlet of quaternary – outlet of IUA9B)
10	HN87	B60J	Sandspruit, including Rietspruit and Qunduhlu
	HN88	B60J	Blyde (EWR site – EWR12)
	HN89	B60J	Blyde (confluence with Olifants)
	HN90	B71A	Paardevlei (confluence with Tongwane)
	HN91	B71A	Tongwane (confluence with Olifants)
	HN92	B71B	Olifants (EWR site – EWR8)
	HN93	B71C	Mohlapitse (upper reaches)
	HN94	B71D	Kgotswane (confluence with Olifants)
	HN95	B71D, B71F	Olifants (confluence with Steelpoort)
	HN96	B71G, H, J	Olifants (EWR11, confluence with Blyde)
	HN97	B72A	Makhutswi, including Moungwane and Malomanye

IUA	Node no	Quaternary catchment	Hydro-Nodes
	HN98	B72C	Olifants (outlet – outlet of IUA10)
11	HN99	B72E	Ngwabatse (confluence with Ga-Selati)
	HN100	B72F, G	Ga-Selati (outlet of quaternary)
	HN101	B72H	Ga-Selati (EWR site – EWR14a)
	HN102	B72J	Molatle (confluence with Ga-Selati)
	HN103	B72K	Ga-Selati (EWR site – EWR14b)
	HN104	B72K	Ga-Selati (outlet of quaternary – outlet of UIA11)
12	HN105	B72D	Olifants (EWR site – EWR13)
	HN106	B73A	Klaserie (EWR site – OLI-EWR7)
	HN107	B73B	Klaserie (confluence with Olifants)
	HN108	B73C	Tsiri (confluence with Olifants)
	HN109	B73C	Tshutshi (confluence with Olifants)
	HN110	B73D	Nhlaralumi, including Machaton, Nyameni and Thlaralumi
	HN111	B73E	Sesete (confluence with Timbavati)
	HN112	B73F	Timbavati (outlet of quaternary)
	HN113	B73G	Timbavati, including Shisakashonghondo
	HN114	B73G, B73H	Olifants (EWR site – EWR16)
	HN115	B73J	Hlahleni (confluence with Olifants)
	HN116	B73J	Olifants (outlet of quaternary – outlet of IUA12)
13	HN117	B60A	Blyde (confluence with Lisbon)
	HN118	B60B	Lisbon, including Heddelspruit and Watervalspruit
	HN119	B60B	Blyde (outlet of quaternary)
	HN120	B60C	Treur (EWR site – TRE-EWR1)
	HN121	B60D	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)

4.4 SOCIO-ECONOMIC EVALUATION AND DECISION ANALYSIS FRAMEWORK

The socio-economic components of Steps 1 and 2 of the WRCS, requires the definition of the evaluation and decision analysis framework. The WRCS therefore places the following principles at the forefront of implementation:

- Maximising economic returns from the use of water resources;
- Allocating and distributing the costs and benefits of utilising the water resource fairly; and
- Promoting the sustainable use of water resources to meet social and economic goals without detrimentally impacting on the ecological integrity of the water resource.

In order to ensure that the determination of a management class is supported by a robust technical assessment and decision-analysis process, the methodology supporting the socio-economic components of the WRCS implementation in the Olifants addressed the following key components:

- Source and critically review the available socio-economic data describing the communities and economies of the Olifants WMA and aligned to the IUAs identified for the Olifants WMA;

- Identify socio-economic zones describing the socio-economic status aligned to the IUAs based on the land tenure and land use within the study area. The Olifants WMA is divided into four relatively homogenous socio-economic zones, namely; rural agriculture, conservation and agricultural, energy zone and metallic minerals zone;
- Review specific studies for all major sectors in the WMA *i.e*. mining, agriculture, energy and tourism and where possible consult sectors to address information gaps;
- Describe and value the use of water and aquatic ecosystems in order to establish the dependence of communities on these ecosystems. The economic value of water use in the Olifants WMA and the dependence of communities on the in-stream goods and services provided by the water resources was assessed.

The key outputs of this stage of the classification process included the following:

- A summary of available economic data essentially describing the present-day socio-economic status of the WMA;
- Measurement of economic value and the measures of economic implications and social well-being;
- Understanding the future water use scenarios and the impacts that they will have on business, communities and the environment;
- A socio-economic valuation framework that links changes in water resource variables, such as yield, water quality and aquatic ecosystem health, to economic benefits and social well-being; and
- A decision-analysis framework developed to make provision for assessing the current socio-economic status and the potential economic and social implications related to future water resource management scenarios implied by each management class. The framework incorporates commonly used economic modelling techniques that form the basis for the cost-benefit analysis for evaluating implications of water resource management scenarios on the regional economy and social well-being.

Based on the above outputs four models and accounts (see Figure 6) were developed to support the macro-economic evaluation of scenarios as part of the scenario analysis step of the WRCS process and have been used to value the economy of the Olifants WMA:

- The Social Accounting Matrices for Mpumalanga and Limpopo Provinces;
- The Olifants Hybrid Water Environmental Economic Account;
- The Olifants Aquatic Ecosystem Services Account based on the Millennium Assessment framework and building on the prior work done by DWA (2010); and
- The Olifants Water Quality Model expressed through a Marginal Cost of Abatement Curve and a Load Model.

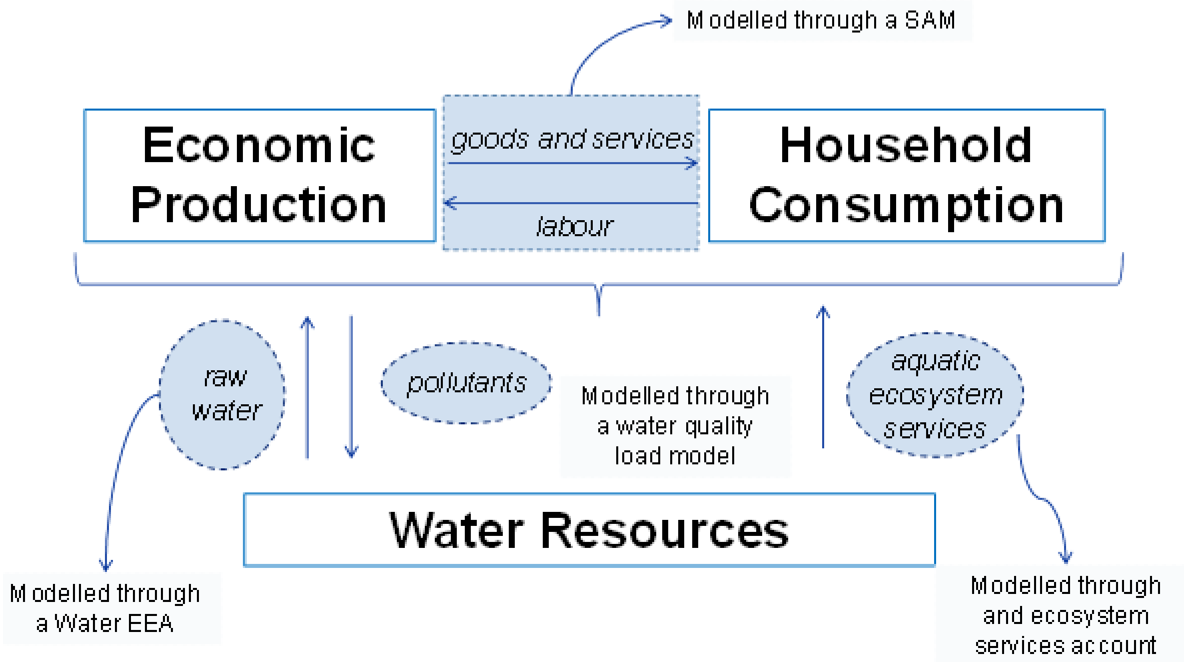


Figure 6: Schematic representation of the economic modelling techniques required to address the transactions of the Olifants WMA water economy

The proposed approach and framework, the methodology and the data sources used for the economic modelling done so far in support of the classification of significant water resources in the Olifants Water Management Area (WMA) has been reviewed and accepted by representative stakeholder organisations at two focus group meetings held on 7 July 2011 and 31 January 2012 at Loskop Dam. The modelling process is iterative and suggestions and data additions by the stakeholders were gladly welcomed and incorporated wherever identified. Stakeholders had the opportunity to review and provide inputs on the approach and models which was then taken forward to this step in the study. More detailed information on the socio-economic framework is available in the study report.

The above socio-economic decision-analysis framework was used for the analyses of scenarios in this evaluation of scenarios step (Step 5 of WRCS process) that links the socio-economic and ecological value and condition of the relevant water resources with requirements of the various scenario class configurations proposed.

The objective of the socio-economic evaluation and decision analysis framework is to enable the assessment of the implications of different catchment configuration scenarios at an IUA level on economic prosperity, social wellbeing and ecological condition.

4.5 ECOLOGICAL WATER REQUIREMENTS QUANTIFICATION

The classification process requires the quantification of ecological water requirements (EWRs) that have either been determined through previous Reserve studies or through Reserve determination processes that would need to be investigated for the purpose of classification. However, in the case of an existing preliminary Reserve in some instances an extrapolation process would be required, and if necessary, high confidence EWR data collected.

It is necessary to provide ecological and Reserve data to enable the determination of the MC of all the significant water resources of the Olifants WMA by quantifying the EWRs. The process followed to quantify the EWRs is described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWA, February 2007a and 2007b).

In terms of the RDM data required as part of the WRCS process, all available ecological/EWR information has been assessed and reviewed and the information required for the analysis of the catchment configuration scenarios has been collated.

A number of Reserve studies have been undertaken since 2001 at various levels of detail. The most significant study was the comprehensive study undertaken during 2001 to 2003. The comprehensive Olifants River Ecological Water Requirements study of 2001 presented the results of 16 EWR sites for the preliminary Reserve (see Table 3). These sites are situated in the Olifants River main stem as well as major tributaries. An initiative between DWA and the World Conservation Union (IUCN) in 2007 identified additional sites in smaller tributaries and lower confidence Reserve studies were conducted on the Bronkhorspruit (Rapid III), Treur River (Rapid III) and Dwars River (intermediate) (see Table 3). These studies were undertaken mainly to address specific water use license applications and they were focused on smaller tributaries.

Results from both these studies have been used in this classification study to quantify the EWRs.

Table 3: Information from previous Reserve studies in the Olifants catchment

EWR site	River	Quaternary catchment	PES 2001	EIS	REC	VMAR [1)] ($10^6 m^3$)	%EWR	Level
EWR1	Olifants	B11J	E	Moderate	C	184.5	18.6	Comprehensive
EWR2	Olifants	B32A	C	High	B	500.6	23.8	Comprehensive
EWR3	Klein Olifants	B12E	D	Moderate	C	81.5	27.0	Comprehensive
EWR4	Wilge	B20J	B	High	B	175.5	29.9	Comprehensive
EWR5	Olifants	B32D	C	High	C	571	19.1	Comprehensive
EWR6	Elands	B31G	D	Moderate	D	60.3	17.9	Comprehensive
EWR7	Olifants	B51G	E	Moderate	D	726.5	12.7	Comprehensive
EWR8	Olifants	B71B	E	Moderate	D	813	15.2	Comprehensive
EWR9	Steelpoort	B41J	D	High	D	120.2	15.2	Comprehensive
EWR10	Steelpoort	B41K	D	High	D	336.6	12.1	Comprehensive
EWR11	Olifants	B71J	E	High	D	1321.8	13.7	Comprehensive
EWR12	Blyde	B60J	B	High	B	383.7	34.5	Comprehensive
EWR13	Olifants	B72D	C	Moderate	B	1760.7	23.6	Comprehensive
EWR14a	Ga-Selati	B72H	C	Moderate	C	52.2	31.2	Comprehensive
EWR14b	Ga-Selati	B72K	E	Moderate	D	72.7	24.8	Comprehensive
EWR16	Olifants	B73H	C	Very high	B	1916.9	21.6	Comprehensive
TRE-EWR1	Treur	B60C	A/B	Very high	A/B	49.3	45.4	Rapid III
NOU-EWR1	Noupoort-spruit	B11G	C/D	Moderate	C/D	4.3	25.9	Rapid III
DWA-EWR1	Dwars	B41H	B/C	High	B/C	31.4	25.9	Intermediate

[1)] VMAR – Virgin Mean Annual Runoff is based on the updated hydrology from the DWA 2009 study

Additional rapid Reserve determination studies have been undertaken to enhance the existing information and to enable the extrapolation of EWRs to all the identified hydro-nodes. A total of 9 additional rivers have been identified where no or very little information was available for further use during the classification of the significant water resources of the Olifants River catchment. Through this current classification rapid assessments were undertaken during August 2011 at these 9 sites to determine the EWRs (Table 4).

Table 4: Details of additional EWR sites assessed (Rapids) as part of the current classification study

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Ecoregion level 2*	Virgin MAR ($10^6 m^3$)
OLI-EWR1	B12C	Upper Klein Olifants	Rapid III	S 25.8169°	E 29.5904°	11.05	44.46
OLI-EWR2	B41B	Upper Steelpoort	Rapid III	S 25.3831°	E 29.8383°	9.05	63.46
OLI-EWR3	B32A	Kranspoortspruit	Rapid III	S 25.4376°	E 29.4758°	11.01	4.71
OLI-EWR4	B41F	Klip	Rapid I	S 25.2249°	E 30.0523°	9.02	5.20
OLI-EWR5	B42G	Watervals	Rapid III	S 24.8912°	E 30.3105°	9.02	36.39
OLI-EWR6	B42D	Upper Spekboom	Rapid III	S 25.0094°	E30.5003°	9.02	28.04
OLI-EWR7	B73A	Klaserie	Rapid III	S 24.5427°	E31.0349°	3.07	25.54
OLI-EWR8	B60H	Ohrigstad	Rapid II	S 24.5403°	E 30.7223°	9.02	65.49
OLI-EWR9	B42B	Dorpspruit	Rapid I	S 25.0758°	E 30.4399°	9.02	63.19

*EcoRegional classification allows for the grouping of rivers according to similarities. The available information was used to delineate EcoRegion boundaries at a very broad scale (*i.e.* Level I) for South Africa. Attributes such as physiography, climate, rainfall, geology and potential natural vegetation were evaluated in this process and 18 Level I EcoRegions were identified (Kleynhans *et al*., 2005). The next level, Level II, which used the same attributes but included more detail was defined in 2007 (Kleynhans *et al*., 2007).

The initial hydro nodes selected as part of the IUA delineation process were then revised and finalised following discussions with various specialists and especially with the information that became available after the additional rapid Reserves were undertaken for selected tributaries of the Olifants River where no or very little information was available (refer to Table 2).The EWR sites (from the previous Reserve studies and additional Rapid sites) and final selected hydro-nodes are indicated in Figure 5.

The rules as determined during the comprehensive study to obtain the ecological requirements have been used during this study for the existing EWR sites and where applicable for estimation and/or extrapolation to other areas. The existing hydraulic profiles were used during a specialist workshop to confirm the flows and determine possible ecological consequences of the various flow scenarios at the EWR sites during this step of scenario evaluation.

The information as generated from the update of the Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) study of the Olifants River (DWA, 2011) has been used where applicable.

4.6 PRESENT ECOLOGICAL STATE (PES)

The Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) per hydro-node have been provided by the DWA desktop PES, EI and ES study that was undertaken for the Olifants River during 2010 (DWA, 2010). In situations where the selected hydro-node is an existing EWR site from a previous Reserve study, the PES and EIS information provided was obtained from these studies. The PES, REC (at EWR sites), EI and ES per hydro-node and the consideration for node selection in the Olifants WMA are indicated in Table 5 and PES per node is indicated in Figure 7. The PES assessment was undertaken external to the Olifants classification process by the DWA, however it formed a key input in terms of the ecological condition of the water resources in the Olifants. The supporting information and reports for the PES study may be obtained from the DWA, Chief Directorate Resource Directed Measures. A summary of the PES of the water resources in the Olifants WMA is described in Table 6.

The river Freshwater Ecosystem Priority Areas (FEPAs) identified through the National Freshwater Ecosystem Priority Areas Project of the Water Research Commission (WRC, 2011), were assessed to determine if they were adequately protected through the PES categories for the nodes for these catchments. FEPAs have been identified as those areas that are important for sustaining the integrity and continued functioning of their related ecosystems. The FEPAs identified in the Olifants WMA are shown in Figure 8. Forty nine (49) FEPAs are present in the Olifants WMA (Refer to Appendix B). The assessment of the FEPAs in relation to the hydro-nodes and the catchment areas requiring higher ecological protection identified for the Olifants WMA through this classification process show good alignment (refer to Figure 9). The FEPAs will be protected by the level of protection proposed in this process – 82 % of the FEPAs (40) are within areas of the IUAs that require a higher level of protection than the overall IUA class.

Table 5: Hydro nodes selected for the Olifants WMA indicating PES and consideration for selection

IUA	Node no	Quaternary catchment	Nodes	EI	ES	PES	REC	Consideration for selection
1	HN1	B11A, B11B	Olifants (confluence with Steenkoolspruit)	High	High	C		Management Unit, biophysical, water quality impacts
	HN2	B11C	Piekespruit (confluence with Steenkoolspruit)	High	High	B		Biophysical
	HN3	B11D	Dwars-indie-Wegspruit (confluence with Trichardtspruit)	High	High	C		Biophysical
	HN4	B11D	Steenkoolspruit (outlet of quaternary)	Moderate	High	D		Management Unit, water quality impacts
	HN5	B11E	Blesbokspruit (confluence with Rietspruit)	High	High	B		Biophysical
	HN6	B11E	Steenkoolspruit (confluence with Olifants)	Moderate	High	D		Management Unit, water quality impacts
	HN7	B11F	Olifants (outlet of quaternary)	Moderate	High	D		Management Unit, impacts of Klippoortjie & Tweefonteinspruit
	HN8	B11G	Noupoortspruit (EWR site – NOU-EWR1) (existing)	EIS=Moderate		C/D		Management Unit, water quality impacts on Witbank Dam
	HN9	B11G	Olifants (releases from Witbank Dam)	Moderate	High	D		Downstream Witbank Dam – releases from dam
	HN10	B11H	Spookspruit (confluence with Olifants)	High	High	C		Biophysical
	HN11	B11J	Olifants (EWR site 1 – EWR1) (existing)	EIS= Moderate		D	D	Biophysical
	HN12	B11K, B11L	Klipspruit (confluence with Olifants)	High	Moderate	D		Management Unit, water quality impacts
	HN14	B12A	Boschmansfontein (confluence with Klein Olifants)	Moderate	High	C		Biophysical
	HN15	B12A	Klein Olifants (outlet of quaternary)	High	High	C		Biophysical
	HN16	B12B	Klein Olifants (outlet of quaternary)	Moderate	High	D		Impacts of mining in tributary catchments
	HN17	B12C	Klein Olifants (EWR site – OLI-EWR1) (Rapid site)	EIS=Low		C		Impacts from upstream mining and agricultural activities
	HN18	B12C	Klein Olifants (releases from Middelburg Dam)	Moderate	High	D		Biophysical, releases from Middelburg Dam
	HN19	B12D	Vaalbankspruit (confluence with Klein Olifants)	Moderate	High	D		Biophysical
	HN20	B12D	Klein Olifants (outlet of quaternary)	Moderate	High	D		Management Unit, impacts from dam and Middelburg town
2	HN21	B20A	Bronkhorstpruit (outlet of quaternary)	Moderate	High	C		Management Unit, biophysical, impacts from Delmas area

IUA	Node no	Quaternary catchment	Nodes	EI	ES	PES	REC	Consideration for selection
	HN22	B20B	Koffiespruit (confluence with Bronkhorstspruit)	Moderate	High	C		Biophysical
	HN23	B20C	Osspruit (inflow to Bronkhorstspruit Dam)	Moderate	High	D		Biophysical
	HN24	B20C	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)	High	High	C		Management Unit, biophysical
	HN25	B20D	Hondespruit (confluence with Bronkhorstspruit)	High	High	C		Biophysical
	HN26	B20D	Bronkhorstpruit (confluence with Wilge)	High	Very high	C		Management Unit, biophysical, impacts from Bronkhorstspruit
	HN27	B20E, B20F	Wilge (confluence with Bronkhorstspruit	High	Very high	C		Management Unit, biophysical
	HN28	B20G	Saalboomspruit (confluence with Wilge)	Moderate	High	C		Management Unit, future mining impacts
	HN29	B20H	Grootspruit (confluence with Wilge)	High	Very high	C		Biophysical
	HN30	B20H	Wilge (outlet of quaternary)	High	Very high	B		Management Unit, biophysical
	HN31	B20J	Wilge (EWR site – EWR4, outlet of IUA2) (existing)	EIS=High		C	B	Biophysical & outlet of IUA2
3	HN32	B12E	Doringboomspruit (confluence with Klein Olifants)	High	High	B		Biophysica
	HN33	B12E	Keeromspruit (confluence with Klein Olifants)	High	High	C		Biophysical
	HN34	B12E	Klein Olifants (EWR site – EWR3) (existing)	EIS =Moderate		C	C	Biophysical, Management Unit
	HN35	B32A	Kranspoortspruit (EWR site – OLI-EWR3) (Rapid site)	EIS=Very high		B		Biophysical, inflow to Loskop Dam
	HN36	B32A	Boekenhoutloop (inflow to Loskop Dam)	High	High	B		Biophysical
	HN37	B32A	Olifants (EWR site – EWR2) (existing)	EIS=High		C	B	Management Unit, biophysical
	HN38	B32B, B32C	One node at confluence of Selons with Olifants in B32C. Included: Klipspruit (confluence with Selons) Kruis (confluence with Selons) Selons (confluence with Olifants)	 High High High	 High High Very high	 B B C		 Biophysical Biophysical Biophysical
	HN39	B32C	Olifants (releases from Loskop Dam)	High	High	D		Management of system
	HN40	B32C	Olifants (outlet of quaternary – outlet of IUA3)	High	High	D	B	outlet of IUA3
4	HN41	B31A, B, C	One node at outlet of B31C, releases from Rust de Winter Dam.					

