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SUPPORT TO PHASE 2 OF THE ORASECOM BASIN-WIDE INTEGRATED WATER RESOURCES MANAGEMENT PLAN

Work Package 5:

Assessment of Environmental Flow Requirements

Desktop Ecoclassification Assessment

December 2010

ORASECOM

The *Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan* Study was commissioned by the Secretariat of the Orange-Senqu River Basin Commission (ORASECOM) with technical and financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ) in delegated cooperation with the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID). The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) implemented the study.

Prepared by

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REPORTS,WPS AND OTHER DELIVERABLES SUBMITTED	**TYPE**	No.
Overall Study		
Inception Report	Report	004/2010
Project Executive Summary	Report	013/2011
Work Package 1: WATER RESOURCES MODELLING OF THE ORANGE-SENQU BASIN		
Strengths and Weaknesses of Existing Models	Report	005/2010
Setting up and Testing of the Final Extended and Expanded Models; Changes in Catchment Yields and Review of Water Balance	Report	001/2011
Modelling software and datasets	Software	None
Capacity Building and Setting up the Models in each Country; Process of Continuous Review	Report	003/2011
Work Package 2: EXTENSION AND EXPANSION OF HYDROLOGY OF ORANGE-SENQU BASIN		
Improvements to Gauging Network and Review of Existing Data Acquisition Systems	Report	005/2011
Extension of Hydrological Records	Report	006/2011
Hydrological Database o	Database	None
Work Package 3: INTEGRATED WATER RESOURCES QUALITY MANAGEMENT PLAN		
Development of Water Quality Monitoring programme and Data Management Framework	Report	007/2011
Development of Specifications for the Water Quality Model	Report	006/2010
Work Package 4: CLIMATE CHANGE IN THE ORANGE-SENQU RIVER BASIN		
Downscaling Methodology and Ongoing Climate Modelling Initiatives	Report	007/2010
GCC Downscaling for the Orange-Senqu River Basin	Report	008/2011
Projection of impacts and Guidelines on Climate Change Adaptation Strategies	Report	009/2011
Work Package 5: ASSESSMENT OF ENVIRONMENTAL FLOW REQUIREMENTS		
Literature survey and Gap Analysis	Report	008/2010
Delineation of Management Resource Units	Report	009/2010
Desktop EcoClassification Assessment	***Report***	***016/2010***
Goods and Services Report	Report	010/2010
Environmental Flow Requirements	Report	010/2011
Work Package 6: WATER CONSERVATION AND WATER DEMAND IN THE IRRIGATION SECTOR		
The Promotion of WC WDM in the Irrigation Sector	Report	011/2011
Irrigation GIS Database, Interactive Database and Irrigation Scenario Tools	Report	012/2011
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Certain adaptations had to be made to the above models to be more applicable to ephemeral systems where the instream aspects are not relevant. In these situations the focus was on the riparian and fauna, other than instream, biota. Dr Andrew Deacon and James Mackenzie are acknowledged for their method development to include the fauna and riparian vegetation in the EIS evaluation.

The wetland contribution and chapter was provided by and authored by Mark Rowntree.

The specialists that contributed to a study in terms of providing input to the ratings are:

- Brown, Cate (Southern Waters)
- Clarke, Tassie (Beuster, Clarke and Associates) (maps)
- Deacon, Andrew (SANParks): Development of method to include fauna
- Heath, Ralph (Golder)
- Hughes, Jessica
- Huggins, Greg (Nomad Consulting);
- Koekemoer, Johan (KAS)
- Kotze, Piet (Clean Stream Biological Services)
- Louw, Delana (Rivers for Africa);
- Mackenzie, James (Mackenzie Ecological & Development Services): Development of method to include riparian vegetation
- Mare, Manie (WRP)
- Mor, Christoff (ORASECOM)
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EXECUTIVE SUMMARY

BACKGROUND

This work forms part of the wider *Support to Phase II ORASECOM Basin Wide Integrated Water Resources Management Plan* study and falls under Work Package 5, which focussed on the determination of Environmental Flow Requirements (EFRs) at selected key areas of the Orange River Basin at an Intermediate Level (detail) of assessment (as per the DWA:RSA criteria).

This report focuses on the results of the *scoping (Desktop) level assessment of ecological and socio-cultural condition and importance across the Basin* task under Work Package 5. The study determined the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of water resources (rivers, wetlands and groundwater) across the whole study area at a desktop level. This assessment enabled areas of importance (high PES and/or EIS) to be identified across the catchment so that more detailed assessments could be undertaken at these priority hotspots. The broad overview of the entire catchment characteristics also allowed for Management Resource Units (zones of similar ecological and water use characteristics) to be delineated. Environmental Flow Requirement study sites can then be selected to take into account the representation of the Management Units and be cognisant of the hotspots across the catchment.

APPROACH

A Desktop (or Reconnaissance) EcoClassification process was followed to determine the Integrated Environmental Importance in terms of three components, namely the Ecological Importance and Sensitivity (EIS), the Socio-Cultural Importance (SCI), and the Present Ecological State (PES), for the whole study area. The Integrated Environmental Importance and Water Resource Use Importance were used to identify "hotspot" priority areas of critical Environmental and/or Water Resource Use Importance (Figure I). These priority hotspots will require more detailed assessments when future developments (amongst others) are considered. This information also plays a critical role in identifying areas where EFR sites should be selected.

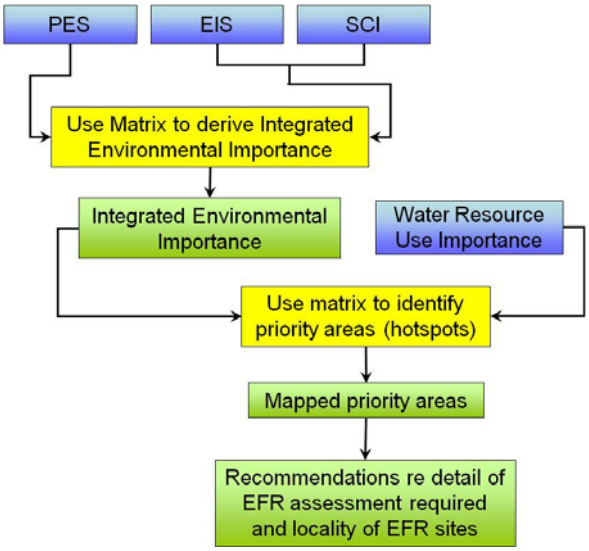

Figure I: The procedure used to integrate Environmental and Water Resource Use Importances to identify priority areas (hotspots)

The procedures to identify the priority areas (hotspots) and provide the final recommendations regarding level are:

- Desktop EcoClassification which included the determination of the Ecological Importance and Sensitivity (EIS); Socio-Cultural Importance (SCI) and Present Ecological State (PES).
- Determination of the Integrated Environmental Importance (IEI) by integrating the EIS, SCI and the PES. Significant wetlands were also identified and rated in terms of their PES and EIS. This information contributed to the determination of Integrated Environmental Importance;
- Determine the Water Resource Use Importance (WRUI); and
- Identification of the areas which are priority hotspots and require more detailed studies by locating areas of high Integrated Environmental Importance and/or Water Resource Use Importance.

This assessment was applied to each main river (and some main tributaries) in every quaternary catchment. In Namibia, where quaternary catchments have not been delineated, river reaches (provided by Beuster, Clarke and Associates and modified after ground-truthing in this study) were used.

RESULTS

This report provides the results of the Desktop EcoClassification (Integrated Environmental Importance) and the Water Resource Use Importance assessments. These two information sources were correlated to identify priority areas ("*hotspots"*) in the catchment. The report summarises the approach, documents the results on a quaternary (and where applicable on sub-quaternary) catchment scale, highlights the priority areas in the catchment where environmental flow requirement studies are required and provides recommendations on the level (detail) at which the EFA studies should be undertaken. For ease of data and map presentation, the large study area was subdivided in to six basins (Figure II). The summarised results are described per basin below.

ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS) RESULTS

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai

No areas of Very High[1] EIS are present. The areas of High EIS include the upper source areas of Lesotho such as the Tholatzi, Khubela, Tsoelike, Qhuali, Mantsonyana, Lesobeng and Quithing Rivers and also sections in the Malibamatso, and Senzu Rivers. The High rating is primarily due to the presence of the endangered Maluti minnow (PQUA), Rock catfish (ASCL), several rare frogs and stoneflies, and the presence of protected areas. The Presence of wetlands in some areas also contributed to the High importance ratings.

In the Caledon Basin , all the quaternary catchments were rated as having a Low EIS apart from D21A and D21D which fell within the Moderate EIS category. This is due to the fact that the Little Caledon is situated within Golden Gate National Park and a section of the Caledon borders the Park. Most of the quaternary catchments in the Kraai Basin are of Moderate EIS due to the presence of rare and unique riparian vegetation, as well as the sensitivity of the habitat associated with a small and steep (gradient) river.

The rest of the quaternary catchments in this unit (Orange in South Africa) have Low EIS ratings.

[1]Model results from the EIS and SCI will be presented with a capital letter, e.g. 'High'. Where no capital letter is used, the word is just used in the normal descriptive form.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The main Orange River shows a Moderate importance compared to the Low importance of all the tributaries. The Moderate importance is based on individual high ratings for the biota importance and sensitivity metrics. These high ratings include:

- Rare and Endangered: Presence of *Simulium gariepense* and BKIM;
- Unique: Fish sp such as ASCL, BAEN, LCAP which are endemic to the Orange-Vaal system and therefore qualify for some level of importance;
- Flow sensitive species: *Similium gariepense* and large number of semi-rheophilic fish species; and
- Refuge: Orange River as a whole is an important refuge area due to lack of perennial tributaries.

As the Orange River is a large river and the habitat shows a low sensitivity to change, these metrics were rated low and resulted in an overall Moderate EIS. Most of the tributaries are seasonal or ephemeral and this resulted in a Low EIS rating.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

D73F is the only area with a High EIS rating in this section, with the rest of the Orange River being of Moderate EIS. The High evaluation is due to the more diverse habitat downstream of Upington, as well as all the other metrics rated High as described above for BASIN 2. Apart from some Moderate EIS evaluations in the Sak, Riet and Vis System, the rest of the quaternary catchments are evaluated as Low. Again this is related to the seasonal nature of these systems.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

A large section of the Orange River is evaluated as being of High EIS. This is mainly due to the presence of National Parks, other protected and/or wilderness areas. All the tributaries are of Low importance which is mainly due to their ephemeral nature.

Basin 5: Molopo River

There are three High EIS (D41A_R1, D41H, D42E) quaternary catchments in the Molopo River. This is due to

- the presence of rare riparian plant species;
- the role of vegetation as a refuge and a corridor for migration of birds and other fauna; and
- the presence of the Molopo Eye, the Molopo Game Reserve and the Riemvasmaak protected area.

There are two areas of Moderate EIS in the Molopo River (D41E and F) which is due to riparian vegetation importance. The rest of the evaluations are all Low and this is linked to the general Low PES and/or the ephemeral nature of the tributaries.

Basin 6: Fish and Nossob catchments

There are two areas with a Very High EIS rating, namely the Nossob and Auob Rivers in the Kgalagadi National Park. This is due to their presence in the Transfrontier Park, as well as the presence of rare and endangered birds, animals and plants, and the role these rivers (specifically the vegetation corridor) play as a refuge and migration corridor.

The Fish River is for most of its length is of High EIS due to the:

- Presence of rare and endangered Red Data and other listed fish and riparian species;

- Presence of unique, endemic riparian species;
- Presence of flow and water quality sensitive species;
- Presence of important, sensitive and varied habitats;
- Role of the river as a refuge and migration corridor; and
- Presence of the lower river in protected areas.

Most of the rest of the rivers are of Moderate or Low EIS. The Low evaluations are linked either to the excessive invasion of *Prosopys sp* (exotic invader) and/or its ephemeral nature.

SOCIO-CULTURAL INDEX (SCI) RESULTS

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai

In the Lesotho highlands the Socio-Cultural Importance ratings are mostly High. The marginal nature of the Lesotho Highland society is one that dictates that there is close dependence on the resources of the area.

In the Caledon and Kraai River Basin s, characterised by farmlands and rural settlements combined with the subsistence farming areas of some of the former homelands and Lesotho, the influence of the Lesotho areas and rural settlements elevates many of the scores to Moderate (in fact the higher end of the Moderate range). However, the generally degraded nature of the Caledon and Kraai Rivers and associated riparian zones and in particular the perceived water quality issues, mean that the utilisation of the area (from a socio-cultural perspective) is not as high as it may have been historically.

In the remaining section of this unit includes the farmlands of the Eastern Cape and Free State, combined with the subsistence farming areas of some of the former homelands. As with the Caledon, the degraded nature of the area means that the utilisation of the area (from a socio-cultural perspective) is not as high as it may have been historically.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The quaternary areas and associated river reaches vary from Low to Moderate in the catchment section and are similar in many respects to BASIN 3, even though population densities are somewhat higher. Scores are dominated by those in the Low category as the area is generally utilised for farming (predominately extensive but with some intensive irrigation) and ancillary associated economic activities. With Low dependence on the riverine resources for livelihood, subsistence agriculture, combined with Low to relatively Moderate population densities; very few of the quaternary catchments display characteristics that would elevate the scores.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

The SCI varies from Low to Moderate. Ratings are dominated by a Low category as the area is generally utilised for farming (predominately extensive but with some intensive irrigation) and ancillary associated economic activities. With Low dependence on the riverine resources for livelihood, subsistence agriculture combined with Low to relatively Moderate population densities, very few of the quaternary catchments display characteristics that would elevate the scores.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

The SCI varies from Low to Moderate. The exception is the Orange River Mouth that scores High with respect to recreational usage, aesthetic value as well as historical and cultural value. The relatively low population densities of the rest of the catchment mean that socio-cultural importance is generally low.

Basin 5: Molopo River

The SCI varies from Low to Moderate in the catchment section. The reasons for this are mainly the relatively low population densities, the generally low intermittent nature of the riverine sections and the commercial nature of the area. The exception is the Kuruman Eye that has high recreational value (given the surrounding park area) and also scored relatively high with respect to aesthetic quality.

Basin 6: Fish and Nossob catchments

The SCI varies from Low to Moderate. This is not surprising given the relatively intermittent flows that generally preclude socio-cultural dependencies, combined with low population densities and overall utilisation. Two notable exceptions are D42A (910 - Nossob) and 1009 (Fish). The Fish River section scored very high in terms of recreational and aesthetic values. The Nossob section scored very high in terms of recreational usage and scored relatively high in terms of aesthetic value and resource dependence.

PRESENT ECOLOGICAL STATE (PES) RESULTS

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai

In the upper Lesotho areas, only one river section, namely the upper Tsoelike, has a PES in an A Ecological Category (EC). This is largely due to its protective status and the inaccessibility of the area. A number of rivers with A/B status occur in the source areas. These sections are in a good condition due to inaccessibility and some measure of protection. The majority of the rivers are however in a C and B/C state. Impacts are mostly related to overgrazing, erosion, sedimentation, terracing, removal of riparian vegetation and the presence of alien vegetation. Below Katse and Mohale Dam, changes in the flow regime also plays a role. The three river sections falling within an EC of E is mostly due to the same impacts as mentioned above, with increased intensity and extent.

Further downstream along the Orange in South Africa, most of the rivers are in a C/D and a D state. This is due to extensive utilisation, as well as the cumulative effects of impacts originating in Lesotho. The Bamboesbergspruit is in a D/E PES where there are extensive dams in the tributaries and significant erosion in places.

Along the Caledon River and its tributaries, EC's range from a C to an E. The majority of the quaternary catchments are in a D EC. The E PES river flowing from Botswana is due to agriculture to the river's edge and extensive erosion and sedimentation. The E section in the Caledon River is due to the riparian bank conditions and estimated riparian state, as well as sedimentation and flow modification. The Mopeli tributary flowing to the Caledon from South Africa, is in an E state due to the extensive number of dams in the tributary, as well as the presence of exotic vegetation.

The impacts in the Kraai Basin are associated with agriculture, abstraction and farm dams, as well as exotic vegetation. PES scores range from a C to C/D with one section (the lowest Kraai River quaternary catchment) in a D PES, but the majority of the quaternary catchments have a C PES.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The main Orange River falls in a D and D/E state. These impacts are all associated with the flow regulation and operation due to the presence of ESCOM's hydro-electric schemes. The tributaries range from an A to a C PES with the majority being in an A/B and B PES. The moderate to good states of the tributaries are related to the fact that most of these rivers are seasonal (ephemeral) and therefore there is limited development associated with the rivers.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

The Orange River is still mostly in a D PES due to the same reasons mentioned above, as well as the presence of irrigation schemes. There are two sections in a C state of which D72B is not as accessible as the rest of the Orange River and D72 F (downstream of Upington) which is very wide and anatomising. Levees in this section do therefore not have the same impact as in the single channel sections. The tributaries range also from an A to a C PES with the majority being in a B PES. Reasons are similar to those mentioned under BASIN 2.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

The main Orange River is in a C PES. This improvement is due to the fact that the river is inaccessible or protected in many sections and the increasing abstractions of flow upstream, has lessened the impact of the flow releases for hydro-power and agriculture.

All the tributaries from Namibia are in an A/B PES as there is no development apart from tracks and crossings. The absence of other activities is likely due to the extremely ephemeral nature of the system.

Basin 5: Molopo River

Two large quaternary catchments of the Molopo River around Mafikeng are in an E PES. The poor state is due to the abstraction of water from the Eye, the extensive abstraction for agriculture-irrigation practices, the inadequate sewage system in Mafikeng and the associated water quality problems. The Kuruman River downstream from the Eye is also in an E PES. This is due to the extensive abstraction of flow from the Eye, as well as the canalisation of the river.

The tributaries from Botswana are in a B state, as there is limited development due to their ephemeral nature.

In the South African portion there are three A/B PES quaternary catchments:

- The lower Kuruman (which is ephemeral and not developed);
- The Phephane River (which mostly flows through the Molopo Game Reserve and is referred to as a 'relic' river); and
- The Lowest Molopo quaternary catchment which flows through the Riemvasmaak protected area.

Other quaternary catchments in South Africa range from a B to a D PES. The lower evaluations are mostly due to extensive presence of dams, physical disturbance and the presence of *Prosopys sp* (an aggressive invader plant species).

Basin 6: Fish and Nossob catchments

The upper Nossob River is in a C PES due to the extensive presence of dams and abstraction in the area. The Nossob is in an E PES in the area upstream of where it flows into South Africa, due to the channel being completely overgrown by *Prosopys sp* and the impact of decreased flooding. Within the Kgalagadi in South Africa, both the Nossob and the Auob Rivers are in a B PES.

The main Fish River ranges from an A/B to a C PES. The C PES is due to the impacts of Hardap Dam, as well as the presence of *Prosopys sp*. The A/B PES is due to protection through National Parks or, as in the upper area, absence of development. Many of the tributaries are also in an A/B state which is due to the limited development association with its ephemeral state.

INTEGRATED ENVIRONMENTAL IMPORTANCE (IEI) RESULTS

The Integrated Environmental Importance results (Figure II) integrate the PES, EIS and SCI per quaternary catchment to derive an overall socio-ecological importance rating. These ratings are categorised as Very High, High, Moderate or Low.

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai

Most of the SCI in Lesotho are High which results in a High IEI. The IEI of the Senqu section in the east, downstream of D17L, is Very High as a result of a combination of a High SCI and a reasonably high PES. Apart from some High IEI ratings in the upper Kraai catchments, the rest of Basin 1 quaternaries are all classified as having a Low IEI. This is due to a combination of Low PES, EIS and SCI.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The main Orange River has a Low IEI and this is due to the Low PES. Most of the tributaries have a High PES, resulting in a High IEI despite the generally low EIS and SCI.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

Most of the main Orange River has a Moderate IEI. This is higher than the upstream Basin 2 because of higher PES scores resulting from lower impacts from hydro-electric releases. Very High IEI ratings in six quaternary catchments are due to important wetlands located there.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

There are 4 quaternaries (D82A, H, J, K) with a Very High IEI. These include sections of the min Orange River and are related to the High EIS and reasonably High PES. The only two Moderate areas are the Orange River (D81B and D) and this is due to the lower PES originating from the upstream agricultural impacts. The rest of the area is mostly of High IEI due to generally very High PES.

Basin 5: Molopo River

A similar situation was observed for Basin 5 where the ephemeral tributaries tend to have High PES and therefore High IEI. The two Very High IEI quaternary catchments are due to the presence of important wetlands (catchment D42D) and the good condition of the Molopo River and the presence of protected areas (catchment D42E). The Low IEI evaluations for the rest of the quaternary catchments are mainly due to a Low PES related to agricultural and domestic use activities, as well as the presence of alien vegetation such as *Prosopys sp*.

Basin 6: Fish and Nossob catchments

The Very High IEI evaluations in the Nossob and Auob (D42A) are due to the high PES and EIS associated with the protected status afforded by the Kgalagadi Transfrontier Park. Very High IEI areas are located in (1) the inaccessible, high PES upper Fish River catchment, and (2) the Fish River National Park in the lower catchment which is characterised by high EIS, SCI and moderate PES. The rest of the Basin 6 is of High IEI apart from the Auob (reach 898) and Nossob (reach 890) which is low due to the Low PES and EIS as a result of the excessive growth of *Prosopys sp*.

RESULTS: IDENTIFICATION OF PRIORITY HOTSPOTS

Basin 1: Orange Catchment to Gariep Dam

Most of the priority areas (hotspots) are within Lesotho and are associated with the Senqu/Orange portion of Lesotho (Figure III). This is due to the combination of a High IEI as well as the High Water Resource Use Index (WRUI). The WRUI is generally High due to the importance of the yield to Gauteng (transfers) and to the lower Gariep Dam.

There are also moderately high priority areas in the Caledon system, where WRUI is similarly important in terms yield to Knelpoort and Welbedacht Dams and to the suppliers from these dams.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The only hotspots here are associated with tributaries of the Orange River that flow into the Gariep Dam. Their relatively High WRUI is associated with the water quality amelioration that these tributaries provide to the dam and the Orange-Fish transfer.

The rest of the tributaries are mostly rated as a 3 due to the High IEI and the relatively High WRUI related to the local importance of this resource for agriculture.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

The hotspots in the tributaries of the Orange River are situated in the quaternary catchments that contribute to Van Wyksvlei Dam, and Rooiberg Dam. There are two hotspots in the Orange River with D72B due to the importance of Boegoeberg Dam and D73F due to the Kakamas and Keimoes irrigation schemes.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

The extensive developments and irrigations in sections alongside the main river in the lower reaches have resulted in a High WRUI. This, in combination with the high IEI, has resulted to the whole Orange River within this cluster being rated as a hotspot.

Basin 5: Molopo River

The two hotspots in the D41A quaternary catchment are associated with the High IEI and the high WRUI due to the role of water supply to Mafikeng.

Basin 6: Fish and Nossob catchments

Due to the water scarce nature of this area, the Fish River is a major resource and has resulted in most of the reaches upstream of Hardap Dam to be evaluated as hotspots. The situation is similar in the upper Nossob reaches, where the yield to the various dams is vital for Windhoek and other smaller towns.

RECOMMENDATIONS

The information produced in this report indicates water resource priority areas (hotspots) where there is high Environmental Importance and/or High Water Resource Use Importance (Figure III). When undertaking further water resource investigations in the Orange Basin, studies should focus on the hotposts to improve knowledge and management of these priority areas.

Most of the hotspots are located in Lesotho (Figure III). The current Environmental Flow Requirement (EFR) assessment associated with this study excludes Lesotho (Basin 1) and Basin 6. These basins are to be assessed in a separate study, and therefore hotspots in these basins are not considered further in this project.

The remaining hotspots (considering the Very High and High ratings, Figure III) fall along the Orange, Caledon, Kraai and the upper Molopo Rivers. The intermediate EFR assessment should thus focus on the rivers that contain large clusters of hotspots, and where possible, EFR sites for should be situated in the hotspots in order to provide increased confidence information for these priority areas of the catchment.

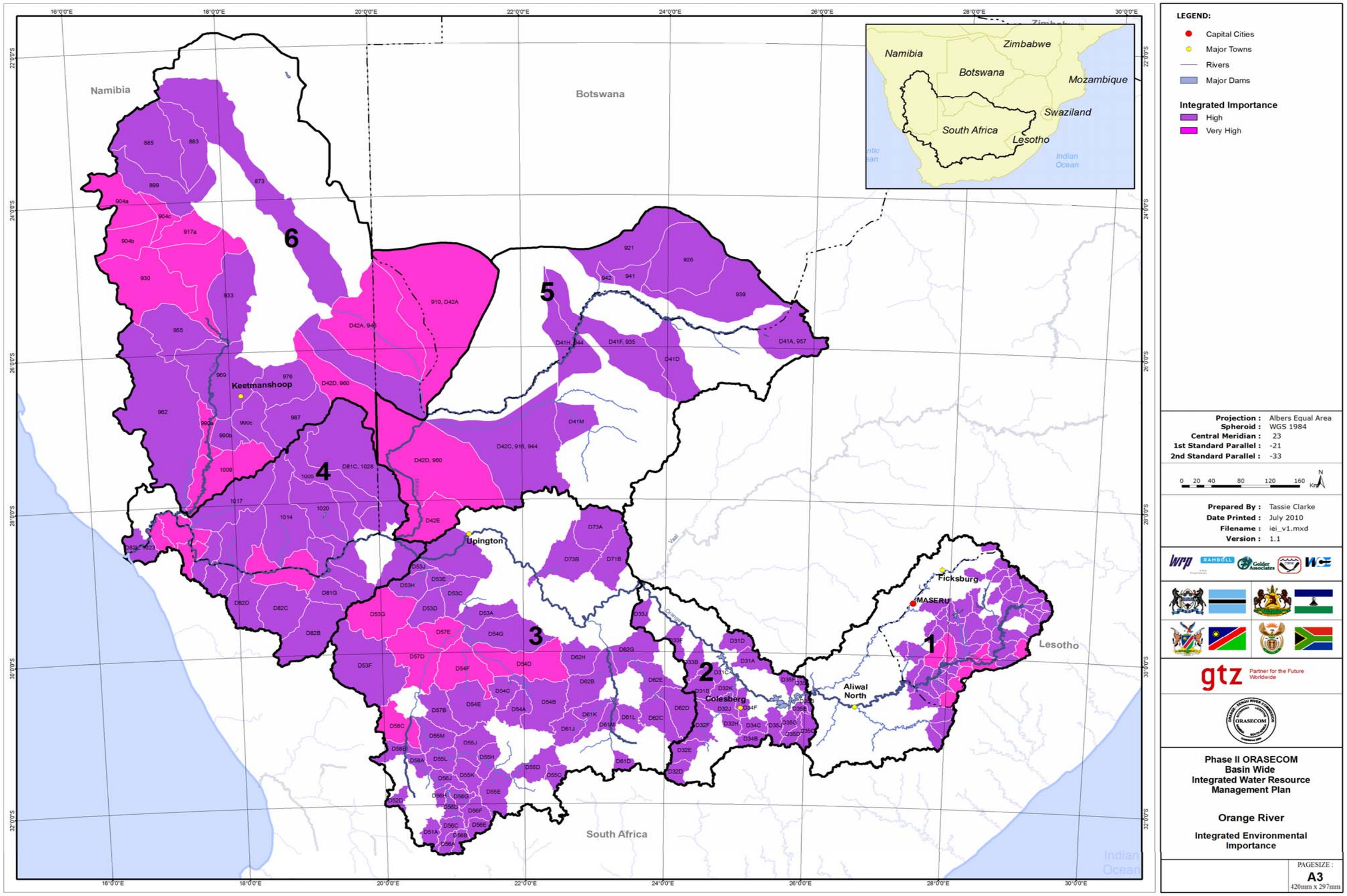

Figure II : Integrated Importance for the water resources of the Orange River Basin. The denoted six basins comprise the study area.