IUA	Node no	Quaternary catchment	Nodes	EI	ES	PES	REC	Consideration for selection
			Included: B31A (Elands) B31B (Hartbeesspruit) B31C (Elands)	High High High	High Very high Very high	C C C		Biophysical Biophysical Biophysical, management of system releases from dam
	HN42	B31D	Enkeldoringspruit (confluence with Elands)	High	High	C		Biophysical
	HN43	B31F	Elands (releases from Mkumbe Dam)	High	High	C		Management Unit, biophysical, releases from dam
	HN44	B31G	Kameel (upper part only	Moderate	High	D		Biophysical, before impacts of town and villages
	HN45	B31G	Elands (EWR site – EWR6) (existing)	EIS=Moderate		D	D	Biophysical
	HN46	B31G	Elands (outlet of quaternary – outlet of IUA4)	Low	Moderate	E		Management Unit & outlet of IUA4
5	HN47	B31H, B31J	Elands (outlet of quaternary, confluence with Olifants))	Low	Moderate	E		Management Unit
	HN48	B32E, B32F	One node at confluence with Olifants in B32F Included: B32E (Bloed) B32F (Doringpoortloop, Diepkloof and Bloed)	Moderate High	High Moderate	B C		Biophysical Biophysical
	HN49	B32G, H	One node at outlet of B32H, confluence with Olifants Included: B32G (Moses) B32H (Mametse and Moses)	High High	High High	C D		Biophysical Biophysical
	HN50	B32D	Olifants (EWR site – EWR5) (existing)	EIS=Moderate		C	C	Management Unit, biophysical, confluence with Elands
	HN51	B51B	Puleng (upper part only)	High	High	B		Biophysical
	HN52	B51B	Olifants (releases from Flag Boshielo Dam)	Moderate	High	D		Management of system
	HN53	B51D, B51E	Olifants (outlet of quaternary– outlet of IUA5)	Moderate	High	D		Management Unit & outlet of IUA5
6	HN54	B41A	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit	High High	High Very high	C D		Biophysical Biophysical
	HN55	B41B	Steelpoort (EWR site – OLI-EWR2) (Rapid site)	EIS=Moderate		D	C	Biophysical
	HN56	B41C	Masala (confluence with Steelpoort), including	High	High	C		Biophysical

IUA	Node no	Quaternary catchment	Nodes	EI	ES	PES	REC	Consideration for selection
			Tonteldoos and Vlugkraal)					
	HN57	B41D, B41E	Steelpoort (inflow to De Hoop Dam)	High	Very high	C		Biophysical & management unit
	HN58	B41F	Draaikraalspruit (confluence with Klip)	High	Very high	B		Biophysical
	HN59	B41F	Klip (EWR site – OLI-EWR4) (Rapid site)	EIS=Moderate		C		Biophysical, inflow to De Hoop Dam
	HN60	B41G	Kraalspruit (confluence with Groot Dwars)	High	Very high	B		Biophysical
	HN61	B41G	Klein Dwars (Confluence with Groot Dwars)	High	High	D		Biophysical
	HN62	B41G	Upper reaches of Dwars (before mining impacts)	High	Very high	C		Biophysical
	HN63	B41H	Dwars (EWR site – DWA-EWR1) (existing)	EIS=High		B/C	B/C	Biophysical, mining impacts, confluence with Steelpoort
	HN64	B41H	Steelpoort	EIS=Moderate		D		Biophysical, releases from De Hoop Dam
	HN65	B41J	Steelpoort (EWR site – EWR9) (existing)	EIS=High		D	D	Biophysical
	HN66	B41J, B41K	Steelpoort (EWR site – EWR10) (existing) (confluence with Olifants – outlet of IUA6)	Moderate	High	D	D	Management Unit & outlet of IUA6
7	HN67	B51F	Nkumpi (outlet of quaternary)	High	Moderate	C		Biophysical
	HN68	B51G	Olifants (EWR site – EWR7) (existing)	EIS=Moderate		E	D	Biophysical & management unit
	HN69	B52E	Palangwe (confluence with Olifants)	High	High	C		Biophysical
	HN70	B52F	Hlakaro (outlet)	High	High	C		Biophysical
	HN71	B52J	Mphogodima (confluence with Olifants)	High	High	C		Biophysical
	HN72	B52A, E, G, J	Olifants (outlet of quaternary – outlet of IUA7)	Moderate	High	D	D	Management Unit & outlet of IUA7
8	HN73	B42A, B42B	One node for Dorpspruit at outlet of B42B. Included: Hoppe se Spruit (confluence) Doringbergspruit (confluence)	 Moderate High	 High High	 C C		 Biophysical Biophysical
	HN74	B42B	Dorpspruit (EWR site – OLI-EWR9) (Rapid site)	EIS=Low		C/D		Biophysical, water quality impacts from Lydenburg
	HN75	B42C	Potloodspruit (confluence with Dorps)	High	High	C		Biophysical
	HN76	B42D, B42E	Dorps (confluence with Spekboom) Spekboom (confluence with Dorps)	High High	High Very high	C C		Biophysical, water quality impacts from Lydenburg Biophysical

IUA	Node no	Quaternary catchment	Nodes	EI	ES	PES	REC	Consideration for selection
	HN77	B42D	Spekboom (EWR site – OLI-EWR6) (Rapid site)	EIS=High		C		Biophysical
	HN78	B42F	Potspruit (confluence with Watervals)	High	High	C		Biophysical
	HN79	B42F	Watervals (releases from Buffelskloof Dam)	High	Very high	C		Biophysical & management unit
	HN80	B42G	Rooiwalhoek-se-Loop (confluence with Watervals)	High	Very high	B		Biophysical
	HN81	B42G	Watervals (EWR site – OLI-EWR5) (Rapid site)	EIS=Moderate		C	C	Biophysical, confluence with Spekboom
	HN82	B42H	Spekboom (outlet of quaternary – outlet of IUA 8)	High	Moderate	B	B	Confluence with Steelpoort & outlet of IUA8
9	HN83	B60E, B60F	One node at outlet of B60F. Included: Kranskloofspruit (confluence with Ohrigstad) Mantshibi (confluence with Ohrigstad) Ohrigstad (outlet of quaternary)	 High High Moderate	 Very high Very high Very high	 C C D		 Biophysical Biophysical Biophysical & management unit
9	HN84	B60G	Vyehoek (confluence with Ohrigstad)	High	Very high	C		Biophysical
9	HN85	B60H	Ohrigstad (EWR site – OLI-EWR8) (Rapid site)	EIS=Moderate		C	C	Biophysical
9	HN86	B60H	Ohrigstad (outlet of quaternary – outlet of IUA9)	High	Very high	D	D	Inflow to Blyderivierpoort Dam & outlet of IUA9
10	HN87	B60J	Sandspruit, including Rietspruit and Qunduhlu	High	Moderate	B		Biophysical, confluence with Blyde
10	HN88	B60J	Blyde (EWR site – EWR12) (existing)	EIS=High		B/C	B	Biophysical & releases from Blyderivierpoort Dam
10	HN89	B60J	Blyde (confluence with Olifants)	Very high	Very high	C		Biophysical
10	HN90	B71A	Paardevlei (confluence with Tongwane)	High	Very high	B		Biophysical
10	HN91	B71A	Tongwane (confluence with Olifants)	High	High	B		Biophysical
10	HN92	B71B	Olifants (EWR site – EWR8) (existing)	EIS=Moderate		D	D	Biophysical & management unit
10	HN93	B71C	Mohlapitse (upper reaches)	Very high	Very high	B		Biophysical, conservation area
10	HN94	B71D	Kgotswane (confluence with Olifants)		Moderate	B		Biophysical
10	HN95	B71D, B71F	Olifants (confluence with Steelpoort)	High	Very high	D		Biophysical & management unit
10	HN96	B71G, H, J	Olifants (EWR11, confluence with Blyde) (existing)	EIS=High		E	D	Biophysical & management unit
10	HN97	B72A	Makhutswi, including Moungwane and Malomanye	High	High	C		Biophysical
10	HN98	B72C	Olifants (outlet – outlet of IUA10)	High	High	C	C	Biophysical, management unit & outlet of IUA10
11	HN99	B72E	Ngwabatse (confluence with Ga-Selati)	High	Very high	D		Biophysical

IUA	Node no	Quaternary catchment	Nodes	EI	ES	PES	REC	Consideration for selection
	HN100	B72F, G	Ga-Selati (outlet of quaternary)	High	Very high	C		Biophysical
	HN101	B72H	Ga-Selati (EWR site – EWR14a) (existing)	EIS=Moderate		C	C	Biophysical
	HN102	B72J	Molatle (confluence with Ga-Selati)	Moderate	Moderate	B		Biophysical
	HN103	B72K	Ga-Selati (EWR site – EWR14b) (existing)	EIS=Moderate		E	C	Biophysical, management unit & outlet of IUA11
	HN104	B72K	Ga-Selati (outlet of quaternary – outlet of UIA11)	High	High	E	C	Management, confluence with Olifants & outlet of IUA11
12	HN105	B72D	Olifants (EWR site – EWR13) (existing)	EIS=Moderate		C	C	Biophysical & management unit
	HN106	B73A	Klaserie (EWR site – OLI-EWR7) (Rapid site)	EIS=High		B/C		Biophysical & management unit
	HN107	B73B	Klaserie (confluence with Olifants)	High	High	C		Biophysical, releases from Klaserie Dam
	HN108	B73C	Tsiri (confluence with Olifants)	High	Low	B		Biophysical
	HN109	B73C	Tshutshi (confluence with Olifants)	High	Low	B		Biophysical
	HN110	B73D	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	High	Low	B		Biophysical
	HN111	B73E	Sesete (confluence with Timbavati)	High	Low	B		Biophysical
	HN112	B73F	Timbavati (outlet of quaternary)	High	Moderate	B		Biophysical
	HN113	B73G	Timbavati, including Shisakashonghondo	High	Moderate	B		Biophysical
	HN114	B73G, B73H	Olifants (EWR site – EWR16) (existing)	EIS=High		C	B	Biophysical & management unit
	HN115	B73J	Hlahleni (confluence with Olifants)	High	Low	A		Biophysical
	HN116	B73J	Olifants (outlet of quaternary – outlet of IUA12)	High	Low	C	B	Biophysical, management unit & outlet of IUA12
13	HN117	B60A	Blyde (confluence with Lisbon)	High	Very high	C		Biophysical
	HN118	B60B	Lisbon, including Heddelspruit and Watervalspruit	High	Very high	B		Biophysical
	HN119	B60B	Blyde (outlet of quaternary)	High	Very high	B		Biophysical
	HN120	B60C	Treur (EWR site – TRE-EWR1) (existing)	EIS=Very high		B		Biophysical
	HN121	B60D	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	High	Very high	B	A/B	Biophysical, dolomitic fountains, conservation area including Kadishispruit, Belvedere, Muilhuisspruit,

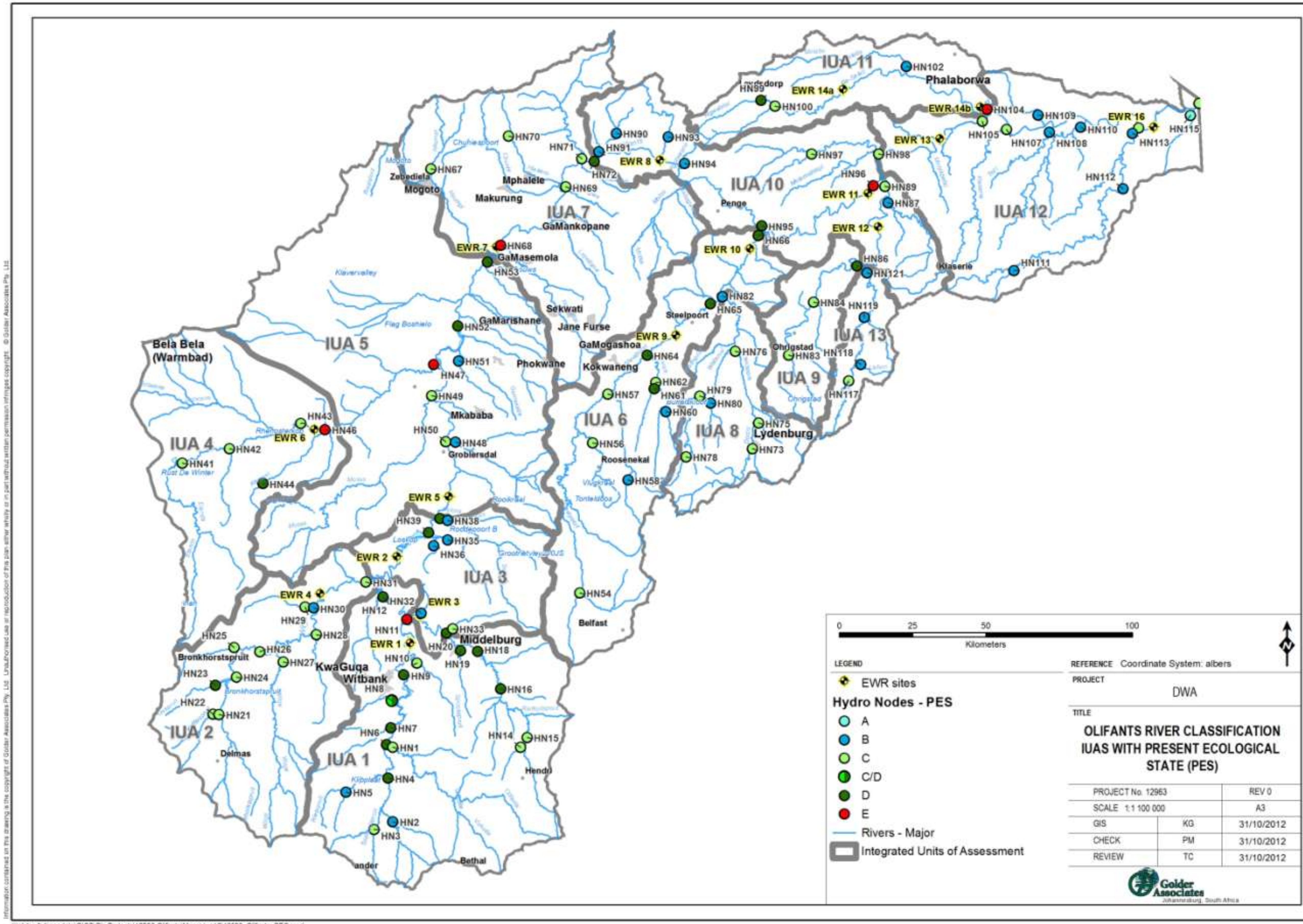


Figure 7: PES per hydro-node

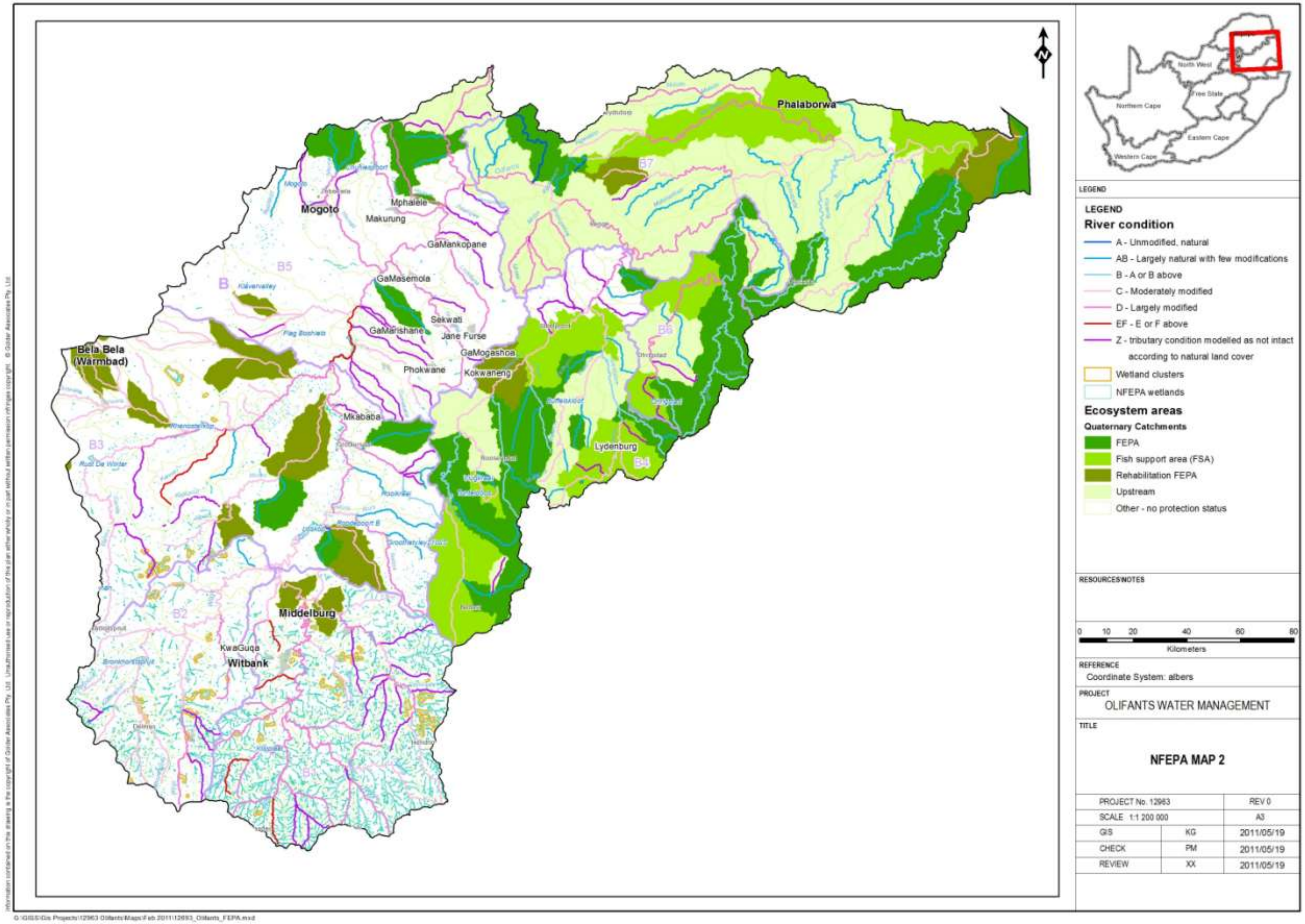


Figure 8: FEPAs identified for the Olifants WMA

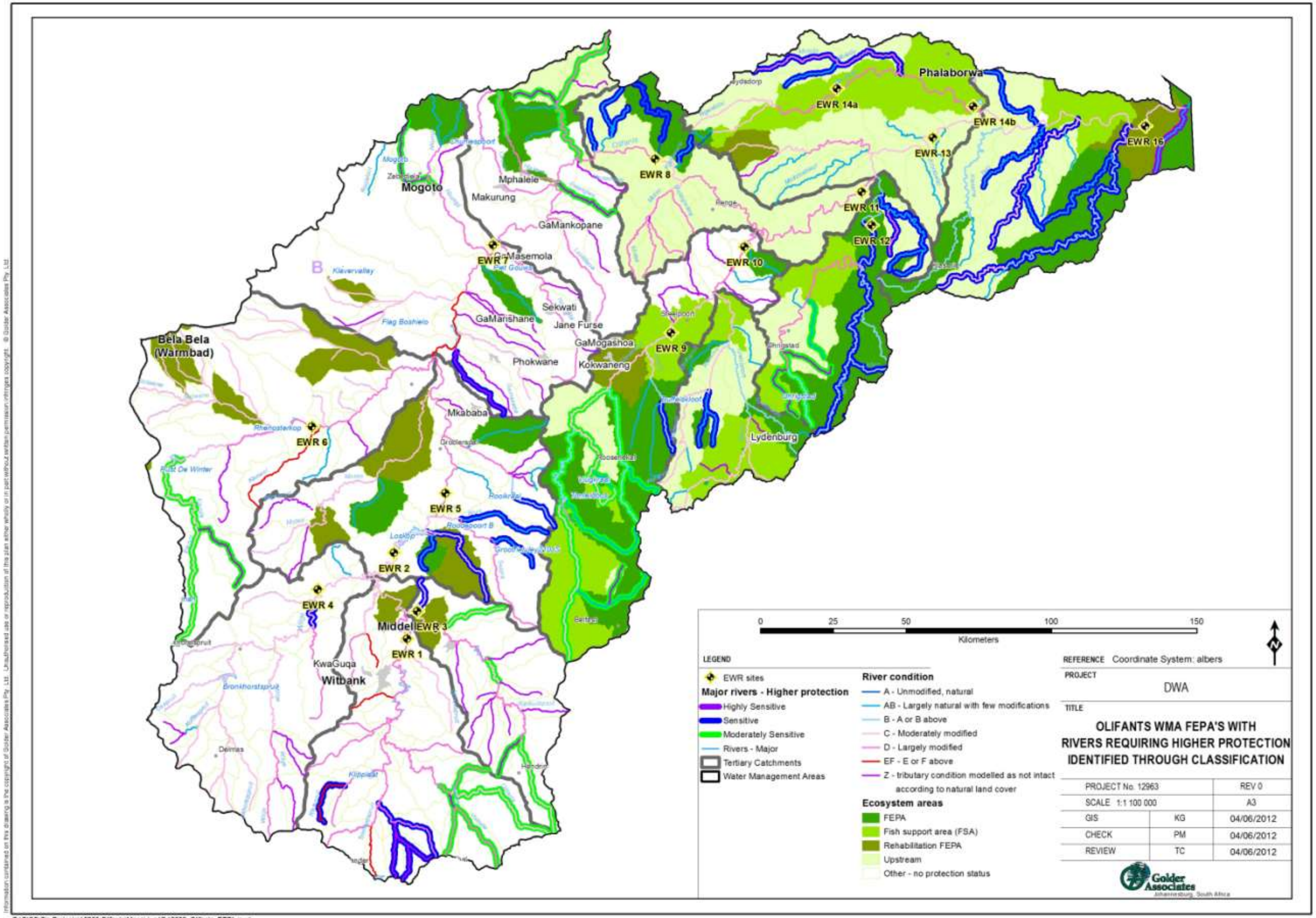


Figure 9: Correlation between FEPAs and hydro-nodes in Olifants WMA requiring higher level of protection

Table 6: Summary of Present ecological status of water resources in the Olifants WMA

IUA 1: Upper Olifants River catchment
Olifants, Steenkoolspruit and Upper Klein Olifants rivers The water resources in the IUA are degraded and mainly in an E category presently due to the coal mining activities, large dams and urbanisation. The ecological importance is low except around the Witbank Dam area. This area still has some local, undeveloped areas. A number of wetlands are present in the upper reaches of the catchment.
EWR sites • Comprehensive site on Olifants River downstream of Witbank Dam (EWR1, B11J) • Rapid III site on Noupoortspruit (B11G)
IUA 2: Wilge River catchment area
Bronkhorstspruit, Saalboomspruit and Upper Wilge rivers: The rivers in the IUA are in a moderately modified state (category C) with less developed areas in the catchment. Impacts within the catchment are related to agriculture, dams and some mining. The importance of the resources is moderate especially in terms of good water quality they contribute to the main stem Olifants above Loskop Dam.
EWR sites Comprehensive site.on Lower Wilge River, just below Emvelo game park (EWR4, B20J)
IUA 3: Selons River area including Loskop Dam
Lower Klein Olifants, Selons and Loskop Dam: The state of the water resources in the IUA have been degraded (B to C category), mainly due to the upstream impacts from the Olifants and Klein Olifants. The PES of the main stem of the Olifants River is a C with the REC of a B due to upstream flow regulation and water quality. However, the presence of un-proclaimed wilderness areas and nature reserves provides habitats for the various biota in the system that give this area a high ecological importance.
EWR sites • Comprehensive site on Klein Olifants River (EWR 3, B12E) • Comprehensive site on Olifants River (EWR 2, B32A), upstream Loskop Dam • Rapid III site on Kranspoortspruit (B32A)
IUA 4: Elands River catchment area
Elands River: The IUA is mainly rural in the upper reaches of the catchment with impacts from agriculture, dams, towns and informal settlements in the lower reaches of the catchment. The upper reaches of the Elands River are still in a very good ecological state (C category), but degrades along the river to a D category below the dams. The river is a moderately important system as it provides good habitats for the biota present. Some conservation areas are present in this IUA.
EWR sites Elands River below Mkhombo Dam (EWR6, B31G)
IUA 5: Middle Olifants up to Flag Boshielo Dam
Olifants below Loskop Dam, Lower Elands, Moses rivers: The water resources are mainly in a C category as the upstream impacts (mainly water quality related) are somewhat mitigated by Loskop Dam. The ecological importance of the rivers in the IUA is moderate with a few conservation areas present. Large areas of this IUA are almost endoreic and groundwater is the major source of water in these catchments.

EWR sites

Olifants below Loskop Dam (EWR5, B32D) – Comprehensive site. No sites on Moses, Bloed or other smaller tributaries.

IUA 6: Steelpoort River catchment

Steelpoort, Klip and Dwars rivers:

The present state of the Steelpoort River has been modified from the natural (D category) due to impacts from agriculture and settlements. The Klip and Dwars rivers are still in a good present state. However, the impacts from mining on the Dwars river have resulted in a moderately modified state (B/C category).

The main stem Steelpoort River is of moderate ecological importance. However, the Klip and Dwars rivers have a high importance and sensitivity due to the presence of the Veloren Vallei nature reserve, the transition from mountain to bushveld and the unique geology.

EWR Sites

- Steelpoort below De Hoop Dam (EWR9, B41H) – Comprehensive site
- Steelpoort just before confluence with the Olifants (EWR10, B41K) – Comprehensive site
- Dwars just before the confluence with the Steelpoort (B41H) – Intermediate site.

IUA 7: Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River

Main stem Olifants and smaller tributaries:

The ecological importance of these systems is low to moderate, especially for some of the tributaries. The present state of the main stem is in an E category that is mainly due to agricultural impacts.

EWR sites

Olifants below Flag Boshielo Dam (EWR7, B51G) - Comprehensive site

IUA 8: Spekboom catchment

Spekboom, Dorps and Waterfalls rivers:

The present state of these rivers are ranging from almost natural (Waterfalls source) to degraded (Dorps). The ecological importance of the Spekboom and Waterfalls is high and moderate for the Dorps. A number of protected areas have been identified in the upper reaches of this IUA. The impacts are mainly from urbanisation and some agriculture in the catchment.

EWR sites

Watervals River ((OLI-EWR5, B42G) - Rapid III site

IUA 9: Ohrigstad River catchment

Ohrigstad:

The Ohrigstad River has been impacted by agriculture and is presently in a C category.

EWR sites

Orighstad River ((OLI-EWR8, B60H) - Rapid II site

IUA 10: Lower Olifants

Main stem Olifants, Lower Blyde and smaller tributaries:

The main stem Olifants is presently in a D category with the lower Blyde and Mohlapitse in a B. The impacts on the Olifants are from irrigation along the river and the Flag Boshielo Dam. The ecological importance is high for the lower Blyde (links Olifants to the Highveld) and Mohlapitse (Wolkberg area is a declared wilderness area, Tufa's Waterfalls, caves).

EWR sites

- Olifants below confluence with Mohlapitse (EWR8, B71B) - Comprehensive
- Olifants upstream confluence with Blyde (EWR11, B71J) - Comprehensive
- Lower Blyde below Blyderivierspoort Dam (EWR12, B60J) – Comprehensive.

IUA 11: Ga Selati River catchment

Ga-Selati River:

The present state of the Ga-Selati River ranges from a C (in the upper reaches) to an E category just before the confluence with the Olifants. This is mainly due to the impacts from mining and town development in the lower reaches. The ecological importance of the system is high for the upper part (foothills zone) to low. The middle reaches of the IUA forms part of a protected area.

EWR sites

- Ga-Selati (EWR14a, B72H) - Comprehensive
- Ga-Selati (EWR14b, B72K) - Comprehensive

IUA12: Lower Olifants within Kruger National Park

Olifants main stem and tributaries:

The water resources of this IUA fall almost entirely within the Kruger National Park and surrounding protected areas. The ecological importance is thus very high. However, the present state is in a C category that is mainly due to the impacts of the upstream developments on the Olifants River.

EWR sites

- Olifants before confluence with Ga-Selati (EWR13, B72D) – Comprehensive site
- Olifants in KNP (EWR16, B73H) – Comprehensive site

IUA 13: Blyde River catchment area

Treur and upper Blyde:

The ecological importance of the water resources in this IUA is high with the present state of the Treur and upper Blyde almost natural. A number of protected and conservation areas are present in this IUA.

EWR sites

Treur (B60C) – Rapid III site

4.7 ECOLOGICAL BASE CASE CONFIGURATION

4.7.1 Introduction

As part of the classification process Step 4 requires that the Ecologically Sustainable Base Configuration (ESBC) Scenario is defined, to support alternate scenario configuration definition and evaluation.

In terms of the classification of water resources, an ESBC scenario is established in order to understand what the result would be in terms of system yield of implementing the minimum base level of ecological protection required to ensure sustainable use of the catchment water resources (which includes the consideration of ecological, water quality and quantity needs). It is not the target scenario but informs the minimal protection level required, constructed as a starting point for the hydrological analysis of the water resource system.

Once this sustainable ecological protection level is understood, various levels of resource directed protection can be assessed in terms of the overall socio-economic implications to the IUAs and WMA.

The following sections detail the establishment of the ESBC scenario for the Olifants WMA water resources and the system water balance that results by implementation of the scenario.

4.7.2 Approach

The process followed in terms of the establishment of the ESBC is that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWAF, February 2007a and 2007b).

The ESBC scenario, which would permit the maximum water use scenario, requires that the base condition for each water resource is at minimum established as either a D category or as whichever higher category is required to maintain all downstream nodes in at least a D category. However where the ecological condition requires it, a higher ecological category needs to be set.

The ESBC scenario is established once this base condition is hydrologically and ecologically tested to ensure that it is feasible and can be achieved. This result will reflect if the catchment water balance would be in a surplus or deficit by implementing a D category EWR.

In terms of the Olifants WMA the D ecological category (EC) was not selected as the default ESBC. Rather the selected EC per IUA was based on the assessment of the present ecological state (PES) and ecological/conservation importance of water resources within the IUAs.

Based on the present ecological condition of water resources within the Olfants WMA, the IUA scale ESBC ECs tested are listed in Table 7. An ESBC ecological category for each IUA is representative of the PES of the hydro- nodes within that IUA (based on EC proportional representation of the nodes in the sub-quartenary catchments).

The WRCS guidelines recommend that the MC be determined based on the ECs of the biophysical nodes residing in an IUA. Among other methods the guidelines recommend the application of Table 8 below, where the percentage of biophysical hydro-nodes falling into the indicated ecological category groups determines the IUA's MC. The IUA MCs associated with this ESBC scenario are also indicated in Table 9 and Table 10. The approach applied to determining the proposed MCs for each of the IUAs was to follow the guidelines of the WRCS. In summary the WRCS guidelines recommend that the MC be determined based on the ECs of the biophysical nodes residing in an IUA. Among other methods the guidelines recommend the application of Table 8 below, where the percentage of biophysical hydro-nodes falling into the indicated EC groups determines the IUA's MC.

Where a node is different to the overall IUA ESBC ecological category (*i.e.* requiring a higher level of ecological protection), this higher ecological category is accounted for in the hydrological model by the inclusion of this higher PES for that hydro-node (refer to Table 11 and Figure 10 for these instances). The simulated flows at these hydro-nodes were analysed to provide an average flow that should be maintained at the hydro-nodes to ensure that the PES is maintained.

Table 7: EC (PES) tested for the ecological sustainable base configuration per IUA

IUA	Catchment area	Aggregated Ecological Category (ESBC)
1	Upper Olifants River catchment	D
2	Wilge River catchment area	C
3	Selons River area including Loskop Dam	C
4	Elands River catchment area	D
5	Middle Olifants up to Flag Boshielo Dam	D
6	Steelpoort River catchment	D
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	D
8	Spekboom catchment	C
9	Ohrigstad River catchment area	D
10	Lower Olifants	C
11	Ga-Selati River area	D
12	Lower Olifants within Kruger National Park	C
13	Blyde River catchment area	A/B

Table 8: Preliminary guidelines for determining the IUA class for a scenario

		Percentage (%) of nodes in the IUA falling into the indicated EC groups				
		> = A/B	**>= B**	**> = C**	**> = D**	**< D**
Class I		40	60	80	99	
Class II			40	70	95	
Class III	**Either**			30	80	
	Or				100	

Table 9: IUA Classes for Olifants IUAs for ESBC scenario based on percentage representation of indicated EC groups as per Table 8 (main stem river)

	Percentage (%) of nodes in the IUA falling into the indicated EC groups					IUA Class for ESBC Scenario
IUA	> = A/B	>= B	> = C	> = D	< D	
1		11%	37%	53%		III
2		9%	82%	9%		II
3		44%	33%	22%		II
4			50%	33%	17%	III
5		29%	29%	29%	13%	III
6		23%	38%	38%		III
7			67%	17%	17%	III
8		20%	80%			II
9			75%	25%		III*
10		50%	25%	17%	8%	II
11		17%	33%	17%	33%	III
12	8%	58%	33%			II
13		80%	20%			I

*Main stem Ohrigstad is highly impacted (D). Tributaries are in a higher ecological condition (C).

Table 10: IUA Class associated with the ESBC (PES) scenario

IUA	Catchment area	Aggregated Ecological Category (ESBC)	IUA Management Class associated with scenario
1	Upper Olifants River catchment	D	III
2	Wilge River catchment area	C	II
3	Selons River area including Loskop Dam	C	II
4	Elands River catchment area	D	III
5	Middle Olifants up to Flag Boshielo Dam	D	III
6	Steelpoort River catchment	D	III
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	D	III
8	Spekboom catchment	C	II
9	Ohrigstad River catchment area	D	III
10	Lower Olifants	C	II
11	Ga-Selati River area	D	III
12	Lower Olifants within Kruger National Park	C	II
13	Blyde River catchment area	A/B	I

Table 11: Sub-nodes within IUAs requiring a higher level of ecological protection than the IUA ESBC

IUA	Sub-Node	Quaternary catchment	River	EI	ES	Sub-node PES	IUA PES (ESBC)
1 Upper Olifants River catchment	HN2	B11C	Piekespruit	High	High	**B**	D
	HN3	B11D	Dwars-indie-Wegspruit	High	High	**C**	
	HN5	B11E	Blesbokspruit	High	High	**B**	
	HN14	B12A	Boschmansfontein	Moderate	High	**C**	
2 Wilge River catchment area	HN30	B20H	Wilge	High	Very high	**B**	C
3 Selons River area including Loskop Dam	HN32	B12E	Doringboomspruit	High	High	**B**	C
	HN33	B12E	Keeromspruit	High	High	**C**	
	HN35	B32A	Kranspoortspruit (EWR site – OLI-EWR3)	EIS=Very high		**B**	
	HN36	B32A	Boekenhoutloop (inflow to Loskop Dam)	High	High	**B**	
	HN38	B32B, B32C	One node at confluence of Selons with Olifants in B32C. Included: Klipspruit (confluence with Selons) Kruis (confluence with Selons) Selons (confluence with Olifants)	 High High High	 High High Very high	 **B** **B**	
4 Elands River catchment area	HN41	B31A, B, C	One node at outlet of B31C, releases from Rust de Winter Dam. Included: B31A (Elands) B31B (Hartbeesspruit)	 High High High	 High Very high Very high	 **C** **C** **C**	D
5 Middle Olifants up to Flag Boshielo Dam	HN48	B32E, B32F	One node at confluence with Olifants in B32F Included: B32E (Bloed) B32F (Doringpoortloop, Diepkloof and Bloed)	 Moderate High	 High Moderate	 **B** **C**	D
	HN51	B51B	Puleng (upper part only)	High	High	**B**	

IUA	Sub-Node	Quaternary catchment	River	EI	ES	Sub-node PES	IUA PES (ESBC)
6 Steelpoort River catchment	HN54	B41A	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary)	High	High	**C**	D
	HN56	B41C	Masala (including Tonteldoos and Vlugkraal)	High	High	**C**	
	HN57	B41D, B41E	Steelpoort	High	Very high	**C**	
	HN58	B41F	Draaikraalspruit	High	Very high	**B**	
	HN60	B41G	Kraalspruit	High	Very high	**B**	
	HN63	B41H	Dwars (EWR site – DWA-EWR1)	EIS=High		**B/C**	
7 Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	HN67	B51F	Nkumpi (outlet of quaternary)	High	Moderate	**C**	D
	HN69	B52E	Palangwe	High	High	**C**	
	HN70	B52F	Hlakaro (outlet)	High	High	**C**	
	HN71	B52J	Mphogodima	High	High	**C**	
8 Spekboom catchment	HN80	B42G	Rooiwalhoek-se-Loop	High	Very high	**B**	C
9 Ohrigstad River catchment area	HN83	B60E, B60F	One node at outlet of B60F. Included: Kranskloofspruit Mantshibi	 High High	 Very high Very high	 **C** **C**	D
	HN84	B60G	Vyehoek	High	Very high	**C**	
10 Lower Olifants	HN87	B60J	Sandspruit, including Rietspruit and Qunduhlu	High	Moderate	**B**	C
	HN88	B60J	Blyde (EWR site – EWR12)	EIS=High		**B/C**	
	HN90	B71A	Paardevlei	High	Very high	**B**	
	HN91	B71A	Tongwane	High	High	**B**	
	HN93	B71C	Mohlapitse (upper reaches)	Very high	Very high	**B**	
	HN94	B71D	Kgotswane		Moderate	**B**	
11 Ga-Selati River area	HN102	B72J	Molatle	Moderate	Moderate	**B**	D

IUA	Sub-Node	Quaternary catchment	River	EI	ES	Sub-node PES	IUA PES (ESBC)
12 Lower Olifants within Kruger National Park	HN108	B73C	Tsiri	High	Low	**B**	C
	HN109	B73C	Tshutshi	High	Low	**B**	
	HN110	B73D	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	High	Low	**B**	
	HN112	B73F	Timbavati	High	Moderate	**B**	
	HN113	B73G	Timbavati, including Shisakashonghondo	High	Moderate	**B**	
	HN115	B73J	Hlahleni	High	Low	**A**	
13 Blyde River catchment area	HN117	B60A	Blyde	High	Very high	**C**	A/B B
	HN118	B60B	Lisbon, including Heddelspruit and Watervalspruit	High	Very high	**B**	
	HN119	B60B	Blyde (outlet of quaternary)	High	Very high	**B**	
	HN120	B60C	Treur (EWR site – TRE-EWR1) (existing)	EIS=Very high		**B**	
	HN121	B60D	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	High	Very high	**B**	

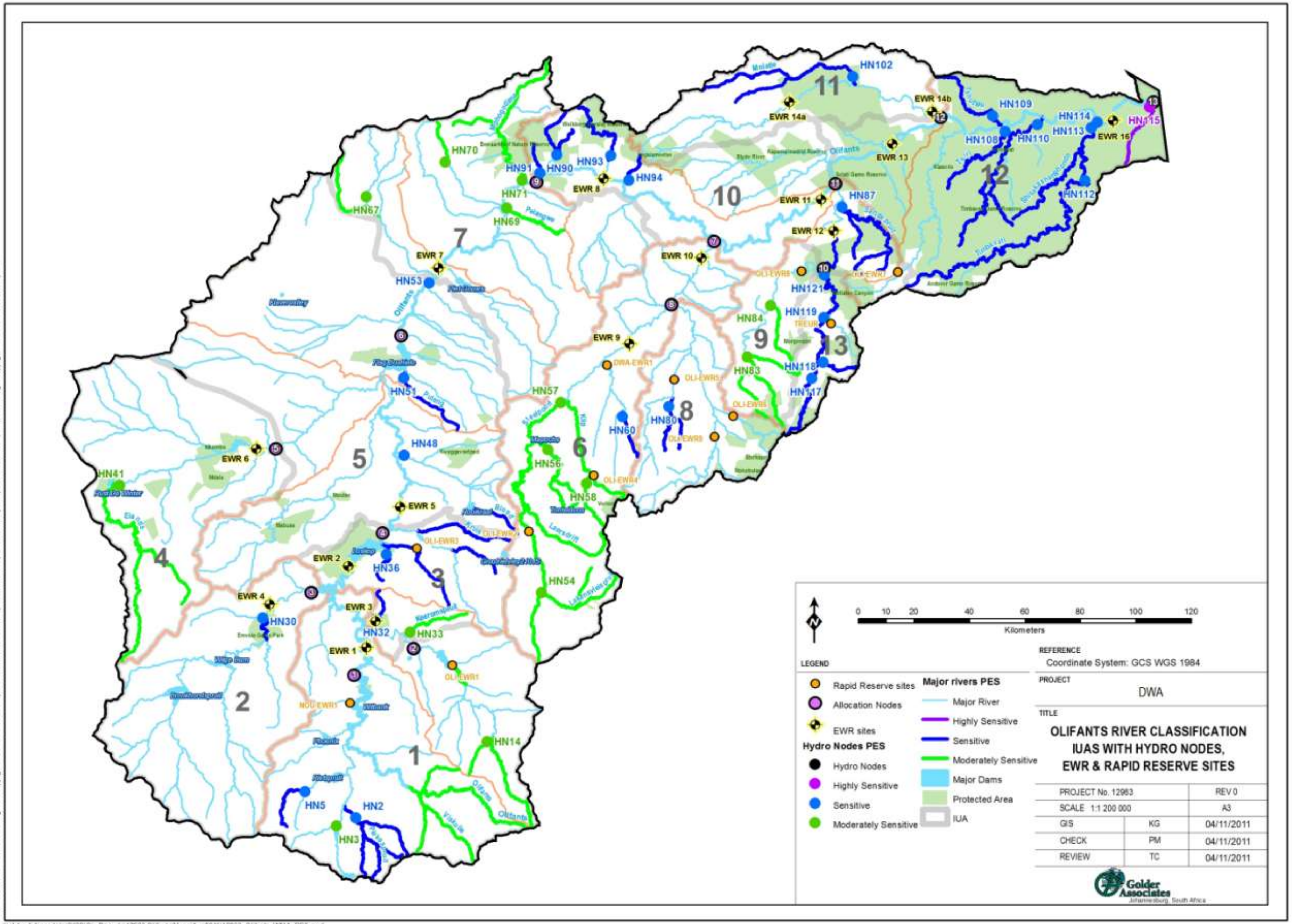


Figure 10: Hydro-nodes with higher PES than overall IUA ecological category (requiring higher level of protection)

Having established the ecological categories (ECs) required for the sustainable use of the water resources in the Olifants WMA PES, the ESBC scenario has been hydrologically and ecologically tested to ensure that it is feasible and can be achieved. The ESBC scenario (Scenario 1) was tested in the water resources yield model (WRYM) with the following parameters:

ESBC Scenario (PES scenario)	Water Requirements	EWR
1	2010 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows

This current level of development modelled for the Olifants WMA included the present day (2010) water requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). The details of the ESBC scenario and the results are included in the 'Ecologically Sustainable Base Configuration (ESBC) Scenario Report. Report No: RDM/WMA04/00/CON/CLA/0611', March 2012.

4.8 ALTERNATE CATCHMENT SCENARIOS DEFINITION

Following the establishment of the ESBC, the classification process requires that additional catchment scenarios are configured for the IUAs within the WMA to assess the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible and achievable in terms of a MC.

At the study Project Steering Committee (PSC) of 08 November 2011 and the subsequent Technical Task Group meeting of 31 January 2012, the stakeholders in the WMA confirmed acceptance of the ESBC (PES) scenario (Scenario 1) and proposed four additional catchment scenarios to be evaluated for the Olifants WMA as part of the alternate scenario analysis – refer to Table 12. The ESBC scenario is included in the Table 12 for completeness.

Table 12: Alternate catchment scenarios (2 to 5)

Scenario	Scenario Description	Water Requirements	EWR
1	ESBC (PES Scenario)	2010 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows
2	REC Scenario (Recommended Ecological Reserve)	2010 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows
3	Maximum use scenario	2010 Water Requirements as per Reconciliation Strategy	Class III throughout the system (EWR D Category)
4	Future growth PES scenario	2035 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows
5	Future growth REC Scenario (Recommended Ecological Reserve)	2035 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows

The scenario evaluation results were presented to the PSC at meeting held on 15 May 2012. The PSC made specific recommendations to be taken forward for stakeholder consultation. It was recommended that all 5 of the above scenarios be presented at the stakeholder consultation meetings. During these stakeholder meetings, a request was made that an additional scenario be analysed (Scenario 6), focusing on the use of excess mine water over and above the volume required to maintain the proposed MCs; that could potentially improve the class of water resource in some IUAs (Table 13). This additional scenario has been formulated and evaluated.

The catchment scenarios are described in more detail in Section 5.

Table 13: Catchment scenarios

Scenario	Scenario Description	Water Requirements	EWR
1	ESBC (PES Scenario)	2010 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows
2	REC Scenario (Recommended Ecological Reserve)	2010 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows
3	Maximum use scenario	2010 Water Requirements as per Reconciliation Strategy	Class III throughout the system (EWR D Category)
4	Future growth PES scenario	2035 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows
5	Future growth REC Scenario (Recommended Ecological Reserve)	2035 Water Requirements as per Reconciliation Strategy	Recommended Ecological category (REC) Maintenance/ Low flows
6	Scenario 4 plus release of additional treated mine water to river system	2035 Water Requirements as per Reconciliation Strategy	PES EC Maintenance/ Low Flows

4.9 TOWARDS SCENARIO EVALUATION

The inputs of the Olifants classification process emanating thus far described in sections 4.1 to 4.8 above, serve as building blocks to scenario analysis and evaluation. Scenario evaluation includes these individual parts, which requires combining these ‘blocks’ in different configurations to obtain results that reflect:

- A water balance (yield required – surplus or deficit in the IUA)
- A specific ecological protection level (a management class),
- An ecological consequence, and
- A socio-economic implication (cost-benefit analysis of the on the regional economy and social well-being).

Refer to Figure 11 for an illustration of the evaluation process.