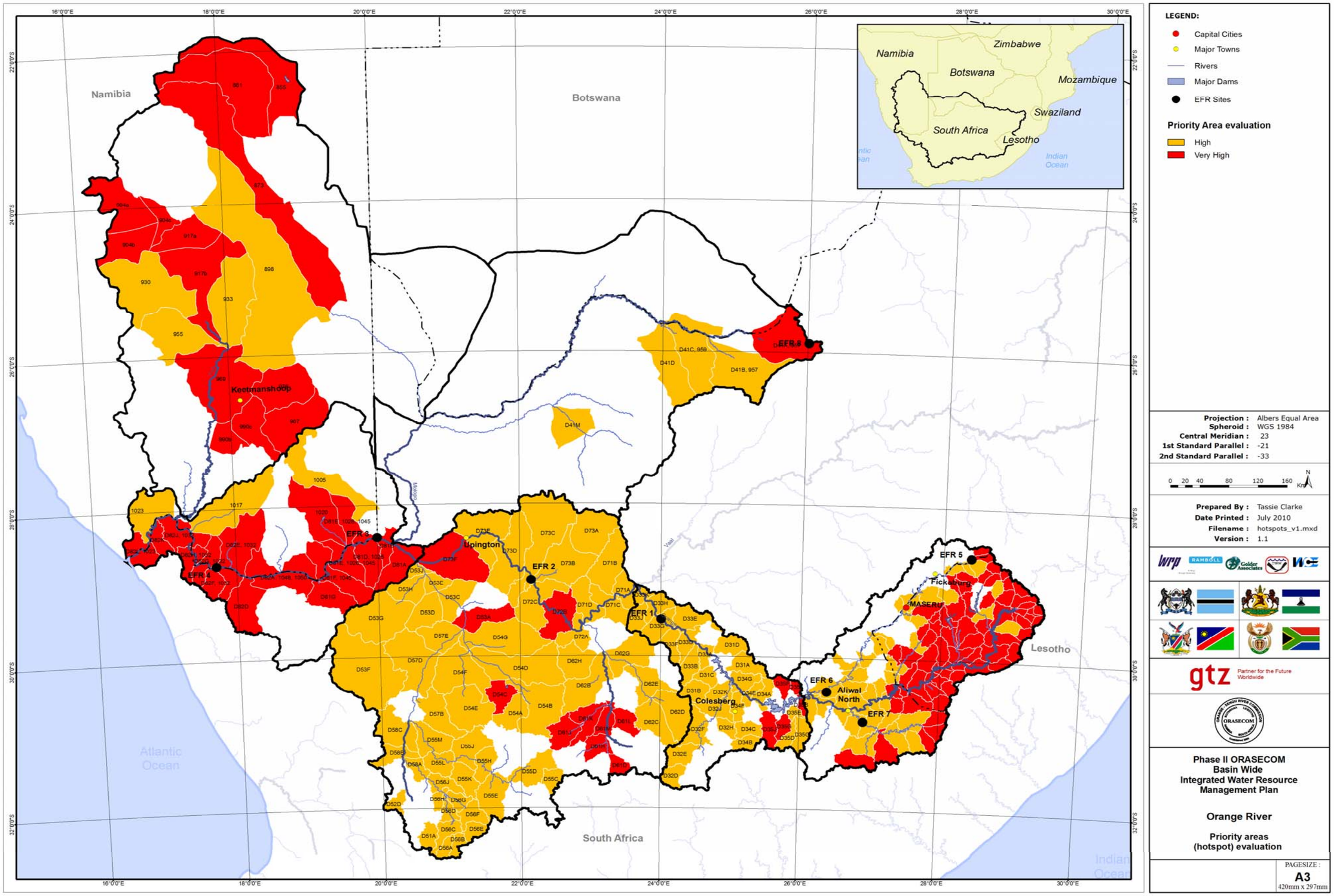

Figure III : High and Very High priority hotspots (based on environmental and water use importances) for the Orange Basin.

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ABBREVIATIONS AND ACRONYMS

AM	Aquatic Macrophytes
ASCL	*AUSTROGLANIS SCLATERI* (BOULENGER, 1901)
BAEN	*LABEOBARBUS AENEUS* (BURCHELL, 1822)
BBM	Building Block Methodology
CD: RDM	Chief Directorate: Resource Directed Measures
CMA	Catchment Management Agency
D:RQS	Directorate: Resource Quality Services
DRIFT	Downstream Response to Imposed Flow Transformation
DTM	Digital Terrain Model
DWA	South African Department of Water Affairs (formerly DWAF)
DWAF	South African Department of Water Affairs and Forestry
EC	Ecological Category
EcoSpecs	Ecological Specifications
EFR	Environmental Flow Requirements
EIS	Ecological Importance and Sensitivity
EPA	Environmental Protection Agency
EWR	Ecological Water Requirements
FD	Fast Deep
FRAI	Fish Response Assessment Index
FS	Fast shallow
GAI	Geomorphological Driver Assessment Index
GDP	Gross Domestic Product
geozone	Geomorphological zone
GIS	Geographic Information System
G & S	Goods & Services
GGP	Gross Geographic Product
ha	hectare
HAI	Hydrological Driver Assessment Index
HFSR	Habitat Flow Stressor Response
IEI	Integrated Environmental Importance
IFR	Instream Flow Requirements
IHI	Index of Habitat Integrity
LCAP	*LABEO CAPENSIS* (SMITH, 1841)
LB	Left bank
MAP	Mean Annual Precipitation
MIRAI	Macroinvertebrate Response Assessment Index
MRU	Management Resource Units
NGO	Non Governmental Organization
NRU	Natural Resource Units
NWA	National Water Act
NWRS	National Water Resource Strategy
OV	Overhanging Vegetation
ORASECOM	Orange-Senqu River Commission
PAI	Physico Chemical Driver Assessment Index
PES	Present Ecological State

BASIN	One of six basins comprising the Orange Catchment
PMT	Project Management Team
PSP	Professional Service Provider
QHI	Quick habitat integrity
quat	Quaternary catchment
RB	Right Bank
RAU	Reserve Assessment Units
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
RQS	Resource Quality Services
RSA	Republic South Africa
RU	Resource Unit
SANBI	South African National Biodiversity Institute
SCI	Socio Cultural Importance
SD	Slow Deep
SPATSIM	Spatial and Time Series Information Modelling
sp	species
SS	Slow Shallow
SUB	Substrate
ToR	Terms of Reference
TPC	Threshold of Potential Concern
UB	Undercut banks and root wads
VB	Valley Bottom (usually referring to a type of wetland)
VEGRAI	Riparian Vegetation Response Assessment Index
WC	Water Column
WHI	Wetland Habitat Index
WMA	Water Management Area
WRUI	Water resource use importance
WRYM	Water Resource Yield Model

GLOSSARY

EcoClassification	This is a procedure to determine and categorise the ecological state of various biological and physical attributes compared to the reference state. The procedure of EcoClassification describes the health of a water resource and derives and formulates management targets / objectives / specifications for the resource. This provides the context for monitoring the water resource within an adaptive environmental management framework. The classification ranges from A (natural) to F (highly impacted).
Ecoregions	"*Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources*", and are designed to serve as a spatial framework for the research, assessment, management and monitoring of ecosystems and ecosystem components (US EPA). Several levels or scales of EcoRegions can be delineated (eg: Level I low resolution/detail; Level III high resolution and detail). In South Africa, EcoRegions form the basis of the River Health monitoring assessments.
EcoStatus	The overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component Ecostatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).
Floodplain	Linear fluvial, net depositional valley bottom surfaces which have a meandering channel. The meandering channel flows within an unconfined depositional valley, and ox-bows or cut-off meanders - evidence of meandering – are usually visible at the 1:10 000 scale.
Interdune wetlands	Wetlands typically found in dunefields of coastal and semi-arid areas that are located in interdune depressions.
Pan	A wetland which occurs predominantly in depressions in crest positions in the landscape; which has a circular or oval shape.
Present Ecological State	The current ecological condition of the resource. This is assessed relative to the deviation from the Reference State.

Reference Condition	(*also Reference Condition*). The natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development.
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows.
Un-channelled valley bottom	A type of wetland that is located on a valley floor that is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas.
Washouts	*The depositional feature that forms where a river flows out on to a flat plane and the channe rapidly loses confinement and capacity.*
Wetland	*"land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).

1 INTRODUCTION

1.1 BACKGROUND

This work forms part of the following study: *Support to Phase II ORASECOM Basin Wide Integrated Water Resources Management Plan*. The main objective of the Work Package 5 is to assess Environmental Flow Requirements (EFRs) at selected key areas of the Orange River Basin at an Intermediate Level of assessment (DWA RSA criteria). An Intermediate level implies specific steps, of which the following are relevant for this study:

- **A scoping (Desktop) level assessment of ecological and socio-cultural condition and importance across the Basin (this report);**
- Delineation into Management Resource Units and selection of EFR sites;
- One biophysical survey to collect the relevant data at each EFR site;
- Two measurements at a low and a high flow to calibrate the hydraulic model;
- Assessment of the Present Ecological State and other scenarios in terms of ecological state;
- Assessment of flow requirements following a holistic approach, preferably those developed specifically for Southern African conditions for each ecological state;
- Assessment of the ecosystem services, also referred to as Goods and Services (G&S); and
- Monitoring aspects.

This report provides an overview of the ecological condition and importance and socio-cultural importance of water resources of the Orange River catchment. A Desktop (or Reconnaissance) EcoClassification process is followed to determine the Integrated Environmental Importance (IEI) in terms of three components, namely the Ecological Importance and Sensitivity (EIS), the Socio-Cultural Importance (SCI), and the Present Ecological State (PES) for the catchment. This information, together with the Water Resource Use Importance (WRUI), is then used to identify priority areas or hotspots that have high IEI and/or WRUI. These priority areas provide focal points for undertaking more detailed assessments of the catchment water resources, specifically by indicating regions of the catchment where Environmental Flow Requirement information is likely to be most important for maintaining ecological goods and service delivery.

1.2 APPROACH

The *Desktop EcoClassification* is applied for each main river in a quaternary catchment and in some cases tributaries are considered. In Namibia where quaternary catchments have not been delineated, river reaches (provided by Beuster, Clarke and Associates with modifications after ground-truthing in this study) were used.

The steps (illustrated in Figure 1.1) required for identifying important areas of the catchment ("hotspots") and areas for EFR sites are:

- PES, EIS and SCI Desktop EcoClassification:
- Using a Matrix to determine the Integrated Environmental Importance by integrating PES, EIS and SCI results;
- Identify priority or hotspot areas within the study area; and
- Provide recommendations for the required detail of assessment at the EFR sites.

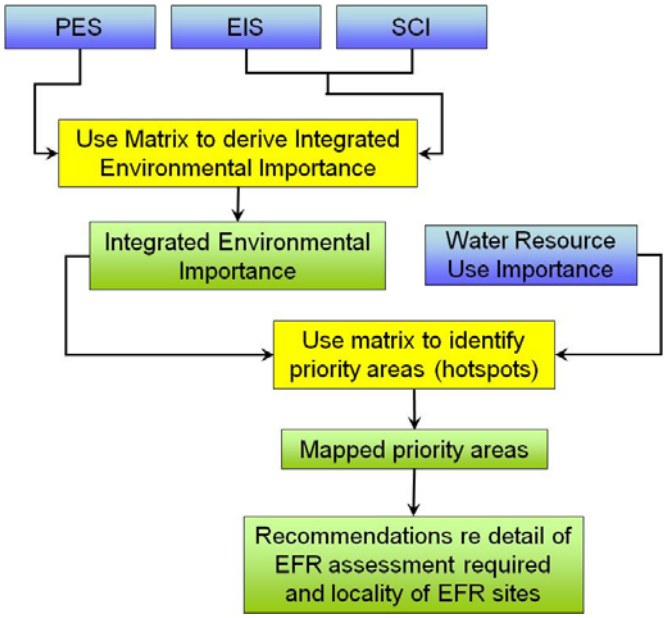

Figure 1.1: Process and use of tools to provide final outcome

The approaches, methods, models and tools used are detailed in Chapter 2 and 3.

1.3 PURPOSE OF THIS REPORT

This report provides the results of the Desktop EcoClassification (integrated PES, EIS and SCI) and Water Resource Use Importance assessments, and identifies important (hotspot) areas of the catchment where more detailed assessments are required. The report summarises the approaches used, with results provided at the quaternary (and sub-quaternary) catchment scale. Recommendations on the required level of detail of environmental flow requirement studies are provided.

1.4 REPORT OUTLAY

This report combines various aspects that relate to the Desktop EcoClassification. The chapters are summarised as follows:

- **Introduction (Chapter 1, this chapter)**

- **Methodology: EcoClassification process used to determine Integrated Environmental Importance (Chapter 2)**
  An overview is provided of the EcoClassification methods and the process used to determine Integrated Environmental Importance. The Present Ecological State (PES), Socio-Cultural Importance (SCI) and the Ecological Importance and Sensitivity (EIS) models are described.

- **Methodology: Determination of Integrated Environmental Importance and Water Resource Use Importance (Chapter 3)**

This chapter provides an overview of the process to derive Integrated Environmental Importance and Water Resource Use Importance.

- **Methodology: Determination of hotspots / priority areas (Chapter 4)**
  The process to identify priority areas of which the highest priority is called a *hotspot* is described.

- **Study area & sources used for Desktop EcoClassification (Chapter 5)**
  To simplify the assessment and presentation of results from such a large study area, the Orange River catchment was divided in to six basins, namely:

  - Basin 1: Orange Catchment to Gariep Dam (Upper Orange, Caledon and Kraai Rivers);
  - Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence;
  - Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence;
  - Basin 4: Orange Catchment from the Hartbees confluence to the estuary;
  - Basin 5: Molopo River; and
  - Basin 6: Fish and Nossob catchments.

  Assessments of the Ecological Importance and Sensitivity (EIS), Socio-Cultural Importance (SCI) and Present Ecological State (PES) were undertaken for each quaternary catchment area (in Lesotho and South Africa) or river reach (as delineated for Namibia).

- **Ecological Importance and Sensitivity Results (Chapter 6)**
  The EIS results are tabulated and presented graphically for each of the quaternary catchments within the study area.

- **Socio-Cultural Importance Results (Chapter 7)**
  The SCI are tabulated and presented graphically for each of the quaternary catchments within the study area.

- **Present Ecological State Results (Chapter 8)**
  The PES results are tabulated and presented graphically for each of the quaternary catchments within the study area.

- **Integrated Environmental Importance Results (Chapter 9)**
  The IEI are tabulated and presented graphically for each of the quaternary catchments within the study area.

- **Identification of Priority Areas and Hot Spots (Chapter 10)**
  The Water Resource Use Importance information is compared with the IEI results to derive priority areas. Priority areas with the *hotspots* as the highest rated priority are identified and presented graphically for each of the quaternary catchments within the study area.

2 METHODOLOGY: ECOCLASSIFICATION PROCESS USED TO DETERMINE INTEGRATED ENVIRONMENTAL IMPORTANCE

2.1 BACKGROUND

EcoClassification(Kleynhans *et al.,* 2007) is the term used for Ecological Classification. It refers to, amongst others, the determination and categorisation of the Present Ecological State (PES) – ecological health or integrity - of various biophysical attributes of rivers (e.g. fish, riparian vegetation, etc) as compared to the expected "natural" conditions of 100 to 150 years ago (this expected natural condition is also referred to as the reference condition). The purpose of undertaking EcoClassification is to gain insight into the reasons responsible for the current ecological condition of various biophysical attributes (i.e. the causes and sources resulting in the current PES being different from the expected natural conditions). Linking the PES the causes and sources of change (e.g. a certain level of reduced flows) allows for ecological responses to be predicted under alternative flow scenarios.

Part of the EcoClassification process involved assessing Ecological Importance and Sensitivity (EIS) and the Socio-Cultural Importance of water resources. These components allow for water resources that have very high importance to be identified and it is often recommended, based on the high importance, that such water resources are managed in or towards a better PES to allow for enhanced ecological goods and service provision.

2.2 ECOCLASSIFICATION APPROACH

The steps followed during the application of a detailed level of EcoClassification are as follows:

- Determine the reference conditions for each component;
- Determine the PES for each component, as well as for the EcoStatus;
- Determine the trend (in terms of improvement or deterioration) for each component, as well as for the EcoStatus. The EcoStatus represents an integrated status considering the status of each component;
- Determine causes and sources for the PES and whether these are flow or non-flow related;
- Determine the EIS for the biota and habitat;
- Determine the SCI;
- Considering the PES, the EIS and the SCI; suggest a realistic Recommended Ecological Category (REC) for each component, as well as for the EcoStatus; and
- Determine alternative Ecological Categories (ECs) for each component, as well as for the EcoStatus.

The flow diagram presented in Figure 2.1 (Kleynhans *et al*., 2007) illustrates the above mentioned process.

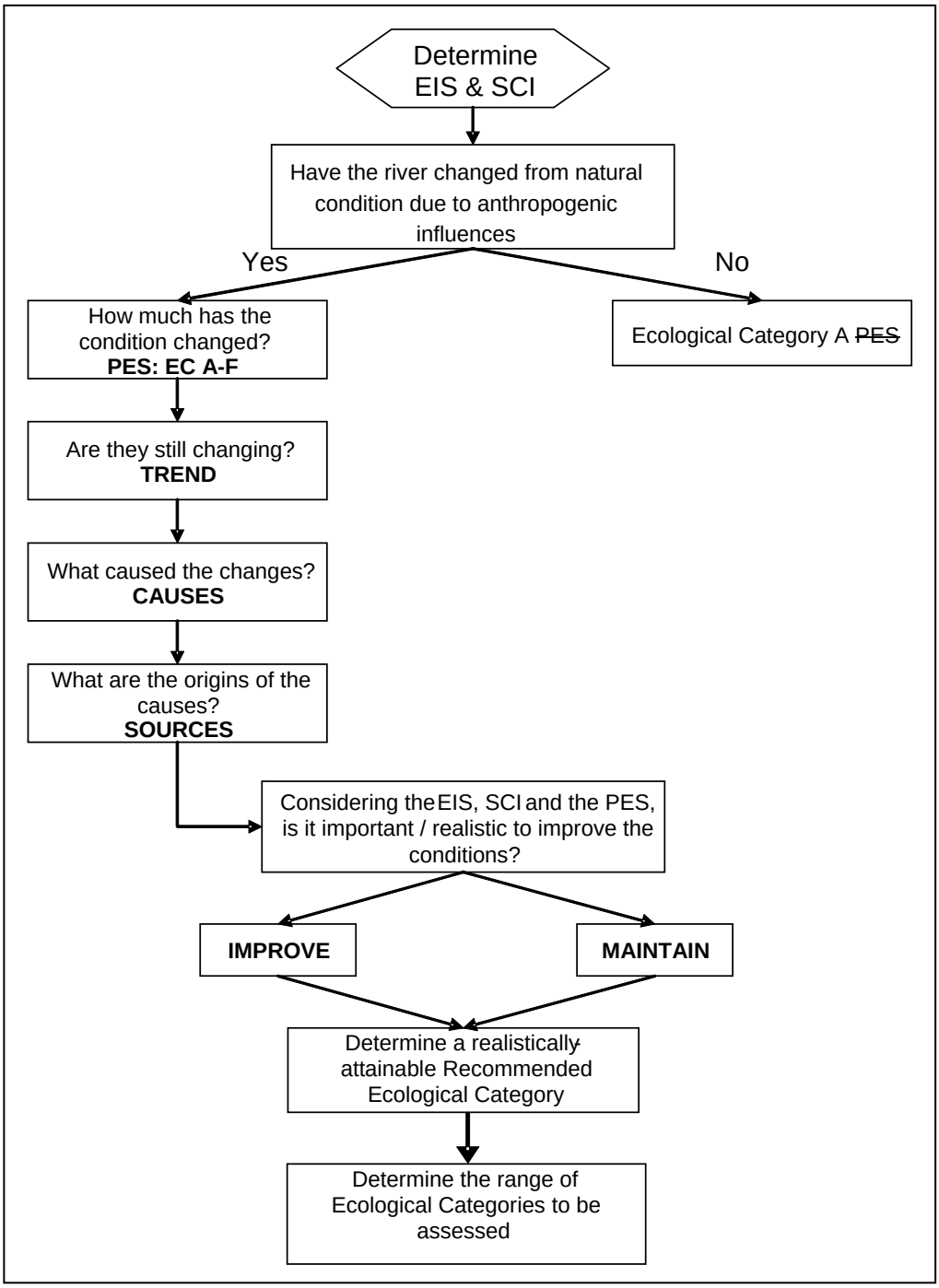

Figure 2.1: Flow diagram illustrating the information generated to determine the range of Ecological Categories for which EFRs will be determined.

The process as described in Figure 2.1 is the Level 4 EcoClassification which is used during detailed assessments(such as intermediate or comprehensive Environmental Flow Requirement determinations in South Africa), usually for specific river reaches called Management Resource Units. For a catchment-wide application, the appropriate level is the ***Desktop EcoClassification*** approach. The Desktop EcoClassification approach, as applied during this phase of the study, is as follows:

- Determining the Present Ecological State (PES) of the system, applying a Quick Habitat Integrity (QHI), as well as considering the biota's responses;

- Determining the Ecological Importance and Sensitivity (EIS): This assessment of the EIS uses indicators such as presence of rare and/or sensitive species and sensitive habitats to provide an evaluation; and
- Determining the Socio-Cultural Importance (SCI): This assessment of the importance of the river is undertaken in terms of sustainable utilisation of the ecological goods and services provided by the river, as well as assessing the cultural use and aesthetic values of the river.

Evaluations are provided on a quaternary (or identified reach) scale with the degree of confidence in the evaluations attached to each quaternary catchment. The above mentioned assessments are then used to determine the Integrated Environmental Importance of each quaternary catchment. More detail is provided below.

2.2.1 Present Ecological State (PES)

a) PES Model (Modified from Kleynhans et al, 2007)

The PES of a river is expressed in terms of various components, i.e. **drivers** (physico-chemical variables, geomorphology, hydrology) and **biological responses** (fish, riparian vegetation and aquatic invertebrates), as well as in terms of an integrated state, the **EcoStatus**. Different processes are followed for each component to assign a category from A→F (where A is natural, and F is critically modified) (Table 2-1). Ecological evaluation against the expected reference conditions, followed by integration of the categories of each component, provides a description of the Ecological Status or *EcoStatus* of a river. Thus, the EcoStatus can be defined as the totality of the features and characteristics of the river (instream and riparian zones) that influence its ability to support an appropriate natural flora and fauna (modified from: Iversen *et al*., 2000). This ability relates directly to the capacity of the system to provide a variety of goods and services.

Table 2-1 Ecological Categories (ECs) and descriptions

EC	DESCRIPTION OF EC
A	Unmodified, natural.
A/B	Boundary category between A and B.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
B/C	Boundary category between B and C.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
C/D	Boundary category between C and D.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
D/E	Boundary category between D and E.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
E/F	Boundary category between E and F.
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

It must be emphasised that the A→F scale represents a continuum, and that the boundaries between categories are notional, artificially-defined points along the continuum. Therefore there may be cases where there is uncertainty as to which category a particular entity belongs. This situation falls within the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes (Robertson *et al*., 2004). For practical purposes, these situations are referred to as boundary categories and are denoted as B/C, C/D etc. The B/C boundary category, for example, is indicated as the dark-blue to light-green area in **Figure 2.2**.

Figure 2.2 Illustration of the distribution of ecological categories on a continuum

b) Desktop PES assessment

A Desktop Level EcoStatus assessment (Figure 2.3), as applied during this phase of the project, was designed for use when assessments for planning purposes on large scale have to be undertaken. As the name indicates, this method is usually carried out at desktop level, and is therefore based on available information and expert judgement. Reconnaissance site visits are sometimes carried out in areas where very little information is available.

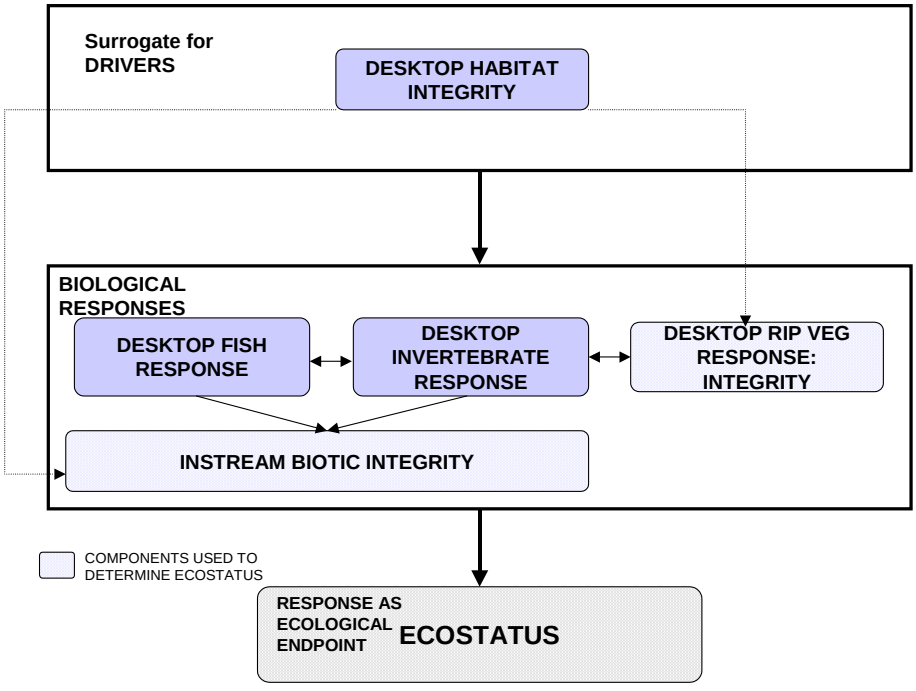

Figure 2.3 Desktop EcoStatus determination

This assessment therefore serves as a scoping phase to investigate the WMA at a desktop level and at the scale of quaternary catchments. This provides the basis for the planning of a detailed EFR study. This scoping assessment provides an overview of the WMA and a better understanding when focussing on the EFR sites and the sections of rivers where comprehensive

assessments will be undertaken. The output of the information also identifies areas of potential concern based on an Integrated Environmental Importance (combination of Ecological Importance and Sensitivity, Socio-Cultural Importance and Present Ecological State).

To accommodate the less-detailed process, the following deviations from the detailed EcoStatus level method were required (Note that the detailed level will be applied to river reaches in which the EFR sites are situated):

- A Quick Habitat Integrity assessment was developed. This approach allows for a coarse assessment and rates the habitat according to a scale of 0 (close to natural) to 5 (critically modified), according to the following metrics:
  - Bed modification;
  - Flow modification;
  - Introduced instream biota;
  - Inundation;
  - Riparian / bank condition; and
  - Water quality modification.
- This Quick Habitat Integrity approach serves as a substitute for the drivers, as well as playing a role in assessing the EcoStatus. This is necessary because the response information is of low confidence; and
- To accommodate the lack of fish and invertebrate response information, the Quick Habitat Integrity results are brought into the equation to calculate the Instream Ecological Category (EC). The instream EC is therefore a combination of the Desktop Habitat Integrity and the desktop fish, invertebrate and riparian vegetation ECs.

For information on the model and the calculations, refer to Kleynhans *et al* 2007, Module A.

c) PES confidence evaluation

Confidence is evaluated by considering the information available, the tools used and the expert knowledge available. The confidence is indicated in the database and summary tables. It must be noted that for a Desktop EcoClassification, confidence is expected to be low to moderate, except where relevant detailed information is available.

The Confidence levels(out of 5)were evaluated as follows and illustrated on maps using the colours below for shading of quaternary catchments:

0– 1: Very Low
1.1 – 2: Low
2.1 – 3: Moderate
3.1 – 4: High
4.1 – 5: Very High

d) Information utilised for the PES assessment

This study aimed to collate all information pertaining to the EcoClassification with specific emphasis on the PES, the EIS and the SCI. Information on the EcoClassification for the study area was sourced from:

- Previous Ecological Reserve assessments;
- Extensive fish surveys covering the whole study area;

- Invertebrate surveys;
- Desktop PES and EIS database for South Africa and quaternary catchments (Kleynhans, 2000);
- Reconnaissance site visits to some areas with a lack of available information. The catchments visited during this study were the Fish, Nossob and Molopo Rivers;
- Google Earth; and
- 1:50 000 topographical maps covering the region.

Databases of literature used (see chapter 4 for more detail) as well as the EcoStatus models are supplied in electronic format as Excel Spreadsheets. The EcoStatus spreadsheets are summarised in this document, using tables, graphs and maps.

2.2.2 Ecological Importance and Sensitivity (EIS)

a) EIS Model (developed by Kleynhans, DWAF 1999a)

The EIS model was developed by Dr CJ Kleynhans (DWAF, 1999a). The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh *et al*., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of Ecological Importance and Sensitivity (EIS).

This approach estimates and classifies the EIS of the streams in a catchment by considering a number of components surmised to be indicative of these characteristics. This procedure was originally developed for assessment of mainstream rivers in quaternary catchments (Schulze *et al.,* 1997). Although the delineation of quaternary catchments is not based on ecological principles, the EIS approach can be used for any river delineation.

The following ecological aspects were considered as the basis for the estimation of EIS (Kleynhans in DWAF, 1999a):

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity were taken into account for both the instream and riparian components of the river; and
- Habitat diversity was also considered. This included specific habitat types such as reaches with a high diversity of habitat types, i.e. riffles, rapids, waterfalls, riparian etc.

With reference to the points above, biodiversity in its general form (i.e., Noss, 1990) was taken into account as far as the available information allowed:

- The importance of a particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provided a migration route or corridor for species, was considered;
- The presence of conservation or relatively natural areas along the river section also served as an indication of Ecological Importance and Sensitivity; and
- The sensitivity (or fragility) of the system and its resilience (i.e. the ability to recover following disturbance) of the system to environmental changes was also considered. Consideration of both the biotic and abiotic components was included here.

This system is regarded as a guideline for the professional ecological judgement by individuals familiar with a particular area.

b) EIS evaluation

The assessors scored a number of biotic and habitat determinants considered to be important for the determination of EIS. The median of these scores was calculated to derive the EIS category (Table 2-2) for the river reach (the colour coding is constant for all the EIS evaluations).

Table 2-2 EIS categories (Modified from DWAF 1999)

EIS	General Description
VERY HIGH 2.1-4	Quaternaries/delineations that are considered to be unique on a national or even international level, based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.
HIGH 2.1-3	Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications, but in some cases, may have a substantial capacity for use.
MODERATE 1.1-2	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
LOW 0-1	Quaternaries/delineations that is not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

c) EIS confidence evaluation

The confidence levels (out of 4) were evaluated as follows and illustrated on maps using the colours below for shading of quaternary catchments. It is expected that for a desktop assessment, the confidence will be mostly low to moderate.