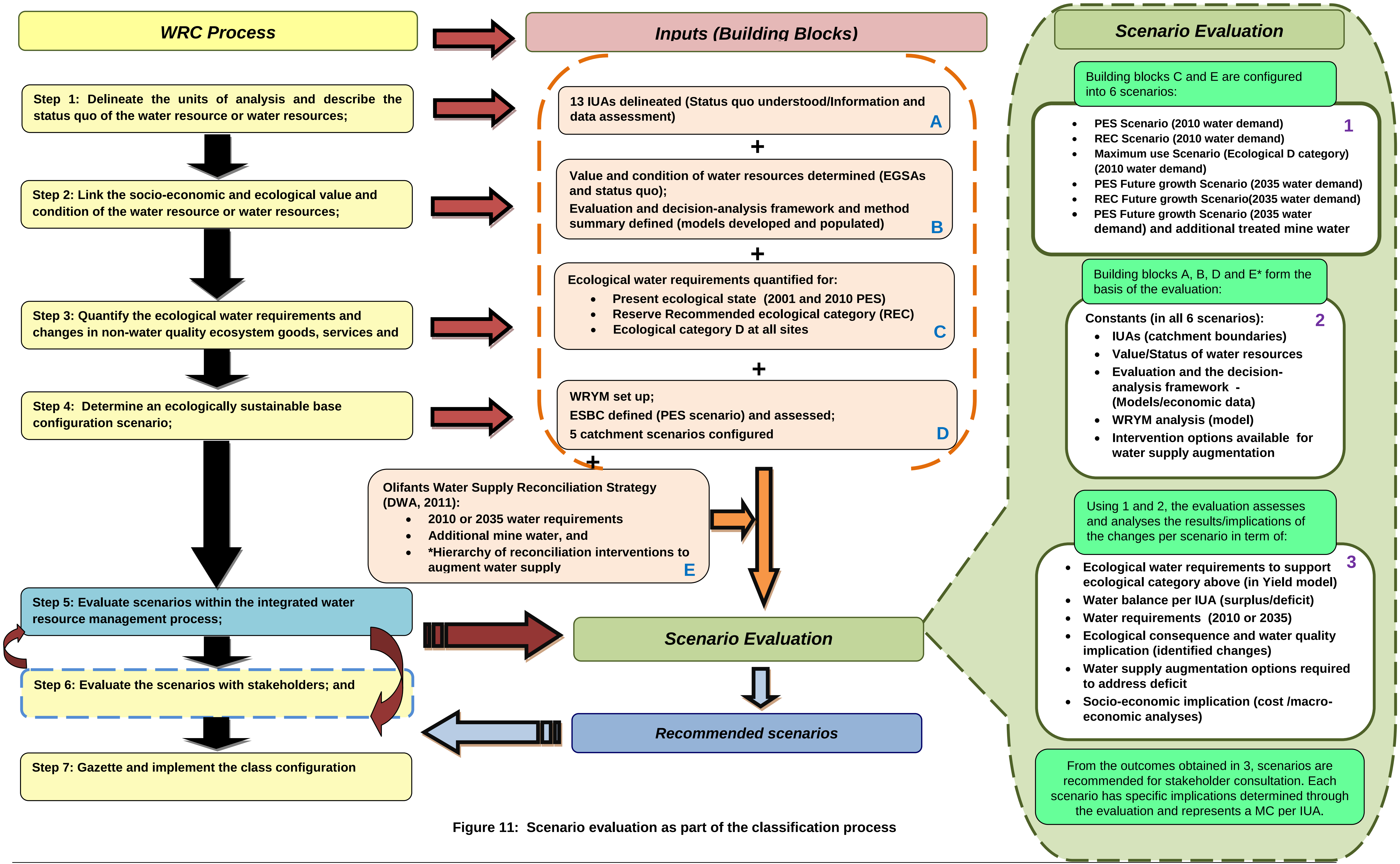


Figure 11: Scenario evaluation as part of the classification process

5 DESCRIPTION OF THE CATCHMENT CONFIGURATION SCENARIOS

A scenario can be defined as “a story of what could happen in the future”, and is used to understand different ways that future events might unfold. Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

Each scenario represents an alternative future condition, generally reflecting a change to the present condition. Analysis thereof gives the ability to compare the implications of one scenario against another, with the ultimate aim to make a selection of the preferred scenario.

In terms of the classification of water resources, a range of scenarios are established in order to understand what the result would be in terms of system yield by implementing a certain level of ecological protection required to ensure sustainable use of the catchment water resources (consideration of ecological, water quality and quantity needs).

Each scenario defines a certain ecological condition (ecological category of A, B, C or D) for each water resource (and the EWRs required for maintaining that category), and the yield that would result. This involves the linking of the flow and resource condition using the selected ecological category as a starting point, ensuring that the river reaches are maintained in a sustainable condition.

To facilitate the classification decision making process for the Olifants WMA, the six catchment scenarios that have been evaluated as part of the analysis are described below.

5.1 SCENARIO 1: ESBC SCENARIO (PES SCENARIO)

The ESBC scenario is defined below and for this scenario the following has been applied:

- The Present Ecological State (PES) was used as the ecological category (Table 14).
- PES EWR low and maintenance flows were applied.
- 2010 Water Requirements per water use sector as detailed in the ‘Olifants Water Supply System Reconciliation Final Strategy Report’ (DWA, 2011) were applied.

Table 14: ECs per IUA for Scenario 1 (PES Scenario – ESBC)

IUA	Catchment name	EWR sites	PES	
			Category at EWR site	WRYM, category at outlet of IUA
1	Olifants	EWR1	D	D
	Klein Olifants	EWR3	D	
2	Wilge	EWR4	B	C
3	Olifants	EWR2	C	C
	Olifants	EWR5	C	
4	Elands	EWR6	D	D

IUA	Catchment name	EWR sites	PES	
			Category at EWR site	WRYM, category at outlet of IUA
5	Olifants	EWR7	D	D
6	Upper Steelpoort	OLI-EWR2ex	C	D
	Steelpoort	EWR9	D	
	Steelpoort	EWR10	D	
	Dwars	DWA-EWR1	B/C	
7	Olifants	EWR8	D	D
8	Watervals	OLI-EWR5ex	C	C
9	Ohrigstad	OLI-EWR8	D	D
10	Olifants	EWR11	D	C
	Blyde	EWR12	B	
11	Ga-Selati	EWR14a	C	D
	Ga-Selati	EWR14b	D	
12	Olifants	EWR16	C	C
	Olifants	EWR13	C	
13	Treur (TRE-EWR1)	B60Dex	B	B

5.2 SCENARIO 2: REC SCENARIO (RECOMMENDED ECOLOGICAL CATEGORY)

The REC scenario includes the recommended Ecological Reserve that has emanated from the Reserve studies discussed in section 4.5 (primarily the 2001, comprehensive Reserve study). This scenario also includes the recommendations made by the stakeholders at the PSC meeting of 08 November 2011, in terms of higher / more protective ECs. These higher ECs are addressed by applying the REC.

This scenario included the following parameters in the WRYM run:

- The recommended ecological category (REC) (Table 15)
- REC EWR low and maintenance flows.
- 2010 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.

Table 15: ECs per IUA for Scenario 2 (REC Scenario)

IUA	Catchment name	EWR sites	REC		
			Category at EWR site	WRYM, category at outlet of IUA	Comment
1	Olifants	EWR1	D	D	New node at outlet
	Klein Olifants	EWR3	C		
2	Wilge	EWR4	B	B	New node at outlet
3	Olifants	EWR2	B	B	Node=EWR5
	Olifants	EWR5	C		
4	Elands	EWR6	D	D	Node=EWR6
5	Olifants	EWR7	D	D	Node=EWR7
6	Upper Steelpoort	OLI-EWR2ex	C	C	Node=EWR10
	Steelpoort	EWR9	D		
	Steelpoort	EWR10	C		
	Dwars	DWA-EWR1	B/C		
7	Olifants	EWR8	D	D	New node at outlet
8	Watervals	OLI-EWR5ex	C	C	Node=OLI-EWR5ex
9	Ohrigstad	OLI-EWR8	C	D	Node=OLI-EWR8
10	Olifants	EWR11	D	C	New node at outlet
	Blyde	EWR12	B		
11	Ga-Selati	EWR14a	C	C	Node=EWR14b
	Ga-Selati	EWR14b	C		
12	Olifants	EWR16	B	B	New node at outlet
	Olifants	EWR13	C		
13	Treur (TRE-EWR1)	B60Dex	A/B	A/B	Node=B60Dex

5.3 SCENARIO 3: MAXIMUM USE SCENARIO

The maximum use scenario assesses what the catchment yield would be by implementing a D category EWR throughout the entire WMA. This scenario considers the maximum use of the water resources to the lowest sustainable ecological condition.

Scenario 3 has included the following parameters in the WRYM run:

- An ecological category of D (Table 16)
- EWR low and maintenance flows.
- 2010 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.

Table 16: ECs per IUA for Scenario 3 (Maximum use)

IUA	Catchment name	EWR sites	D category	
			Category at EWR site	WRYM, category at outlet of IUA
1	Olifants	EWR1	D	D
	Klein Olifants	EWR3	D	
2	Wilge	EWR4	D	D
3	Olifants	EWR2	D	D
	Olifants	EWR5	D	
4	Elands	EWR6	D	D
5	Olifants	EWR7	D	D
6	Upper Steelpoort	OLI-EWR2ex	D	D
	Steelpoort	EWR9	D	
	Steelpoort	EWR10	D	D
	Dwars	DWA-EWR1	D	
7	Olifants	EWR8	D	D
8	Watervals	OLI-EWR5ex	D	D
9	Ohrigstad	OLI-EWR8	D	D
10	Olifants	EWR11	D	D
	Blyde	EWR12	D	
11	Ga-Selati	EWR14a	D	D
	Ga-Selati	EWR14b	D	
12	Olifants	EWR16	D	D
	Olifants	EWR13	D	
13	Treur (TRE-EWR1)	B60Dex	D	D

5.4 SCENARIO 4: FUTURE GROWTH PES SCENARIO

It is important to understand how the water resource system of the Olifants WMA will behave with future growth into the years to come. To accommodate this, the future growth scenarios are assessed in terms of the Olifants WMA Reconciliation Strategy, by considering future water demands. Scenario 4 is similar to the ESBC scenario however it includes the future growth water demands for the Olifants WMA projected for year 2035.

Scenario 4 included the following parameters in the WRYM run:

- The Present Ecological State (PES) as the ecological category (Table 17).
- PES EWR low and maintenance flows apply.
- 2035 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.

Table 17: ECs per IUA for Scenario 4 (Future Growth PES)

IUA	Catchment name	EWR sites	PES	
			Category at EWR site	WRYM, category at outlet of IUA
1	Olifants	EWR1	D	D
	Klein Olifants	EWR3	D	
2	Wilge	EWR4	B	C
3	Olifants	EWR2	C	C
	Olifants	EWR5	C	
4	Elands	EWR6	D	D
5	Olifants	EWR7	D	D
6	Upper Steelpoort	OLI-EWR2ex	C	D
	Steelpoort	EWR9	D	
	Steelpoort	EWR10	D	
	Dwars	DWA-EWR1	B/C	
7	Olifants	EWR8	D	D
8	Watervals	OLI-EWR5ex	C	C
9	Ohrigstad	OLI-EWR8	D	D
10	Olifants	EWR11	D	C
	Blyde	EWR12	B	
11	Ga-Selati	EWR14a	C	D
	Ga-Selati	EWR14b	D	
12	Olifants	EWR16	C	C
	Olifants	EWR13	C	
13	Treur (TRE-EWR1)	B60Dex	B	B

5.5 SCENARIO 5: FUTURE GROWTH REC SCENARIO

Scenario 5 is as per scenario 2, however, the 2035 water demands are applied in the WRYM run, again to understand how the water resource system will behave.

Scenario 5 included the following parameters in the WRYM run:

- The recommended ecological category (REC) (Table 18)
- REC EWR low and maintenance flows.
- 2035 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.

Table 18: ECs per IUA for Scenario 5

IUA	Catchment name	EWR sites	REC		
			Category at EWR site	WRYM, category at outlet of IUA	Comment
1	Olifants	EWR1	D	D	New node at outlet
	Klein Olifants	EWR3	C		
2	Wilge	EWR4	B	B	New node at outlet
3	Olifants	EWR2	B	B	Node=EWR5
	Olifants	EWR5	C		
4	Elands	EWR6	D	D	Node=EWR6
5	Olifants	EWR7	D	D	Node=EWR7
6	Upper Steelpoort	OLI-EWR2ex	C	C	Node=EWR10
	Steelpoort	EWR9	D		
	Steelpoort	EWR10	C		
	Dwars	DWA-EWR1	B/C		
7	Olifants	EWR8	D	D	New node at outlet
8	Watervals	OLI-EWR5ex	C	C	Node=OLI-EWR5ex
9	Ohrigstad	OLI-EWR8	C	D	Node=OLI-EWR8
10	Olifants	EWR11	D	C	New node at outlet
	Blyde	EWR12	B		
11	Ga-Selati	EWR14a	C	C	Node=EWR14b
	Ga-Selati	EWR14b	C		
12	Olifants	EWR16	B	B	New node at outlet
	Olifants	EWR13	C		
13	Treur (TRE-EWR1)	B60Dex	A/B	A/B	Node=B60Dex

5.6 SCENARIO 6: FURTURE GROWTH PES SCENARIO WITH ADDITIONAL TREATED MINE WATER

Scenario 6 is as per Scenario 4 with additional treated mine water released from the Upper Olifants to meet the water requirements of the Middle Olifants.

The use of excess mine water in the Upper Olifants Catchment to meet the water requirements was identified in the reconciliation strategy as a source of water to achieve reconciliation. The mine water has been used in the first 5 scenarios as a source of water. However, the impact on in-stream flow and quality of releasing the excess treated mine water to the river system to supply the water requirements in the Middle Olifants was not considered. In this scenario, the 2035 water requirements were used together with the PES EWR. The excess mine water not required to meet the water requirements in the Upper Olifants Catchment was released to the river to supply the water requirements in the Middle Olifants. The resulting increase in the flow and improved water quality in the main stem Olifants through IUA 3, 5 and 7 were assessed to see if an improved ecological category can be achieved with the releases. The PES and REC ecological category at EWR 5 is a C and at EWR site 7 a D. The use of the river to transport the water in improving the ecological category in these IUA's was assessed.

Scenario 6 included the following parameters in the WRYM run:

- The PES ecological category (PES) (Table 19)
- PES EWR low and maintenance flows.
- 2035 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.
- After meeting upstream water requirements (18 million m^3/a), 37 million m^3 annum can be released from Witbank and Middelburg dams to meet downstream requirements, as follows:
    - 21 million m^3/a in Klein Olifants (0.67 m^3/s)
    - 16 million m^3/a in Olifants downstream Witbank Dam (0.51 m^3/s)
    - EWR 2 will get combined flow of 1.18 m^3/s – Olifants upstream of Loskop Dam

Table 19: ECs per IUA for Scenario 6

IUA	Catchment name	EWR sites	PES	
			Category at EWR site	WRYM, category at outlet of IUA
1	Olifants	EWR1	D	D
	Klein Olifants	EWR3	D	
2	Wilge	EWR4	B	C
3	Olifants	EWR2	C	C
	Olifants	EWR5	C	
4	Elands	EWR6	D	D
5	Olifants	EWR7	D	D
6	Upper Steelpoort	OLI-EWR2ex	C	D
	Steelpoort	EWR9	D	
	Steelpoort	EWR10	D	
	Dwars	DWA-EWR1	B/C	
7	Olifants	EWR8	D	D
8	Watervals	OLI-EWR5ex	C	C
9	Ohrigstad	OLI-EWR8	D	D
10	Olifants	EWR11	D	C
	Blyde	EWR12	B	
11	Ga-Selati	EWR14a	C	D
	Ga-Selati	EWR14b	D	
12	Olifants	EWR16	C	C
	Olifants	EWR13	C	

IUA	Catchment name	EWR sites	PES	
			Category at EWR site	WRYM, category at outlet of IUA
13	Treur (TRE-EWR1)	B60Dex	B	B

A summary of the 6 scenarios indicating the ecological category at EWR sites and the EWR required to maintain this category are indicated in Table 20.

Table 20: Summary of scenarios indicating ecological category at EWR sites and the EWR required

IUA	Water Resource	EWR sites	(1) PES (ESBC)		(2) REC		(3) Maximum use		(4) Future growth PES		(5) Future growth REC		(6) Future growth PES with additional treated mine water	
			2010		2010		2010		2035		2035		2035	
			Ecological category	EWR m^3/s (PES, ML)	Ecological category	EWR m^3/s (REC, ML)	Ecological category	EWR m^3/s (D, ML)	Ecological category	EWR m^3/s (PES, ML)	Ecological category	EWR m^3/s (REC, ML)	Ecological category	EWR m^3/s (PES, ML)
1	Olifants	EWR1	D	0.448	D	0.448	D	0.448	D	0.448	D	0.448	D	0.448
	Klein Olifants	EWR3	D	0.229	C	0.375	D	0.229	D	0.229	C	0.375	D	0.229
2	Wilge	EWR4	B	0.918	B	1.002	D	0.594	B	0.918	B	1.002	B	0.918
3	Olifants	EWR2	C	1.643	B	2.349	D	0.594	C	1.643	B	2.349	C	1.643
	Olifants	EWR5	C	2.039	C	2.879	D	1.613	C	2.039	C	2.879	C	2.039
4	Elands	EWR6	D	0.204	D	0.204	D	0.204	D	0.204	D	0.204	D	0.204
5	Olifants	EWR7	D	1.447	D	1.447	D	1.447	D	1.447	D	1.447	D	1.447
6	Upper Steelpoort	OLI-EWR2ex	C	0.830	C	0.830	D	0.602	C	0.830	C	0.830	C	0.830
	Steelpoort	EWR9	D	0.720	D	0.720	D	0.720	D	0.720	D	0.720	D	0.720
	Steelpoort	EWR10	D	1.579	C	1.971	D	1.579	D	1.579	C	1.971	D	1.579
	Dwars	DWA-EWR1	B/C	0.190	B/C	0.190	D	0.101	B/C	0.190	B/C	0.190	B/C	0.190
7	Olifants	EWR8	D	1.852	D	1.852	D	1.852	D	1.852	D	1.852	D	1.852
8	Watervals	OLI-EWR5ex	C	0.765	C	1.089	D	0.588	C	0.765	C	1.089	C	0.765
9	Ohrigstad	OLI-EWR8	D	0.238	C	0.238	D	0.238	D	0.238	C	0.238	D	0.238
10	Olifants	EWR11	D	7.424	C	8.434	D	7.424	D	7.424	C	8.434	D	7.424
	Blyde	EWR12	B	3.270	B	3.270	D	1.538	B	3.270	B	3.270	B	3.270
11	Ga-Selati	EWR14a	C	0.264	C	0.264	D	0.165	C	0.264	C	0.264	C	0.264
	Ga-Selati	EWR14b	D	0.302	C	0.313	D	0.302	D	0.302	C	0.313	D	0.302
12	Olifants	EWR16	C	7.474	B	10.592	D	5.790	C	7.474	B	10.592	C	7.474
	Olifants	EWR13	C	7.144	C	10.210	D	5.474	C	7.144	C	10.210	C	7.144
13	Treur (TRE-EWR1)	B60Dex	B	2.759	A/B	3.534	D	1.552	B	2.759	A/B	3.534	B	2.759

6 SCENARIO EVALUATION

Determining the class of a water resource in terms of the process, involves taking into account the social, economic and ecological landscape in a catchment in order to assess the costs and benefits associated with utilisation versus protection of a water resource. As such, classification is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use and the broader goals of the IUA and WMA.

The basis for determining the MC is the determination of the ecological sustainable level of protection that is required for water resources and integrating this with the economic and social goals. It is therefore important that an appropriate ecological protection base condition is established for the water resources; and from this determine what is feasible by understanding the economic and social implications of attaining this ecological protection level. Once this sustainable ecological protection level is understood, various levels of ecological protection and degrees of water use/growth (possible scenarios) can be assessed in terms of the overall implications to the WMA.

The Olifants Classification study has progressed to the point of establishment and evaluation of the ESBC (PES) scenario and configuration of the alternate catchment scenarios. The following sections describe and present the results of the evaluation of these alternate scenarios.

6.1 WATER BALANCE PER SCENARIO

6.1.1 THE APPROACH FOLLOWED

Background and setup

The Water Resources Yield Model (WRYM) that was used as part of the development of the Olifants Reconciliation Strategy was obtained and used for yield analysis per scenario.

The following are the specific considerations that were included in the setup for the scenarios:

- Present day or future water use for irrigation, mining, domestic, rural and afforestation as provided in the water requirements and water resources report that forms part of the reconciliation strategy;
- De Hoop Dam was included;
- Raised Flag Boshielo Dam was included;
- Compensation releases from Flag Boshielo Dam, De Hoop Dam and Phalaborwa Barrage;
- Water court orders from Witbank, Middelburg and Loskop Dams; and
- All the major dams in the system were included.
- The additional mine water available for supplying the Middle Olifants water requirements is added to the systems at the nodes below Witbank and Middelburg dams.

System schematic – Major nodes/points

Detailed schematic diagrams were obtained from the study team responsible for the development of the Olifants Water Supply System Reconciliation Strategy and this was used as the basis for changing, checking and evaluation of the scenarios. The following major nodes were included as part of the setup per IUA:

- All major dams as well as combined farm dams and irrigation areas; and
- Ecological requirements for all the EWR sites for the PES ecological category or REC or D ecological category.

The detailed system diagrams are available as part of the Olifants Water Supply System Reconciliation Strategy Study.

Yield Model Runs

The WRYM was run with present day (2010) or future growth (2035) water requirements and with the EWR requirements for PES, REC or D ecological category as listed in Table 20. For Scenario 6, the additional treated mine water after supplying the upstream water requirements were added to the nodes downstream of Witbank and Middelburg Dams.

This allowed for the determination of the resulting water balance for the Olifants WMA with the implementation of the alternate scenarios. The yield results of the water balances were then used as input to the economic analyses to determine the macro-economic consequences of each scenario.

The results for these models run per scenario are provided in Section 6.1.3 below.

6.1.2 THE OLIFANTS WATER SUPPLY SYSTEM RECONCILIATION STRATEGY

The Olifants River Water Supply Reconciliation strategy (DWA, 2011) identified a series of interventions to achieve a balance in the Olifants WMA between water availability and water requirements. The identified measures lean towards management interventions rather than development interventions. The interventions include:

- Eliminating unlawful water use
- Introducing water conservation and demand management (WC/WDM) in all sectors;
- Trading of water saved through water efficiency measures;
- Use of excess mine water.
- Removal of alien vegetation and;
- Development of groundwater resources;
- Re-use of return flows from Polokwane and Mokopane by the urban or mining sector.

For the purpose of this study, the above listed reconciliation water supply options have been used in the analyses to meet the water deficit where identified. The marginal costs per option as outlined in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) have been used as input to the economic analysis (to determine the cost of the augmentation). These are listed in section 6.3.3.5.

While some of the interventions identified through the Olifants River Water Supply System Reconciliation Strategy have been assessed through the socio-economic evaluation component of the scenario analysis, the selection of the required interventions and the decision on the provision of this water is beyond the scope of the Olifants WMA Classification study.

6.1.3 RESULTS OF THE YIELD ANALYSIS PER SCENARIO

The assessment of the scenarios included running of the WRYM using the required EWRs per scenario and water requirements (as per the Reconciliation strategy) to test whether these EWRs for all nodes can be met. The WRYM for the Olifants WMA was setup and run with the scenarios as described above. The current assessment included the running of the WRYM for Scenarios 2 to 6.

Scenario 6 is the same as Scenario 4 in terms of water requirements and PES ecological EWRs. The additional mine water is merely an addition to the flows at EWR 1 and EWR 3 downstream of Witbank and Middelburg Dams. Allowance has been made for 5% losses as the water flows down the Olifants River through Loskop Dam to Flag Boshielo Dam where water is abstracted to meet the water requirements of Mokopane. The remaining additional mine water is then released from Flag Bashielo Dam where it will supplement the flow downstream of the dam until it is abstracted at the Lebalelo weir and abstracted to supply Polokwane. The additional mine water impacts on the flow conditions at EWR 1, EWR 3, EWR 2, EWR 5 and EWR 7.

The assessment allows for evaluation of the yield that would result in the catchment with the EWRs required for maintaining the different ecological categories per scenario. This allows for the determination of the water balance (surpluses/deficits) per IUA.

6.1.3.1 The PES (ESBC) Scenario - Scenario 1:

The yield analysis results per IUA for the ESBC scenario indicates varying degrees of water surpluses and deficits as shown in Table 21. The deficit in the catchment without De Hoop Dam in place with the 2010 water requirements is 159 million m^3/a. The Olifants WMA has an overall water deficit of 159 million m^3/a with the implementation of the ESBC scenario (EWR required for the maintaining the water resources in a PES ecological condition). However the De Hoop Dam is under construction and will deliver water in 2013. For the ESBC scenario therefore it is assumed that De Hoop Dam is in place and delivering water and the water requirements are set at the 2010 requirements. The balance per IUA for this case is given in Table 21.

Table 21: Water balance per IUA for ESBC (PES) scenario with De Hoop Dam

IUA	Catchment	* Water User Requirements (2010) (million $m^{3/}$/a)	Yield with PES EWR (million m^3/a)	Transfer in (million m^3/a)	Transfer out (million m^3/a)	Water Balance (million m^3/a)
1	Upper Olifants River catchment	109	75	0	0	(34)
2	Wilge River catchment area	29	44	0	15	0
3	Selons River area including Loskop Dam	22	161	0	139	0
4	Elands River catchment area	36	20	15	0	(1)
5	Middle Olifants up to Flag Boshielo Dam	209	90	119	0	0
6	Steelpoort River catchment	43	88	0	34	11

7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	49	7	20	0	(22)
8	Spekboom catchment	36	30	0	0	(6)
9	Ohrigstad River catchment area	28	26	0	0	(2)
10	Lower Olifants	119	6	107	0	(6)
11	Ga-Selati River area	69	35	24	0	0
12	Lower Olifants within Kruger National Park	1	1	0	0	0
13	Blyde River catchment area	2	109	0	107	0
	TOTAL	**752**	**692**			
OLIFANTS WMA WATER BALANCE						**(60)**

*Water user requirements includes that of the irrigation, domestic, industrial, mining and forestry sectors within the Olifants WMA.

6.1.3.2 The REC Scenario - Scenario 2:

The yield analysis results per IUA for the REC scenario is shown in Table 22. The Olifants WMA has an overall water deficit of 171 million m^3/a with implementation of the REC scenario.

Table 22: Water balance per IUA for REC scenario

IUA	Catchment	* Water User Requirements (2010) (million m^3/a)	Yield with REC EWR (million m^3/a)	Transfer in (million m^3/a)	Transfer out (million m^3/a)	Water Balance (million m^3/a)
1	Upper Olifants River catchment	109	67	0	0	(42)
2	Wilge River catchment area	29	39	0	10	0
3	Selons River area including Loskop Dam	22	129	0	107	0
4	Elands River catchment area	36	16	10	0	(10)
5	Middle Olifants up to Flag Boshielo Dam	209	78	107	0	(24)
6	Steelpoort River catchment	43	72	0	29	0
7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	49	7	0	0	(42)
8	Spekboom catchment	36	24	0	0	(12)
9	Ohrigstad River catchment area	28	22	0	0	(6)
10	Lower Olifants	119	6	83	0	(30)
11	Ga-Selati River area	69	35	29	0	(5)
12	Lower Olifants within Kruger National Park	1	1	**0**	0	0
13	Blyde River catchment area	2	85	0	83	0
	TOTAL	**752**	**581**			
OLIFANTS WMA WATER BALANCE						**(171)**

*Water user requirements includes that of the irrigation, domestic, industrial, mining and forestry sectors within the Olifants WMA.

6.1.3.3 The Maximum use Scenario - Scenario 3:

The yield analysis results per IUA for the maximum scenario is shown in Table 23. The Olifants WMA has an overall water deficit of 9 million m^3/a with the implementation of the maximum use scenario (EWR required for the maintaining all the water resources in a D ecological category).

Table 23: Water balance per IUA for the maximum use scenario

IUA	Catchment	* Water User Requirements (2010) (million m^3/a)	Yield with Class D EWR (million m^3/a)	Transfer in (million m^3/a)	Transfer out (million m^3/a)	Water Balance (million m^3/a)
1	Upper Olifants River catchment	109	75	0	0	(34)
2	Wilge River catchment area	29	44	0	14	1
3	Selons River area including Loskop Dam	22	178	0	155	1
4	Elands River catchment area	36	22	14	0	0
5	Middle Olifants up to Flag Boshielo Dam	209	96	113	0	0
6	Steelpoort River catchment	43	96	0	27	26
7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	49	7	42	0	0
8	Spekboom catchment	36	33	0	0	(3)
9	Ohrigstad River catchment area	28	28	0	0	0
10	Lower Olifants	119	6	113	0	0
11	Ga-Selati River area	69	35	34	0	0
12	Lower Olifants within Kruger National Park	1	1	0	0	0
13	Blyde River catchment area	2	122	0	120	0
	TOTAL	**752**	**743**			
OLIFANTS WMA WATER BALANCE						**(9)**

*Water user requirements includes that of the irrigation, domestic, industrial, mining, power generation and forestry sectors within the Olifants WMA.

6.1.3.4 The Future Growth PES Scenario - Scenario 4:

The yield analysis results per IUA for the future growth PES scenario is shown in Table 24. The Olifants WMA has an overall water deficit of 219 million m^3/a with implementation of the future growth PES scenario with the high water requirement projection (EWR required for the maintaining the water resources in the PES ecological categories with 2035 high water requirements).

Table 24: Water balance per IUA for the future growth PES scenario

IUA	Catchment	* Water User Requirements (2035) (million m^3/a)	Yield with PES EWR (million m^3/a)	Transfer in (million m^3/a)	Transfer out (million m^3/a)	Water Balance (million m^3/a)
1	Upper Olifants River catchment	118	75	0	0	(43)
2	Wilge River catchment area	31	44	0	13	0
3	Selons River area including Loskop Dam	22	161	0	139	0
4	Elands River catchment area	44	20	13	0	(11)
5	Middle Olifants up to Flag Boshielo Dam	246	90	139	0	(17)
6	Steelpoort River catchment	86	88	0	0	2
7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	90	7	0	0	(83)
8	Spekboom catchment	37	30	0	0	(7)
9	Ohrigstad River catchment area	29	26	0	0	(3)
10	Lower Olifants	121	6	72	0	(43)
11	Ga-Selati River area	83	35	35	0	(13)
12	Lower Olifants within Kruger National Park	2	1	0	0	(1)
13	Blyde River catchment area	2	109	0	107	0
	TOTAL	**911**	**692**			
OLIFANTS WMA WATER BALANCE						**(219)**

Water user requirements includes that of the irrigation, domestic, industrial, mining and forestry sectors within the Olifants WMA.

6.1.3.5 The Future Growth REC Scenario - Scenario 5:

The yield analysis results per IUA for the future growth REC scenario is shown in Table 25. The Olifants WMA has an overall water deficit of 330 million m^3/a with implementation of the future growth REC scenario with high water requirements (EWR required for the maintaining the water resources in the recommended ecological categories with 2035 high water requirements).

Table 25: Water balance per IUA for the future growth REC scenario

IUA	Catchment	* Water User Requirements (2035) (million m^3/a)	Yield with REC EWR (million m^3/a)	Transfer in (million m^3/a)	Transfer out (million m^3/a)	Water Balance (million m^3/a)
1	Upper Olifants River catchment	118	67	0	0	(51)
2	Wilge River catchment area	31	39	0	8	0
3	Selons River area including Loskop Dam	22	129	0	107	0
4	Elands River catchment area	44	16	8	0	(20)
5	Middle Olifants up to Flag Boshielo Dam	246	78	107	0	(61)
6	Steelpoort River catchment	86	72	0	0	(14)
7	Middle Olifants Flag Boshielo Dam to u/s of Steelpoort River	90	7	0	0	(83)
8	Spekboom catchment	37	24	0	0	(13)
9	Ohrigstad River catchment area	29	22	0	0	(7)
10	Lower Olifants	121	6	48	0	(67)
11	Ga-Selati River area	83	35	35	0	(13)
12	Lower Olifants within Kruger National Park	2	1	**0**	0	(1)
13	Blyde River catchment area	2	85	0	83	0
	TOTAL	**911**	**581**			
OLIFANTS WMA WATER BALANCE						**(330)**

Water user requirements includes that of the irrigation, domestic, industrial, mining and forestry sectors within the Olifants WMA.

6.1.3.6 The Future Growth PES Scenario with additional treated mine water- Scenario 6:

The water balance per IUA for Scenario 6 is same as for Scenario 4 (water deficit of 219 million m^3/a with implementation of the future growth PES scenario) (Table 24). The only difference is that there is additional flow at some of the EWR sites. The additional flow, average PES EWR water requirement and the new total flows are listed in Table 26.

Table 26: Flow changes in Scenario 6

IUA	EWR site	AMD volume treated	Additional flow	Abstraction	PES/REC	PES with additional treated mine water
1	EWR site 1 (Witbank Dam Catchment)	0.51 m^3/s			D/D 0.45 m^3/s	0.96 m^3/s
3	EWR site 2 (u/s Loskop Dam)		1.18 m^3/s		C/B 1.65 /2.35 m^3/s	2.83 m^3/s
	EWR site 3 (Middelburg Dam Catchment)	0.67 m^3/s			D/C 0.23/0.38 m^3/s	0.90 m^3/s Potential C category

5	EWR site 5 (d/s Loskop Dam)		1.06 m^3/s		C/C 2.04 m^3/s	3.10 m^3/s Potential B category
7	EWR site 7 (d/s Flag Bashielo Dam)		1.06 m^3/s into Flag Bashielo	0.54 m^3/s To meet water demands in Mokopane	D/D 1.45 m^3/s	1.97 m^3/s Potential C category

6.1.4 SUMMARY OF WATER BALANCE (YIELD ANALYSIS)

As indicated in Table 27, the yield analyses undertaken reflect water balances that result in a water deficit in the Olifants WMA for all 6 scenarios. The water resource system would have to provide for the required volume of water supply needed (to maintain any of the scenario configurations). The deficits that exist indicate that additional water would have to be supplied in the Olifants WMA system through the interventions proposed in the Olifants River Water Supply Reconciliation Strategy (DWA, 2011). The interventions assessed to augment water supply and the associated cost evaluation in detailed in section 6.3.3.5.

Table 27: Summary of Water Balance per Scenario

Scenario	Scenario Description	Water Balance (Million $m^{3/}$annum)
1	ESBC (PES Scenario) – with De Hoop Dam	60 million m^3/a deficit
2	REC Scenario	(60 +111 additional water to meet REC) 171 million m^3/a deficit
3	Maximum use scenario	(60 - 51 due to reduction in EWR requirements) 9 million m^3/a deficit
4	Future growth PES scenario	(60+159 future water requirements) 219 million m^3/a deficit
5	Future growth REC Scenario	(171+159 future water requirements) 330 million m^3/a deficit
6	Scenario 4 plus release of additional treated mine water to river system	219 million m3/a + additional water at EWR 1, 2, 3, 5 and 7

6.2 ECOLOGICAL CONSEQUENCES

The purpose of this section is to provide the ecological consequences of catchment scenarios, *i.e.* the impact on the Ecological Category of the Ecological Water Requirement (EWR) sites where applicable. The purpose of this is to provide information regarding the implications of the flow scenario and corresponding Ecological Category (EC) on the ecology, by predicting the biota responses to each scenario.

6.2.1 Assessment of ecological consequences

Specific high confidence EWR sites where hydraulic information was available were identified to undertake detail assessment of the ecological consequences. Existing hydraulic cross-sections from the comprehensive Reserve determination study, 2000-2003 were used to assess the ecological consequences with higher confidence. Cross-sections were obtained from the hydraulic specialist and re-worked to be interpreted by the ecologists. As the methods and modelling approaches have changed since this study, a number of the cross-sections could not be used. In the application of the WRYM, the additional water required to meet the shortages was not provided and a high priority was given to the EWR.

Priority EWR sites were assessed. These included EWR sites 3, 4, 5, 8, 9, 11, 12, 13, 14b, 16 (refer to Figure 12). The aim was to at least have one EWR site per IUA where detailed ecological consequences were determined. These sites are listed in Table 28.

Table 28: EWR sites with detailed ecological consequences assessment

IUA	Delineation	EWR used	Notes
1	Upper Olifants River catchment	EWR3	EWR3, Klein Olifants downstream Middelburg Dam EWR1 downstream Witbank Dam could not be assessed in detail due to the complexity of the hydraulic cross-section
2	Wilge River catchment area	EWR4	Wilge River before confluence with Olifants
3	Selons River area including Loskop Dam	EWR5	EWR5, Olifants downstream Loskop Dam EWR2, Olifants upstream Loskop Dam could not be assessed in detail due to the complexity of the hydraulic cross-section
4	Elands River catchment area	-	EWR6, Elands below Mkumbe Dam could not be assessed in detail due to the complexity of the hydraulic cross-section, this site was assessed using flow duration curves to check if the EWRs are met
5	Middle Olifants up to Flag Boshielo Dam	EWR7	EWR7,Olifants below Flag Boshielo Dam could not be assessed in detail due to the complexity of the hydraulic cross-section
6	Steelpoort River catchment	EWR9	EWR9, Steelpoort downstream De Hoop Dam

IUA	Delineation	EWR used	Notes
			EWR10 before confluence of Steelpoort with Olifants was not used as EWR9 provided adequate information
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	EWR8	Olifants, downstream Mohlapitse confluence
8	Spekboom catchment	-	No high confidence EWR site
9	Ohrigstad River catchment area	-	No high confidence EWR site
10	Lower Olifants	EWR11 EWR12	Olifants, downstream Blyde confluence Blyde, downstream Blyderivierspoort Dam
11	Ga-Selati River area	EWR14b	Lower Selati, just before confluence with Olifant River
12	Lower Olifants within Kruger National Park	EWR13 EWR16	Olifants, downstream of Phalaborwa Olifants in KNP
13	Blyde River catchment area	-	No high confidence EWR site

The other EWR sites from the comprehensive Reserve determination study and the additional rapid studies were analysed using flow duration curves (FDC) for the identified optimum flow months (high and low optimum flows). These curves were used to determine if the EWRs were met during the specific months. The sites that were analysed using FDCs are listed in Table 30.

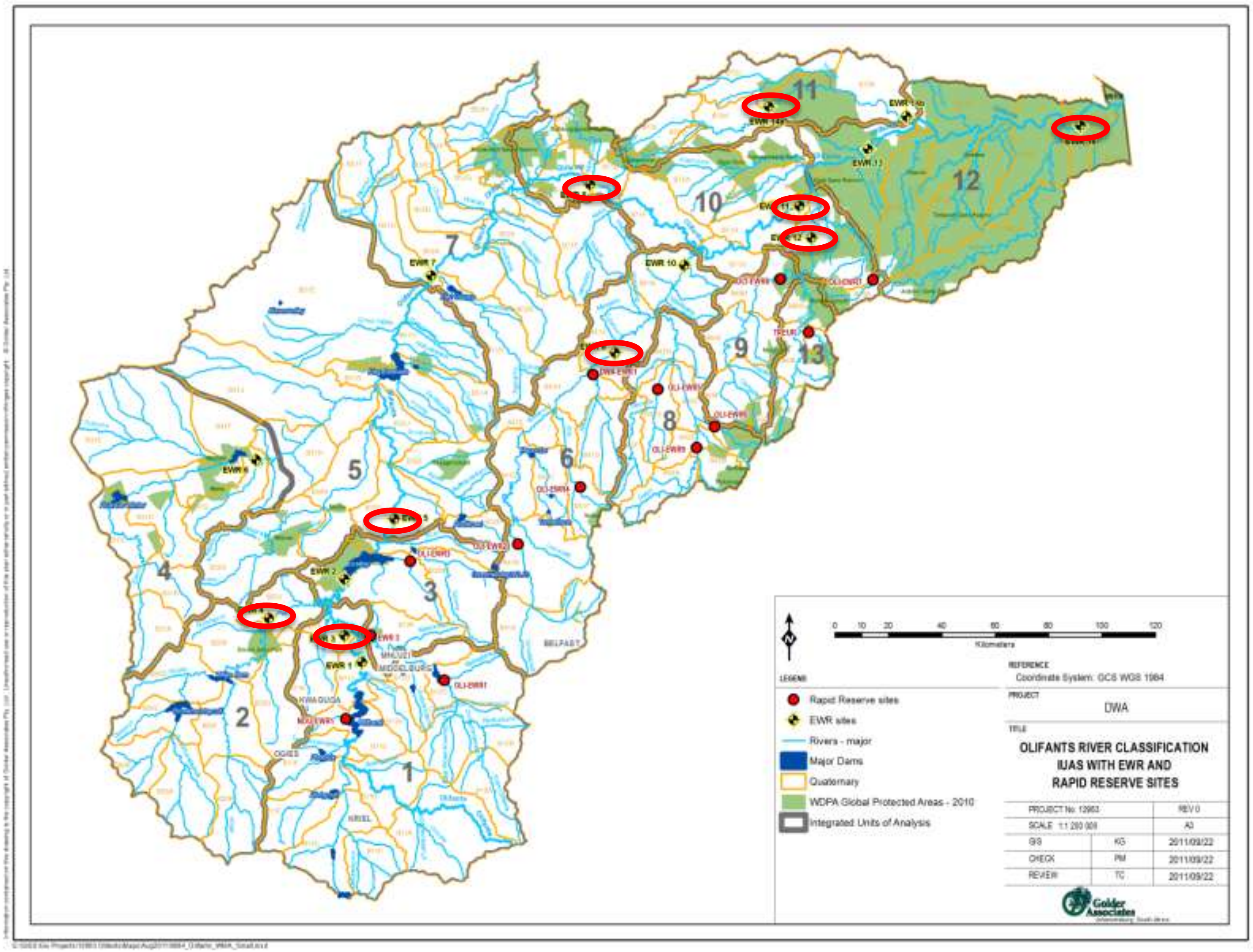


Figure 12: Priority EWR sites at which the ecological consequences assessment was undertaken

Table 29: EWR sites analysed with Flow Duration Curves

IUA	Delineation	EWR sites	Notes
1	Upper Olifants River catchment	EWR1 OLI-EWR1 NOU-EWR1	Olifants downstream Witbank Dam Klein Olifants u/s Mburg Dam Noupoortspruit
2	Wilge River catchment area	-	
3	Selons River area including Loskop Dam	EWR2 OLI-EWR3	Olifants upstream Loskop Dam, not assessed Kranspoortspruit
4	Elands River catchment area	EWR6	Elands below Mkumbe Dam
5	Middle Olifants to Flag Boshielo Dam	-	
6	Steelpoort River catchment	OLI-EWR2 DWA-EWR1 EWR10	Upper Steelpoort Dwars Steelpoort, not assessed
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	EWR7	Olifants downstream Flag Boshielo Dam
8	Spekboom catchment	OLI-EWR6 OLI-EWR5 OLI-EWR9	Upper Spekboom Watervals Dorps
9	Ohrigstad River catchment area	OLI-EWR8	Ohrigstad
10	Lower Olifants	-	
11	Ga-Selati River area	EWR14a	Upper Selati
12	Lower Olifants within Kruger National Park	OLI-EWR7	Klaserie
13	Blyde River catchment area	TRE-EWR1	Treur

6.2.2 Results of the ecological consequences assessment

The Fish Frequency Habitat Assessment (FFHA) and Invertebrate Frequency Habitat Assessment (IFHA) models were used by the ecologists to interpret the results of the various scenarios. The ecological consequences provided by the ecologists based on the models were based on flow only and quality and marginal vegetation were not included. Thus, only the instream ecological category is determined by these models.

Optimum flows based on the natural hydrology at the EWR sites are being used by the models. These optimum flows exclude floods and freshets and represent the minimum stress in the rivers for fish and macroinvertebrates during the wet and dry season. The months identified to represent the optimum flows for use in the FFHA and IFHA models were September (dry) and June (wet).

The ecological assessment of responses to various flow scenarios were based on the approach developed by Kleynhans for application in the Habitat Flow Stressor Response Model (Kleynhans, pers. comm., 2012).The flow patterns for the various scenarios were presented to ecological experts at a workshop. The consequences of the shortages in meeting the full EWR requirements on the fish and invertebrates were discussed. The changes in the optimum flows were in some of the scenarios so small that the models were not sensitive enough to show any changes in ecological categories. Thus, only selected scenarios were assessed by the ecologists. The results are presented in Table 30 and Table 31.

The main conclusion of the assessment was that the flow requirements at EWR sites 4 and 16 could not be met. The best that can be achieved at EWR 4 is an EC of a D where the PES is a C and the REC is a B. At EWR 16 although the REC is a B, the best that could be achieved was a B/C.

The EWR as EWR site 4 as determined in 2001 and later adjusted with new hydrology from the reconciliation strategy was found not to be adequate to provide the required flow necessary for fish and macroinvertebrates. SPATSIM was used to adjust the flows until the PES of a C was achieved. This resulted in that 43% of the natural MAR is required for the EWR in the Wilge. The consequences of this on water availability in the Wilge River catchment need to be further assessed.

The assessment of the EWR sites using flow duration curves showed that the EWRs could be met in most of the scenarios for September and June. Those sites where the EWRs could not be met for both September and June and for most of the scenarios are highlighted. A summary of the FDC results for the additional EWR sites are provided in Table 32.

Table 30: Summary of results of ecological consequences workshop

IUA	River	EWR sites	Present 2010 (no EWR implemented)			Sc 1: PES EWR			Sc 2: REC 2010			Sc 5: REC 2035		
			EC at EWR site (PES)	Ecological Con-sequence of flows	Recommendation	EC at EWR site	Ecological Con-sequence of flows	Recommendation	EC at EWR site	Ecological Con-Sequence of flows	Recommendation	EC at EWR site	Ecological Con-sequence of flows	Recommendation
1	Klein Olifants	EWR3	D	E	X	D	B/C	✓	C	B/C	✓	C	C	✓
2	Wilge	EWR4	B	D	X	B	D	X	B	C/D	X	B	D	X
3	Olifants	EWR5	C	D	X	C	D	X	C	C	✓	C	C	✓
6	Steelpoort	EWR9	D	E/F	X	D	C	✓	D	C	✓	D	C	✓
7	Olifants	EWR8	D	C	✓	D	C	✓	D	B	✓	D	B	✓
10	Olifants	EWR11	D	C	✓	D	D	✓	D	C	✓	D	C	✓
	Blyde	EWR12	B	A	✓	B	A	✓	B	A	✓	B	A	✓
11	Ga-Selati	EWR14b	D	C	✓	D	C	✓	C	C	✓	C	C	✓
12	Olifants	EWR16	C	B/C	✓	C	B/C	✓	B	B/C	X	B	B/C	X
	Olifants	EWR13	C	C	✓	C	C	✓	C	C	✓	C	C	✓

✓ - EC flow requirement met

X – EC requirement not met

Table 31: Summary of ecological consequence results

Scenario		EWR sites where flows do NOT meet categories	Consequence	Note
1	ESBC (PES Scenario)	EWR 4	Insufficient flow for fish wet weather flow	PES C /REC B Best achieve D
2	REC Scenario	EWR 4 EWR 16	Insufficient flow for fish wet weather and inverts wet and dry flow	EWR 4 as for Sc 1 Best achieved at EWR 16 is B/C (REC is B)
3	Maximum use scenario	Not Assessed Not considered by ecologists as acceptable		
5	Future growth REC Scenario	EWR 4 EWR 16	Insufficient flow for fish wet weather flow and inverts wet and dry flow	EWR 4 as for Sc 1 Best achieved at EWR 16 is B/C (REC is B)

Table 32: Summary of Flow duration curve results

IUA	Site	River	Quat	PES	REC	Comments
1	EWR1	Olifants	B11J	D	D	EWR met for Sep and Jun, all scenarios
	OLI-EWR1	Upper Klein Olifants	B12C	C	C	EWR met for Sep and Jun, all scenarios
	NOU-EWR	Noupoortspruit	B11G	C/D	C/D	EWR met for Sep and Jun, all scenarios
2	EWR4	Wilge	B20J	B	B	See Table A.6 for assessment
3	EWR2	Olifants	B32A	C	B	Not assessed
	OLI-EWR3	Kranspoortspruit	B32A	B	A/B	EWR not met for Sep and Jun
4	EWR6	Elands	B31G	D	D	EWR not met in Jun, only met for PES in Sep
5	EWR7	Olifants	B51G	D	D	EWR not met for present
6	OLI-EWR2	Upper Steelpoort	B41B	C	C	EWR met for Sep and Jun, all scenarios
	DWA-EWR	Dwars	B41H	B/C	B/C	EWR met in Jun, not in Sep
7	IUA7	Olifants	B52J	D	D	EWR not met in present & recon
8	OLI-EWR6	Upper Spekboom	B42D	C	B/C	EWR met for Sep and Jun, all scenarios
	OLI-EWR9	Dorpspruit	B42B	C/D	C/D	EWR met for Sep and Jun, all scenarios
	OLI-EWR5	Watervals	B42G	C	C	EWR met for Sep and Jun, all scenarios
9	OLI-EWR8	Ohrigstad	B60H	D	D	EWR not met in Jun (all scenarios) & not met in Sep for present & PES

IUA	Site	River	Quat	PES	REC	Comments
11	EWR14a	Ga-Selati	B72H	C	C	EWR partially met in Jun, not met in Sep
12	OLI-EWR7	Klaserie	B73A	B/C	B	EWR met for Sep and Jun, all scenarios
13	TRE-EWR	Treur	B60C	A/B	A/B	EWR met for Sep and Jun, all scenarios

6.3 WATER QUALITY IMPLICATIONS

As part of the scenario evaluation, the classification process requires that water quality is assessed at two levels:

- The present-day water quality requirements for all water users (Fitness for use).
- The water quality implications of different scenarios for different users.