0 – 1: Low
1.1 – 2: Moderate
2.1 – 3: High
3.1 – 4: Very High

d) Information utilised for the EIS assessment

See chapter 4 for a detailed list.

2.2.3 Socio-Cultural Importance (SCI)

a) SCI model

The SCI was generated by scoring each quaternary catchment based on the following features:

Ritual Use: This was scored between 0 -5. The question that was asked was “How much ritual use of the river takes place?” Typically this would be for ceremonial purposes or for spiritual/religious activities. An example would be pools used for traditional initiation purposes. Both intensity and significance of use are valued and the higher of the two scores is adopted. Intensity relates to the

number of people likely to make use of the river for ritual use and significance relates to the degree to which the river is of critical importance to people.

Aesthetic Value: This was scored between 0 -5. The question that was asked was "How important is the aesthetic value to people? Does the river stretch add value to people's life as an object of natural beauty? Would changing flows detract from this value?" Both intensity and significance of appreciation are valued and the higher of the two scores is adopted. Intensity relates to the number of people likely to view the river and appreciate its aesthetic value and significance relates to the degree to which the river is of critical aesthetic importance to people.

Resource Dependence: This was scored between 0 -5. This refers to the goods and services delivered by the river system and peoples dependence on these components. This is usually a critical element of the SCI score and is designed to cater for river resource dependence by those who rely directly on such aspects for their survival. It should be noted that commercial or "for financial gain" usage of resources is excluded from consideration in this instance. Both intensity and significance of use are valued and the higher of the two scores is adopted. Intensity relates to the number of people likely to make use of the river for resource importance and significance relates to the degree to which the river is of critical importance to people. A sustainability modifier is allowed for.

Recreational Use: This was scored between 0 -5. The question that was asked was "Does the river stretch provide recreational facilities to people and would this be affected by changing flows?" Both intensity and significance of use are valued and the higher of the two scores is adopted. Intensity relates to the number of people likely to make use of the river for recreational purposes and significance relates to the degree to which the river is of critical importance to people.

Historical/Cultural Value: This was scored between 0 -5. The question that was asked was "Does the river have a strong cultural or historical value?" Examples would be Fugitives drift on the Buffalo River or components of the Mzimvubu River that have played a central role in Xhosa cultural history. Both intensity and significance of use are valued and the higher of the two scores is adopted. Intensity relates to the number of people likely to appreciate the river for its historical or cultural significance and significance relates to the degree to which the river is of critical importance to people

Scores were then modified to reflect the adjudged importance of each component relative to the other. In the model the following mechanism for arriving at the final score has been adopted.All five SCI categories are scored but the category scoring lowest is ignored. This ensures that an SCI score is not penalized for a category that is not relevant to the catchment or resource section under consideration. Among the four remaining categories the highest score is counted a second time. The double counted category is modified (in its second enumeration) which then reflects the importance of the most important category with that of the least important category. In the Mokolo model a modifier of 0.75 was used. This allows the adjudication process to make an assessment (even if subjective) of how critical the overall SCI of the resource is and weight the score.

By way of example.

- Where the SCI categories scored as follows (prior to modification); (a) Ritual Use = 2, Aesthetic = 2, Resource Dependence = 0, Recreational use = 3, Historical/Cultural Value = 4, Total = 11.
- After modification the score would be: (a) Ritual Use = 2, Aesthetic = 2, Resource Dependence = ignored, Recreational use = 3, Historical/Cultural Value = 4, Historical/Cultural Value recounted with factor of 0.75 = 3, Total = 14.

b) SCI evaluation

The final scores were then combined to generate an overall score between 0 and 5. The meaning of the score is as set out in Table 2.3 below.

Table 2-3 SCI rating

SCI score	Category	Comment
0-0.99	**VERY LOW**	Of little or no socio-cultural importance.
1-1.99	**LOW**	Of some importance. PES not critical, but caution should be displayed with regard to negative impact on dependent communities.
2-2.99	**MODERATE**	Of moderate importance. PES should not be allowed to be negative affected without strong motivation.
3-3.99	**HIGH**	Of high importance. A score in this range motivates for maintain or potentially positive change to PES.
4-5	**VERY HIGH**	Of extreme importance. A score in this range motivates for positive change to PES.

c) SCI confidence evaluation

The Confidence levels out of 5 were evaluated as follows and illustrated on maps using the colours below for shading of quaternary catchments:

0 – 1: Very Low
1.1 – 2: Low
2.1 – 3: Moderate
3.1 – 4: High
4.1 – 5: Very High

d) Information utilised for the SCI assessment

The Socio-Cultural Importance (SCI(SCI) was determined from (i) a set of site visits that covered points along the river, (ii) extrapolation to sites not visited by reference to available literature (particularly for the lower Senqu areas) as well as to existing mapping. Given the size of the budget and the geographical scope of the work most of the information used to influence the score was derived from direct observation and consideration of the literature available. A limited number of direct interviews were held with people who are resident proximate to the river.

The following additional sources were utilised.

- Google-earth Pro (2010). Aerial imagery of the earth. www.googleearth.com
- Acocks, J.P.H. (1988). Veld types of South Africa, 3rd edition. Memoirs of the Botanical Survey of South Africa No. 57.
- Lesotho Lowlands Joint Venture (LLWJV 2008). Instream Flow Requirement (IFR) Assessment for the Lesotho Lowlands Water Supply Scheme: EcoStatus Level III Assessment for the Makhaleng, Hlotse and Hololo Rivers, Lesotho. Jeffares Green.
- LHDA 2002: Contract 648: Establishment and Monitoring of the Instream Flow Requirements Downstream of LHEP Dams.

3 METHODOLOGY: DETERMINATION OF INTEGRATED ENVIRONMENAL IMPORTANCE AND WATER RESOURCE USE IMPORTANCE

3.1 INTEGRATED ENVIRONMENTAL IMPORTANCE

As described above, the Ecological and Socio-Cultural importance are assessed separately and are then integrated with the PES to determine the Integrated Environmental Importance. The PES forms part of the Integrated Environmental Importance as rivers in good condition are scarce, and therefore important in their own right. A river that is in very good condition, but of low EIS, and/or SCI; might still be important from an ecological perspective, as it could be one of a limited number of that type of river that is still in good condition. The Integrated Environmental Importance also provides an indication of the restoration potential. The restoration potential refers to the probability of achieving the rehabilitation of the river to an improved state. For example, if a river has very high Ecological and Socio-Cultural importance, but is in bad condition, the restoration potential is often low and that will result in a low Integrated Environmental Importance.

The EIS and SCI ratings are not averaged, but the highest score of the two are used to integrate it with the PES. A matrix (Figure 3.1) to aid in consistently providing an integrated rating comparing EIS, SCI, and PES was designed during 2006 (Louw and Huggins 2007). The matrix (note, the curves have not been fitted, but have been 'hand drawn'), is used to derive an Integrated Environmental Importance value (1: low importance to 4: high importance).As previously stated, the highest score between EIS and SCI is used to when comparing importance to PES. As an example, an EIS of moderate and a PES of a B/C would score an Integrated Environmental Importance of a 2 or a 3. Confidence and the exact importance score must be considered when making the decision on the 2 (moderate) or 3 (high) importance.

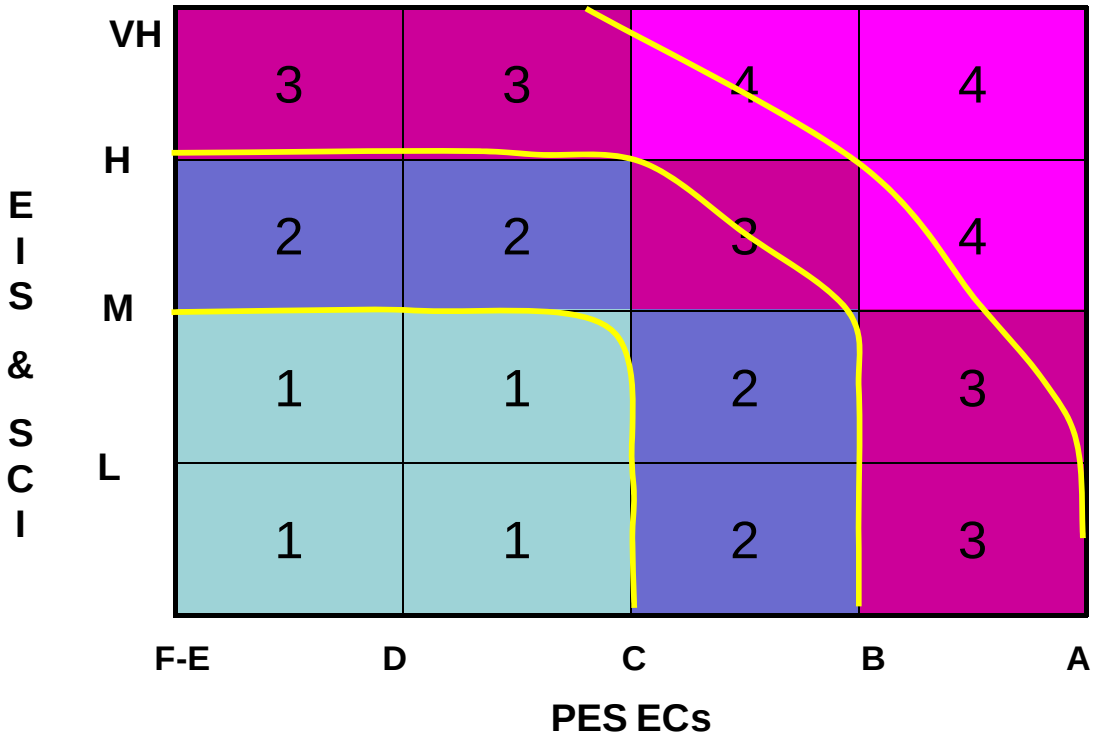

Figure 3.1 Matrix used to determine a combined EIS/SCI and PES value which provides an Integrated Environmental Importance value on a scale of 0 – 4

The Integrated Environmental Importance Ratings are derived from Figure 3.1 and translated as in to importance categories (Table 3.1).

Table 3-1 Integrated Environmental Importance value, description and colour coding

Integrated Environmental Importance Value	Description
1	Low importance
2	Moderate importance
3	High importance
4	Very high importance

3.2 WATER RESOURCE USE IMPORTANCE

The Water Resource Use Importance (WRUI) (DWAF 2007) is assessed by assigning a qualitative score to a river reach for four variables that represent the status of the in-stream flow. The scores of the four variables are combined to determine (qualitatively) an overall score which represents the importance of the river reach in terms of the water resource use. Most often, the maximum value is used to represent the final score. Severity and extent of the variables must be considered to determine whether the maximum is the appropriate rating for the quaternary catchment.

The variables included in the rating method aim to represent the status and function of the river reach. The variables and the associated characteristics associated with a score ranging from zero to four are presented in Table 3.2.

Table 3-2 Water Resource Use Priority rating variables and scoring characteristics

Variables	Score range and associated characteristic descriptions	
	0	4
Current water balance of catchment contributing flow to the river reach.	Very little water use occurs in the upstream catchment. Low, maintenance and high flow is largely natural.	Significant utilisation of water from the upstream catchment. Low and maintenance flows have been reduced and/or there exists significant regulating storage in the catchment.
Utilisation of the river reach for operational purposes.	Minimum changes in the river flow due to operational purposes.	The river reach is utilised as a conveyance conduit.
Possible future developments and/or water use expected in the catchment.	No known development planned in the catchment that could change the flow in the river reach.	It is expected that future developments which could change the flow in the river could occur.
Water quality related problems, assimilative capacity.	The water quality in the river reach is excellent and large assimilative capacity is present.	The river contains very high loads of pollutants.
Overall score.	There is no reason to determine the EFR in the river reach from a water resource management perspective.	A comprehensive EFR determination is necessary from a water use point of view.

These ratings are supplied in tables in this document and colour coded in the same manner as for Integrated Environmental Importance.

4 DETERMINATION OF PRIORITY/HOTSPOT AREAS

The final output of this study it to determine the locality of hotspots (priority areas with overall importance) by comparing (or overlaying) Integrated Environmental Importance with Water Resource Use Importance. A biodiversity/ecological hotspot is a biogeographic region which is a significant reservoir of biodiversity which is threatened with destruction (http://en.wikipedia.org/wiki/Biodiversity_hotspot). In the context used here, the hotspot represents a river reach with a high Integrated Environmental Importance which could be under threat due to its importance for water resource use.

The hotspots are an indication of areas where detailed investigations would be required if development was being considered. These hotspots usually represent areas which are already stressed or will be stressed in future. This assessment can therefore guide decision-making with regard to which areas are in need of detailed EFR and other environmental studies(modified from Louw & Huggins 2007). It also guides the identification of the reaches in which EFR sites should be situated for the detailed EFR assessments.

A matrix was designed (modified from Louw & Huggins, 2007) to guide the consistent identification of hotspots (Figure 4.1). The X-axis is based on the Integrated Environmental Importance value derived from the first matrix (Figure 3.1). The Y-axis depicts an estimate of water resource use (cf 3.2), with 0 being of no importance and 4 being of very high importance. The information derived from the matrix provides an indication of the level of studies required. Although the terminology used is the same as that used for the different levels of EFR studies in South Africa, it is a descriptive term which is relevant for any environmental assessment required.

As an example – an Integrated Environmental Importance of 2.5 and water resource use importance value of 3.5 would require a comprehensive EFR assessment and this specific quaternary catchment would represent a hotspot.

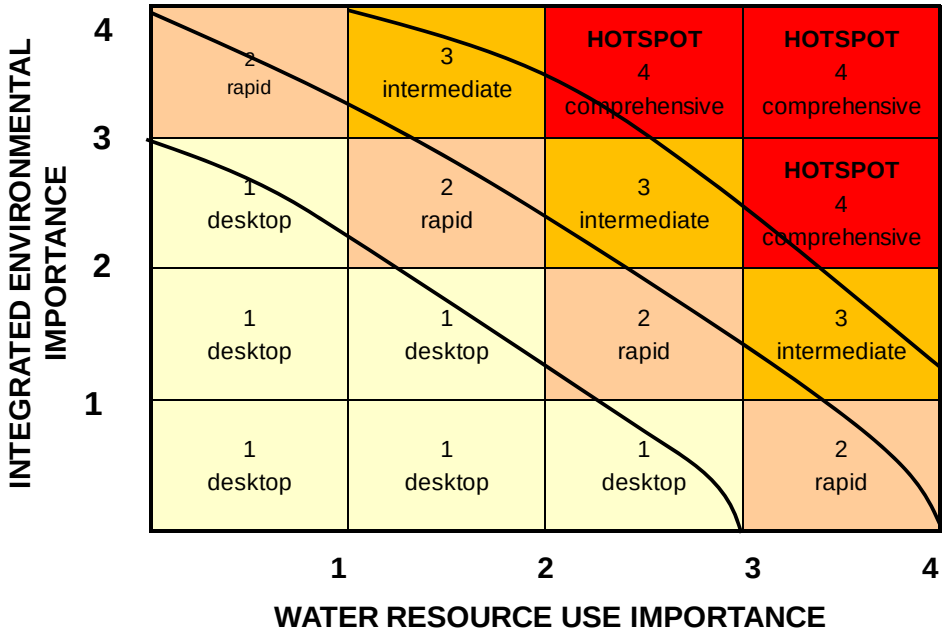

Figure 4.1 Matrix indicating the level of EFR assessments or priority areas for more detail investigations

The hotspot ratings are derived from Figure 4.1 and are ranked according to the ratings indicated in Table 4.1.

Table 4-1 Priority areas for detail areas, description and colour coding

Hotspot rating	Description
1	Desktop assessments required.
2	Rapid assessments required.
3	Intermediate assessments required.
4	Identified hotspot. Comprehensive assessments required.

5 STUDY AREA& SOURCES USED FOR DESKTOP ECOCLASSIFICATION

The study area consists of the Orange River Basin but excludes the Vaal River System where a comprehensive Reserve Determination (including this catchment scale assessment) has already been undertaken (DWAF, 2008).

For mapping purposes, the study area was grouped into various clusters as follows (Fig 5.1):

- BASIN 1: Orange River catchment upstream of Gariep Dam wall. This includes the D1 and D2 catchments. BASIN 1 were further subdivided into smaller areas for modelling purposes and presentation of graphs:
  - Sub-basin 1_LesothoOrange (D11, D15, D16, D17, D18)
  - Sub-basin 1_Orange (D12, D14)
  - Sub-basin 1_Caledon (D2)
  - Sub-basin 1_Kraai (D13)
- BASIN 2: Orange River catchment from Gariep Dam to the Vaal River confluence. This includes the D3 catchments.
- BASIN 3: Orange River from the Vaal River confluence to the Hartbees River confluence. This includes the D5, D6 and D7 catchments.
- BASIN 4: Orange River DS from the Hartbees River confluence to the estuary. This includes the D8 catchments in South Africa and the Namibian tributaries excluding the Fish River which is included in BASIN 6.
- BASIN 5: Molopo Catchment excluding the Nossob River. This includes the D4 catchments in South Africa and the Botswana tributaries.
- BASIN 6: Fish and Nossob Rivers. This includes D42A as well as the Namibian reaches.

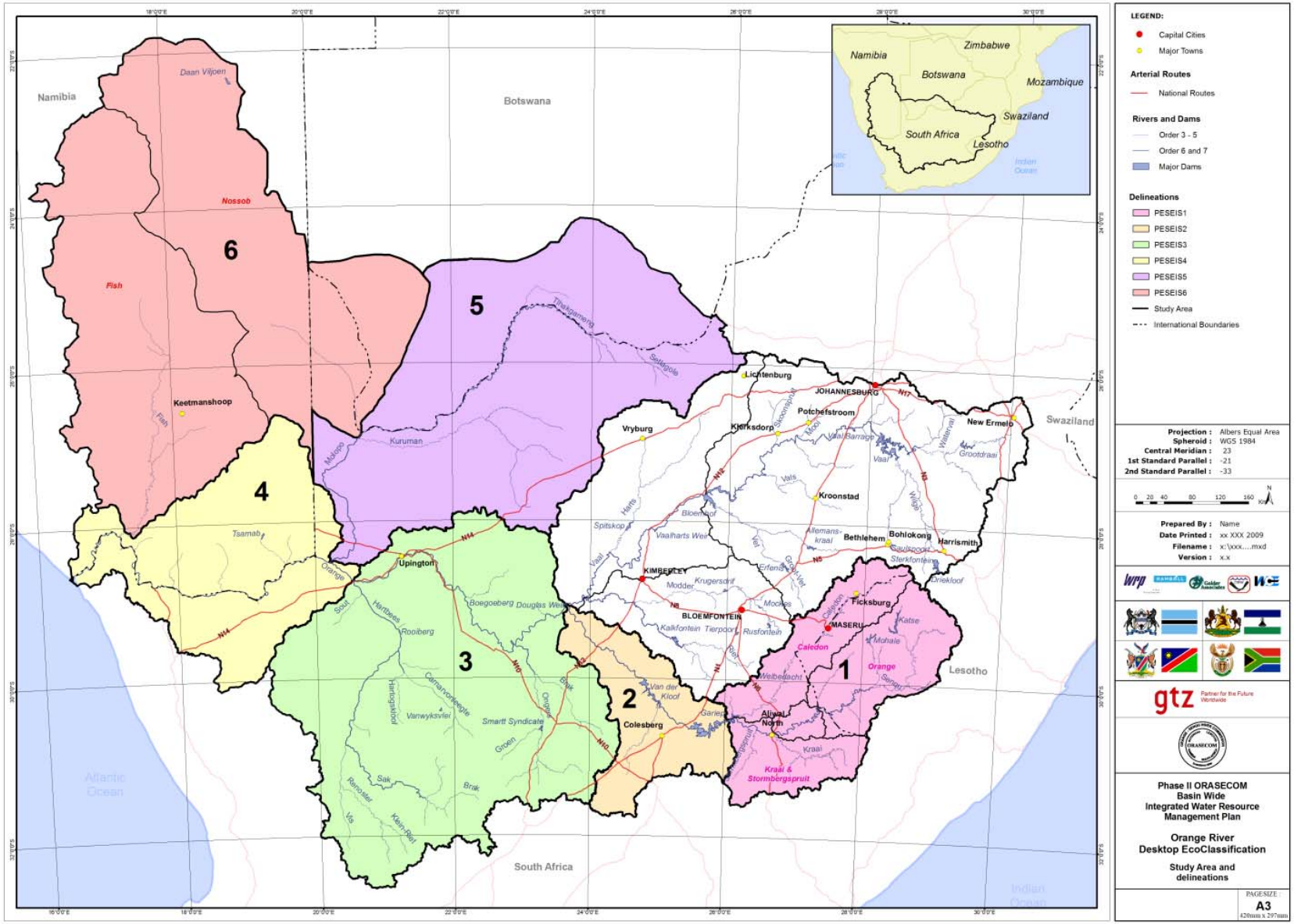

Figure 5.1 Delineation of the study area clusters used for mapping and assessment purposes

The sources used to populate the desktop model are tabulated below:

Study Area	Source
BASIN 1	Acocks, J.P.H. (1988). Veld types of South Africa, 3rd edn. Memoirs of the Botanical Survey of South Africa No. 57. B NIEHAUS, PJ KOTZE 2003 Rapid Reserve determination of the Little Caledon River (D21D, D21E), Caledon River (D21H, D22H), Grootspruit (D21G), Leeuspruit (D23D): Macroinvertebrate Assessment Bethune S., Griffin M. and Joubert D. (2004). NATIONAL REVIEW OF INVASIVE ALIEN SPECIES NAMIBIA. MINISTRY OF ENVIRONMENT AND TOURISM DIRECTORATE OF ENVIRONMENTAL AFFAIRS, WINDHOEK. Bezuidenhout, H. (1996). The major vegetation communities of the Augrabies Falls National Park, Northern Cape. 1. The southern section. Koedoe 39 (2): 7-24. Bezuidenhout, H. and Jardine, C.L. (2001). A reconnaissance botanical survey of the Lower Orange River (Blouputs to Onseepkans) in the Northern Cape, South Africa. Koedoe 44 (1): 1-8. BRANCH, B. 1988. Field guide to the snakes and other reptiles of Southern Africa. Struik Publishers, Cape Town. 328 pp. De Villiers P & Seaman MT (1998?) A general assessment of the in-stream requirements of the fish species in the Upper Orange River. In: DWAF, BKS & Ninham Shand. Orange River Development Projects Replanning Study, Starter Document. Du Preez, L. & Carruthers, V. 2009. A complete guide to the frogs of Southern Africa. Struik Nature, Cape Town. DWAF (1996) .Orange River Development Project Replanning Study: Environmental overview of the Orange River. Compiled by BKS & Ninham Shand. Friedman, Y., Daly, B. 2004. Red Data Book of the Mammals of South Africa. A conservation assessment: CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust. South Africa. Gerber, A., Cilliers, C.J., van Ginkel, C. and Glen, R. (2004). Easy Identification of Aquatic Plants RQS, DWAF, Pretoria. Gibbons, G., Maclean, G. 1997. Roberts' Multimedia: Birds of Southern Africa. Southern African Birding cc. GOLDER ASSOCIATES 2009 Summary of the Orange River water quality status Google-earth Pro (2010). Aerial imagery of the earth. www.googleearth.com Hamman KCD (1980) Post-impoundment trends in the fish populations of the Hendrik Verwoerd Dam, South Africa. *J. Limnol. Soc. sth.* Afr. 6: 101-108. HARRISON, J. A., ALLAN, D. G., UNDERHILL, L. G., HERREMANS, M., TREE, A. J., PARKER, V., BROWN, C. J. 1997a. The atlas of southern African birds. Volume 1: Non-passerines. Birdlife South Africa, Johannesburg. 785 pp. HARRISON, J. A., ALLAN, D. G., UNDERHILL, L. G., HERREMANS, M., TREE, A. J., PARKER, V., BROWN, C. J. 1997b. The atlas of southern African birds. Volume 2: Passerines. Birdlife South Africa, Johannesburg. 732 pp. Henderson, L. (2001). Alien Weeds and Invasive Plants. Plant Protection Research Institute Handbook No. 12. Henderson, L. and Cilliers C.J. (2002). Invasive Aquatic Plants Plant Protection Research Institute Handbook No. 16. IUCN, 2010. IUCN Red List of Threatened Species. Website: www.iucn.org/redlist Jubb (1967) Freshwater Fishes of Southern Africa. Balkema, Cape Town. 248pp. Kleynhans CF & Louw D (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission. **Lesotho Lowlands Joint Venture (LLWJV 2008).** Instream Flow Requirement (IFR) Assessment for the Lesotho Lowlands Water Supply Scheme: EcoStatus Level III Assessment for the Makhaleng, Hlotse and Hololo Rivers, Lesotho. Jeffares Green. Low, A.B. and Rebelo, A.G. (eds). (1996). Vegetation of South Africa, Lesotho and Swaziland. Department Environmental Affairs & Tourism. Pretoria. Low, A.B., Rebelo, G. 1996. Vegetation of South Africa, Lesotho and Swaziland. Dept of Environmental Affairs & Tourism, Pretoria. 85 pp. MDTP 2007. A review of the status and threats of priority species of Herpetofauna of the Lesotho Highlands. Report for Biodiversity assessment and development of a monitoring

	programme. Prepared by N Jacobsen for MDEC cc. MDTP 2007. Biodiversity assessment and development of a monitoring programme: rivers and aquatic invertebrates. Report prepared by Nepid cc. for MDEC. MDTP 2007. Fish species in the Lesotho Highlands. Report for Biodiversity assessment and development of a monitoring programme. Prepared by EcoSun for MDEC cc. MDTP 2007. Spatial assessment of biodiversity priorities in the Lesotho Highlands - technical report. Report for Biodiversity assessment and development of a monitoring programme. Prepared by MDEC cc: J Hughes, G Benn and M Laros Minter, L.R., M. Burger, J. A. Harrison, H.H. Braack, P.J. Bishop, and D. Kloepfer, eds. 2004. Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland. SI/MAB Series #9. Smithsonian Institution, Washington, DC. Mucina, L. and Rutherford, M.C. (eds) (2006). The Vegetation of South Africa, Lesotho and Swaziland. Strelizia 19. South African National Biodiversity Institute, Pretoria. N SLABBERT 2007 The potential impact of an interBasin water transfer on the Modder and Caledon River systems Ph D thesis National Environmental Management: Biodiversity Act (No. 10 of 2004) (NEMBA). 2004. Species Listing Schedule A and B. Palgrave, K.C. (1988). Trees of Southern Africa Struik. Cape Town. Palmer R. W. (1995) Environmental overview of the Orange River downstream of the Lesotho Border. Unpublished Report (Avridev). PASSMORE, N. I. & CARRUTHERS, V. C. South African frogs. Witwatersrand University Press, Johannesburg. 270 pp. PJ KOTZE, B NIEHAUS 2003 Rapid Reserve determination of the Little Caledon River (D21D, D21E), Caledon River (D21H, D22H), Grootspruit (D21G), Leeuspruit (D23D): Fish Assessment, Habitat Integrity + Ecological Importance and Sensitivity (EISC) Rutherford, M.C. (1997). Categorization of biomes. In: (eds. Cowling, R.M., Richardson, D.M. and Pierce, S.M.). Vegetation of Southern Africa. Cambridge University Press, Cambridge. Scott, L.E.P., Skelton, P.H., Booth, A.J., Verheust, L., Harris, R. and Dooley, J. (2006) Atlas of Southern African Freshwater Fishes. Smithiana Publication, Monograph 2. The South African Institute for Aquatic Biodiversity, Grahamstown, South Africa. Skelton, P.H. (1986) Fish of the Orange Vaal System. In Davies B.R. and Walker K.F. (eds), The ecology of river systems, Dr W Junk Publishers, Dordrecht. 143 161 pp. Skelton, P.H. (2001). A complete guide to freshwater fishes of Southern Africa. Struik Publishers (Pty) Ltd., Cape Town, South Africa. 395pp. SKINNER, J. D., SMITHERS, H. N. 1990. The mammals of the southern African sub region. University of Pretoria. 771 pp. SMITHERS, R. H. N. 1986. Land mammals of southern Africa. Printpak Books, Cape Town. 229 pp. T COLEMAN + A VAN NIEKERK 2007 Orange River Integrated Water Resources Management Plan: Water quality in the Orange River. ORASECOM report 007/2007 Van Oudtshoorn, F. (1992). Guide to Grasses of South Africa. Briza Publications. Pretoria. Van Wyk, B. and van Wyk, P. (1997). Field Guide to Trees of Southern Africa. Struik. Cape Town. Wolhuter L.E. & Impson D. (2007) The state of the Yellowfishes in South Africa, 2007. WRC Report no. TT 302/07, Pretoria, South Africa.
BASIN 2	Allanson, BR and Jackson, PBN. (1983) Limnology and fisheries potential of Lake le Roux. South African Scientific Programmes Report No 77, FRD, Pretoria. 182 pp. De Villiers P & Seaman MT (1998?) A general assessment of the in-stream requirements of the fish species in the Upper Orange River. In: DWAF, BKS & Ninham Shand. Orange River Development Projects Replanning Study, Starter Document. Department of Water Affairs and Forestry (DWAF) (1996) Refinement of the instream flow requirements for the Orange River. DWAF Report No. PD000/00/6197. DWAF (1990) Orange River Ecology: Assessment of environmental water requirement of the Orange River between PK le Roux Dam and the mouth. Orange River Environmental Task Group & BKS. DWAF (1996) .Orange River Development Project Replanning Study: Environmental overview of the Orange River. Compiled by BKS & Ninham Shand. GOLDER ASSOCIATES 2009 Summary of the Orange River water quality status Google-earth Pro (2010). Aerial imagery of the earth. www.googleearth.com Hamman KCD (1980) Post-impoundment trends in the fish populations of the Hendrik Verwoerd Dam, South Africa. *J. Limnol. Soc. sth.* Afr. 6: 101-108.