6.3.1 PRESENT DAY WATER QUALITY ASSESSMENT

6.3.1.1 Background

A water quality present day assessment was undertaken for the Olifants WMA based on the routine monitoring conducted by the DWA in recent years. This was a high level qualitative assessment of current in stream water quality making use of the data available to the study team.

The primary source of data for the water quality analysis was the Directorate Resource Quality Services of the DWA. Historical data for water quality monitoring points in the Olifants WMA was obtained from the national monitoring network (Water Management System). The water quality monitoring data at these sites have different time scales, different sampling frequencies, variation in the water quality variables monitored and different laboratories and analytical methods used. In addition many of the tributary catchment’s points monitoring data records are poor. There were gaps in the available data.

The present day water quality status at these points for the period 2006 to 2009 was assessed by determining the compliance of the current water quality state to the resource water quality objectives derived from the South African Water quality guidelines (SAWQGs) in terms of ‘fitness for use’. The water quality data was analysed statistically and compared to the RWQOs and SAWGs to determine the compliance of water quality variables of concern in the different parts of the catchment. This assessment provided an indication of the overview water quality status of the Olifants WMA.

6.3.1.2 Water quality status in summary

The analysis of the results and expert knowledge of the Olifants WMA highlight the following:-

- The salinity related impacts due to mining, power generation and industries in the upper areas of the WMA are highlighted with electrical conductivity (EC) and sulphate concentrations at unacceptable levels.
- The unacceptable EC concentrations in the lower reaches of the Elands River are due to irrigation return flows and concentration due to evaporation of water from the low flows.
- The pH in places marginally exceeds the 8.4 upper limit. There are however localised acid conditions in sub-catchments associated with acid mine drainage. The acid mine drainage generally emanates from defunct coal mines.
- The trophic status in the dams is mesotrophic. However in the upper reaches of the Loskop Dam, eutrophic conditions have been observed. These have resulted in blooms of blue-green algae. The eutrophic conditions in the upper reaches of Loskop Dam are due to high

nutrient inputs from the WWTWs discharging below Witbank and Middelburg Dams.

- There are unacceptable phosphate concentrations in the Selati and in the lower Olifants below the Selati confluence. These are associated with sewage return flows and effluents from the mining and industrial activities around Phalaborwa.
- There is limited heavy metal concentration information in the catchment. The available data however shows unacceptably high levels in parts of the catchment. In fact high aluminium concentrations have been cited as a possible cause of the fish deaths in Loskop Dam.
- The intensive agricultural activities in the Elands and Moses River catchments could contribute pesticides and herbicides to the local river systems. These are not currently monitored.

In addition to the above present day assessment, the recent water quality assessment undertaken as part of the 'Development of a Reconciliation Strategy for the Olifants River Water Supply System Study' by DWA in 2011 was also reviewed. This study assessed 'current' water quality status in the Olifants WMA based historical data available at DWA monitoring sites in the catchment. The data range at the identified monitoring sites ranged from 1972 to 2007.

In terms of water quality requirements of the key water user sectors (irrigation, urban use, industrial use) it was found that the water quality in the study area generally meets the water quality guidelines. The water quality in the Olifants WMA is fit for use by the water user sectors in the catchment. There are specific water quality problems that were identified at Middelburg Dam (Station B1H004) where the pH, nitrite/nitrate and ammonia levels fall in the unacceptable range. Some areas in the Witbank Dam Catchment, Wilge River, Loskop Dam Catchment and in the Middle Olifants Catchment were found to have sulphate levels that fall in unacceptable ranges. The phosphates are marginally exceed the guielines throughout the study area.

While the assessments indicate that the water resources of the Olifants WMA on a whole are fit for use, localised water quality problems are significant and still remain a major concern.

The threats of the coal mining (mine water decants) and specifically acid mine drainage is a serious water quality issue that needs to be addressed as a matter of urgency. However some measures have been undertaken in this regard. Some mine water reclamation schemes have been constructed which are supplying water for potable use to the local municipalities. These schemes have to be developed and coordinated to address the future decants. The reclamation of the excess mine water has been earmarked as a future source of water to meet the growing water requirements in the upper areas of the Olifants WMA. This will help to address the potential water quality deterioration to the point where the fitness for use of downstream users is compromised.

There are a number of defunct mines in the WMA. Some of these mines are abandoned (ownerless) and are decanting into the river system. A strategy needs to be developed and implemented to deal with the water discharging from the defunct mines.

The majority of the wastewater treatment works associated with the local municipalities are producing an effluent which does not meet their license requirements. The works are discharging water to the river system which contains high organic, nutrient and microbiological loads. The high nutrient concentrations lead to eutrophic conditions in the river systems and dams. The trophic status of the upper reaches of Loskop Dam which receives effluent from the major treatment works of the Emalahleni and Steve Tshwete Local Municipalities has been classified as eutrophic with periodic outbreaks of the toxic blue green algae. Not only do the wastewater treatment works have to be operated and maintained correctly but the license conditions should be reviewed to implement more stringent discharge standards regarding nutrients in particular phosphorus.

Agricultural runoff has the potential to contribute nutrients and toxic organic chemicals associated with herbicides and pesticides to the water resource. The potential certainly exists in the Olifants WMA for contributions of these pollutants to the river system from agricultural areas. The water quality monitoring network has not allowed for the quantification of the contribution of organic pollutants from agriculture, in particular the intensive irrigation areas to the river system.

6.3.2 THE WATER QUALITY IMPLICATIONS OF THE DIFFERENT CATCHMENT SCENARIOS

This component of the WRCS process requires assessing the change a scenario would have on water quality and specifically the implications on the fitness for use for the water users.

Concentrations of chemical constituents and values of physical variables are frequently dependent on flow. Consequently, changes in the flow regime (scenarios) can cause shifts in water quality. Since efficient functioning of aquatic ecosystems is dependent, not only on an appropriate hydrological regime, but also on water of a suitable quality, there is a need to assess what this implication could be.

The following approach was followed for assessing the water quality changes related to the scenarios:

- The water quality related changes and impacts were assessed for sulphate, total inorganic nitrogen and phosphate.
- The water quality REC associated with the scenarios for the EWR sites were determined from the 2001 comprehensive Reserve determination and the DWA guideline 'Methods for determining the Water Quality Component of the Reserve (DWAF, 2008). The water quality categories associated with the scenarios are listed in Table 33 and Table 34. The water quality requirements for the water quality variables analysed are listed in Table 35.
- The current water quality status at the EWR sites was obtained from the data for the water quality variables assessed.
- The WRYM was run and the simulated flows at the EWR sites were taken from the model for the historic hydrological sequence.
- The load that needed to be removed from the system to achieve the water quality requirements at the EWR sites was calculated. The volume to be removed to achieve the EWR WQ EC was calculated using a source concentration for sulphate, total inorganic nitrogen (TIN) and phosphate of 2500 mg/l, 6 mg/l and 10 mg/l respectively. The methodology is described in the socio-economic report (a supporting report to this scenario evaluation).

The water quality eco-classification per EWR site as determined through the 2001 Comprehensive Reserve Study is reflected in Table 33.

Table 33: Olifants WMA EWR sites indicating PES (2001 and 2010), REC and Water Quality EC (2001)

EWR site	River	Quaternary catchment	PES	EIS	REC	Water Quality REC (2001)
EWR1	Olifants	B11J	E	Moderate	C	C
EWR2	Olifants	B32A	C	High	B	B
EWR3	Klein Olifants	B12E	D	Moderate	C	C
EWR4	Wilge	B20J	B	High	B	B

EWR5	Olifants	B32D	C	High	C	C
EWR6	Elands	B31G	D	Moderate	D	D
EWR7	Olifants	B51G	E	Moderate	D	D
EWR8	Olifants	B71B	E	Moderate	D	D
EWR9	Steelpoort	B41J	D	High	D	C
EWR10	Steelpoort	B41K	D	High	D	C
EWR11	Olifants	B71J	E	High	D	C
EWR12	Blyde	B60J	B	High	B	B
EWR13	Olifants	B72D	C	Moderate	B	B/C
EWR14a	Ga-Selati	B72H	C	Moderate	C	B
EWR14b	Ga-Selati	B72K	E	Moderate	D	D
EWR16	Olifants	B73H	C	Very high	B	B

Table 34 shows the 2001 Reserve water quality REC category as compared to the EC of the PES and REC and maximum use scenarios. Table 35 indicates how current water quality status compares to the ecological water quality limits for the scenarios.

From Table 35, the comparison does reflect a deterioration in water quality at some EWR sites from the proposed ecological category, PES and REC. Water quality impacts along some river reaches that influence ecological status. Water quality is in E category in the Upper Olifants, Middle Olifants (middle reaches) and lower reaches of Ga-Selati, due to flow and non flow related impacts. The absence of water quality monitoring points in some river reaches makes it difficult to understand the true status on water quality (in the vicinity of EWR 1 and downstream EWR 5, upstream Flag Bashielo Dam).

It is important to understand that water quality category that is reflected is from an eco-classification perspective and not a fitness for use perspective (not RWQO or guideline). The resource water quality objectives (limit or range) for the water resources of the Olifants WMA will be set as part of the establishment of Resource Quality Objectives (RQO) process, which will ensure that the water quality requirements as per the Ecological Reserve are met as well as those of the water users. This will in many instances result in stricter water quality objectives, as user requirements are more stringent than the ecological component.

This RQO study has recently been initiated by the DWA, and will build on the outcome of this WRCS process. The ecological protection levels emanating from the selected scenario *i.e.* the MC established will guide the establishment of the in-stream resource water quality objectives.

Table 34: Water quality category per EWR sites in terms of ecological category for IUA assessed

IUA	Scenario	(1) PES (ESBC) and (4) Future growth PES, (6) Sc 4 with additional treated mine water		(2) REC and (5) Future growth REC		(3) Maximum use	
	Water requirement	2010		2010		2010	
	Catchment	EWR Ecological category (EC)	2001 Water Quality REC	EWR Ecological category (EC)	2001 Water Quality REC	EWR Ecological category (EC)	2001 Water Quality REC
1	Upper Olifants River (EWR 1; EWR 3)	D	C	D	C	D	C
2	Wilge River (EWR 4)	C	B	B	B	D	B
3	Selons River area including Loskop Dam (EWR 2; EWR 5)	C	B/C	B	B/C	D	B/C
4	Elands River (EWR 6)	D	D	D	D	D	D
5	Middle Olifants up to Flag Boshielo Dam (EWR 7)	D	D	D	D	D	D
6	Steelpoort (EWR 9)	D	C	D	C	D	C
	Steelpoort (EWR 10)		C		C		C
7	Middle Olifants below Flag Boshielo Dam to u/s Steelpoort River (EWR 8)	D	D	D	D	D	D
8	Spekboom	C		B		D	
9	Ohrigstad	D		D		D	
10	Lower Olifants (EWR 11)	C	C	C	C	D	C
11	Ga-Selati River (EWR 14a)	D	B	C	B	D	B D
	Ga-Selati River (EWR 14b)		D		D		
12	Lower Olifants within KNP (EWR 16)	C	B	B	B	D	B
13	Blyde River	B	B	A/B	B	D	B

Table 35: Comparison of the present state water quality (TDS) at EWR sites to the ecological water quality TDS Limits

EWR site	River: Site name	WQ Site	Present State TDS mg/l	Ecological Reserve Limits[$] mg/l				Present state Compliance To Reserve Limits (Ecological category that present TDS state falls within)	WQ REC (2001)	Meets PES	Meets REC
				A Category	B Category	C Category	D Category				
1	Olifants, below Witbank Dam	B1H010Q01	406.06*	≤195	195.1 - ≤358	358.1- ≤553	>553	C* (E)	C	X	X
2	Olifants, Loskop Nature Reserve	No WQ site in proximity							B	No WQ site	No WQ site
3	Klein Olifants, Downstream Middelburg Dam	B1H015Q01	765.21					D	C	X	X
4	Wilge, Kranskop	B2H015Q01#	450					C	B	X	X
5	Olifants, downstream Loskop Dam	B3H001Q01#	328					C** (E)	C	✓	✓
6	Elands, downstream Rhenosterkop Dam	B3R005Q01	326.3					B	D	✓	✓
7	Olifants, downstream Flag Boshielo Dam	B5H004Q01	364.55					C	D	✓	✓
8	Olifants, confluence of Mohlapitse River	B7H013Q01#	202.8					B	D	✓	✓
9	Steelpoort, Steelpoort Park	B4H003Q01#	242.9					B	C	✓	✓
10	Steelpoort upstream confluence with Olifants	B4H011Q01	530.92					C	C	✓	✓
11	Olifants, Upstream Blyde confluence	B7H007Q01#	373.43					C	C	✓	✓
12	Blyde, downstream Blyderivierspoort Dam	B6H014Q01	133.09					A	B	✓	✓
13	Olifants, Tulani	B7H007Q01	373.43					C	B/C	✓	✓
14a	Selati, Ermelo Ranch	B7H014Q01#	198.78					B	B	✓	✓
14b	Selati, Foskor Mine	B7H019Q01	1769.63					E	D	X	X
16	Olifants, downstream Mamba weir	B7H017Q01	427.15					C	B	✓	X

*No WQ monitoring point in vicinity of EWR site 1. The influence of tributaries causes deterioration to E at site.
** At EWR site 5 WQ is in a C category, however quality deteriorates down stream at confluence with the Elands River there is no WQ monitoring site at this confluence.
[$]Methods for determining the Water Quality Component of the Reserve (DWAF, 2008)
WQ sites that are not in vicinity of EWR site but either upstream or downstream
Note* Ecological water quality (eco-classification) related to an ecological category does not equate to fitness for use requirements

6.3.3 ECONOMIC ASSESSMENT PER SCENARIO

6.3.3.1 Macro-Economic Analyses

Water resource management scenarios need to be evaluated in terms of their implications on the broader economy at a regional scale. The WRCS Guidelines proposes the use of a Social Accounting Matrix (SAM) (such as that developed by the Development Bank of Southern Africa (DBSA)) to model the macro-economic and social implications of different scenarios.

A SAM is a matrix that summarises the linkages that exist between the different role players in the economy *i.e.* business sectors, households and government. Thus, a SAM reflects all of the inter-sectoral transactions in an economy and the activities of households. A household is a very important economic definition, as it is the basic unit where significant decisions regarding important economic variables such as expenditure and saving are taken. A SAM combines households into meaningful groups, and thus enables analysis of different household groups, and its dependence on the rest of the economy. A SAM thus enables modelling of changes in economic activity on economic growth (*i.e*. the impact on GDP); job creation (i.e. the impact on labour requirements); impact on capital formation; and income distribution (i.e. the impact on low-income, poor households and the total income households).

A SAM enables the simulation of changes in sector turnover (please see the table below for a definition of sectors covered by a SAM) to estimate macro-economic impacts using economic multipliers. Economic models fundamentally incorporate a number of "multipliers" that form the nucleus of the modelling system. A multiplier specifies the nature and extent of the impact of a change in a specific economic quantity (e.g. agriculture) on another economic quantity or quantities (e.g. food manufacturing or employment). Multipliers consist of direct, indirect and induced multipliers. The direct multiplier measures an economic effect occurring in a specific sector, whilst the indirect multiplier measures those effects occurring in the different economic sectors that link backwards and forwards to this sector. The induced effect measures the additional economic activity generated by the spending of additional salaries and profits generated. Sectoral multipliers are calculated using information contained in the Sectoral SAMs and data obtained from the Reserve Bank of South Africa and Stats SA.

The DBSA has published SAMs for each of the nine Provinces of South Africa. The Olifants WMA straddles the Limpopo and Mpumalanga Provinces and thus the SAMs for these two provinces been used in the decision framework.

6.3.3.2 Analyses of Water Yield Effects

The economic transactions associated with water supply and use in the economy is officially captured in a format, which is referred to as Environmental Economic Accounts for Water. The United Nations sets out guidelines the System of Environmental Economic Accounting for Water (SEEAW). Statistics South Africa has developed various Water EEAs for South Africa. These accounts are compatible with SAMs.

Water EEAs, also referred to here as Water Hybrid Accounts, provide an accounting framework that enables the integration of specialised physical resource sector data with other information on the economics of water supply and use in a structure that is consistent with the way data on economic activities are organised in the System of National Accounts (SNA). In addition to facilitating integration and sharing of a more comprehensive knowledge base, the Natural Resource Accounting (NRA) framework provides the basis for evaluating the consistency between the objectives and priorities of water resource management and broader goals of economic development planning and policy at national and local scales.

In Water EEAs, physical accounts present the physical flow of water resources (measured by volume), and monetary accounts convert the volumetric flow of water to economic values.

The physical accounts provide information on the volumetric supply and use of water. The monetary accounts provide a basket of measures that describe the economic and welfare impacts of water supply and use.

6.3.3.3 Analyses of Aquatic Ecosystem Services

Ecosystem Services Accounts have been constructed for the Olifants WMA based on the Millennium Ecosystems Assessment (MEA) Framework. As in the case of Water Hybrid Accounts, Ecosystem Services Accounts provide an accounting framework that enables the integration of ecosystem service values with other information on the economics of water supply and can be integrated into a structure that is consistent with the System of National Accounts (SNA).

Production of aquatic ecosystem services is highly dependent upon the flow of water through rivers and wetlands. Thus reduction in flow is a hazard that puts aquatic ecosystem services at risk. This results through the desiccation of wetlands and riparian zones.

6.3.3.4 Modelling of Scenarios

The overall analysis framework for the scenario evaluation thus consists of four analytical components:

- Sectoral and SAM analyses;
- Ecosystem services analyses based on the MEA Framework;
- Water quality analyses using a water quality load model; and
- Water yield analyses using a Hybrid Water Account.

The analysis starts with the development of a set of plausible water resource management scenarios for all the IUAs. The risks to every economic sector, aquatic ecosystems and households are estimated, whereafter these risks are quantified through the Water SEEA, the WDCS simulation, the ERE analysis and finally the sectoral and SAM analyses.

Such analyses will enable cost-benefit assessment comparison of the different scenarios.

All results are provided in 2010 values.

6.3.3.5 Alignment of this study with the Olifants Water Supply System Reconciliation Final Strategy

Every scenario requires a different hydrological yield and different resource water quality objectives.

The DWA 2011, Olifants Reconciliation Strategy provides a list of yield augmentation options at various costs and is presented in Table 36.

Table 36: Summary of water yield augmentation options available in the Olifants WMA (DWA 2011)

Yield augmentation options		Zone	Yield / Water Saving	Unit Reference Value (URV)	Total cost (2010)	NPV / Cost of project	Year	Start
			(million m^3/a)	(R/m^3)	R'million / a	R'million		
1	Eliminating Unlawful Irrigation Use	Upper	6.4	0.12	0.768	13	5	2015
2	Removal of Alien Invasive Plants	Upper	5.9	0.76	4.484	120	23	2012
3	Groundwater Development	Upper	5	1.48	7.4		23	2012
4	WC/WDM: Irrigation	Upper	8.8	1.48	13.024	286	5	2013
5	WC/WDM: Urban	Upper	10.5	1.48	15.54	287	5	2013
6	WC/WDM: Mining	Upper	1.5	1.48	2.22	288	10	2013
7	Water Reuse from Coal mines	Upper	55	10.72	107.2		10	2020
8	Eliminating Unlawful Irrigation Use	Middle	2.1	0.12	0.252	13	5	2015
9	Removal of Alien Invasive Plants	Middle	1.6	0.76	1.216	120	23	2012
10	Groundwater Development	Middle	15	1.48	11.1		23	2012
11	WC/WDM: Irrigation	Middle	2.8	1.48	4.144	286	5	2013
12	WC/WDM: Urban	Middle	6.4	1.48	9.472	287	5	2013
13	WC/WDM: Mining	Middle	1.6	1.48	2.368	288	10	2013
14	De Hoop Dam (already included in balances)	Middle	99	18.00	1782		5	2012
15	Removal of Alien Invasive Plants	Steelpoort	1.6	0.76	1.216	120	23	2012
16	Groundwater Development	Steelpoort	7.5	1.48	11.1		23	2012
17	Removal of Alien Invasive Plants	Lower	3	0.76	2.28	120	23	2012
18	Groundwater Development	Lower	15	1.48	22.2		23	2012
19	WC/WDM: Irrigation	Lower	5.4	1.48	7.992	286	5	2013
20	WC/WDM: Urban	Lower	3.1	1.48	4.588	287	5	2013
21	WC/WDM: Mining	Lower	1.8	1.48	2.664	288	10	2013
22	Additional dam development: Middle Olifants	Middle	59	2.14	126.3	1140	23	2025

6.4 SCENARIO ANALYSIS

In terms of the yield analysis, the water balances per scenario indicate the following deficits for the Olifants WMA:

Table 37: Additional yield required in each Scenario (million m^3/a)

Scenario	Additional water required
1	60
2	171
3	9
4	219
5	330
6	219

The Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) proposes a series of water yield augmentation and water quality improvement measures to be implemented by 2016 and by 2035 respectively (refer to Table 36)

Scenarios 1, 2 and 3 below implements the 2016 yield augmentation options and Scenarios 4 and 5 below implements the 2035 yield augmentation options.

For the purpose of comparative analysis, water use efficiency was kept constant and all values are presented in 2010 Rands.