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BASIN 3	Benade C (1993) Management Proposals for the Regulated Orange River System within the Borders of the Cape Province. Internal report. Cape Nature Conservation, Kimberley. 32 COLEMAN T + VAN NIEKERK A 2007 Orange River Integrated Water Resources Management Plan: Water quality in the Orange River. ORASECOM report 007/2007 Department of Water Affairs and Forestry (DWAF) (1996) Refinement of the instream flow requirements for the Orange River. DWAF Report No. PD000/00/6197. DWAF (1990) Orange River Ecology: Assessment of environmental water requirement of the Orange River between PK le Roux Dam and the mouth. Orange River Environmental Task Group & BKS. DWAF (1996).Orange River Development Project Replanning Study: Environmental overview of the Orange River. Compiled by BKS & Ninham Shand. GOLDER ASSOCIATES 2009 Summary of the Orange River water quality status Google-earth Pro (2010). Aerial imagery of the earth. www.googleearth.com Hamman (1993?) Conservation status of the fish species of the middle and lower Orange River. In: ORETG. Oranjerivier Ekologiese studies, vergadering by Oranjemund. Jubb (1967) Freshwater Fishes of Southern Africa. Balkema, Cape Town. 248pp. Kleynhans CF & Louw D (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission. Palmer R. W. (1995) Environmental overview of the Orange River downstream of the Lesotho Border. Unpublished Report (Avridev). Scott, L.E.P., Skelton, P.H., Booth, A.J., Verheust, L., Harris, R. and Dooley, J. (2006) Atlas of Southern African Freshwater Fishes. Smithiana Publication, Monograph 2. The South African Institute for Aquatic Biodiversity, Grahamstown, South Africa. Skelton, P.H. (1986) Fish of the Orange Vaal System. In Davies B.R. and Walker K.F. (eds), The ecology of river systems, Dr W Junk Publishers, Dordrecht. 143 161 pp. Skelton, P.H. (2001). A complete guide to freshwater fishes of Southern Africa. Struik Publishers (Pty) Ltd., Cape Town, South Africa. 395pp. Skelton, P.H. and Cambray, J.A. (1981) The freshwater fishes of the middle and lower Orange River. Koedoe 24: 51-66. Wolhuter L.E. & Impson D. (2007) The state of the Yellowfishes in South Africa, 2007. WRC Report no. TT 302/07, Pretoria, South Africa.
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6 ECOLOGICAL IMPORTANCE AND SENSITIVITY RESULTS

Note: Quaternary catchments were dam backup inundated more than 80% of the catchment (i.e. the catchment is no longer representative of a river) were not assessed in this study.

6.1 ELECTRONIC DATABASE

The electronic database is provided and explained below. There are 3 sheets relevant for EIS namely:

- EIS_Old: This contains the 1999 information as background and for reference during assessment.
    - EIS_INPUT: This contains the ratings for the EIS metrices.
    - EIS_RESULT: This sheet uses the results inputted in the EIS_INPUT sheet to calculate the EIS score and an average confidence evaluation.

The EIS information is on the Excel Sheet: EIS_input. The columns are explained below:

- Column A: Quaternary catchments: Quaternary catchments
- Column B: Main river in the quaternary catchment with comments of specific reach where relevant.
- Column C: Tributaries other than main rivers, if specifically addressed.
- Column D – AL: EIS metrics. Importance rating (zero (no importance) to 4 (Very High importance) for each EIS metric) alternated with confidence ratings with 1 (low confidence) to 4 (very high confidence for each EIS metrics). Comments provided in comment blocks.
- Column AM: Provides the sources of the information
- Column AN: Comment block for any generalised comments.

The results are calculated on the EIS_RESULT sheet. The relevant columns are columns Q and R where column Q provides the median EIS score and column R translates this into a descriptive value as follows:

- Low (0 -.99)
- Moderate 1 – 1.99)
- High (2 – 2.99)
- Very High (3 – 4)

6.2 ORANGE CATCHMENT EIS UPSTREAM OF GARIEP DAM (BASIN 1)

This basin has been divided in to four smaller units for the purposes of tabulated and graphical information. The graphs and tables display results for the four sub-basins as follows:

- Basin 1_LesothoOrange: The Orange River within Lesotho (Table 6.1; Figure 6.1);
- Basin 1_Orange: The Orange River outside Lesotho (Table 6.2; Figure 6.2);
- Basin 1_Caledon: The Caledon River catchment (Table 6.3; Figure 6.3);
- Basin 1_Kraai: The Kraai and Stormbergspruit catchments (Table 6.4; Figure 6.4);

The map showing the results of the EIS assessment (Figure 6.10) displays the results for the whole of BASIN 1.

6.2.1 Orange River EIS within Lesotho (BASIN 1_LesothoOrange)

Table 6-1 Summarised EIS results per quaternary catchment (BASIN 1_LesOrange)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D11A	Tholatzi	HIGH	2.1
D11B	Malibamatso	LOW	1.6
D11C	Motete	LOW	1.6
D11F	Bokong (Section not inundated by Katse)	MODERATE	1.8
D11G	Matsoku	LOW	1.8
D11H	Matsoku (includes the portion in D11J to the Orange confluence)	LOW	1.8
D11J	Malibamatso	MODERATE	2.8
D11K	Malibamatso	HIGH	2.8
D15A	Makhaleng (source to Likolobeng)	LOW	3.9
D15A	Makhaleng (DS of Likolobeng confl)	LOW	3.7
D15B	Makhaleng	MODERATE	2.4
D15C	Makhaleng tributary	LOW	2.3
D15D	Makhaleng	MODERATE	3.5
D15E	Makhaleng	MODERATE	3.7
D15F	Ohoqhoane	LOW	3.7
D15G	Makhaleng	LOW	3.8
D15H	Makhaleng	LOW	3.8
D16A	Khubelu	HIGH	2.0
D16B	Khubelu	MODERATE	2.0
D16C	Khubelu	MODERATE	1.9
D16D	Senqu	HIGH	2.2
D16E	Senqu	MODERATE	2.3
D16F	Sanqebethu upper source area	LOW	2.1
D16F	Sanqebethu lower grazed area	MODERATE	2.5
D16G	Mokhotlong (upper source area)	LOW	2.2
D16G	Mokhotlong (lower more disturbed - agriculture - area)	MODERATE	2.5
D16H	Mokhotlong	MODERATE	2.3
D16H	Bafali	LOW	2.3
D16J	Sehonghong (upper undisturbed section)	LOW	2.1
D16J	Sehonghong (lower disturbed section)	MODERATE	2.5
D16K	Sani (focussing on Sani River from the border post that includes the large wetland	MODERATE	1.9
D16 L	Linaheng	MODERATE	1.3
D16M	Senqu	MODERATE	2.3
D17A	Senqunyane	MODERATE	1.9
D17B	Senqunyane (DS of Mohale)	HIGH	2.8
D17C	Senqunyane	HIGH	2.8
D17D	Mantsonyana	HIGH	2.8
D17 E	Lesobeng	HIGH	2.8
D17 F	Senqunyane	HIGH	2.8
D17 G	Senqu (incl Mashai confl)	MODERATE	2.8
D17 H	Senqu (Orange)	MODERATE	2.8
D17 J	Tsoelike (Sehlabathebe, disturbed areas	HIGH	2.2

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
	assessed in lower quat).		
D17 K	Tsoelike	LOW	2.2
D17 L	Senqu (Orange)	MODERATE	2.8
D17 M	Senqu (Orange)	MODERATE	2.8
D18A	Maletsanyane	MODERATE	2.1
D18B	Qhoali (undisturbed section - lower disturbed section same as D18C)	HIGH	2.2
D18C	Qhoali	LOW	2.2
D18C	Orange	MODERATE	2.2
D18D	Ketane	MODERATE	1.9
D18E	Quithing (undisturbed section - lower disturbed section same as D18F)	HIGH	2.2
D18F	Quithing	LOW	2.2
D18F	Orange	MODERATE	2.2
D18G	Sebapala (undisturbed section - lower disturbed section same as D18H)	MODERATE	2.0
D18H	Sebapala	LOW	2.2
D18J	Orange	MODERATE	2.2
D18K	Blikana	MODERATE	2.2
D18L	Orange	MODERATE	2.2

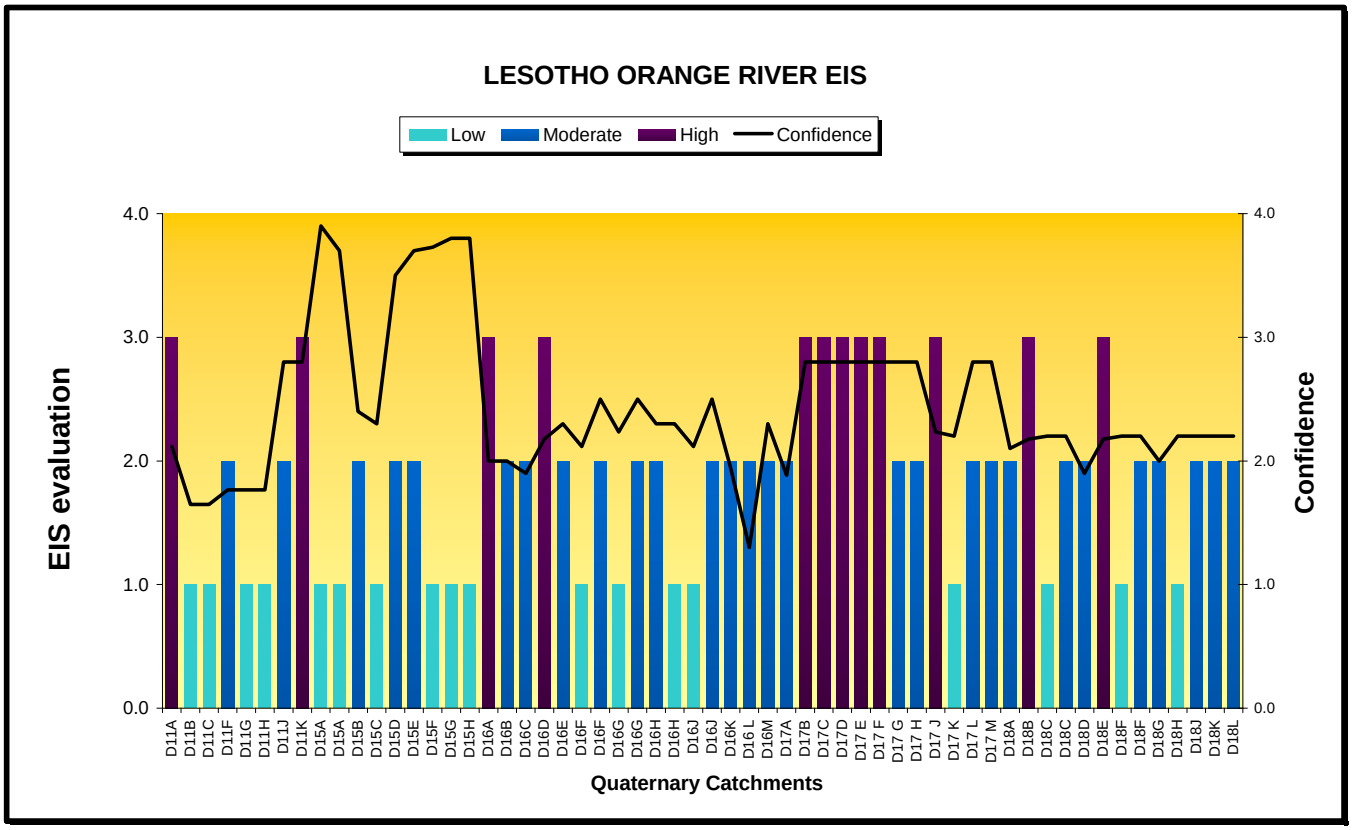


Figure 6.1 EIS and confidence evaluation illustrated as bar graphs (BASIN 1_LesOrange)

6.2.2 Orange River EIS outside Lesotho (BASIN 1_Orange)

Table 6-2 Summarised EIS results per quaternary catchment (BASIN 1_Orange)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D12A	Orange	LOW	2.8
D12B	Kromspruit	LOW	2.4
D12C	Orange	LOW	2.8
D12D	Tributary	LOW	2.3
D12E	Orange	LOW	2.8
D12F	Orange	LOW	2.8
D14A	Orange	LOW	2.8
D14B	Stormbergspruit/Trib	LOW	2.2
D14C	Stormbergspruit/Trib	LOW	2.2
D14D	Bamboesbergspruit	LOW	2.2
D14E	Bamboesbergspruit	LOW	2.2
D14F	Lower Stormbergspruit	LOW	2.2
D14G	Witkopspruit	LOW	2.2
D14H	Lower Stormbergspruit	LOW	2.4
D14J	Orange	LOW	2.8
D14K	Orange	LOW	2.8

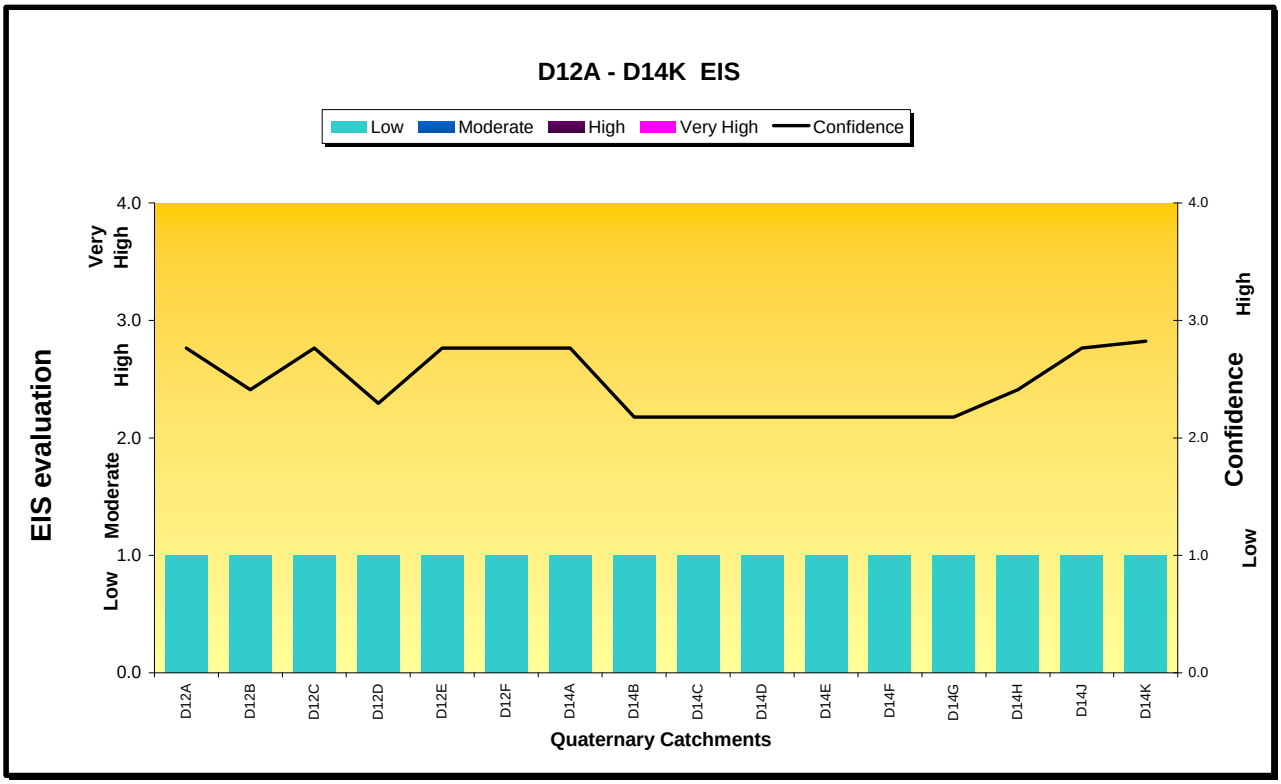


Figure 6.2 EIS and confidence evaluation illustrated as bar graphs (BASIN 1_Orange)

6.2.3 Caledon River EIS (BASIN 1_Caledon)

Table 6-3 Summarised EIS results per quaternary catchment (BASIN 1_Caledon)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D21A	Caledon	MODERATE	2.6
D21B	Hololo (Lesotho)	LOW	2.1
D21C	Caledon (main stem)	LOW	2.5
D21D	Little Caledon	MODERATE	2.7
D21E	Little Caledon	LOW	2.5
D21F	Brandwater	LOW	2.4
D21G	Brandwater	LOW	2.4
D21H	Caledon (main stem)	LOW	2.5
D21J	Hlotse Trib	LOW	2.0
D21K	Morotong	LOW	2.2
D21L	Hlotse	LOW	2.2
D22A	Meulspruit	LOW	2.7
D22B	Meulspruit	LOW	2.7
D22C	Caledon (main stem)	LOW	2.4
D22D	Caledon (main stem)	LOW	2.7
D22E	Liotioaneng	LOW	2.3
D22F	Phuthiatsana	LOW	2.2
D22G	Mopeli	LOW	2.7
D22H	Main stem Caledon	LOW	2.7
D22J	Phutiatsane	LOW	2.6
D22K	Korokara	LOW	2.6
D22L	Phutiatsane - lower (outside of gorge)	LOW	2.2
D22L	Main stem Caledon	LOW	2.7
D23A	Main stem Caledon	LOW	2.5
D23B	Tsoaneng	LOW	2.1
D23C	Leeuspruit (US of Armenia Dam)	LOW	2.5
D23D	Leeuspruit	LOW	2.5
D23E	Main stem Caledon	LOW	2.4
D23F	Tsa-Kholo	LOW	2.1
D23G	Sandspruit	LOW	2.1
D23H	Rietspruit (US of Knelpoort)	LOW	2.5
D23J	Caledon (main stem) (outside of inundation of Welbedacht and US of the Rietspruit confluence	LOW	2.5
D24A	Witspruit US from Egmont Dam	LOW	1.9
D24B	Blaasbalkspruit	LOW	1.9
D24C	Caledon (main stem)	LOW	2.5
D24D	Wilgeboomspruit	LOW	2.4
D24E	Caledon (main stem)	LOW	2.2
D24F	Caledon (main stem)	LOW	2.2
D24G	Caledon (main stem)	LOW	2.2
D24H	Skulpspruit (trib Caledon)	LOW	2.2
D24J	Caledon (main stem)	LOW	2.8
D24K	Slykspruit	LOW	2.2
D24L	Slykspruit	LOW	2.3

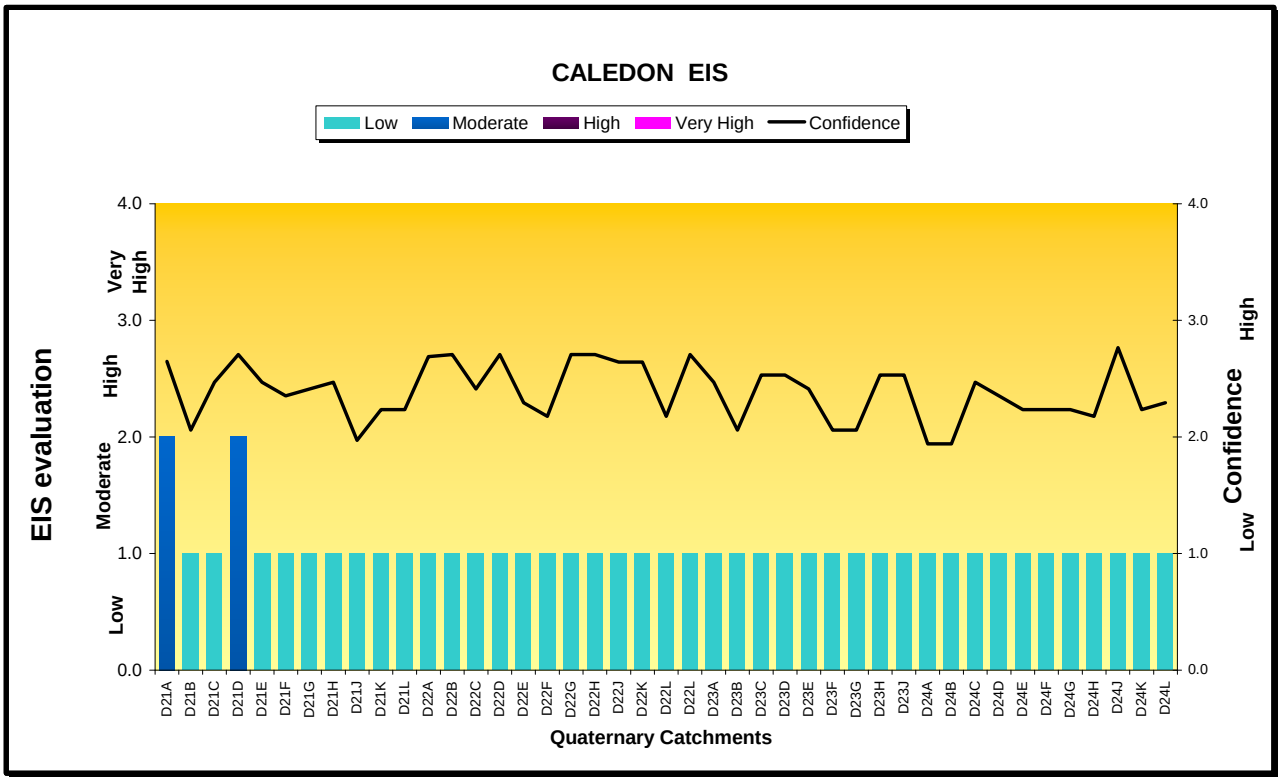


Figure 6.3 EIS and confidence evaluation illustrated as bar graphs (BASIN 1_Caledon)

6.2.4 Kraai and Stormbergspruit EIS (BASIN 1_Kraai)

Table 6-4 Summarised EIS results per quaternary catchment (BASIN 1_Kraai)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D13A	Bokspruit	MODERATE	2.8
D13B	Kraai (goes into D13E)	MODERATE	2.9
D13C	Sterkspruit	MODERATE	2.8
D13D	Langkloof	MODERATE	2.8
D13E	Kraai (main stem)	MODERATE	2.8
D13F	Kraai (main stem)	MODERATE	2.8
D13G	Kraai (main stem)	MODERATE	2.8
D13H	Holspruit	MODERATE	2.8
D13J	Holspruit	MODERATE	2.7
D13K	Kraai trib	LOW	2.7
D13L	Kraai (main stem)	LOW	2.8
D13M	Kraai (main stem)	LOW	3.2

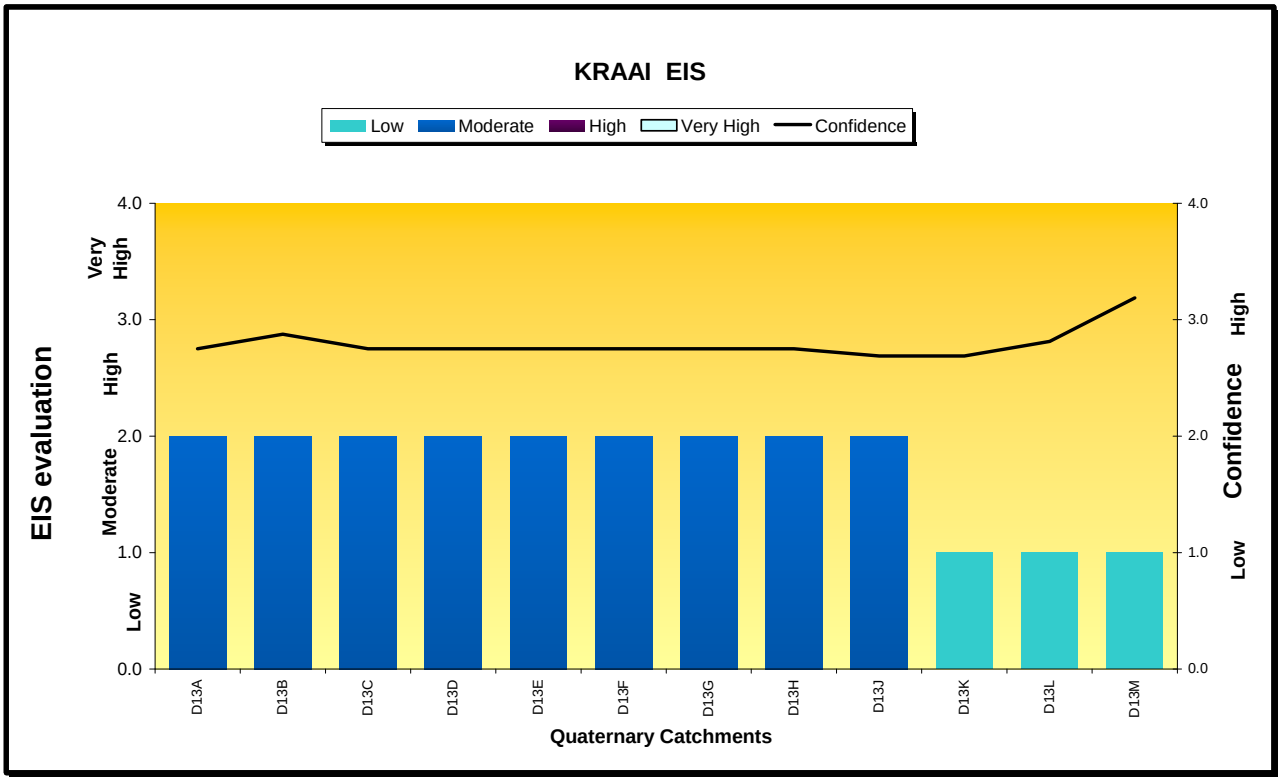


Figure 6.4 EIS and confidence evaluation illustrated as bar graphs (BASIN 1_Kraai)

6.3 ORANGE CATCHMENT FROM GARIEP DAM TO THE VAAL CONFLUENCE (BASIN 2)

This area includes the D3 catchments.

The results are provided as follows:

- Summarised EIS per river reach (Table 6-5);
- Bar graphs (Figure 6.5); and
- Maps (Figure 6.11).

Table 6-5 Summarised EIS results per quaternary catchment (BASIN 2)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D31A	Knapsak	LOW	1.5
D31B	Hondeblaf	LOW	1.8
D31C	Hondeblaf	LOW	1.9
D31D	Berg	MODERATE	1.7
D32A	Elandskloof	LOW	1.8
D32B	Klein Seekoei	LOW	1.8
D32C	Klein Seekoei	LOW	1.8
D32D	Trib of Seekoei	LOW	1.8
D32E	Trib of Seekoei	LOW	1.8
D32F	Seekoei	LOW	2.0
D32G	Noupoortspruit	LOW	1.1
D32H	Elands	LOW	1.6
D32J	Seekoei (includes D32G Seekoei)	LOW	1.9
D32K	Seekoei (excluding backup from VDK Dam)	LOW	1.9
D34A	Main stem Orange	MODERATE	2.8
D34B	Oorlogspoorivier	LOW	2.3
D34C	Oorlogspoort	LOW	2.3

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D34D	Oorlogspoort	LOW	2.1
D34E	Main stem Orange	MODERATE	2.8
D34F	Vanderwaltsfonteinspruit	LOW	2.3
D34G	Main stem Orange	MODERATE	2.8
D35A	Trib draining into Gariep dam (evaluated to US of backup of Bethule Dam)	LOW	2.2
D35B	Oudagspruit (Excl Orange R & Bethulie)	LOW	1.8
D35C	Broekspruit	LOW	1.8
D35D	Broekspruit trib	LOW	1.8
D35E	Broekspruit (excluding backup of Gariep)	LOW	1.4
D35F	Bossiespruit (excl backup from Gariep)	LOW	1.2
D35G	Swarthoekspruit	LOW	1.8
D35J	Suurbergspruit	LOW	1.8
D33A	Orange (main stem)	MODERATE	2.4
D33B	Unanmed trib of Orange (probably highly seasonal)	LOW	2.5
D33C	Lemoenspruit	LOW	1.5
D33D	Orange (main stem)	MODERATE	2.4
D33E	Orange (main stem)	MODERATE	2.4
D33F	Orange trib	LOW	2.6
D33G	Orange (main stem)	MODERATE	2.4
D33H	Orange (main stem)	MODERATE	2.4
D33J	Orange trib	LOW	2.6
D33K	Orange (main stem)	MODERATE	2.4

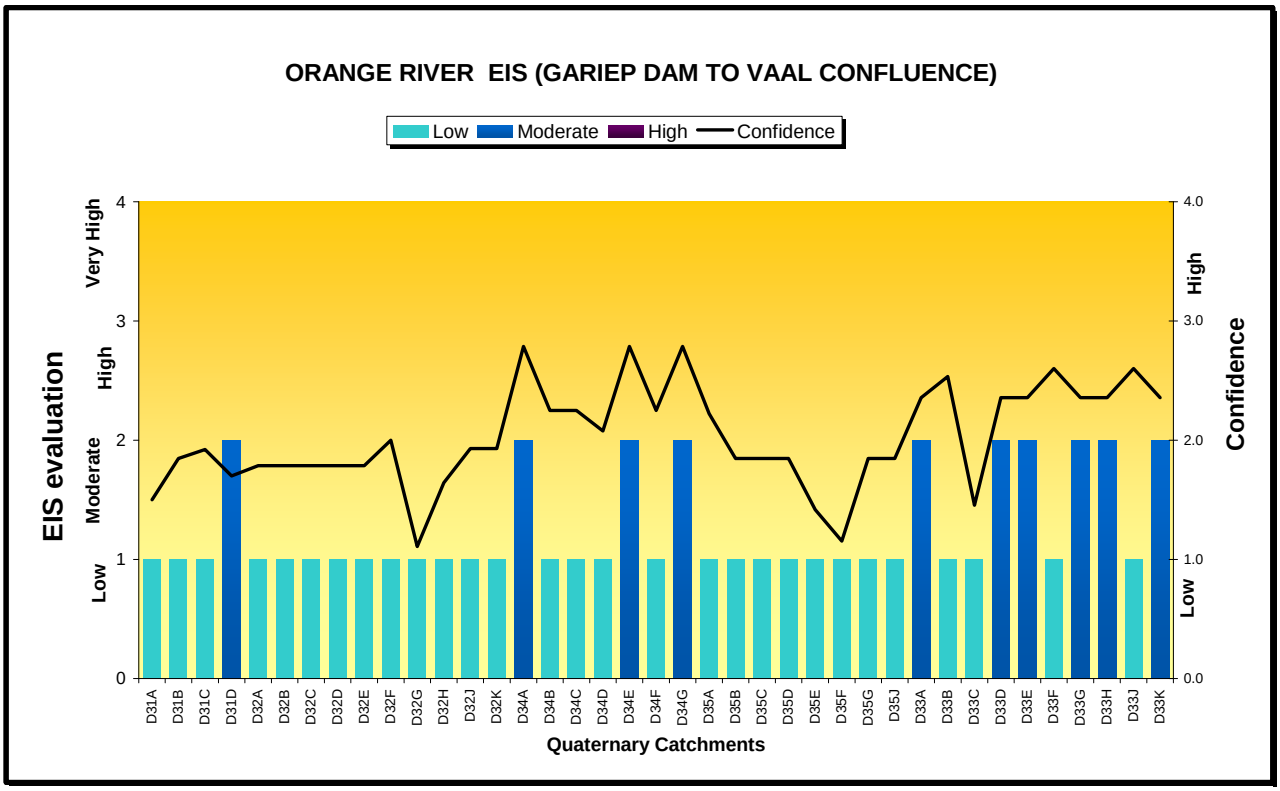


Figure 6.5 EIS and confidence evaluation illustrated as bar graphs (BASIN 2)

6.4 ORANGE RIVER CATCHMENT FROM VAAL CONFLUENCE TO THE HARTBEES CONFLUENCE (BASIN 3)

This area includes the D5, D6 and D7 catchments.

The results are provided as follows:

- Summarised EIS per river reach (Table 6-6);
- Bar graphs (Figure 6.6); and
- Maps (Figure 6.12).

Table 6-6 Summarised EIS results per quaternary catchment (BASIN 3)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D51A	Renoster River	LOW	1.9
D51B	Renoster River: Onderplaas to Sterkfontein	LOW	2.0
D51C	Renoster River	LOW	2.0
D52A	Vis	LOW	1.9
D52B	Vis	LOW	1.9
D52C	Vis	LOW	2.0
D52D	Muiskraal	LOW	1.9
D52E	Vis	LOW	2.0
D52F	Vis	MODERATE	2.3
D53A	Hartbees	LOW	1.6
D53B	Hartbees	LOW	1.6
D53C	Hartbees: Kenhardt to Tuins River confl.	LOW	1.6
D53D	Tuins	LOW	2.2
D53E	Hartbees: Tuins to Sout River confl	LOW	1.6
D53F	(Endorheic)	LOW	2.1
D53G	Sout	LOW	2.5
D53H	Sout	LOW	2.2
D53J	Hartbees	LOW	1.6
D54A	Holsloot	LOW	2.1
D54B	Carnaveronleegte	LOW	2.1
D54C	Vanwyksvlei	LOW	1.9
D54D	Carnaveronleegte	LOW	2.1
D54E	Botterslaagte	LOW	2.1
D54F	Verneukpan	LOW	1.5
D54G	Hartbeespoort	LOW	1.5
D55A	Sak River	LOW	2.1
D55B	Sak River	LOW	2.1
D55C	Brak River	LOW	2.1
D55D	Brak River	LOW	2.1
D55E	Brak River	LOW	2.1
D55F	Gansvlei River	LOW	2.1
D55G	Gansvlei River	LOW	2.1
D55H	Sak River	LOW	2.1
D55J	Sak River	LOW	2.1
D55K	Klein Sak	LOW	2.1
D55L	Sak River	LOW	2.1
D55M	Sak River	LOW	2.1
D56A	Portugals R	LOW	1.9
D56B	Riet River	LOW	1.9
D56C	Portugals R	LOW	1.9
D56D	Portugals R	LOW	1.9
D56E	Klein Riet	LOW	1.9
D56F	Klein Riet	LOW	1.9
D56G	Klein Riet	LOW	2.2
D56H	Riet	MODERATE	2.2
D56J	Riet	MODERATE	2.2
D57A	Sak River	MODERATE	2.2
D57B	Soutloot	LOW	1.9

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D57C	Sak	MODERATE	2.0
D57D	Sak	MODERATE	2.0
D57E	Sak	LOW	2.1
D58A	Vis	LOW	2.3
D58B	Vis	LOW	2.2
D58C	Vis	MODERATE	2.1
D61A	Laken	LOW	2.3
D61B	Laken trib	LOW	2.2
D61C	Laken	LOW	2.2
D61D	Brakpoort	LOW	1.3
D61E	Brak	LOW	2.4
D61F	Klein Brak	LOW	2.4
D61G	Klein Brak	LOW	2.4
D61H	Brak	LOW	2.4
D61H	Visgat	LOW	1.6
D61J	Groen	LOW	1.3
D61K	Groen	LOW	1.7
D61L	Perdepoortsleegte	LOW	1.9
D61M	Ongers	LOW	1.6
D62A	Ongers	LOW	1.6
D62B	Ongers	LOW	1.6
D62C	Elandsfontein	LOW	1.8
D62D	Brak	LOW	1.8
D62E	Brak	LOW	1.7
D62F	(Endorheic)	LOW	2.1
D62G	Brak	LOW	1.7
D62H	(Endorheic)	LOW	2.1
D62J	Ongers	LOW	1.6
D71A	Orange	MODERATE	2.4
D71B	Orange trib	LOW	2.2
D71C	Orange	MODERATE	2.4
D71D	Orange	MODERATE	2.4
D72A	Orange	MODERATE	2.4
D72B	Orange	MODERATE	2.4
D72C	Orange (inundation of Boegoeberg Dam)	MODERATE	2.2
D73A	Skeifonteintspruit	LOW	2.3
D73B	Soutloop	LOW	2.6
D73C	Orange (includes section of Orange in D73B)	MODERATE	2.3
D73D	Orange	MODERATE	2.3
D73E	Orange	MODERATE	2.3
D73F	Orange	HIGH	2.4

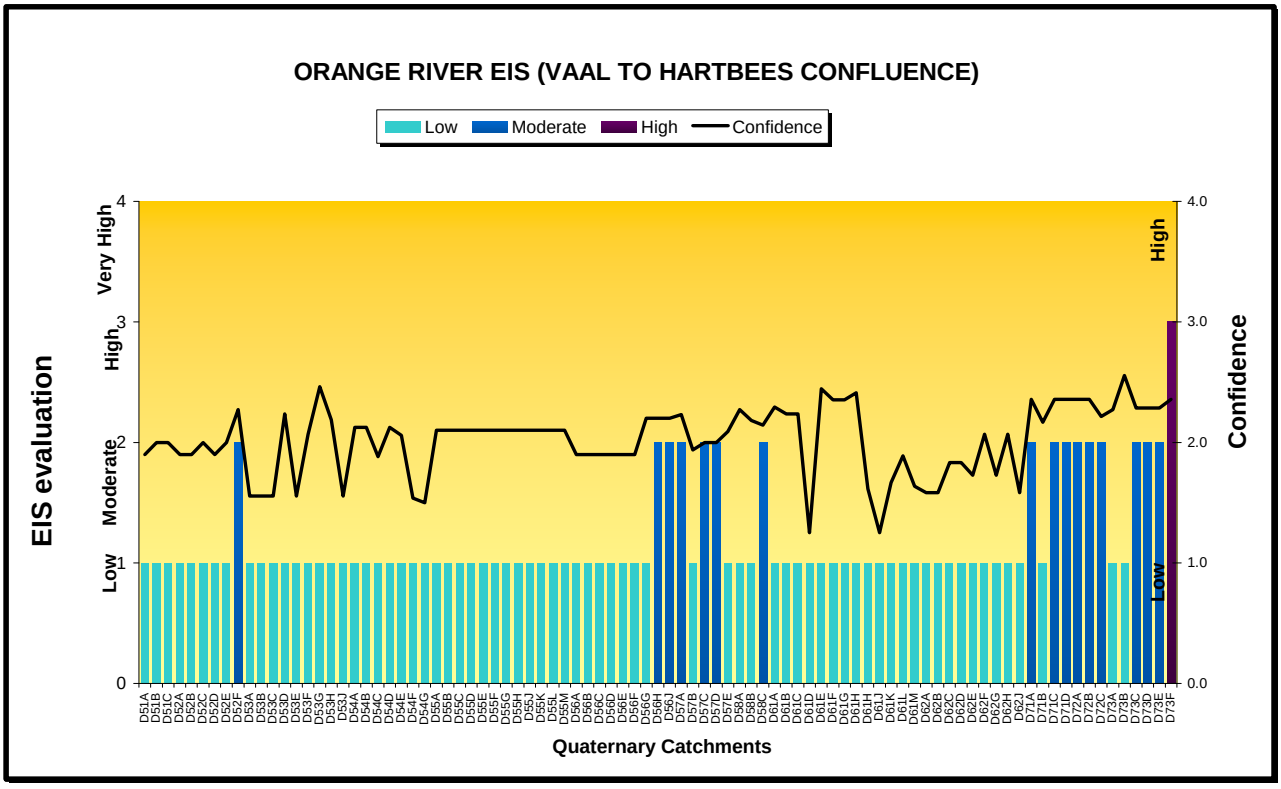


Figure 6.6 EIS and confidence evaluation illustrated as bar graphs (BASIN 3)

6.5 ORANGE RIVER CATCHMENT FROM THE HARTBEES CONFLUENCE TO THE ESTUARY (BASIN 4)

This section includes the D8 catchments in South Africa and the Namibian tributaries excluding the Fish River.

The results are provided as follows:

- Summarised EIS per river reach (Table 6-7);
- Bar graphs (Figure 6.7); and
- Maps (Figure 6.13).

Table 6-7 Summarised EIS results per quaternary catchment (BASIN 4)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D81A	Orange	HIGH	2.2
D81B	Orange	HIGH	3
D81C	Brak R (SA & Namibia)	LOW	1.9
D81D (1026	Orange: Daberas to Skuitdrift	MODERATE	2.7
D81E (1026_45)	Orange: Skuitdrift to Onseepkans	MODERATE	2.8
D81F (1045)	Orange: Onseepkans to Pella	MODERATE	2.7
D81G	Orange: Pella to Klein Pella	MODERATE	2.7
D82A (1048_50)	Orange: Klein Pella to Goodhouse	HIGH	2.9
D82B	(Endorheic)	LOW	2.4
D82C	(Endorheic)	LOW	2.4
D82D	Orange: Pella to Henkries	HIGH	2.9
D82E	Orange	MODERATE	2.9
D82F	Orange: Vioolsdrift	HIGH	3.0
D82G	Orange	HIGH	3.0
D82H	Orange: Stinkfontein se Rivier	HIGH	2.7

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D82J	Orange: Aussenkeer	HIGH	3.0
D82K	Orange: Sendlinsdrift to Annisrivier confl	HIGH	3.0
D82L	Orange: Annisrivier to mouth	MODERATE	3.0
1005 (1)	Keinab	LOW	1.9
1005 (2)	Keinab	LOW	1.9
1017	Gamkab	LOW	1.9
1020	Ham	LOW	1.9
1032	Haib	LOW	1.9
1014	Hom	LOW	1.9

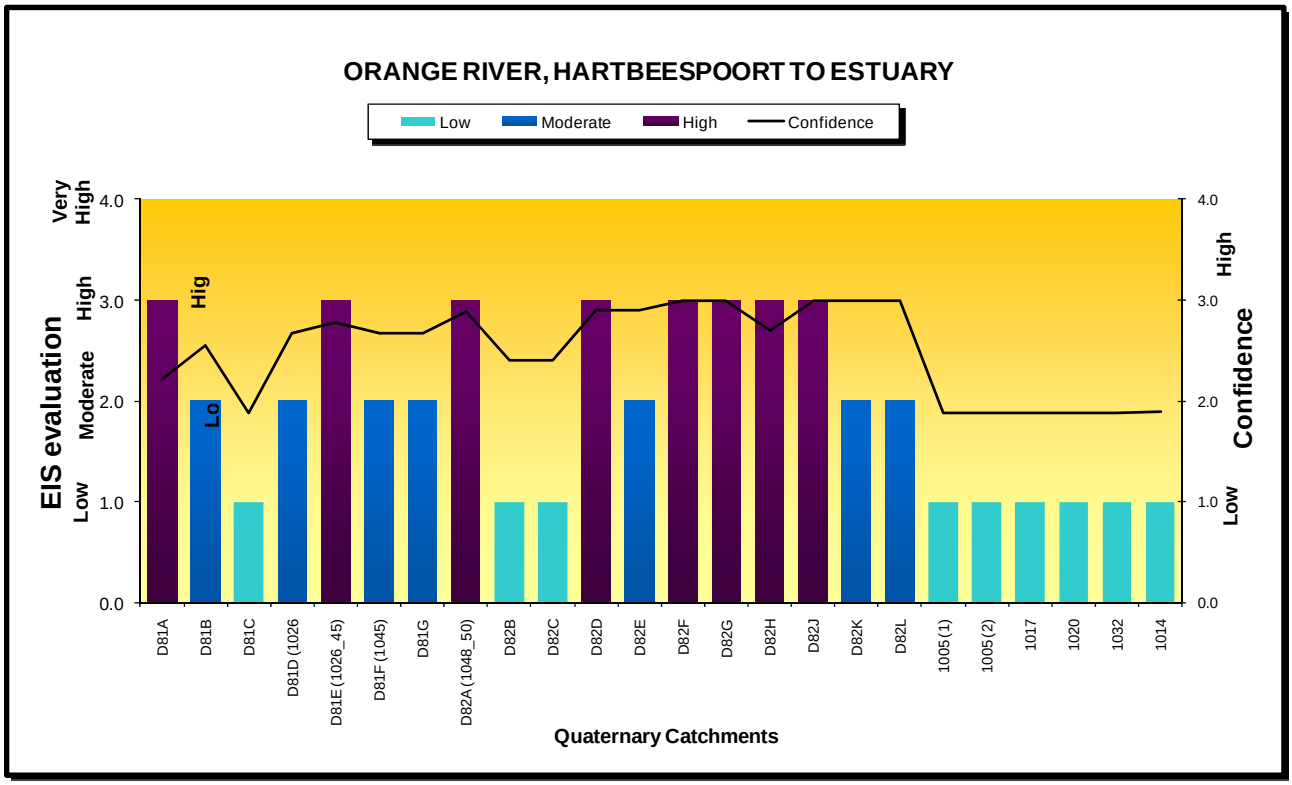


Figure 6.7 EIS and confidence evaluation illustrated as bar graphs (BASIN 4)

6.6 MOLOPO CATCHMENT (BASIN 5)

This area excludes the Nossob River and includes the D4 catchments in South Africa and the Botswana tributaries.

The results are provided as follows:

- Summarised EIS per river reach (Table 6-8);
- Bar graphs (Figure 6.8); and
- Maps (Figure 6.14).

Table 6-8 Summarised EIS results per quaternary catchment (BASIN 5)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
D41A_R1	Molopo: From Source (eye) to barrier:	HIGH	3.1
D41A_R2	Molopo: R1 end to R2 end:	LOW	2.3
D41A_R3	Molopo: R2 end to start of Mafikeng	LOW	2.1
D41A_R4	Molopo: From R3 end to start of Modimola Dam	LOW	2.3
D41A_R5	From Modimola Dam wall to start of Dinaseng Dam	LOW	2.7
D41A_R6	From Dinaseng Dam wall to end of D41A (Ramatlabama confluence on Botswana border)	LOW	3.6
D41A_Ramat.	Ramatlabama confluence	LOW	3.3
D41B (957)	Molopo	LOW	3.2
D41B	Setlagoli	LOW	2.3
D41C (959)	Molopo	LOW	3.3
D41C	Wildebeeshoringlaagte	LOW	3.4
D41D	Thakgamenglaagte	LOW	3.4
D41E	Molopo	MODERATE	3.1
939	Mosolebe	LOW	3.1
941	Mosolebe	LOW	3.1
942 to confl	Mosolebe	LOW	3.1
926	Ukhwi	LOW	3.1
921	Malotswana	LOW	3.1
D41F (935)	Molopo	MODERATE	3.6
D41F	Phepane	LOW	3.3
D41G	Moshaweng	LOW	2.9
D41H	Kgokgole	LOW	2.9
D41H(944)	Molopo	HIGH	3.4
D41J	Ga-Mogana	LOW	2.9
D41K	Ga-Mogana	LOW	2.9
D41L	Kuruman Eye	LOW	3.0
D41M	Kuruman	LOW	3.3
D42C	Kuruman	LOW	3.3
D42C	Molopo	LOW	3.3
D42D	Molopo	LOW	3.3
D42E	Molopo	HIGH	3.3

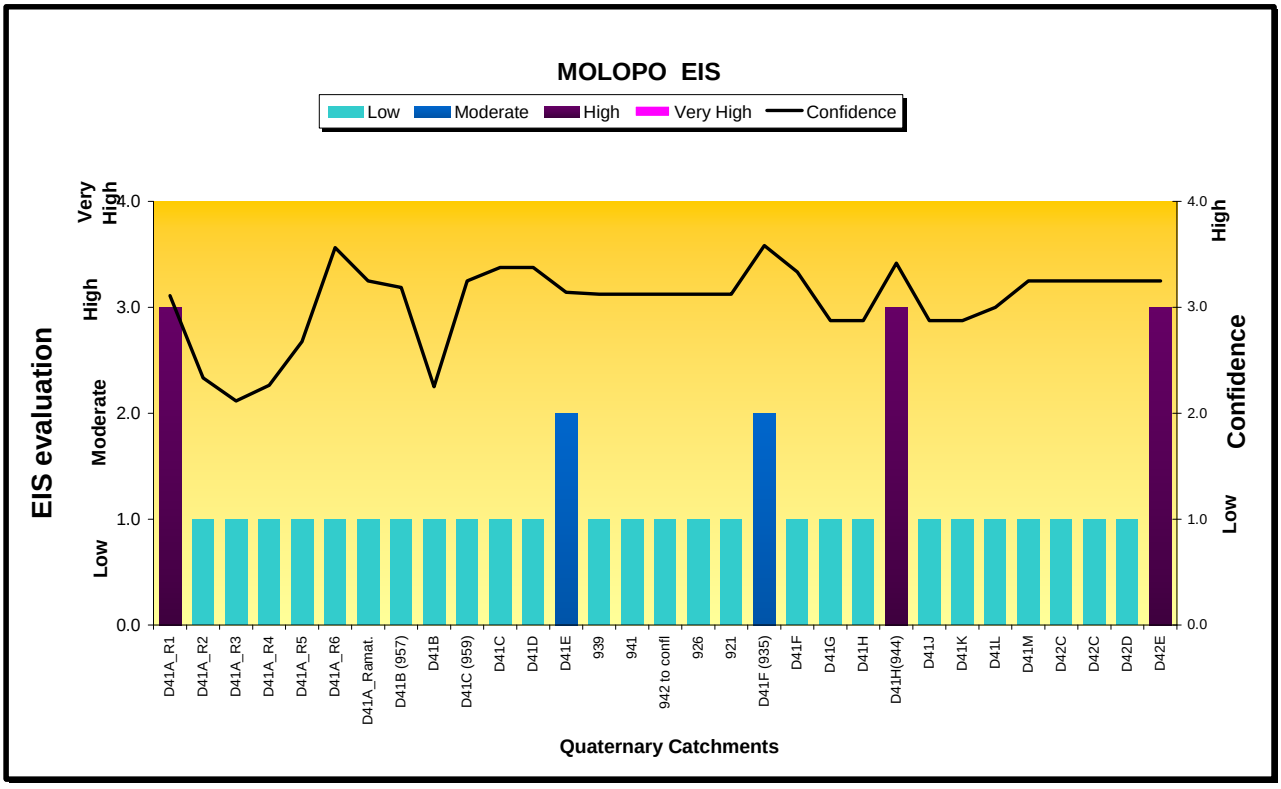


Figure 6.8 EIS and confidence evaluation illustrated as bar graphs (BASIN 5)

6.7 FISH AND NOSSOB RIVERS (BASIN 6)

The results are provided as follows:

- Summarised EIS per river reach (Table 6-9);
- Bar graphs (Figure 6.9); and
- Map (Figure 6.15).

Table 6-9 Summarised EIS results per quaternary catchment (BASIN 6)

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
855	Black Nossob	MODERATE	3.5
861	Wit Nossob	MODERATE	3.5
890	Nossob	LOW	3.0
D42A (910)	Nossob	VERY HIGH	3.7
D42B (960)	Nossob	HIGH	3.6
873	Olifants	LOW	3.8
898	Auob	LOW	3.6
D42A (946)	Auob	VERY HIGH	3.7
899	Nabob	LOW	3.5
904b	Fish to Kam confl	HIGH	3.4
904a	Kam to Fish confl	MODERATE	3.0
904c	Fish DS from Kam confl to Goma-Aub	HIGH	3.4
917 a	Fish to Hardap Dam	HIGH	3.5
917 b	Fish: Dam wall to Hudob-Lewer confl	HIGH	3.5
930	Hudob to Fish confidence	HIGH	3.5
933	Asab	LOW	3.5
955	Kannibes	LOW	3.5
969	Fish	HIGH	3.4
976	Naute	LOW	3.5
987	Lowen	LOW	3.5

QUAT	RIVER REACH	EIS	CONFIDENCE (0 - 4)
990c	Lowen to Naute Dam	MODERATE	3.3
990b	Lowen DS of Naute Dam	HIGH	3.5
990a	Fish (Aub to start of Canyon	HIGH	3.4
962	Konkipe	LOW	3.5
1009	Fish (Canyon to confluence)	HIGH	3.4
885	Osib	LOW	3.4
883	Skaap	LOW	3.4
969	Aub	LOW	3.4

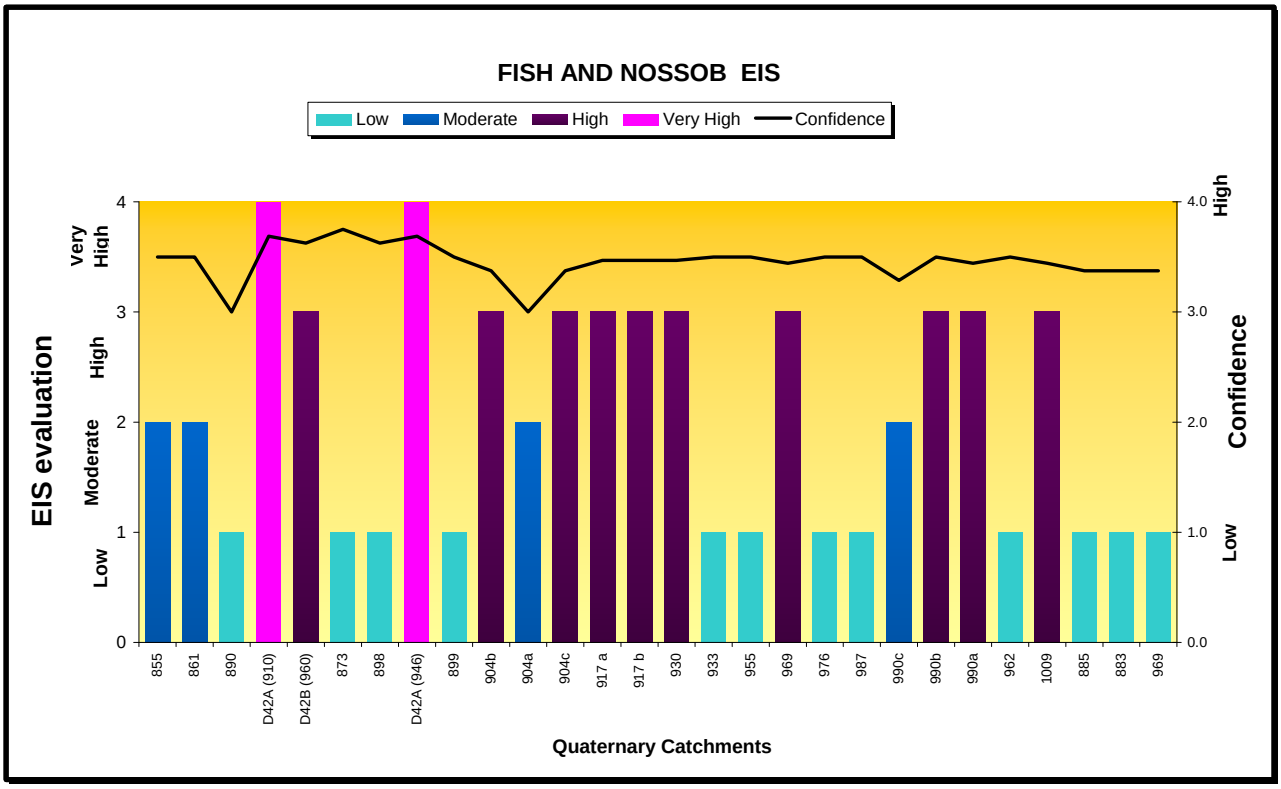


Figure 6.9 EIS and confidence evaluation illustrated as bar graphs (BASIN 6)