6.4.3 SCENARIO 1: ESBC scenario (PES scenario)

For this scenario the following has been applied:

- The Present Ecological State (PES) was used as the ecological category.
- PES EWR low maintenance flows were applied
- The water deficit for the WMA is 60 million m^3/year.
- 2016 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.
- Water demand and supply intervention scenarios were applied as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). This included implementing Options 1-7 and 15 -22 (see Table 36).
- Constant per capita GDP.
- Results (refer to Table 38):
  - Value of output is expected to grow and no net job losses are expected to occur.
  - An increase in ecosystem service value results from increased water yield and improved water quality, and ecosystem service value increases to R 3,150 million / year.
  - Greened GDP reduces to R138,949 million in 2016. The reduction in GDP results from

a reduction in company profits as these profits are used to implement the cost of yield augmentation – this is a trade-off that needs to be made between company profits and river health.

- The cost of yield augmentation is R284 million per year. This cost is borne by the water users and is likely to put upward pressure on water prices.

6.4.4 SCENARIO 2: REC Scenario (Recommended Ecological Reserve)

This scenario includes the following parameters in the WRYM run:

- The recommended ecological category (REC)
- REC EWR low and maintenance flows.
- The Present Ecological State (PES) was used as the ecological category .
- The water deficit for the WMA is 171 million m^3/year.
- 2016 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.
- Water demand and supply intervention scenarios were applied as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). This included implementing Options 1-22, as well as 99 million m^3/year from the De Hoop Dam (see Table 36).
- Results (refer to Table 38):
  - Value of output is expected to grow and no net job losses are expected to occur.
  - An increase in ecosystem service value results from increased water yield and improved water quality, ecosystem service value increases to R 3,310 million / year.
  - Greened GDP reduces to R138,236 million in 2016. The reduction in GDP results from a reduction in company profits as these profits are used to implement the cost of yield augmentation - this is a trade-off that needs to be made between company profits and river health.
  - The cost of yield augmentation is R947 million per year. This cost is borne by the water users and is likely to put upward pressure on water prices.

6.4.5 SCENARIO 3: Maximum use scenario

The maximum use scenario assesses what the catchment yield would be by implementing a D category EWR throughout the entire WMA. This scenario considers the maximum use of the water resources to the lowest sustainable ecological condition.

Scenario 3 included the following parameters in the WRYM run:

- An ecological category of D
- EWR low and maintenance flows.
- The water deficit for the WMA is 9 million m^3/year.
- 2016 Water Requirements per water use sector as detailed in the 'Olifants Water Supply

System Reconciliation Final Strategy Report' (DWA, 2011) were applied.

- Water demand and supply intervention scenarios were applied as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). This included implementing Options 1-7 (see Table 36).
- Results (refer to Table 38):
  - Value of output is expected to grow and no net job losses are expected to occur.
  - An increase in ecosystem service value results from increased water yield and improved water quality, ecosystem service value increases to R 3, 000 million / year. However, this scenario allows ecological categories in various parts of the catchment area to degrade, and thus this is not a desirable scenario.
  - Greened GDP reduces to R138,936 million in 2016. The reduction in GDP results from a reduction in company profits as these profits are used to implement the cost of yield augmentation. (Insufficient evidence exists to suggest that GDP would increase as a result of higher levels of water resource usage).
  - The cost of yield augmentation is R256 million per year. This cost is borne by the water users and is likely to put upward pressure on water prices.

6.4.6 Scenario 4: Future growth PES Scenario

It is important to understand how the water resource system of the Olifants WMA will behave with future growth into the years to come. To accommodate this, the future growth scenarios are assessed in terms of the Olifants WMA Reconciliation Strategy, by considering future water demands. Scenario 4 is similar to the ESBC scenario however it includes the future growth water demands for the Olifants WMA in year 2035.

Scenario included the following parameters in the WRYM run:

- The Present Ecological State (PES) as the ecological category.
- PES EWR low and maintenance flows apply.
- The water deficit for the WMA is 219 million m^3/year.
- 2035 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.
  - This includes a significant growth in Platinum Group Metals (PGM) mining
  - A population growth of 1% / year
  - Constant per capita GDP
- Water demand and supply intervention scenarios were applied as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). This included implementing Options 1-22 (see Table 36).
- Results (refer to Table 38):
  - Value of output is expected to grow and no net job losses are expected to occur.
  - An increase in ecosystem service value results from increased water yield and

improved water quality, ecosystem service value increases to R 3,730 million / year.

- Greened GDP grows to R170,029 million in 2035. The increase in GDP results from an increase in PGM mining activity and its associated multiplier effect. Within the GDP effect there is also a reduction in company profits as these profits are used to implement the cost of yield augmentation - this is a trade-off that needs to be made between company profits and river health.
- The cost of yield augmentation is R701 million per year. This cost is borne by the water users and is likely to put upward pressure on water prices.

6.4.7 Scenario 5: Future growth REC Scenario

Scenario 5 is as per scenario 2, however, the 2035 water demands are applied in the WRYM run, again to understand how the water resource system will behave.

Scenario 5 will include the following parameters in the WRYM run:

- The recommended ecological category (REC)
- REC EWR low and maintenance flows.
- The water deficit for the WMA is 330 million m^3/year.
- 2035 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011) were applied.
    - This includes a significant growth in PGM mining
    - A population growth of 1% / year
    - Constant per capita GDP.
- Water demand and supply intervention scenarios were applied as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). This included implementing Options 1-22 (see Table 36).
- Results (refer to Table 38):
    - Value of output is expected to grow and no net job losses are expected to occur.
    - An increase in ecosystem service value results from increased water yield and improved water quality, ecosystem service value increases to R 3,870 million / year.
    - Greened GDP reduces (compared to Scenario 4) to R169,881 million in 2035. The reduction in GDP results from a reduction in company profits as these profits are used to implement the cost of yield augmentation - this is a trade-off that needs to be made between company profits and river health.
    - The cost of yield augmentation is R1,080 million per year. This cost is borne by the water users and is likely to put upward pressure on water prices.

6.4.8 Scenario 6: Future growth PES Scenario (Scenario 4) plus release of additional treated excess mine water into the river system

As in Scenario 4, an additional 219 million m^3/a is still required to meet the deficit for the scenario. The additional 219 million m^3/a of water is required in the Olifants WMA to ensure improved ecosystem health. There are higher flows at EWR 1, EWR 2, EWR 3, EWR 5 and EWR 7. There is a potential to increase the EC from the PES by one class. However this scenario requires the implementation of management and monitoring systems to ensure that the water reaches the Middle Olifants.

This Scenario includes the treatment of the 55 million m^3/a of acid mine drainage (AMD), at an average treatment cost of R10.72 / m^3.

Scenario 6 will include the following parameters in the WRYM run:

- The Present Ecological State (PES) as the ecological category.
- PES EWR low and maintenance flows apply.
- The EWR requirement was 219 million m^3/year.
- 2035 Water Requirements per water use sector as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2012) were applied.
  - This includes a significant growth in Platinum Group Metals mining
  - A population growth of 1% / year
  - Constant per capita GDP.
- Water demand and supply intervention scenarios were applied as detailed in the 'Olifants Water Supply System Reconciliation Final Strategy Report' (DWA, 2011). This included implementing Options 1-22 (see Table 36).
- Results (refer to Table 38):
  - Value of output is expected to grow and no net job losses are expected to occur.
  - An increase in ecosystem service value results from increased water yield and improved water quality, ecosystem service value increases to R 3,730 million / year.
  - Greened GDP grows to R169,897 million in 2035. The increase in GDP results from an increase in PGM mining activity and its associated multiplier effect. Within the GDP effect there is also a reduction in company profits as these profits are used to implement the cost of yield augmentation – this is a trade-off that needs to be made between company profits and river health. This GDP is lower than in Scenario 4, as AMD treatment costs reduces company profits.
  - The cost of yield augmentation is R1 055 million per year. This cost is borne by the water users and is likely to put upward pressure on water prices.

Table 38: Economic implications of scenarios 1 to 6

Scenario		1	2	3	4	5	6
	Current State	PES	REC	Maximum use	Future growth PES	Future growth REC	Future growth PES with add'n water
		R'million/ year	R'million/ year	R'million/ year	R'million/ year	R'million/ year	R'million/ year
Contribution to GDP	139,050	138,949	138,654	138,936	170, 029	169,881	169,897
Ecosystem Service Value	2,883	3,150	3,310	3,000	3,730	3,870	3830
Cost of yield augmentation	0	284	947	256	701	1,080	1,055

6.4.9 COST OF WATER POLLUTION REDUCTION

6.4.9.1 Overview

Various land use activities including industry, mining, agriculture and urban development and business and household activities could have detrimental effects on the water quality of water resources, which in turn could affect economic activities such as irrigation productivity, operation and maintenance cost of water infrastructure, subsistence fishing, recreation, tourism and human health.

Typical water pollution drivers include:

- Point-source pollution from wastewater treatment plants;
- Stormwater pollution from a variety of sources (engine leaks, tyre and brake wear, fertilizers and pesticides from landscaping and pest management, sediment from erosion of non-landscaped areas and areas disturbed by construction, toxic chemicals from paints, solvents and cleaning compounds, and litter from plastics, paper and cold drink cans);
- Contamination of mine water affected by acid mine drainage and heavy metal concentrations;
- Agricultural runoff (fertilizers, salts, nutrients and pesticides);
- Animal grazing and watering (microbiological, turbidity).

6.4.9.2 Analytical Approach[1]

The economic effects of poor water quality are difficult to measure. Firstly, water quality is an input variable (or intermediate consumption) to final-use goods and services and does therefore not have a direct monetary effect associated with it. Secondly, water quality is often measured by a complex set of indicators or variables, which may change (positively or negatively) along the length of a river and over time. In addition, there is often a disconnect between these water quality indicators and the fitness-for-use of water. The Department of Water Affairs has

[1] DWA 2010

consequently (and recently) adopted a water quality abatement cost approach, as envisaged in the DWA's Waste Discharge Charge System (WDCS), to management of water quality. Although the details of implementation of the WDCS are still to be finalized, the WDCS approach provides a methodology for evaluating the economic effects of poor water quality in the Crocodile (West) and Marico WMA.

The WDCS is premised upon the polluter-pays principle, which intends to assign the cost of preventing such damages to polluters, and thus internalizes the cost of pollution prevention into the economy. The WDCS would reduce pollution to a level where the Resource Quality Objectives (RQOs) of the particular catchment area are met (DWA 2007b).

Water pollution abatement costs can be estimated if a marginal abatement cost curve is available. Such a curve is a multivariate mathematical-statistical function, which should ideally be developed, based on empirical data sourced from the particular catchment area within which the pollution problem is located. The marginal abatement cost curve relates a set of independent variables to the cost of water pollution abatement. The WDCS have identified five sets of water quality measures including salinity, pH, nutrient load, chemical oxygen demand (COD) and heavy metals, and these would thus form the independent variables of the abatement cost curve. For this classification study, sulphate (mining pollution indicator) as well as phosphate and total inorganic nitrogen (eutrophication and sewage treatment plant discharges) were considered in the economic evaluation.

6.4.9.3 Water Quality Degradation Mitigation

The aim of this part of the study was to estimate the cost water pollution reduction to levels that represent an EC A water quality category as defined by DWA, in the Olifants WMA. These estimates represent the water quality externality enjoyed by polluting industries.

This was accomplished by identifying the:

- most important water quality indicators representing the pollution associated with these activities,
- water treatment technologies for the reduction of these identified pollutants,
- target water quality objectives for the identified pollutants and
- estimating the cost of treating to RWQO requirements.

6.4.10 SOCIO ECONOMIC EFFECTS OF SCENARIOS ON ECOSYSTEM SERVICES AND GDP

The distribution of socio-economic effects in terms of ecosystem services and GDP effects per IUA are set out below.

In Scenarios 1, 2, 4, 5 and 6, the ecosystem service benefits increases across the WMA (Table 39). In Scenario 3, the ecosystem service benefits decreases, except in IUA 1.

Table 39: Distribution of changes in ecosystem services across the WMA, by Scenario, in R'million per year

IUA	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6

1	22	36	22	70	80	79
2	8	13	-8	25	28	28
3	19	32	-19	61	70	70
4	24	40	-5	78	89	89
5	40	65	-9	127	145	144
6	25	41	-5	80	91	91
7	26	43	-6	83	95	95
8	12	20	-12	38	44	44
9	8	14	8	27	31	31
10	24	40	-5	77	88	87
11	12	19	-3	37	43	43
12	35	58	-8	112	128	127
13	8	13	-15	25	28	28
Change in Ecosystem services	262	433	-64	838	958	956

The economic effects, as measured in terms of GDP, are set out in Table 40 below.

The implementation of Scenario 1 requires additional annual expenditure to implement the relevant yield augmentation options. This expenditure has some positive economic effects as it creates local business and job opportunities, but has a net negative effect on GDP as the expenditure is expected to be paid from profit margins of water use licence holders. In spite of the reduction in GDP, economic activity increases, no net job losses result and ecosystem service value improves.

In Scenario 2, the cost of yield augmentation is considerably higher than in Scenario 1, with a larger effect on GDP. In spite of the reduction in GDP, economic activity increases, no net job losses result and ecosystem service value improves.

In Scenario 3, although the cost of yield augmentation is the lowest of all the scenarios, the losses in ecosystem services increases the net negative effect on ecosystem service-adjusted GDP.

Scenarios 4, 5 and 6 compares positively to the current state, as a result of expected growth in economic activity. Scenario 5 is a more expensive option than in Scenario 4 as a result of larger yield augmentation costs in relation to the ecosystem service benefits.

Table 40: Distribution of change in ecosystem service-adjusted GDP effects across the WMA, by Scenario, in R'million / year

IUA	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	-35	-130	-35	10,652	10,596	10,596
2	-13	-50	-15	4,110	4,089	4,088

3	-4	-13	-4	1,104	1,098	1,098
4	-6	-24	-7	1,956	1,946	1,946
5	-8	-31	-9	2,553	2,540	2,540
6	-2	-9	-3	718	715	715
7	-8	-29	-9	2,343	2,331	2,331
8	-2	-7	-2	591	588	588
9	-2	-6	-2	482	480	480
10	-1	-3	-1	283	281	281
11	-7	-28	-9	2,302	2,290	2,289
12	-3	-12	-4	947	942	942
13	-1	-4	-2	307	306	306
Polokwane zone	-9	-32	-11	2,644	2,630	2,630
Total	-101	-379	-113	30,992	30,831	30,829

7 SUMMARY OF SCENARIO EVALUATION

The summary of the implications and deficits and the economic costs are given in Table 41. A plot of the economic evaluation for each scenario is presented in Figure 13. The results of the economic analysis of the scenarios are summarised as follows:-

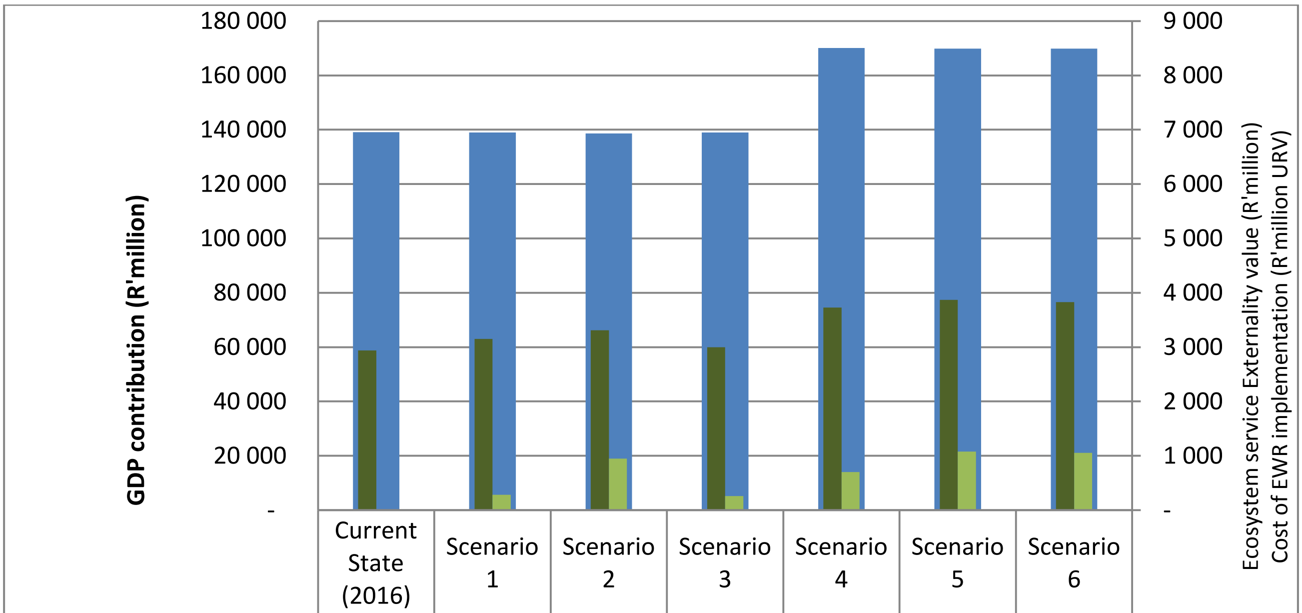
- The ecological consequences evaluation show that the EWR sites in general meet the Present Ecological State (PES) Ecological category (EC) and/or Recommended Ecological Category (REC). However, the flow requirements for some components at EWR sites 4 (Wilge River) and 16 (Olifants in Kruger National Park) could not be met. The best that can be achieved at EWR 4 is an EC of a D where the PES is a C and the REC is a B. At EWR 16 although the REC is a B, the best that could be achieved was a B/C.
- Reconciliation options for EWR incurs implementation costs
- On the one hand these costs reduce Gross Domestic Product (GDP) through reduced company profits. However, the reconciliation options also generate revenues in the economy.
- Most important, they ensure the constant delivery of aquatic ecosystem services. In Scenarios 1, 2, 4, 5, and 6 the ecosystem service benefits increases across the WMA.
- Where GDP decreases this is because company profits have been taken out (out of GDP) to pay for new water infrastructure.
- Ecosystem service changes are directly proportional to changes in flow.
- **Scenario 1:** Requires R 284 million / year (URV)
- **Scenario 2:** Requires nearly R 0.6 bn (R 947 million / year) more to increase ecosystem services by R 160 million
- **Scenario 4/5/6:** Platinum group mining grows significantly, the rest of the economy grows by 1%.
- **Scenario 6:**
    - The increase in flows results in an improvement in water quality in the middle reaches of the Olifants River. The higher flows could potentially increase the ecological categories at EWR sites 5 and 7. However this option requires that necessary management measures are put in place to ensure that the water reaches the middle Olifants.

Table 41: Summary of deficits and implications for scenarios

Scenario		Water Balance (Million m^3/annum)	Cost/Implication of implementation
1	**ESBC (PES Scenario)**	60 million m^3/a deficit	60 million m^3 of water is added to the Olifants WMA to ensure improved ecosystem health. Water quality improves across the WMA. The additional water comes from water savings achieved within the upper and lower parts of the WMA, and 22 million m^3 acid mine drainage

Scenario		Water Balance (Million m^3/annum)	Cost/Implication of implementation
			is treated. GDP of the WMA decreases by R100m per year (0.07%) to pay for the additional water. Zero net job losses are expected to occur. It is possible that water prices increase somewhat to pay for some components of the water addition.
2	**REC Scenario (Recommended Ecological Reserve)**	171 million m^3/a deficit	171 million m^3 of water is added to the Olifants WMA to ensure a higher level of improved ecosystem health. Water quality improves across the WMA, more so than in Scenario 1, especially in the coal mining areas and in the Kruger National Park. The additional water comes from extensive water savings achieved across the whole WMA, 58 million m^3 acid mine drainage is treated, and a water transfer from Gauteng is required. GDP of the WMA decreases by R380m per year (0.27%) to pay for the additional water. Zero net job losses are expected to occur. Water prices are likely to increase about three times more than in Scenario 1 to pay for some components of the water addition.
3	**Maximum use scenario**	9 million m^3/a deficit	9 million m^3 of water is added to the Olifants WMA to ensure improved ecosystem health (this provides a very low level of ecosystem protection and lowest level of ecosystem services of all the scenarios). Water quality improves in coal mining areas, but deteriorates in other parts of the WMA and the Kruger National Park. The additional water comes from water savings achieved within the upper parts of the WMA, and 22 million m^3 acid mine drainage is treated. GDP of the WMA decreases by R110m per year (0.07%) to pay for the additional water. Zero net job losses are expected to occur. There is a low likelihood that water prices would increase to pay for the water addition.
4	**Future growth PES scenario**	219 million m^3/a deficit	219 million m^3 of water is added to the Olifants WMA to ensure improved ecosystem health, and long term ecosystem achieved health is similar to that of Scenario 1. Water quality improves across the WMA. The additional water comes from water savings achieved within the WMA, and 27 million m^3 acid mine drainage is treated. GDP of the WMA grows as a result of general economic growth, although embedded within this growth is a GDP decreases to pay for the additional water. Zero net job losses are expected to occur. Water prices are likely to increase about three times more than in Scenario 1 to pay for some components of the water addition
5	**Future growth RDM (REC) Scenario (Recommended Ecological Reserve)**	330 million m^3/a deficit	In Scenario 5 (2035), 330 million m^3 of water is added to the Olifants WMA to ensure improved ecosystem health, and long term ecosystem achieved health is similar to that of Scenario 2. Water quality improves across the WMA, more so than in Scenario 4, especially in the coal mining areas and in the Kruger National Park. This water comes from extensive water savings achieved across the whole WMA, 58 million m^3 acid mine drainage is treated, and a water transfer from Gauteng is required. GDP of the WMA grows as a result of general economic growth, although embedded within this growth is a GDP decreases to pay for the additional water. Zero net job losses are expected to occur. Water prices are likely to increase about four times more than in Scenario 1 to pay

Scenario		Water Balance (Million m^3/annum)	Cost/Implication of implementation
			for some components of the water addition.
6	**Scenario 4 plus release of excess treated mine water to river system**	219 million m^3/a of Scenario 4	As in Scenario 4, an additional 219 million m^3/a is still required to meet the deficit for the scenario. The additional 219 million m^3/a of water is required in the Olifants WMA to ensure improved ecosystem health, and long term ecosystem achieved health is similar to that of Scenario 1. Water quality improves across the WMA. The additional water comes from water savings achieved within the WMA, and 55 million m^3/a acid mine drainage is treated. GDP of the WMA grows as a result of general economic growth, although embedded within this growth is a GDP decreases to pay for the additional water. Water prices are likely to increase about three times more than in Scenario 1 to pay for some components of the water addition.



	Current State (2016)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Contribution to GDP	139 050	138 949	138 654	138 936	170 029	169 881	169 879
Ecosystem Service Ext.	2 940	3 150	3 310	3 000	3 730	3 870	3 830
Cost of augmentation	0	284	947	256	701	1 080	1 055

Figure 13: Plot of the economic evaluation per scenario

Table 42: Summary of the scenario implications (+ = increase; - = decrease; 0 = no change)

Scenario	Scenario Description	Ecological condition for WMA	Water Balance (Million m^3/annum)	Water Quality	GDP	Water prices
1	**PES Scenario**	Sustain and improve ecological integrity. Improve water quality.	**60** (is required to implement the PES ecological condition)	+	-	+
2	**REC Scenario (Recommended Ecological Reserve)**	Increase ecological integrity to higher protection levels. Improve water quality.	**171** (is required to implement the REC ecological condition)	++	--	++
3	**Maximum use scenario**	Ecological integrity is at the lowest protection level	**9** (is required to implement a D category ecological condition)	-	-	0
4	**Future growth PES scenario**	Sustain and improve ecological integrity with future growth. Improve water quality.	**219** (is required to implement the PES ecological condition with 2035 water requirements)	+	-	+++
5	**Future growth REC Scenario**	Increase ecological integrity to higher protection levels with future growth. Improve water quality.	**330** (is required to implement the PES ecological condition with 2035 water requirements)	++	--	++++
6	**Scenario 4 plus additional flow in Middle Olifants River due release of excess volume of treated mine water**	Improve ecological integrity and water quality (above Reserve requirements) with future growth	**219** (is required to implement the PES ecological condition with 2035 water requirements. However 55m^3/a additional excess treated mine water is released to meet water requirements in Middle Olifants)	++	-	+++

7.1 POST 2035

The successful achievement and maintenance of the MC in the long term (post 2035) depends on the mine water management system in place. By 2035, the majority of the coal mines will be closed and the potential decant volumes if not managed correctly will impact significantly on the water quality of the Olifants River. The use of the excess mine water is a key element of the Reconciliation Strategy, but this depends on ongoing treatment of water which will require the adequate provision of funding post closure to operate and maintain the plants in perpetuity.