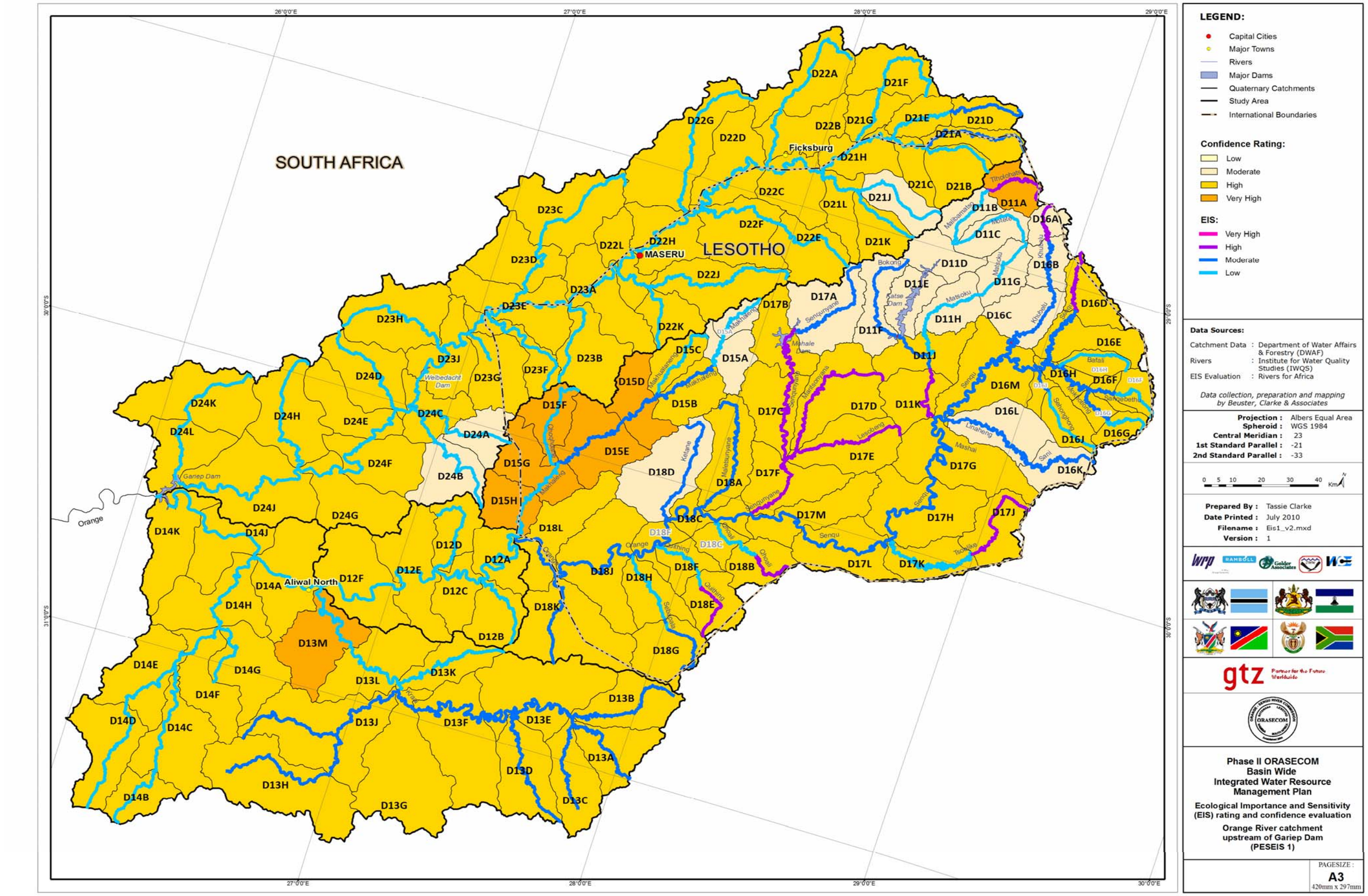


Figure 6.10 The Quaternary Catchment EIS results from BASIN 1

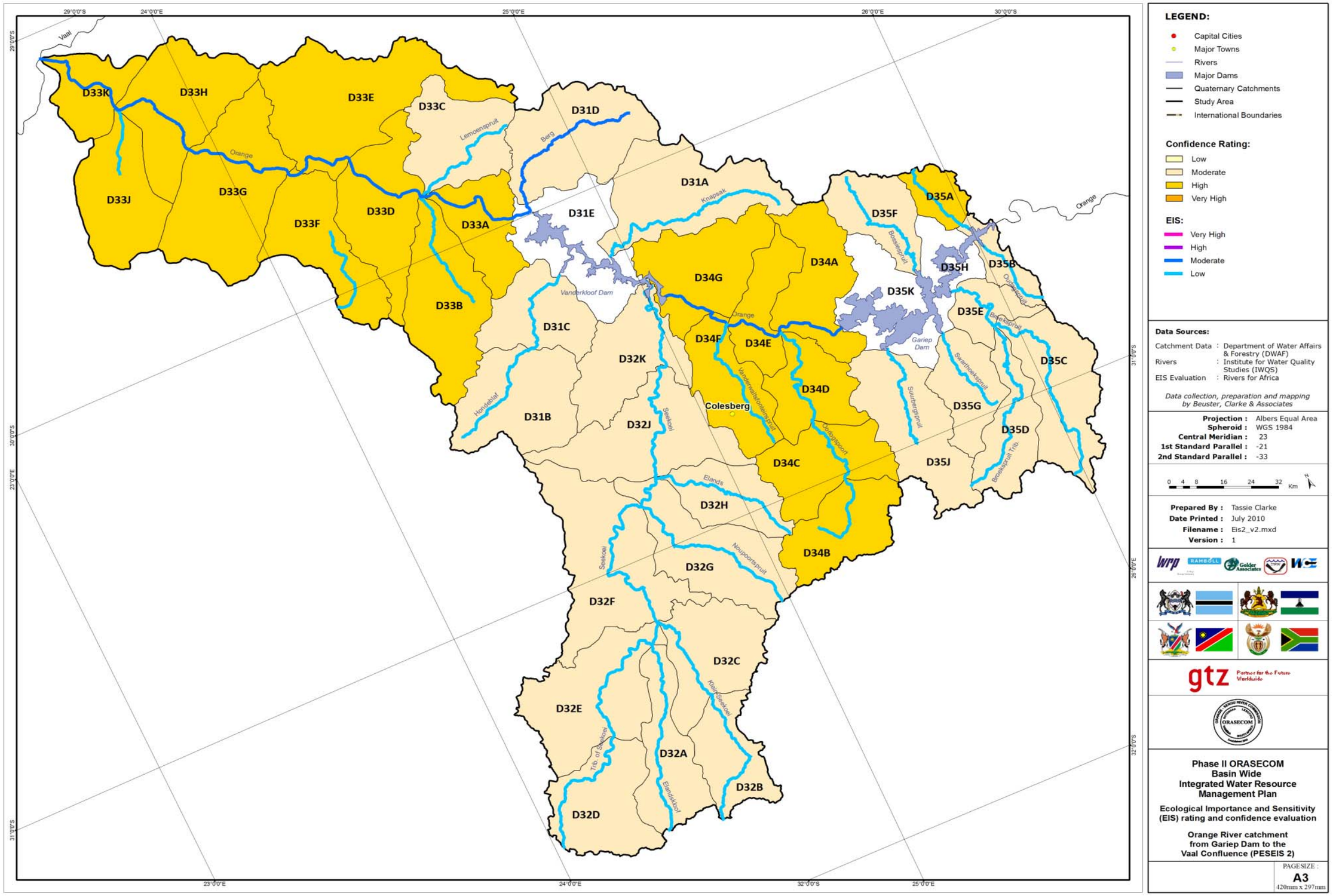


Figure 6.11 The Quaternary Catchment EIS results from BASIN 2

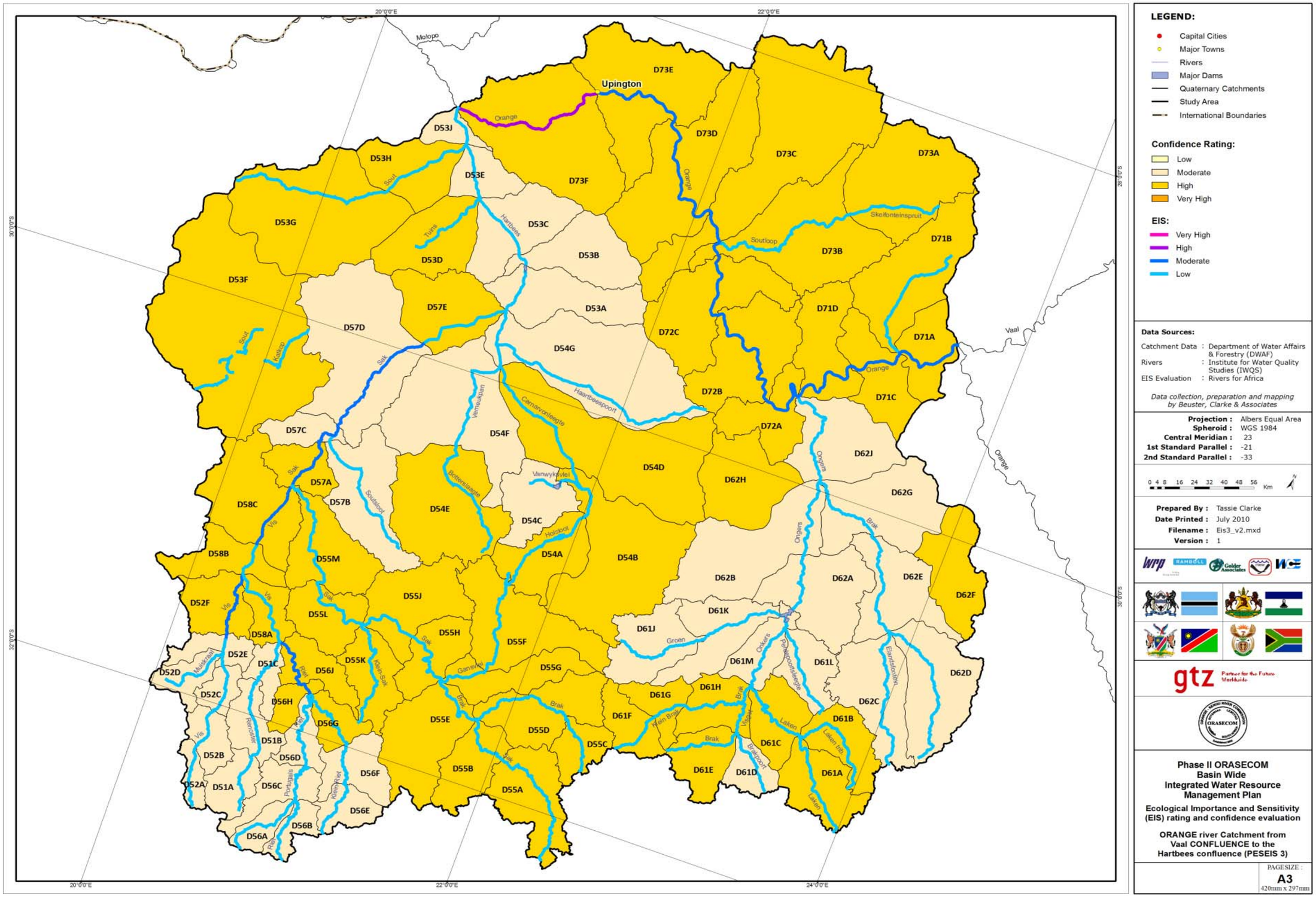
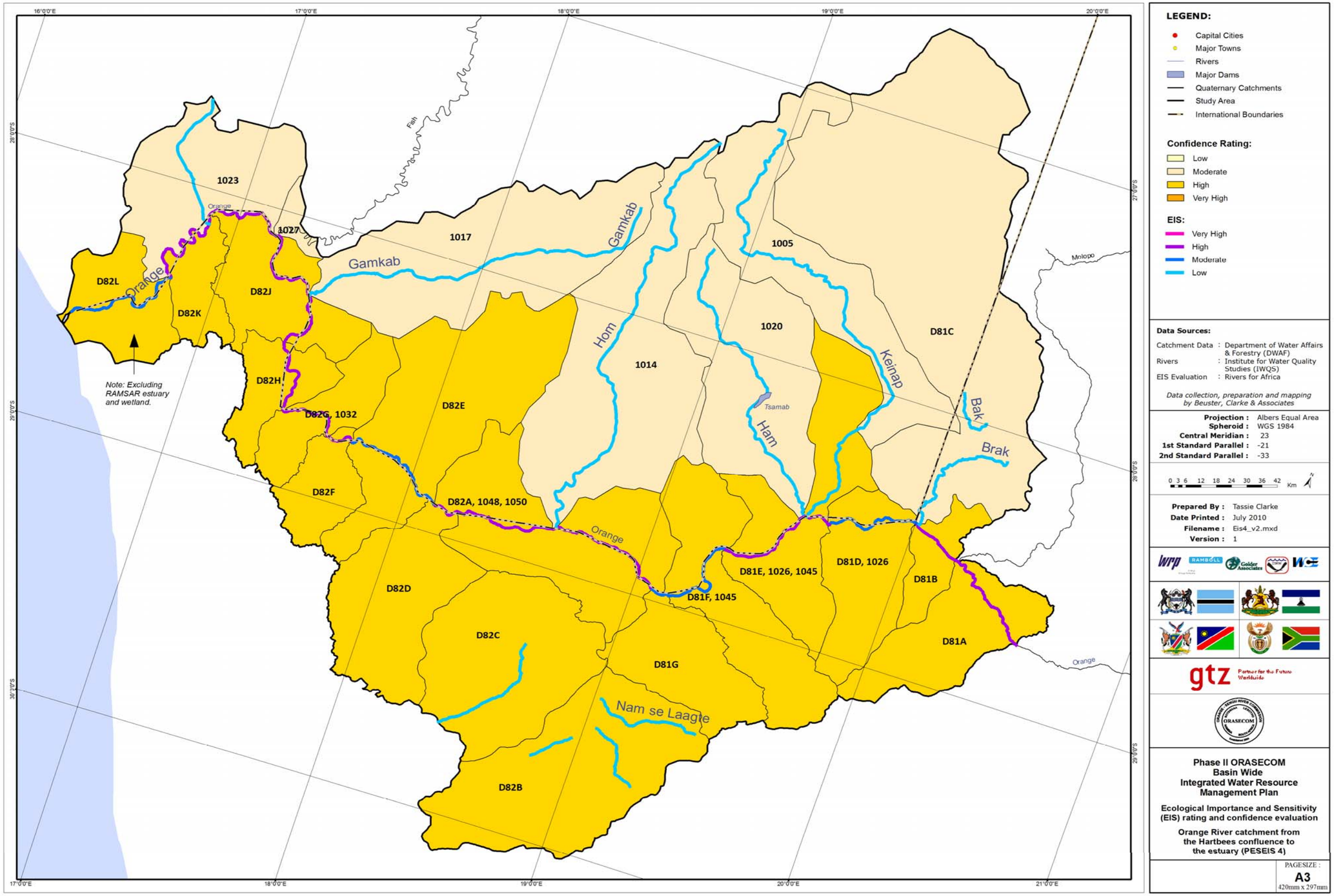


Figure 6.12 The Quaternary Catchment EIS results from BASIN 3



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Confidence Rating:

- Low
- Moderate
- High
- Very High

EIS:

- Very High
- High
- Moderate
- Low

Data Sources:

Catchment Data	:	Department of Water Affairs & Forestry (DWAF)
Rivers	:	Institute for Water Quality Studies (IWQS)
EIS Evaluation	:	Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

0 3 6 12 18 24 30 36 42 Km

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Eis4_v2.mxd
Version : 1

gtz Partner for the Future Worldwide

Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Ecological Importance and Sensitivity (EIS) rating and confidence evaluation

Orange River catchment from the Hartbees confluence to the estuary (PESEIS 4)

PAGESIZE : **A3** 420mm x 297mm

Figure 6.13 The Quaternary Catchment EIS results from BASIN 4

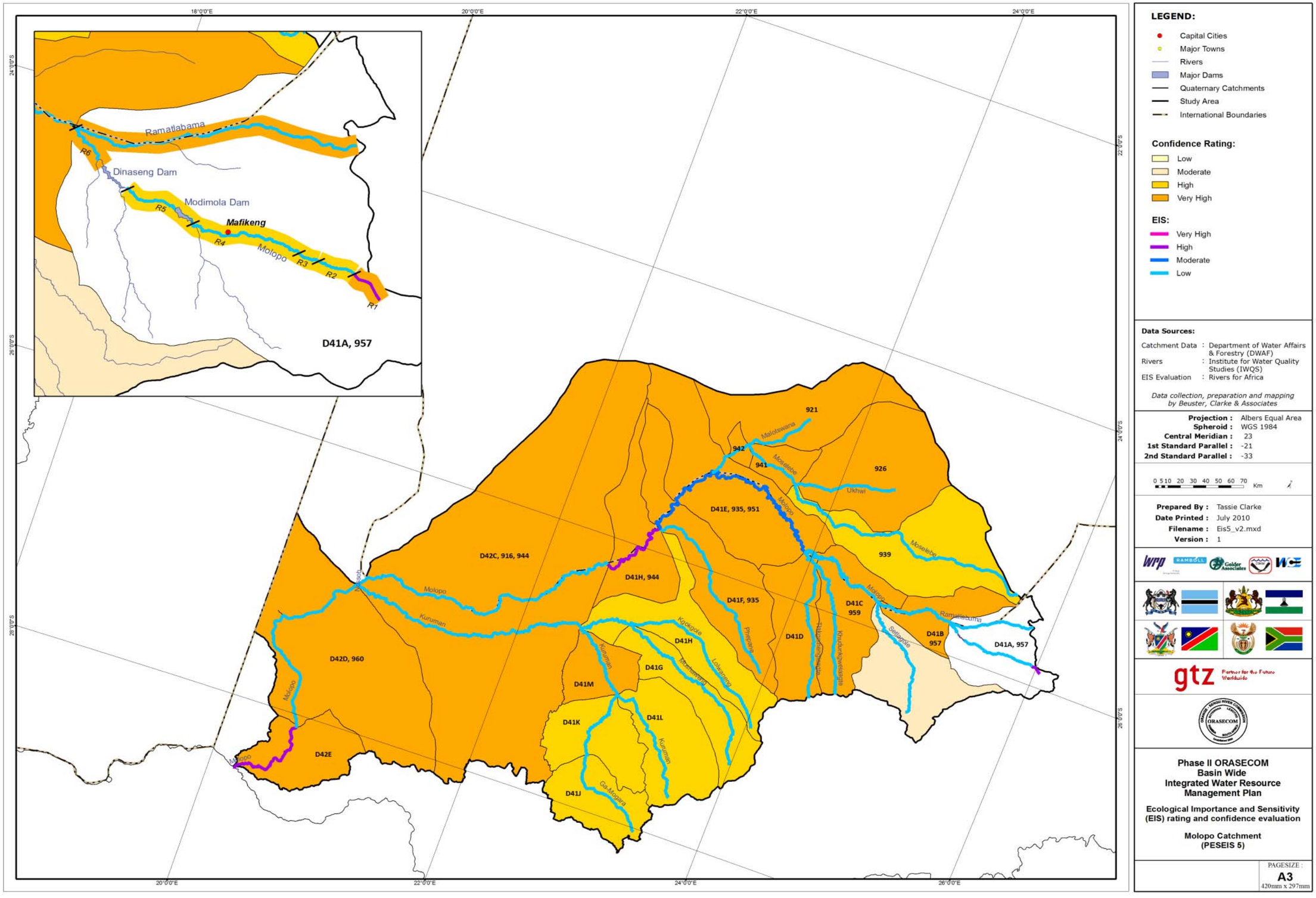


Figure 6.14 The Quaternary Catchment EIS results from BASIN 5

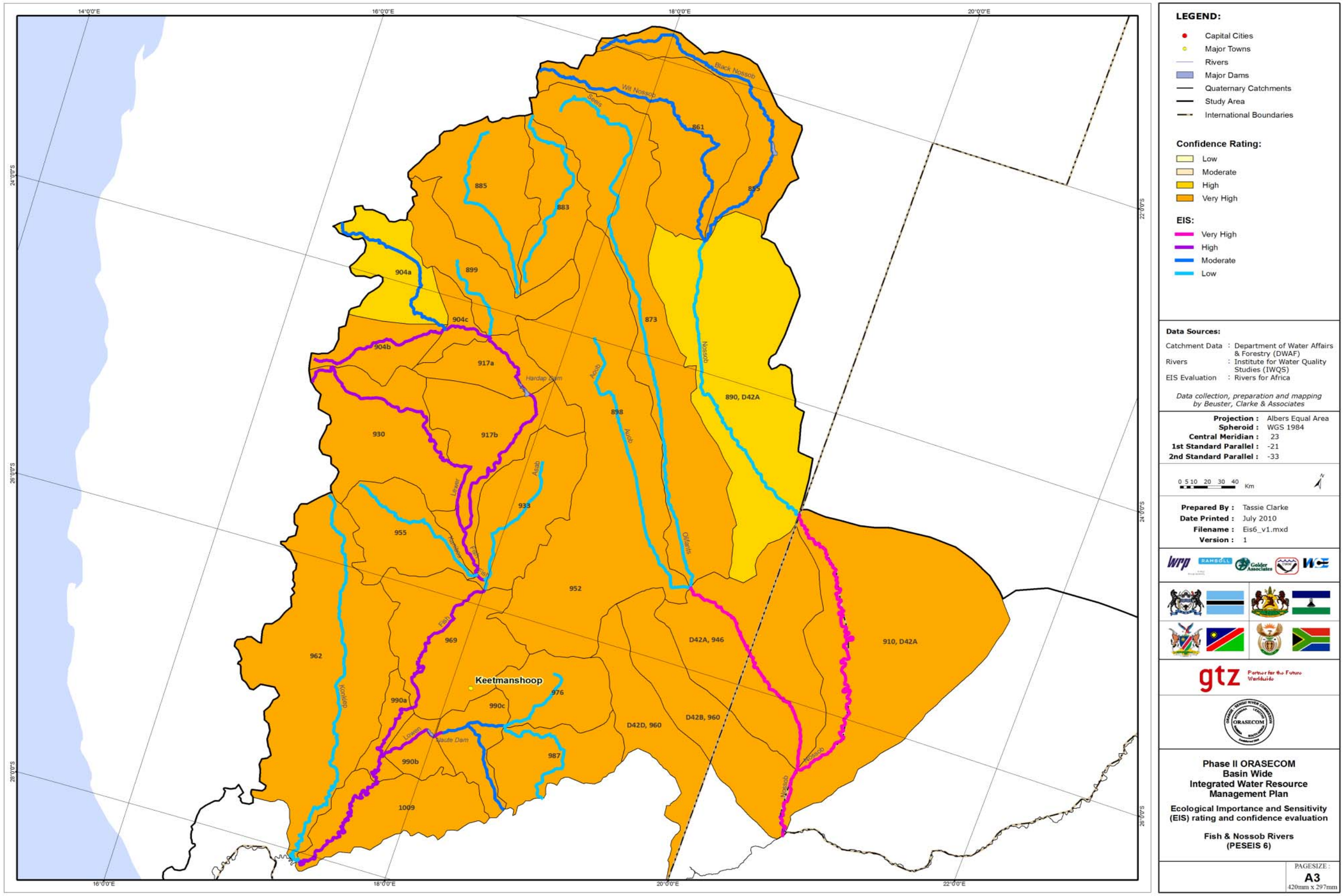


Figure 6.15 The Quaternary Catchment EIS results from BASIN 6

6.8 SUMMARY

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai

No areas of Very High[2] EIS are present. The areas of High EIS include the upper source areas of Lesotho such as the Tholatzi, Khubela, Tsoelike, Qhuali, Mantsonyana, Lesobeng and Quithing Rivers and also sections in the Malibamatso, and Senzu Rivers. The High rating is primarily due to the presence of the endangered Maluti minnow (PQUA), Rock catfish (ASCL), several rare frogs and stoneflies, and the presence of protected areas. The Presence of wetlands in some areas also contributed to the High importance ratings.

In the Caledon Basin , all the quaternary catchments were rated as having a Low EIS apart from D21A and D21D which fell within the Moderate EIS category. This is due to the fact that the Little Caledon is situated within Golden Gate National Park and a section of the Caledon borders the Park. Most of the quaternary catchments in the Kraai Basin are of Moderate EIS due to the presence of rare and unique riparian vegetation, as well as the sensitivity of the habitat associated with a small and steep (gradient) river.

The rest of the quaternary catchments in this unit (Orange in South Africa) have Low EIS ratings.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The main Orange River shows a Moderate importance compared to the Low importance of all the seasonal and ephemeral tributaries. The Moderate importance is based on individual high ratings for the biota importance and sensitivity metrics. These high ratings include:

- Rare and Endangered: Presence of *Simulium gariepense* and BKIM;
- Unique: Fish sp such as ASCL, BAEN, LCAP which are endemic to the Orange-Vaal system and therefore qualify for some level of importance;
- Flow sensitive species: *Similium gariepense* and large number of semi-rheophilic fish species; and
- Refuge: Orange River as a whole is an important refuge area due to lack of perennial tributaries.

As the Orange River is a large river and the habitat shows a low sensitivity to change, these metrics were rated low and resulted in an overall Moderate EIS. Most of the tributaries are seasonal or ephemeral and this resulted in a Low EIS rating.

Confidence of the EIS assessments of the Orange River is high as there has been significant work undertaken by Dr Rob Palmer in this section of the study area. The confidence is however Moderate regarding the tributaries as little work that we are aware of has been undertaken on these systems.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

D73F is the only area with a High EIS rating in this section, with the rest of the Orange River being of Moderate EIS. The High evaluation is due to the more diverse habitat downstream of Upington, as well as all the other metrics rated High as described above for BASIN 2. Apart from some Moderate EIS evaluations in the Sak, Riet and Vis System, the rest of the quaternary catchments are evaluated as Low. Again this is related to the seasonal nature of these systems.

[2]Model results from the EIS and SCI will be presented with a capital letter, e.g. 'High'. Where no capital letter is used, the word is just used in the normal descriptive form.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

A large section of the Orange River is evaluated as being of High EIS. This is mainly due to the presence of National Parks, other protected and/or wilderness areas. All the tributaries are of Low importance which is mainly due to their ephemeral nature.

The confidences of the evaluations are mostly High as the area has been visited often by the evaluators and instream biota surveys have been undertaken. The tributaries in Namibia are low due to their ephemeral nature and the fact that there has been no known applicable ecological work undertaken in these rivers.

Basin 5: Molopo River

There are three High EIS (D41A_R1, D41H, D42E) quaternary catchments in the Molopo River. This is due to

- the presence of rare riparian plant species;
- the role of vegetation as a refuge and a corridor for migration of birds and other fauna; and
- the presence of the Molopo Eye, the Molopo Game Reserve and the Riemvasmaak protected area.

There are two areas of Moderate EIS in the Molopo River (D41E and F) which is due to riparian vegetation importance. The rest of the evaluations are all Low and this is linked to the general Low PES and/or the ephemeral nature of the tributaries.

The confidences in the EIS assessments of this area are mostly Very High and High due to previous work that has been done in the Upper Molopo and a reconnaissance visit undertaken to the rest of the area.

Basin 6: Fish and Nossob catchments

There are two areas with a Very High EIS rating, namely the Nossob and Auob Rivers in the Kgalagadi National Park. This is due to their presence in the Transfrontier Park, as well as the presence of rare and endangered birds, animals and plants, and the role these rivers (specifically the vegetation corridor) play as a refuge and migration corridor.

The Fish River is for most of its length is of High EIS due to the:

- Presence of rare and endangered Red Data and other listed fish and riparian species;
- Presence of unique, endemic riparian species;
- Presence of flow and water quality sensitive species;
- Presence of important, sensitive and varied habitats;
- Role of the river as a refuge and migration corridor; and
- Presence of the lower river in protected areas.

Most of the rest of the rivers are of Moderate or Low EIS. The Low evaluations are linked either to the excessive invasion of *Prosopys sp* (exotic invader) and/or its ephemeral nature.

The confidences of the EIS assessments are mostly Very High (only two reaches evaluated as High) due to the work that has been done in the Fish River and the fact that the most of the reaches were visited during a reconnaissance visit.

7 SOCIO-CULTURAL IMPORTANCE RESULTS

Note: Quaternary catchments were dam backup inundated more than 80% of the catchment (i.e. the catchment is no longer representative of a river) were not assessed in this study.

7.1 ELECTRONIC DATABASE

The electronic database is provided and explained below. The SCI information is on the Excel Sheet: SCI. The columns are explained below:

- Column A: Quaternary catchments;
- Column B: Main river in the quaternary catchment with comments of specific reach where relevant;
- Column C, E, G, I, K: Five metrics scored using a rating of 0 (no importance) to 5 (very high importance);
- Column D, F, H, J, L: Modified metrics scores based on weighted ratings;
- Column M: Weighted rating out of 5; and
- Column N: Confidence rating out of 5.

7.2 ORANGE CATCHMENT SCI UPSTREAM OF GARIEP DAM (BASIN 1)

This basin has been divided in to four smaller units for the purposes of tabulated and graphical information. The graphs and tables display results for the four sub-basins as follows:

- Basin 1_LesothoOrange: The Orange River within Lesotho (Table 7.1; Figure 7.1);
- Basin 1_Orange: The Orange River outside Lesotho (Table 7.2; Figure 7.2);
- Basin 1_Caledon: The Caledon River catchment (Table 7.3; Figure 7.3);
- Basin 1_Kraai: The Kraai and Stormbergspruit catchments (Table 7.4; Figure 7.4);

The map showing the results of the SCI assessment (Figure 7.10) displays the results for the whole of BASIN 1.

7.2.1 Orange River SCI within Lesotho (BASIN 1_LesothoOrange)

Table 7-1 Summarised SCI results per quaternary catchment (BASIN 1_LesOrange)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D11A	Tholatzi	HIGH	3
D11B	Malibamatso	HIGH	3
D11C	Motete	HIGH	3
D11F	Bokong (Section not inundated by Katse)	HIGH	3
D11G	Matsoku	HIGH	3
D11H	Matsoku (includes the portion in D11J to the Orange confluence)	HIGH	3
D11J	Malibamatso	HIGH	3
D11K	Malibamatso	HIGH	3
D15A	Makhaleng (source to Likolobeng)	HIGH	3

D15A	Makhaleng (DS of Likolobeng confl)	HIGH	3
D15B	Makhaleng	MODERATE	3
D15C	Makhaleng tributary	MODERATE	3
D15D	Makhaleng	MODERATE	3
D15E	Makhaleng	MODERATE	3
D15F	Ohoqhoane	MODERATE	3
D15G	Makhaleng	MODERATE	3
D15H	Makhaleng	MODERATE	3
D16A	Khubelu	MODERATE	3
D16B	Khubelu	HIGH	3
D16C	Khubelu	HIGH	3
D16D	Senqu	HIGH	3
D16E	Senqu	HIGH	3
D16F	Sanqebethu upper source area	HIGH	3
D16F	Sanqebethu lower grazed area	HIGH	3
D16G	Mokhotlong (upper source area)	HIGH	3
D16G	Mokhotlong (lower more disturbed - agriculture - area)	HIGH	3
D16H	Mokhotlong	HIGH	3
D16H	Bafali	HIGH	3
D16J	Sehonghong (upper undisturbed section)	HIGH	3
D16J	Sehonghong (lower disturbed section)	HIGH	3
D16K	Sani (focussing on Sani River from the border post that includes the large wetland	HIGH	3
D16 L	Linaheng	HIGH	3
D16M	Senqu	HIGH	3
D17A	Senqunyane	HIGH	3
D17B	Senqunyane (DS of Mohale)	HIGH	3
D17C	Senqunyane	HIGH	3
D17D	Mantsonyana	HIGH	3
D17 E	Lesobeng	HIGH	3
D17 F	Senqunyane	HIGH	3
D17 G	Senqu (incl Mashai confl)	HIGH	3
D17 H	Senqu (Orange)	HIGH	3
D17 J	Tsoelike (Sehlabathebe, disturbed areas assessed in lower quat).	HIGH	3
D17 K	Tsoelike	HIGH	3
D17 L	Senqu (Orange)	HIGH	3
D17 M	Senqu (Orange)	HIGH	3
D18A	Maletsanyane	HIGH	3
D18B	Qhoali (undisturbed section - lower disturbed section same as D18C)	HIGH	3
D18C	Qhoali	HIGH	3
D18C	Orange	HIGH	3
D18D	Ketane	HIGH	3
D18E	Quithing (undisturbed section - lower disturbed section same as D18F)	HIGH	3
D18F	Quithing	HIGH	3
D18F	Orange	HIGH	3

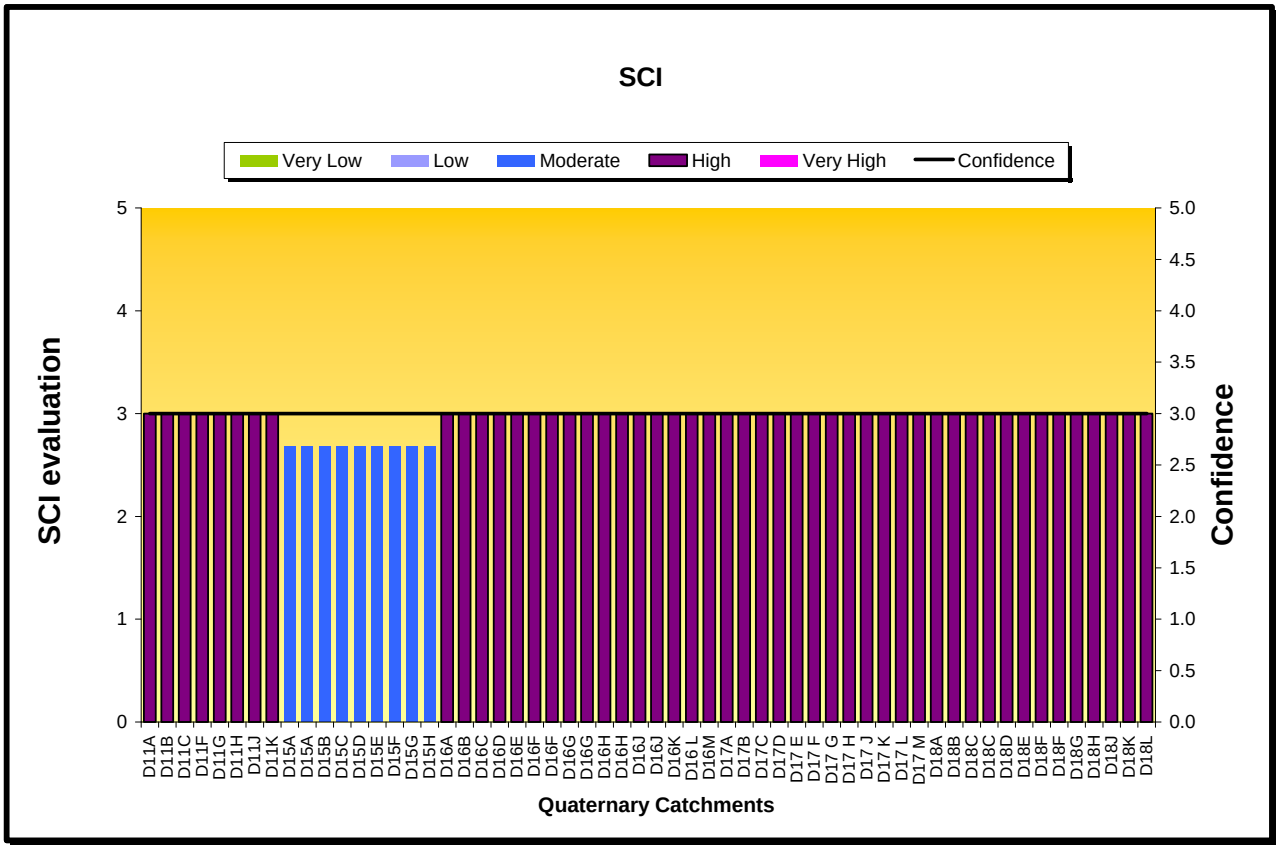


Figure 7.1 SCI and confidence evaluation illustrated as bar graphs (BASIN 1_LesOrange)

7.2.2 Orange River SCI outside Lesotho (BASIN 1_Orange)

Table 7-2 Summarised SCI results per quaternary catchment (BASIN 1_Orange)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D12A	Orange	MODERATE	2
D12B	Kromspruit	MODERATE	2
D12C	Orange	LOW	2
D12D	Trib.	LOW	2
D12E	Orange	MODERATE	2
D12F	Orange	LOW	2
D14A	Orange	LOW	2
D14B	Stormbergspruit/Trib	LOW	2
D14C	Stormbergspruit/Trib	LOW	2
D14D	Bamboesbergspruit	LOW	2
D14E	Bamboesbergspruit	LOW	2
D14F	Lower Stormbergspruit	LOW	2
D14G	Witkopspruit	LOW	2
D14H	Lower Stormbergspruit	LOW	2
D14J	Orange (main stem)	LOW	2
D14K	Orange (main stem)	LOW	2

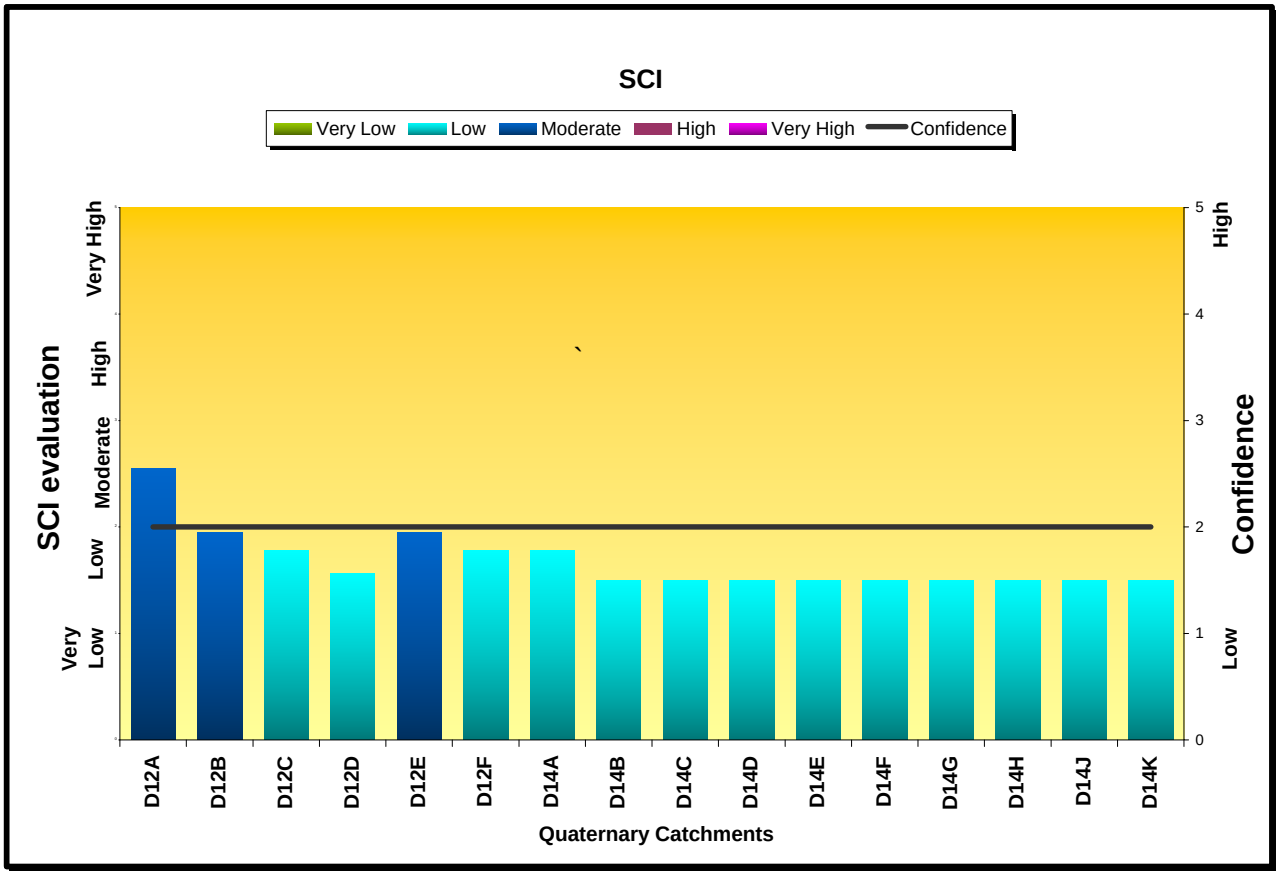


Figure 7.2 SCI and confidence evaluation illustrated as bar graphs (BASIN 1_Orange)

7.2.3 Caledon River SCI (BASIN 1_Caledon)

Table 7-3 Summarised SCI results per quaternary catchment (BASIN 1_Caledon)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D21A	Caledon	MODERATE	3
D21B	Hololo (Lesotho)	MODERATE	3
D21C	Caledon (main stem)	MODERATE	3
D21D	Little Caledon	LOW	3
D21E	Little Caledon	LOW	3
D21F	Brandwater	LOW	3
D21G	Brandwater	LOW	3
D21H	Caledon (main stem)	MODERATE	3
D21J	Hlotse Trib	MODERATE	3
D21K	Morotong	MODERATE	3
D21L	Hlotse	MODERATE	
D22A	Meulspruit	LOW	3
D22B	Meulspruit	LOW	3
D22C	Caledon (main stem)	MODERATE	3
D22D	Caledon (main stem)	MODERATE	3
D22E	Liotioaneng	MODERATE	3
D22F	Phuthiatsana	MODERATE	3
D22G	Mopeli	LOW	3
D22H	Main stem Caledon	MODERATE	3
D22J	Phutiatsane	MODERATE	3

D22K	Korokara	MODERATE	3
D22L	Phutiatsane - lower (outside of gorge)	MODERATE	3
D22L	Main stem Caledon	MODERATE	3
D23A	Main stem Caledon	MODERATE	3
D23B	Tsoaneng	MODERATE	3
D23C	Leeuspruit (US of Armenia Dam)	LOW	3
D23D	Leeuspruit	LOW	3
D23E	Main stem Caledon	MODERATE	3
D23F	Tsa-Kholo	MODERATE	3
D23G	Sandspruit	MODERATE	3
D23H	Rietspruit (US of Knelpoort)	LOW	3
D23J	Caledon (main stem) (outside of inundation of Welbedacht and US of the Rietspruit confluence	LOW	3
D24A	Witspruit US from Egmont Dam	LOW	3
D24B	Blaasbalkspruit	LOW	3
D24C	Caledon (main stem)	LOW	3
D24D	Wilgeboomspruit	LOW	3
D24E	Caledon (main stem)	MODERATE	3
D24F	Caledon (main stem)	LOW	3
D24G	Caledon (main stem)	LOW	3
D24H	Skulpspruit (trib Caledon)	LOW	3
D24J	Caledon (main stem)	LOW	3
D24K	Slykspruit	MODERATE	3
D24L	Slykspruit	MODERATE	3

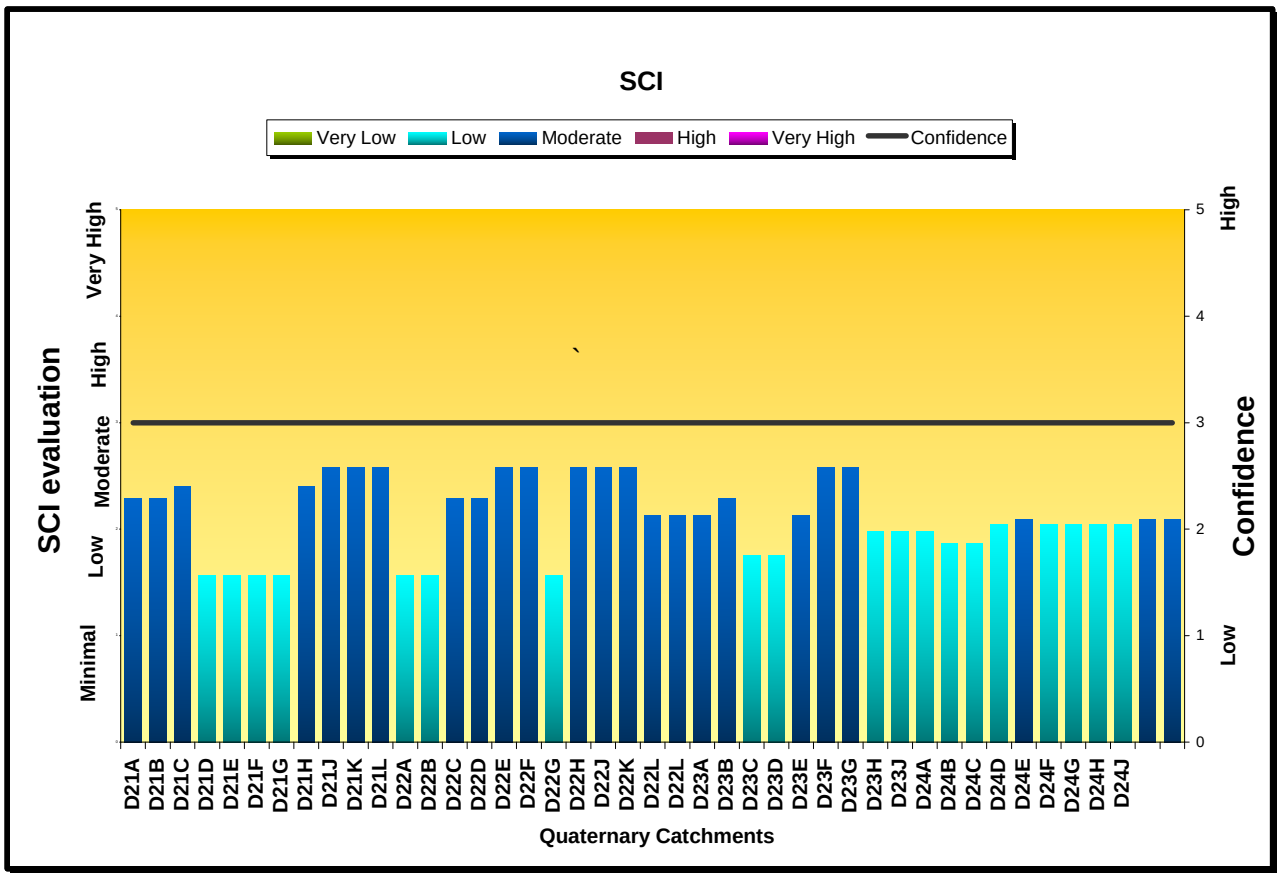


Figure 7.3 SCI and confidence evaluation illustrated as bar graphs (BASIN 1_Caledon)

7.2.4 Kraai and Stormbergspruit SCI (BASIN 1_Kraai)

Table 7-4 Summarised SCI results per quaternary catchment (BASIN 1_Kraai)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D13A	Bokspruit	MODERATE	2
D13B	Kraai (goes into D13E)	MODERATE	2
D13C	Sterkspruit	MODERATE	2
D13D	Langkloof	LOW	2
D13E	Kraai (main stem)	LOW	2
D13F	Kraai (main stem)	LOW	2
D13G	Kraai (main stem)	LOW	2
D13H	Holspruit	MODERATE	2
D13J	Holspruit	MODERATE	3
D13K	Kraai trib	MODERATE	2
D13L	Kraai (main stem)	MODERATE	2
D13M	Kraai (main stem)	LOW	2

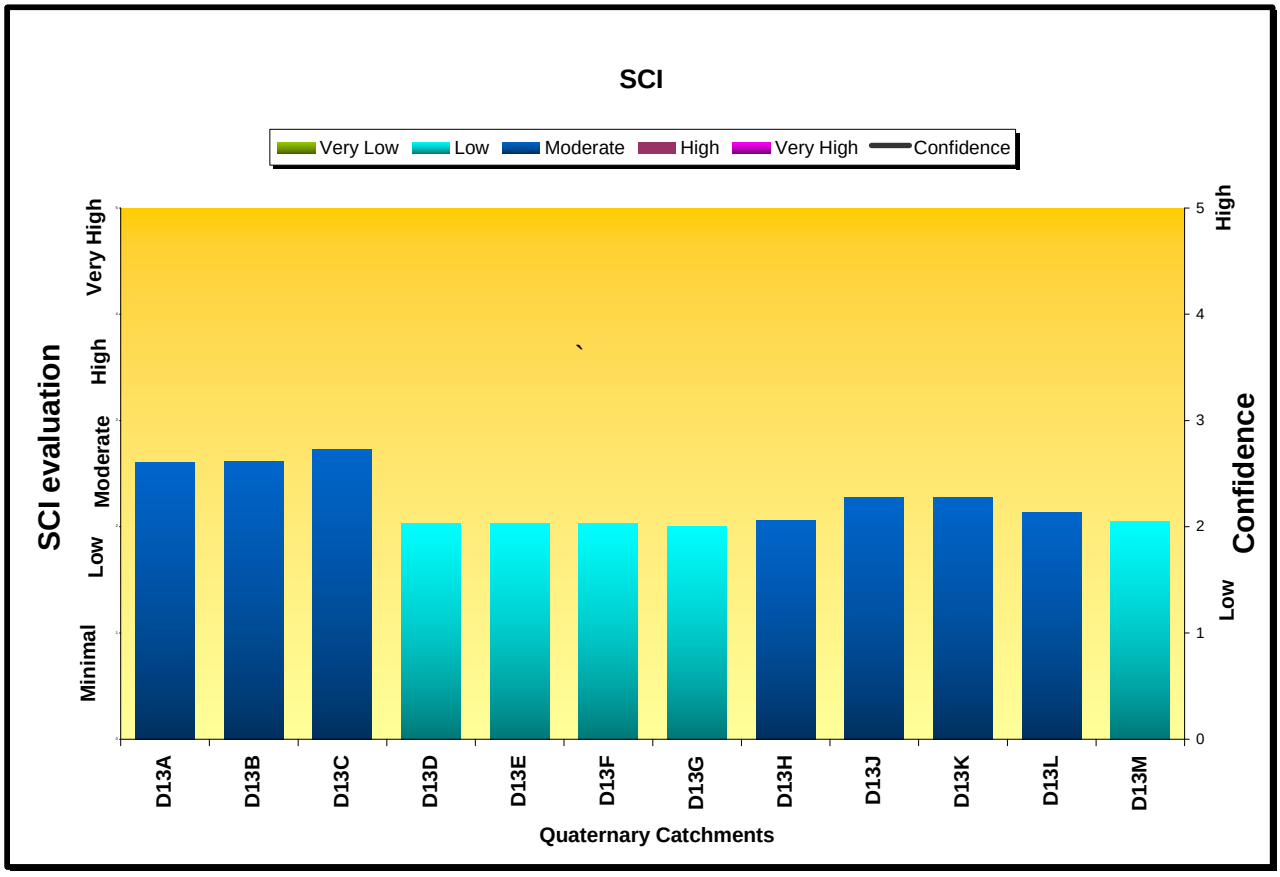


Figure 7.4 SCI and confidence evaluation illustrated as bar graphs (BASIN 1_Kraai)

7.3 ORANGE CATCHMENT FROM GARIEP DAM TO THE VAAL CONFLUENCE (BASIN 2)

This area includes the D3 catchments.

The results are provided as follows:

- Summarised EIS per river reach (Table 7-5);
- Bar graphs (Figure 7.5); and
- Maps (Figure 7.11).

Table 7-5 Summarised SCI results per quaternary catchment (BASIN 2)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D31A	Knapsak	LOW	2.5
D31B	Hondeblaf	LOW	2.5
D31C	Hondeblaf	LOW	2.5
D31D	Berg	LOW	2.5
D32A	Elandskloof	LOW	2.5
D32B	Klein Seekoei	LOW	2.5
D32C	Klein Seekoei	LOW	2.5
D32D	Trib of Seekoei	LOW	2.5
D32E	Trib of Seekoei	LOW	2.5
D32F	Seekoei	LOW	2.5
D32G	Noupoortspruit	LOW	2.5
D32H	Elands	LOW	2.5
D32J	Seekoei (includes D32G Seekoei)	LOW	2.5
D32K	Seekoei (excluding backup from VDK Dam)	LOW	2.5
D34A	Main stem Orange	MODERATE	3
D34B	Oorlogspoorivier	LOW	2.5
D34C	Oorlogspoort	LOW	2.5
D34D	Oorlogspoort	LOW	2.5
D34E	Main stem Orange	MODERATE	2.5
D34F	Vanderwaltsfonteinspruit	LOW	2.5
D34G	Main stem Orange	MODERATE	2.5
D35A	Trib draining into Gariep dam (evaluated to US of Bethule Dam)	LOW	2.5
D35B	Oudagspruit (Excl Orange R & Bethulie)	LOW	2.5
D35C	Broekspruit	LOW	2.5
D35D	Broekspruit trib	LOW	2.5
D35E	Broekspruit (excluding Gariep)	MODERATE	2.5
D35F	Bossiespruit (excl backup from Gariep)	MODERATE	2.5
D35G	Swarthoekspruit	MODERATE	2.5
D35J	Suurbergspruit	LOW	2.5
D33A	Orange (main stem)	LOW	3
D33B	Unanmed trib of Orange	LOW	4
D33C	Lemoenspruit	LOW	4
D33D	Orange (main stem)	LOW	4
D33E	Orange (main stem)	LOW	4
D33F	Orange trib	LOW	4

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D33G	Orange (main stem)	LOW	4
D33H	Orange (main stem)	LOW	4
D33J	Orange trib	LOW	3
D33K	Orange (main stem)	LOW	3

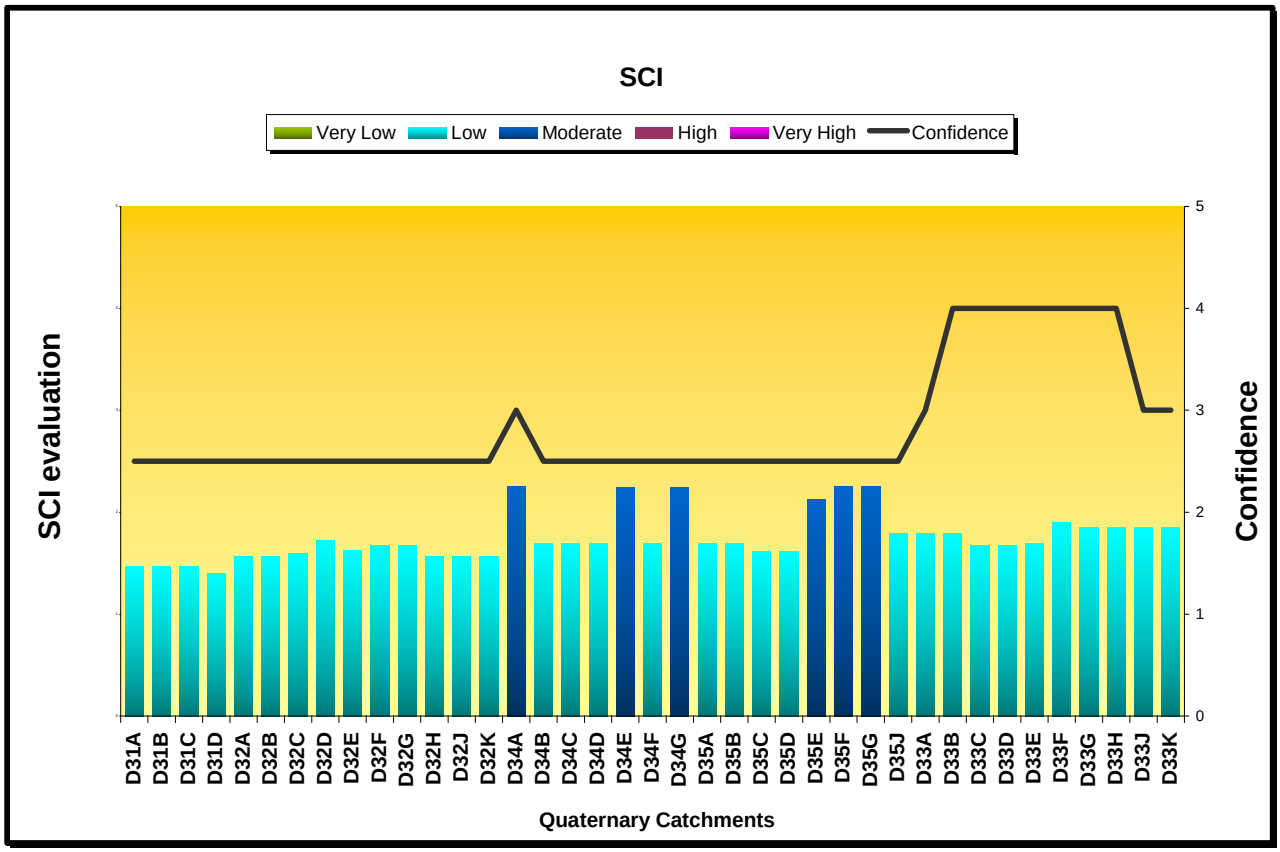


Figure 7.5 SCI and confidence evaluation illustrated as bar graphs (BASIN 2)

7.4 ORANGE RIVER CATCHMENT FROM VAAL CONFLUENCE TO THE HARTBEES CONFLUENCE (BASIN 3)

This area includes the D5, D6 and D7 catchments.

The results are provided as follows:

- Summarised EIS per river reach (Table 7-6);
- Bar graphs (Figure 7.6); and
- Maps (Figure 7.12).