8 RECOMMENDED SCENARIOS

The scenarios and evaluation results were presented to the PSC at a meeting held on the 24 October 2012 with the aim of describing and understanding Scenario 6, the overall scenario evaluation results and selecting recommended scenarios for proposal to the Minister. Based on the technical evaluation and assessment of the following criteria, the 6 scenarios were assessed in terms of EWR implementation, water quality implications, WMA water balance and economic and social implications to determine the most likely go forward options:

- Scientific/Technical Assessment (Attainment/achievement)
- Affordability
- Practicalities of implementation
- Sustainability

In terms of the assessment scenarios 1,2,3 and 5 were 'eliminated' based on the following reasoning:

- Scenario 3: Water resources cannot be sustained in this scenario. Ecological condition and water quality deteriorates.
- Scenario 5: Availability of water is a constraint. Scenarios 5 has a high deficit which means water may have to be transferred into the catchment. The reconciliation strategy for the Olifants WMA showed that there is limited water available for transfer and the stand point of DWA is that the deficits in the Olifants WMA must be met with augmentation actions taken within the Olifants WMA. Water prices could potentially be very high.
- Scenarios 1 and 2: These scenarios do not cater for future growth in water requirements.

Based on the above assessment and on recommendation from the PSC, the go forward options are Scenario 4 and 6 which supply the PES ecological categories and meet the future growth in water requirements in the WMA. In Scenario 6 additional treated mine water released from the Upper Olifants to meet the water requirements of the Middle Olifants.

In terms of Scenario 4 and 6 defined and analysed above, it is therefore proposed that the PES ecological water requirements must be met for the IUAs in the Olifants WMA.

The IUA MCs associated with Scenario 4 and 6 are indicated in Table 43. The approach applied to determining the proposed MCs for each of the IUAs was to follow the guidelines of the WRCS. In summary the WRCS guidelines recommend that a MC be determined based on the ECs of the biophysical nodes residing in an IUA. Among other methods the guidelines recommend the application of Table 44 below, where the percentage of biophysical hydro-nodes falling into the indicated EC groups determines the IUA's MC. (refer to Section 4.7 for more detail).

This categorisation was based largely on the main stem of the Olifants River and major tributaries. Where a sub-node in a tributary catchment is different to the overall IUA MC (*i.e*. requiring a higher level of ecological protection), this higher ecological category is accounted by the implementation of this ecological water requirement.

Table 43: Proposed Management Classes for the Scenarios 4 and 6 (PES ecological condition)

Integrated Unit of Analysis (IUA)		PES EC	Management Class (Scenarios 4 and 6)
1	Upper Olifants River catchment	D	**III**
2	Wilge River catchment area	C	**II**
3	Selons River area including Loskop Dam	C	**II**
4	Elands River catchment area	D	**III**
5	Middle Olifants up to Flag Boshielo Dam	D	**III**
6	Steelpoort River catchment	D	**III**
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	D	**III**
8	Spekboom catchment	C	**II**
9	Ohrigstad River catchment area	D	**III**
10	Lower Olifants	C	**II**
11	Ga-Selati River area	D	**III**
12	Lower Olifants within Kruger National Park	C	**II**
13	Blyde River catchment area	A/B	**I**

Table 44: Preliminary guidelines for determining the IUA class

		Percentage (%) of nodes in the IUA falling into the indicated EC groups				
		> = A/B	>= B	> = C	> = D	< D
Class I		40	60	80	99	
Class II			40	70	95	
Class III	**Either**			30	80	
	Or				100	

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APPENDIX A

VISIONING QUESTIONNAIRE

CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE OLIFANTS WATER MANAGEMENT AREA (WMA 4)

VISIONING

(TOWARDS UNDERSTANDING THE DESIRED STATE OF WATER RESOURCES IN THE WMA)

Purpose of visioning

Visioning is a future-building process

"It is widely acknowledged that a fundamental objective of integrated water resource management (IWRM) is to ensure that resource-based costs and benefits are appropriately distributed in society (Van Wyk *et al*., 2006a)."

Visioning is a process of articulating society's aspirations for the future – in this case, the 'basket' of benefits to be derived from aquatic ecosystem services and the costs associated with their use."

Why is visioning important?

Vision promotes accountable decision-making by all resource users

The visioning process generates a dialogue that promotes ongoing shared awareness and understanding amongst resource users and encourage people to adjust their individual demands on the resource in the broader interests of sustainability and co-operative management. This promotes equity and shared understanding of the costs and benefits of different resource use options.

Benefits for the water user

This visioning exercise will help to translate your issues and concerns into a vision for the area in which you live, work or have interests. The vision will ultimately be translated into management objectives that will drive operational management. In other words, it will help link management actions to the vision and ensure that societal values and management objectives are linked and realised.

What are we developing a vision for?

We will develop a vision **for the water resources** in the Olifants Water Management Area.

The resource is more than water

"In setting a vision it is important to understand how the law expects us to interpret 'the water resource', for which a vision is developed. The 'water resource' is defined to include a watercourse, surface water, estuary or aquifer, on the understanding that a watercourse includes rivers and springs, the channels in which water flows regularly or intermittently, wetlands, lakes and dams into or from which water flows, and where relevant the bed and banks of the system."

The quality of the resource (the 'resource' being the ecosystem providing services beneficial to people) is defined broadly to include fluxes in flow; physical, chemical and biological characteristics of the water; the character and condition of the in-stream and riparian habitat; and composition, condition and distribution of the aquatic biota.

The importance of context: a vision for different areas

A vision is always situation- or context-specific. This means that we need to have a shared understanding of the condition of the water resources and of society within a chosen area.
The Olifants WMA is a very large and diverse area in terms of its ecology, and the economic and social activities that characterize it. Therefore we will use smaller areas that have been identified based on their similar socio-ecological characteristics. These areas are called the units of integrated analysis (IUA) and a map of these 12 IUAs is below (Figure 1). "Use and user needs, plus the state of the resource, are dynamic over space and time." It has therefore been divided into 12 IUAs based on socio-economic, ecological and water infrastructural characteristics. These IUAs are briefly described in this document. We'd like you to identify in which IUA you live in, work in or have an interest in.

You will then have an opportunity, in the questionnaire below, to comment on whether there are features related to water resources that we have missed out on, or are not relevant. You can also describe the ways in which you benefit from water resources in your IUA and what the major water resource issues are and what sort of management focal options you'd like to see focused on in your IUA.

Steps to be taken in this exercise towards developing the vision

There are several steps that need to be taken to develop a vision (DWAF 2006).

In this exercise, we firstly have **defined the geographical area** for which we want to develop a vision *i.e.* the 12 units of integrated analysis (IUA) are described in Appendix A.

Each IUA has been described in terms of the general characteristics related to the water resource. You need to tell us whether we have captured all the important characteristics of each area so that we can agree on a **collective context for each IUA**. This should describe any major issues related to water resources in the IUA. It is helpful for you to be specific about place names in your descriptions or comments.

With this context in mind for each IUA, please fill in the short, 6-question questionnaire at the end of this document.

Please hand in the completed questionnaire to the study team before the conclusion of the Project Steering Committee (PSC) meeting. We are going to use this to **distill the guiding principles or key elements of the vision** that are important in each IUA.

The guiding principles that are distilled from the above process will be used to **develop a vision** for each IUA that you will be able to review in due course.

Your contributions are valuable to the process.

We thank you for your participation.

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APPENDIX A: OLIFANTS WMA: IUA DESCRIPTIONS (Not included in this report).

Questionnaire for an IUA

If your interests or concerns extend over more than one IUA, please fill in another of these forms for that IUA.

1. For which IUA are you filling in this questionnaire?

☐ **IUA 1**	☐ **IUA 4**	☐ **IUA 7**	☐ **IUA 10**
☐ **IUA 2**	☐ **IUA 5**	☐ **IUA 8**	☐ **IUA 11**
☐ **IUA 3**	☐ **IUA 6**	☐ **IUA 9**	☐ **IUA 12**

2. Are there any other important water resource related issues, features or uses that you feel have been left out of the description of this IUA (as detailed in Appendix A)?

____

____

____

____

3. How do you use the river, wetland or groundwater in this IUA area and what sorts of benefits do you get from using them:

River?

____

____

____

Wetlands?

____

____

Groundwater?

____

____

____

4. What are your water resource issues in this IUA?

These can relate to issues of:

- *policy and legislation (e.g. lack of clarity, concern about pricing strategies etc);*
- *resources (e.g. scarcity, threats to or increasing demands on water resources etc);*

- *administration (e.g. delays, roles and responsibilities etc);*
- *capacity/empowerment (e.g. inadequate extension services, education, sense of ownership); or*
- *technological (e.g. water saving, best practices etc). Please indicate if there is an improvement or deterioration in any of the issues that you mention.*

Any other issues?

5. **How strongly do you feel about the following focal options for management in this IUA (mark with an X in the table below)?** *Please add in other focal options in the spaces provided if you so wish.*

Focal options	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Comment
Economic and social objectives						
Economic empowerment of the poor						
Maximise job creation i.*e*. labour intensive activities in order to provide for the most people						
Maximise capital growth and in this way contribute to development						
Social upliftment of the poor including provision of water services						
Maximise economic development through first world activities ranging from agriculture to industry						
Aim for water conservative uses						
Promote and develop recreation and tourism						
Conservation of biodiversity						
Promote the following sectors to achieve some of the above						
Commercial agriculture						
Eco tourism						
Subsistence farming						
Ecological Water Requirement of the water resource						
Maintain overall present ecological status of the catchment or IUA						

Focal options	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Comment
Improve overall present ecological status of the entire catchment or IUA						
Allow deterioration of present ecological status of the entire catchment or IUA for purposes of development						
Protect certain areas the ecological status of which need to be maintained or improved.						
Allow deterioration of the present ecological status of certain areas for the purpose of development						

6. **From the IUA characteristics provided and your knowledge of the IUA, could you please indicate what management class the resources should be managed for?** Reasons or qualifications for your answers would be greatly helpful. The overall present ecological category (present ecological state) for each IUA is given in the table below, with A being unmodified from its natural (pre-development) state and E being critically modified.

Management Classes
Class I - minimally used, minimally altered aquatic ecosystems; **Class II -** moderately used, moderately altered aquatic ecosystems; **Class III -** heavily used, significantly altered aquatic ecosystems.

IUA	Present ecological State	Future Management Class	Comments
1	C		
2	B		
3	A		
4	C		
5	C		
6	D		
7	D/E		
8	B/C		
9	B		
10	C		
11	D		
12	B		

APPENDIX B

FRESHWATER ECOSYSTEM PRIORITY AREAS (FEPAS) IN THE OLIFANTS WMA

List of FEPAs in the Olifants WMA indicating the sub-node PES of Classification Study (higher protection to afforded sub-nodes compared to overall IUA)

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
1	289	FEPA: Fish sp	Hydrocynus vittatus	B73J	A
2	292	FEPA: Fish sp	Amphilius sp. 'natalensis cf. Treur'	B71C	B
	292	FEPA: Fish sp	Barbus lineomaculatus	B71C	B
	292	FEPA: Fish sp	Opsaridium peringueyi	B71C	B
	292	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B71C	B
	292	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B71C	B
	292	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B71C	B
	292	FEPA: Wetland ecosystem type	Lowveld Group 7_Channelled valley-bottom wetland	B71C	B
3	309	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lowland river	B52F/B52G	C
	309	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B52F/B52G	C
	309	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B52F/B52G	C
	309	FEPA: Wetland ecosystem type	Central Bushveld Group 1_Channelled valley-bottom wetland	B52F/B52G	C
	309	FEPA: Wetland ecosystem type	Central Bushveld Group 1_Unchannelled valley-bottom wetland	B52F/B52G	C
	309	FEPA: Wetland ecosystem type	Central Bushveld Group 7_Floodplain wetland	B52F/B52G	C
4	313	FEPA: River ecosystem type	Ephemeral - Northern Plateau - Mountain stream	B51F	C
	313	FEPA: River ecosystem type	Ephemeral - Northern Plateau - Upper foothill	B51F	C
5	315	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B52J	C
6	317	FEPA: River ecosystem type	Ephemeral - Northern Plateau - Upper foothill	B51F	C
7	320	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B52J	C
	320	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B52J	C
8	323	FEPA: Fish sp	Hydrocynus vittatus	B73J	A
	323	FEPA: Number of wetland clusters	1 WetCluster FEPA	B73J	A
	323	FEPA: River ecosystem type	Ephemeral - Lebombo Uplands - Lower foothill	B73J	A

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	323	FEPA: River ecosystem type	Ephemeral - Lebombo Uplands - Upper foothill	B73J	A
	323	FEPA: Wetland ecosystem type	Lowveld Group 4_Depression	B73J	A
9	347	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B52J	C
	347	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B52J	C
10	361	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	361	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	361	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
11	367	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	367	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	367	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
12	368	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	368	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	368	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
13	378	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B71D	B
	378	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B71D	B
14	381	FEPA: Fish sp	Opsaridium peringueyi	B71A	B
	381	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B71A	B
	381	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B71A	B
15	391	FEPA: River ecosystem type	Ephemeral - Lowveld - Lower foothill	B73F	B
	391	FEPA: River ecosystem type	Ephemeral - Lowveld - Upper foothill	B73F	B
16	404	FEPA: Fish sp	Hydrocynus vittatus	B73G	B
	404	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B73G	B
17	424	FEPA: Fish sp	Barbus lineomaculatus	B60J	B
	424	FEPA: Fish sp	Opsaridium peringueyi	B60J	B
	424	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B60J	B
	424	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Upper foothill	B60J	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
18	444	FEPA: Fish sp	Barbus lineomaculatus	B60J	B
	444	FEPA: Fish sp	Opsaridium peringueyi	B60J	B
	444	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B60J	B
	444	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Mountain stream	B60J	B
	444	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Upper foothill	B60J	B
19	461	FEPA: Fish sp	Opsaridium peringueyi	B73A	B/C
	461	FEPA: Number of wetland clusters	1 WetCluster FEPA	B73A	B/C
	461	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Lower foothill	B73A	B/C
	461	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Mountain stream	B73A	B/C
	461	FEPA: River ecosystem type	Permanent/Seasonal - Lowveld - Upper foothill	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Channelled valley-bottom wetland	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Depression	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Flat	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Seep	B73A	B/C
	461	FEPA: Wetland ecosystem type	Lowveld Group 3_Unchannelled valley-bottom wetland	B73A	B/C
20	496	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Lower foothill	B41K	D
	496	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Mountain stream	B41K	D
	496	FEPA: River ecosystem type	Ephemeral - Northern Escarpment Mountains - Upper foothill	B41K	D
21	519	FEPA: River ecosystem type	Permanent/Seasonal - Bushveld Basin - Lower foothill	B51B	B
	519	FEPA: River ecosystem type	Permanent/Seasonal - Bushveld Basin - Mountain stream	B51B	B
	519	FEPA: River ecosystem type	Permanent/Seasonal - Bushveld Basin - Upper foothill	B51B	B
22	525	FEPA: Fish sp	Barbus lineomaculatus	B60D	B
	525	FEPA: Fish sp	Opsaridium peringueyi	B60D	B
	525	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60D	B
	525	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60D	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	525	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60D	B
23	566	FEPA: Fish sp	Barbus anoplus	B60B	B
	566	FEPA: Fish sp	Barbus lineomaculatus	B60B	B
	566	FEPA: Fish sp	Barbus treurensis	B60B	B
	566	FEPA: Fish sp	Opsaridium peringueyi	B60B	B
	566	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60B	B
	566	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Channelled valley-bottom wetland	B60B	B
	566	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Depression	B60B	B
	566	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Unchannelled valley-bottom wetland	B60B	B
24	581	FEPA: Fish sp	Barbus anoplus	B60C	B
	581	FEPA: Fish sp	Barbus lineomaculatus	B60C	B
	581	FEPA: Fish sp	Barbus treurensis	B60C	B
	581	FEPA: Fish sp	Opsaridium peringueyi	B60C	B
	581	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60C	B
	581	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60C	B
	581	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Channelled valley-bottom wetland	B60C	B
	581	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Flat	B60C	B
	581	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Seep	B60C	B
25	626	FEPA: Fish sp	Barbus lineomaculatus	B41J	D
	626	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B41J	D
	626	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B41J	D
26	650	FEPA: Fish sp	Barbus anoplus	B60B	B
	650	FEPA: Fish sp	Barbus lineomaculatus	B60B	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	650	FEPA: Fish sp	Barbus treurensis	B60B	B
	650	FEPA: Fish sp	Opsaridium peringueyi	B60B	B
	650	FEPA: Number of wetland clusters	1 WetCluster FEPA	B60B	B
	650	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60B	B
	650	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60B	B
	650	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60B	B
	650	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Depression	B60B	B
	650	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Flat	B60B	B
	650	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 9_Seep	B60B	B
27	653	FEPA: Fish sp	Amphilius natalensis	B60A	C
	653	FEPA: Fish sp	Amphilius sp. 'natalensis cf. Treur'	B60A	C
	653	FEPA: Fish sp	Barbus anoplus	B60A	C
	653	FEPA: Fish sp	Barbus lineomaculatus	B60A	C
	653	FEPA: Fish sp	Barbus treurensis	B60A	C
	653	FEPA: Fish sp	Opsaridium peringueyi	B60A	C
	653	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B60A	C
	653	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60A	C
	653	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60A	C
28	667	FEPA: Fish sp	Amphilius sp. 'natalensis cf. Treur'	B60E/B60F	C
	667	FEPA: Fish sp	Barbus lineomaculatus	B60E/B60F	C
	667	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B60E/B60F	C
	667	FEPA: Fish sp	Opsaridium peringueyi	B60E/B60F	C
	667	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B60E/B60F	C

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	667	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B60E/B60F	C
29	674	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	674	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41G	B
	674	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
30	685	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	685	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41G	B
	685	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41G	B
	685	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41G	B
	685	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
	685	FEPA: Wetland ecosystem type	Central Bushveld Group 1_Channelled valley-bottom wetland	B41G	B
	685	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Flat	B41G	B
31	699	FEPA: Fish sp	Opsaridium peringueyi	B41F	C
	699	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41F	C
	699	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41F	C
	699	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41F	C
32	705	FEPA: Fish sp	Barbus lineomaculatus	B42D/E	C
	705	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	705	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B42D/E	C
	705	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B42D/E	C
33	721	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	721	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41G	B
	721	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41G	B
	721	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
34	725	FEPA: Fish sp	Barbus lineomaculatus	B42D/E	C
	725	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	725	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B42D/E	C

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	725	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B42D/E	C
35	726	FEPA: Fish sp	Opsaridium peringueyi	B41G	B
	726	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41G	B
	726	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41G	B
36	734	FEPA: Fish sp	Barbus anoplus	B42G	B
	734	FEPA: Fish sp	Barbus lineomaculatus	B42G	B
	734	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B42G	B
	734	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B42G	B
37	743	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B32F	C
	743	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B32F	C
38	762	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	762	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Lower foothill	B42D/E	C
	762	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B42D/E	C
	762	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B42D/E	C
39	777	FEPA: Fish sp	Opsaridium peringueyi	B41D	C
	777	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41D	C
	777	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41D	C
	777	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41D	C
40	788	FEPA: Fish sp	Barbus sp. 'Ohrigstad'	B42D/E	C
	788	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Mountain stream	B42D/E	C
	788	FEPA: River ecosystem type	Permanent/Seasonal - Northern Escarpment Mountains - Upper foothill	B42D/E	C
41	848	FEPA: Fish sp	Barbus anoplus	B41F	B
	848	FEPA: Fish sp	Opsaridium peringueyi	B41F	B
	848	FEPA: Number of wetland clusters	2 WetCluster FEPAs	B41F	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
	848	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41F	B
	848	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Channelled valley-bottom wetland	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Depression	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Flat	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Seep	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Unchannelled valley-bottom wetland	B41F	B
	848	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Valleyhead seep	B41F	B
42	851	FEPA: Fish sp	Opsaridium peringueyi	B41F	B
	851	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41F	B
	851	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41F	B
	851	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41F	B
	851	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Channelled valley-bottom wetland	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Channelled valley-bottom wetland	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Depression	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Flat	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Seep	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Unchannelled valley-bottom wetland	B41F	B
	851	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Valleyhead seep	B41F	B

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
43	862	FEPA: Fish sp	Opsaridium peringueyi	B41C	C
	862	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B41C	C
	862	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B41C	C
44	874	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lowland river	B32H	D
	874	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B32H	D
	874	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B32H	D
45	905	FEPA: Fish sp	Barbus anoplus	B41B	D
	905	FEPA: Fish sp	Opsaridium peringueyi	B41B	D
	905	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41B	D
	905	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Lower foothill	B41B	D
	905	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Mountain stream	B41B	D
	905	FEPA: River ecosystem type	Permanent/Seasonal - Eastern Bankenveld - Upper foothill	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Channelled valley-bottom wetland	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Depression	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Unchannelled valley-bottom wetland	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Channelled valley-bottom wetland	B41B	D
	905	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 7_Unchannelled valley-bottom wetland	B41B	D
46	965	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lower foothill	B32A	B
	965	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Mountain stream	B32A	B
	965	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B32A	B
47	1002	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Depression	B41A	C
	1002	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41A	C
	1002	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41A	C

	FEPA ID	Type of FEPA map category	Biodiversity features	Quartenary Catchment	Sub-node PES
48	1005	FEPA: Fish sp	Opsaridium peringueyi	B41A	C
	1005	FEPA: Number of wetland clusters	1 WetCluster FEPA	B41A	C
	1005	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Lower foothill	B41A	C
	1005	FEPA: River ecosystem type	Ephemeral - Eastern Bankenveld - Upper foothill	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Channelled valley-bottom wetland	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Depression	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Flat	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Seep	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Unchannelled valley-bottom wetland	B41A	C
	1005	FEPA: Wetland ecosystem type	Mesic Highveld Grassland Group 6_Valleyhead seep	B41A	C
49	1047	FEPA: Fish sp	Barbus anoplus	B41A	C
	1047	FEPA: Fish sp	Opsaridium peringueyi	B41A	C
	1047	FEPA: River ecosystem type	Permanent/Seasonal - Highveld - Mountain stream	B41A	C
	1047	FEPA: River ecosystem type	Permanent/Seasonal - Highveld - Upper foothill	B41A	C

Higher ecological protection included in scenarios as required by FEPA