Table 7-6 Summarised SCI results per quaternary catchment (BASIN 3)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D51A	Renoster River	MODERATE	3
D51B	Renoster River: Onderplaas to Sterkfontein	LOW	3
D51C	Renoster River	LOW	3
D52A	Vis	MODERATE	3

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D52B	Vis	LOW	3
D52C	Vis	LOW	3
D52D	Muiskraal	MODERATE	3
D52E	Vis	LOW	3
D52F	Vis	LOW	3
D53A	Hartbees	LOW	3
D53B	Hartbees	LOW	3
D53C	Hartbees: Kenhardt to Tuins River confl.	LOW	3
D53D	Tuins	LOW	3
D53E	Hartbees: Tuins to Sout River confl	LOW	3
D53F	(Endorheic)	LOW	3
D53G	Sout	LOW	3
D53H	Sout	LOW	3
D53J	Hartbees	LOW	3
D54A	Holsloot	LOW	3
D54B	Carnaveronleegte	LOW	3
D54C	Vanwyksvlei	LOW	3
D54D	Carnaveronleegte	LOW	3
D54E	Botterslaagte	LOW	3
D54F	Verneukpan	LOW	3
D54G	Hartbeespoort	LOW	3
D55A	Sak River	MODERATE	3
D55B	Sak River	LOW	3
D55C	Brak River	LOW	3
D55D	Brak River	LOW	3
D55E	Brak River	LOW	3
D55F	Gansvlei River	LOW	3
D55G	Gansvlei River	LOW	3
D55H	Sak River	LOW	3
D55J	Sak River	LOW	3
D55K	Klein Sak	LOW	3
D55L	Sak River	LOW	3
D55M	Sak River	LOW	3
D56A	Portugals R	LOW	3
D56B	Riet River	LOW	3
D56C	Portugals R	LOW	3
D56D	Portugals R	LOW	3
D56E	Klein Riet	LOW	3
D56F	Klein Riet	LOW	3
D56G	Klein Riet	LOW	3
D56H	Riet	LOW	3
D56J	Riet	LOW	3
D57A	Sak River	LOW	3
D57B	Soutloot	LOW	3
D57C	Sak	LOW	3

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D57D	Sak	LOW	3
D57E	Sak	LOW	3
D58A	Vis	LOW	3
D58B	Vis	LOW	3
D58C	Vis	LOW	3
D61A	Laken	LOW	3
D61B	Laken trib	LOW	3
D61C	Laken	LOW	3
D61D	Brakpoort	LOW	3
D61E	Brak	LOW	3
D61F	Klein Brak	LOW	3
D61G	Klein Brak	LOW	3
D61H	Brak	LOW	3
D61H	Visgat	LOW	3
D61J	Groen	LOW	3
D61K	Groen	LOW	3
D61L	Perdepoortsleegte	LOW	3
D61M	Ongers	LOW	3
D62A	Ongers	LOW	3
D62B	Ongers	LOW	3
D62C	Elandsfontein	LOW	3
D62D	Brak	LOW	3
D62E	Brak	LOW	3
D62F	(Endorheic)	LOW	3
D62G	Brak	LOW	3
D62H	(Endorheic)	LOW	3
D62J	Ongers	LOW	3
D71A	Orange	LOW	4
D71B	Orange trib	MODERATE	4
D71C	Orange	MODERATE	4
D71D	Orange	LOW	4
D72A	Orange	LOW	4
D72B	Orange	MODERATE	4
D72C	Orange (inundation of Boegoeberg Dam)	LOW	4
D73A	Skeifonteintspruit	MODERATE	4
D73B	Soutloop	MODERATE	4
D73C	Orange (includes section of Orange in D73B)	MODERATE	4
D73D	Orange	LOW	4
D73E	Orange	LOW	4
D73F	Orange	MODERATE	4

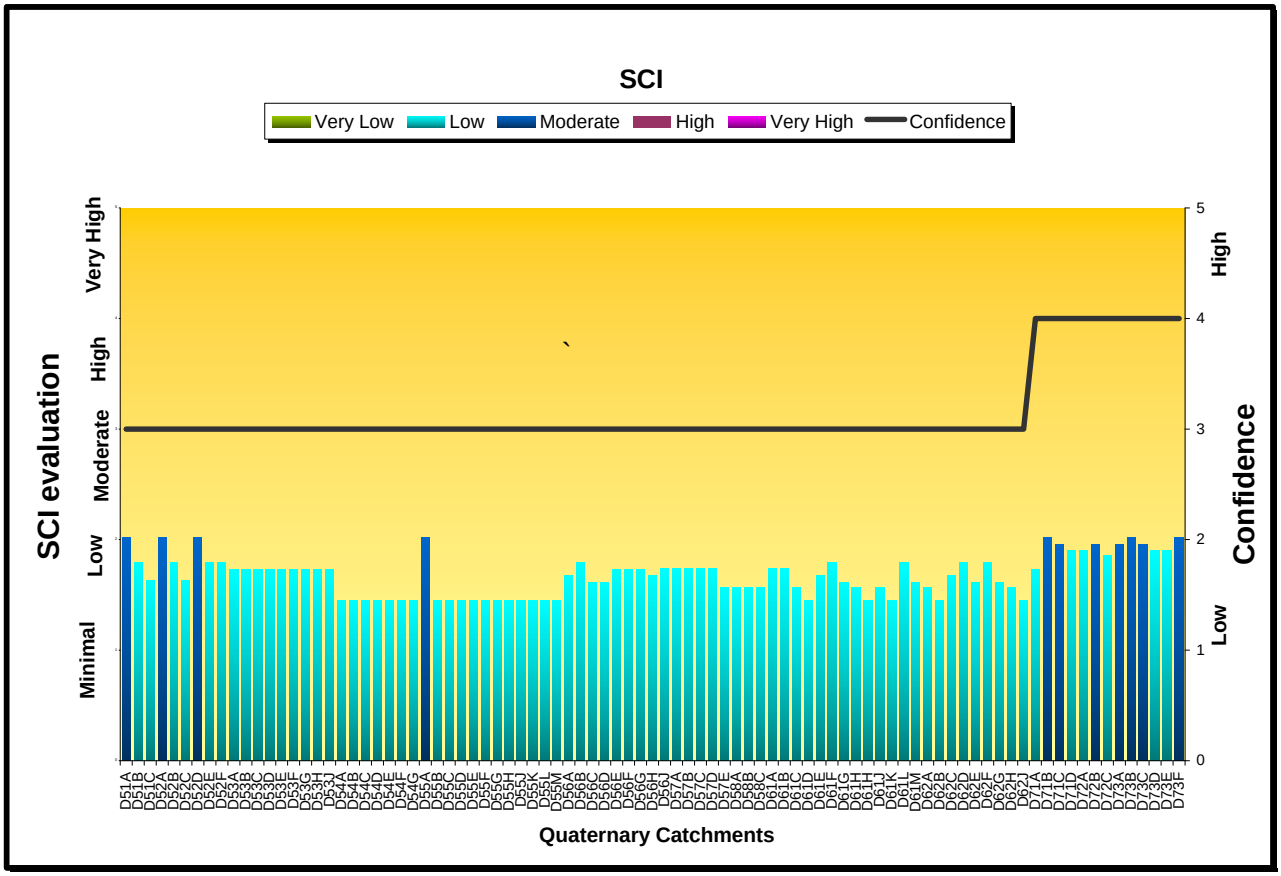


Figure 7.6 SCI and confidence evaluation illustrated as bar graphs (BASIN 3)

7.5 ORANGE RIVER CATCHMENT FROM THE HARTBEES CONFLUENCE TO THE ESTUARY (BASIN 4)

This section includes the D8 catchments in South Africa and the Namibian tributaries excluding the Fish River.

The results are provided as follows:

- Summarised EIS per river reach (Table 7-7);
- Bar graphs (Figure 7.7); and
- Maps (Figure 7.13).

Table 7-7 Summarised SCI results per quaternary catchment (BASIN 4)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D81A	Orange	LOW	4
D81B	Orange	LOW	4
D81C	Brak R (SA & Namibia)	LOW	3
D81D (1026	Orange: Daberas to Skuitdrift	LOW	4
D81E (1026_45)	Orange: Skuitdrift to Onseepkans	MODERATE	3
D81F (1045)	Orange: Onseepkans to Pella	LOW	3
D81G	Orange: Pella to Klein Pella	MODERATE	3
D82A (1048_50)	Orange: Klein Pella to Goodhouse	LOW	3
D82B	(Endorheic)	LOW	4
D82C	(Endorheic)	LOW	4
D82D	Orange: Pella to Henkries	LOW	4

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D82E	Orange	MODERATE	4
D82F	Orange: Vioolsdrift	MODERATE	4
D82G	Orange	LOW	4
D82H	Orange: Stinkfontein se Rivier	LOW	4
D82J	Orange: Aussenkeer	MODERATE	4
D82K	Orange: Sendlinsdrift to Annisrivier confl	MODERATE	4
D82L	Orange: Annisrivier to mouth	HIGH	4
1005 (1)	Keinab	LOW	2
1005 (2)	Keinab	LOW	2
1017	Gamkab	LOW	2
1020	Ham	LOW	2
1032	Haib	LOW	2
1014	Hom	LOW	2

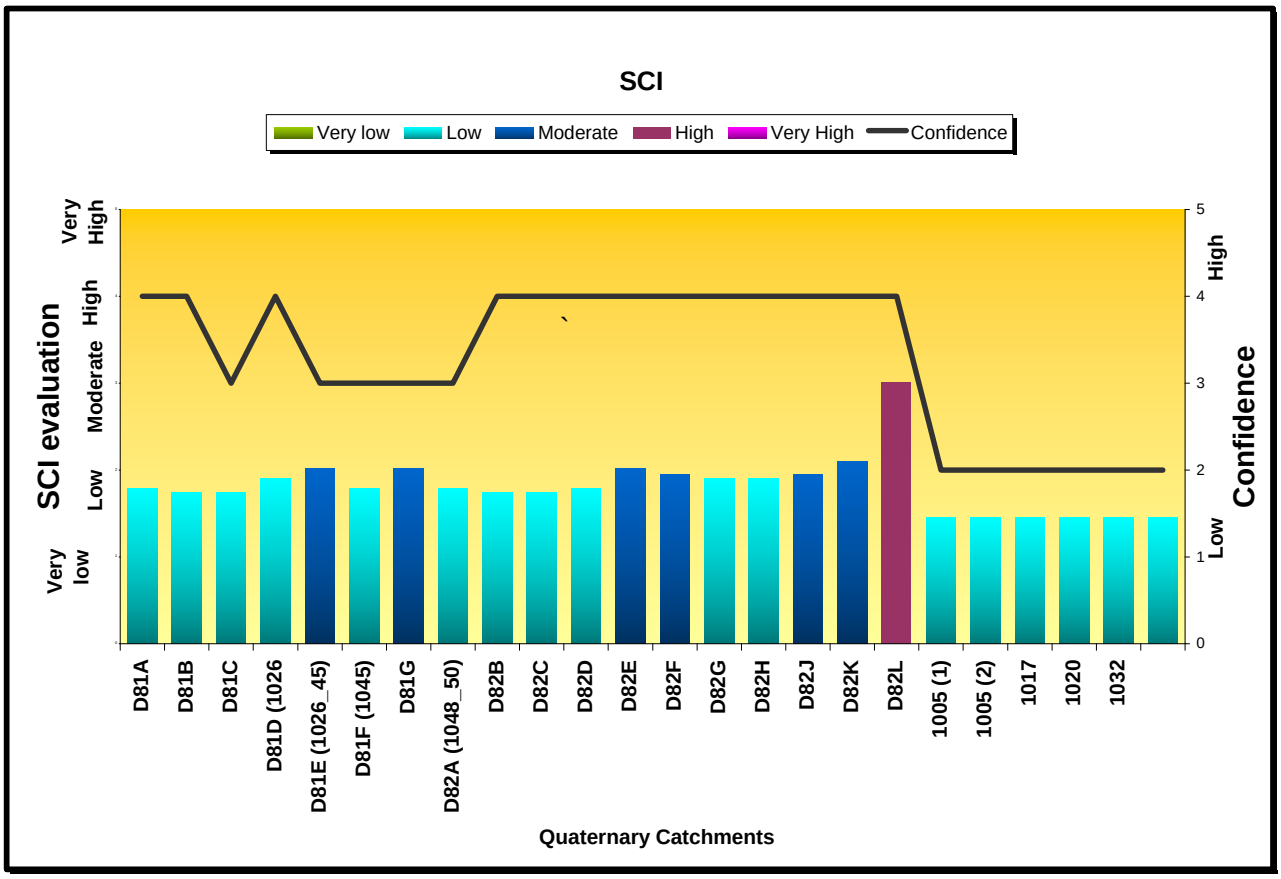


Figure 7.7 SCI and confidence evaluation illustrated as bar graphs (BASIN 4)

7.6 MOLOPO CATCHMENT (BASIN 5)

This area excludes the Nossob River and includes the D4 catchments in South Africa and the Botswana tributaries.

The results are provided as follows:

- Summarised EIS per river reach (Table 7-8);
- Bar graphs (Figure 7.8); and
- Maps (Figure 7.14).

Table 7-8 Summarised SCI results per quaternary catchment (BASIN 5)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
D41A_R1	Molopo: From Source (eye) to barrier:	HIGH	2.0
D41A_R2	Molopo: R1 end to R2 end:	MODERATE	2.0
D41A_R3	Molopo: R2 end to start of Mafikeng	LOW	2.0
D41A_R4	Molopo: From R3 end to start of Modimola Dam	LOW	2.0
D41A_R5	From Modimola Dam wall to start of Dinaseng Dam	LOW	2.0
D41A_R6	From Dinaseng Dam wall to end of D41A (Ramatlabama confluence on Botswana border)	LOW	2.0
D41A_Ramat	Ramatlabama confluence	LOW	2.0
D41B (957)	Molopo	MODERATE	2.0
D41B	Setlagoli	MODERATE	2.0
D41C (959)	Molopo	MODERATE	2.0
D41C	Wildebeeshoringlaagte	LOW	2.0
D41D	Thakgamenglaagte	LOW	2.0
D41E	Molopo	MODERATE	2.0
939	Mosolebe	LOW	2.0
941	Mosolebe	LOW	2.0
942 to confl	Mosolebe	MODERATE	2.0
926	Ukhwi	LOW	2.0
921	Malotswana	LOW	2.0
D41F (935)	Molopo	LOW	2.0
D41F	Phepane	LOW	2.0
D41G	Moshaweng	LOW	2.0
D41H	Kgokgole	LOW	2.0
D41H(944)	Molopo	LOW	2.0
D41J	Ga-Mogana	LOW	2.0
D41K	Ga-Mogana	LOW	2.0
D41L	Kuruman Eye	MODERATE	2.0
D41M	Kuruman	LOW	2.0
D42C	Kuruman	MODERATE	2.0
D42C	Molopo	LOW	2.0
D42D	Molopo	LOW	2.0
D42E	Molopo	LOW	2.0

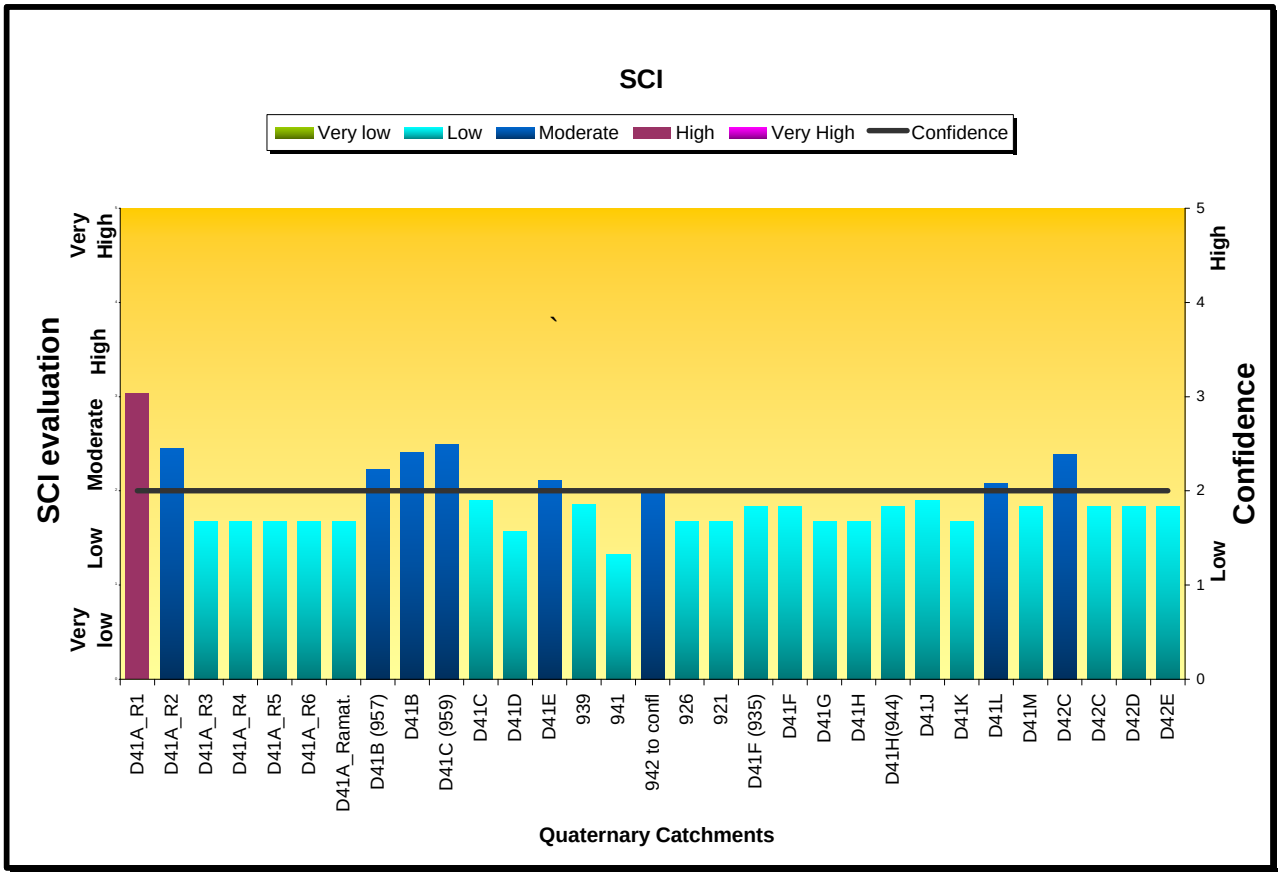


Figure 7.8 SCI and confidence evaluation illustrated as bar graphs (BASIN 5)

7.7 FISH AND NOSSOB RIVERS (BASIN 6)

The results are provided as follows:

- Summarised EIS per river reach (Table 7-9);
- Bar graphs (Figure 7.9); and
- Map (Figure 7.15).

Table 7-9 Summarised SCI results per quaternary catchment (BASIN 6)

QUAT	RIVER	SCI	CONFIDENCE (0-5)
855	Black Nossob	MODERATE	4.0
861	Wit Nossob	MODERATE	4.0
890	Nossob	MODERATE	3.0
D42A (910)	Nossob	HIGH	3.0
D42B (960)	Nossob	MODERATE	3.0
873	Olifants	LOW	3.0
898	Auob	LOW	3.0
D42A (946)	Auob	HIGH	3.0
899	Nabob	LOW	3.0
904b	Fish to Kam confl	MODERATE	3.0
904a	Kam to Fish confl	MODERATE	3.0
904c	Fish DS from Kam confl to Goma-Aub	HIGH	3.0
917 a	Fish to Hardap Dam	HIGH	3.0
917 b	Fish: Dam wall to Hudob-Lewer confl	HIGH	4.0
930	Hudob to Fish confidence	MODERATE	3.0

933	Asab	LOW	3.0
955	Kannibes	MODERATE	3.0
969	Fish	HIGH	3.0
976	Naute	LOW	3.0
987	Lowen	LOW	3.0
990c	Lowen to Naute Dam	LOW	3.0
990b	Lowen DS of Naute Dam	LOW	3.0
990a	Fish (Aub to start of Canyon	MODERATE	3.0
962	Konkipe	MODERATE	3.0
1009	Fish (Canyon to confluence)	HIGH	4.0
885	Osib	VERY LOW	1.0
883	Skaap	VERY LOW	1.0
969	Aub	VERY LOW	1.0

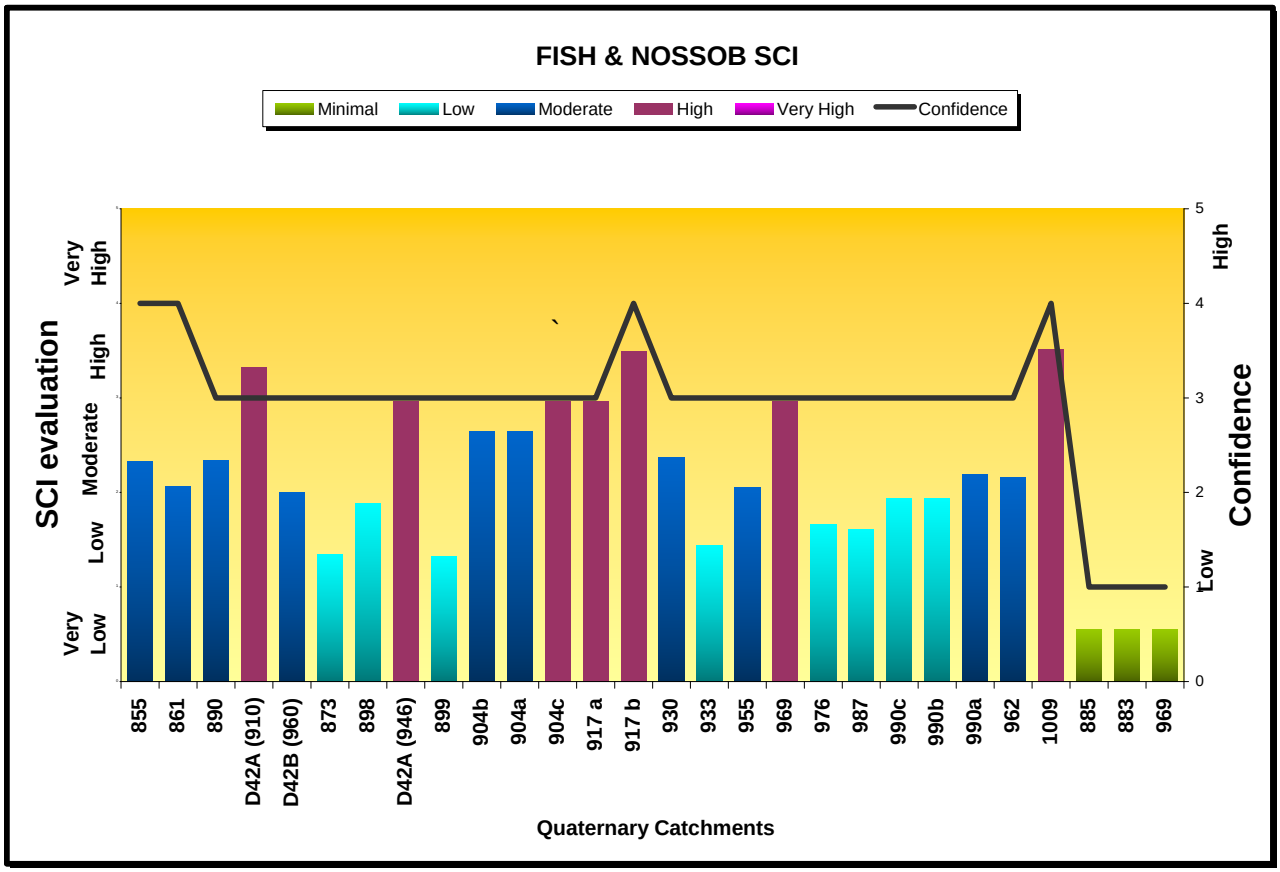
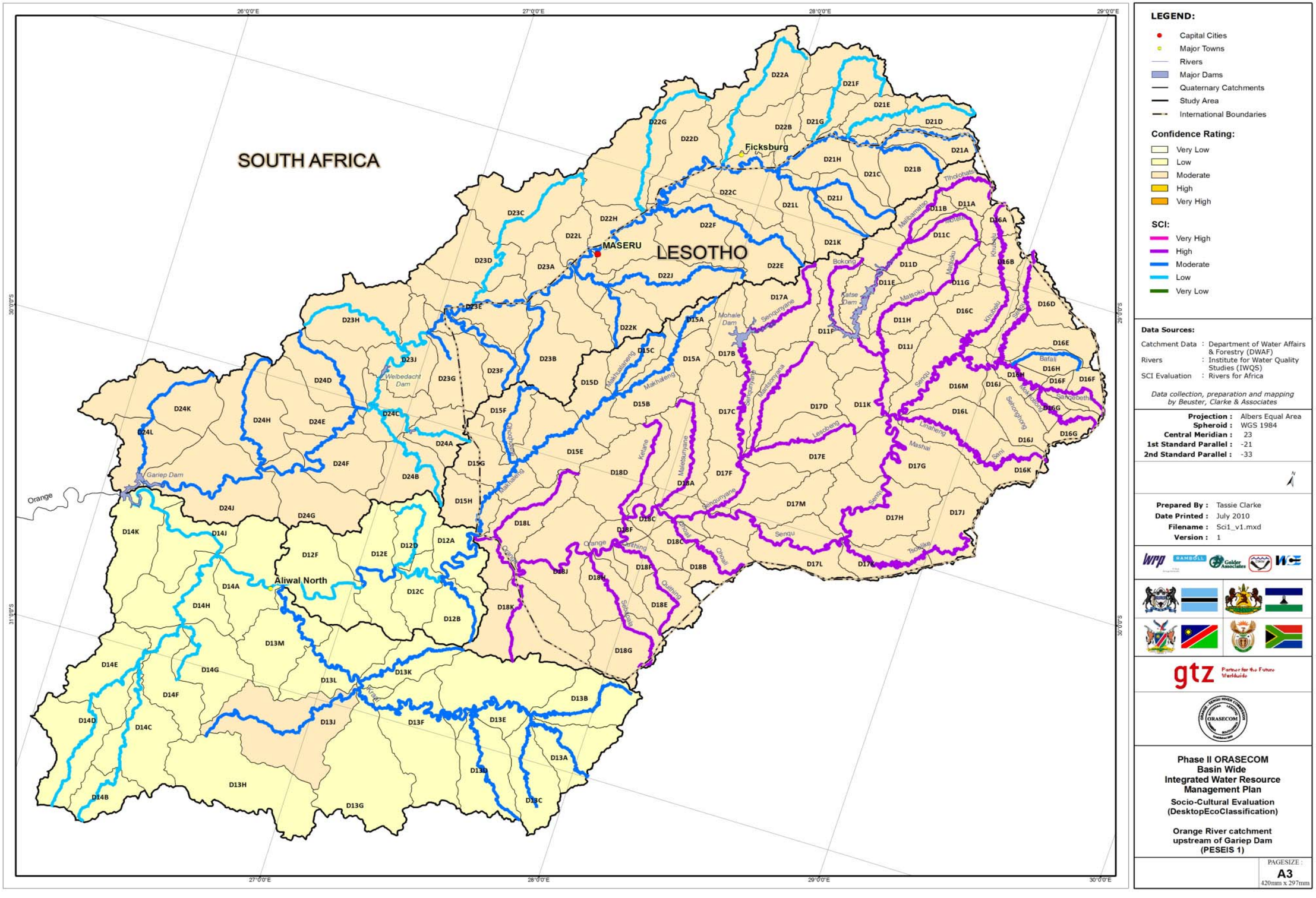


Figure 7.9 SCI and confidence evaluation illustrated as bar graphs (BASIN 6)



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Confidence Rating:

- Very Low
- Low
- Moderate
- High
- Very High

SCI:

- Very High
- High
- Moderate
- Low
- Very Low

Data Sources:

Catchment Data : Department of Water Affairs & Forestry (DWAF)
Rivers : Institute for Water Quality Studies (IWQS)
SCI Evaluation : Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Sci1_v1.mxd
Version : 1

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Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan
Socio-Cultural Evaluation (DesktopEcoClassification)

Orange River catchment upstream of Gariep Dam (PESEIS 1)

PAGESIZE : **A3** 420mm x 297mm

Figure 7.10 BASIN 1 map illustrating the SCI results

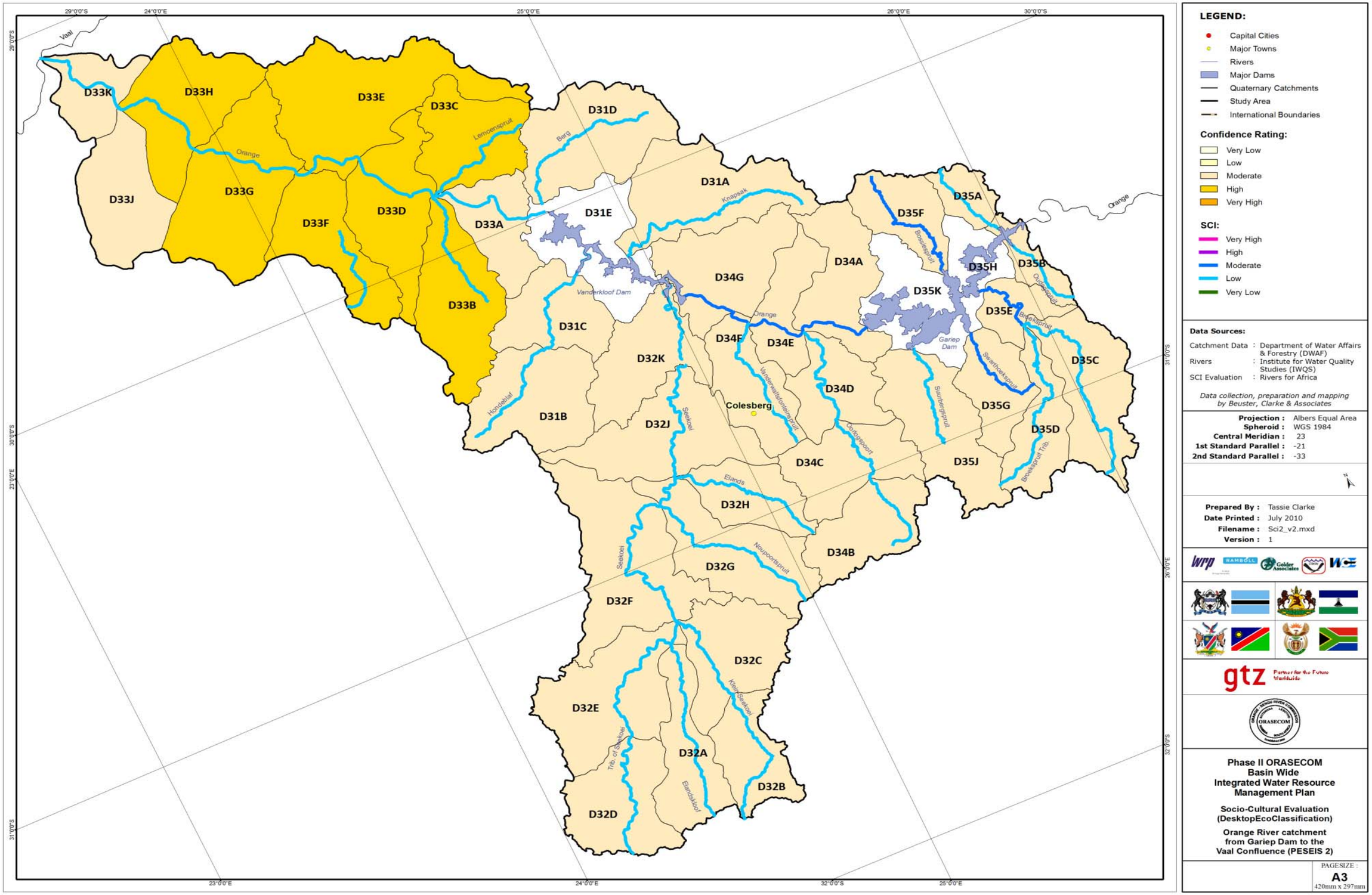


Figure 7.11 BASIN 2 map illustrating the SCI results

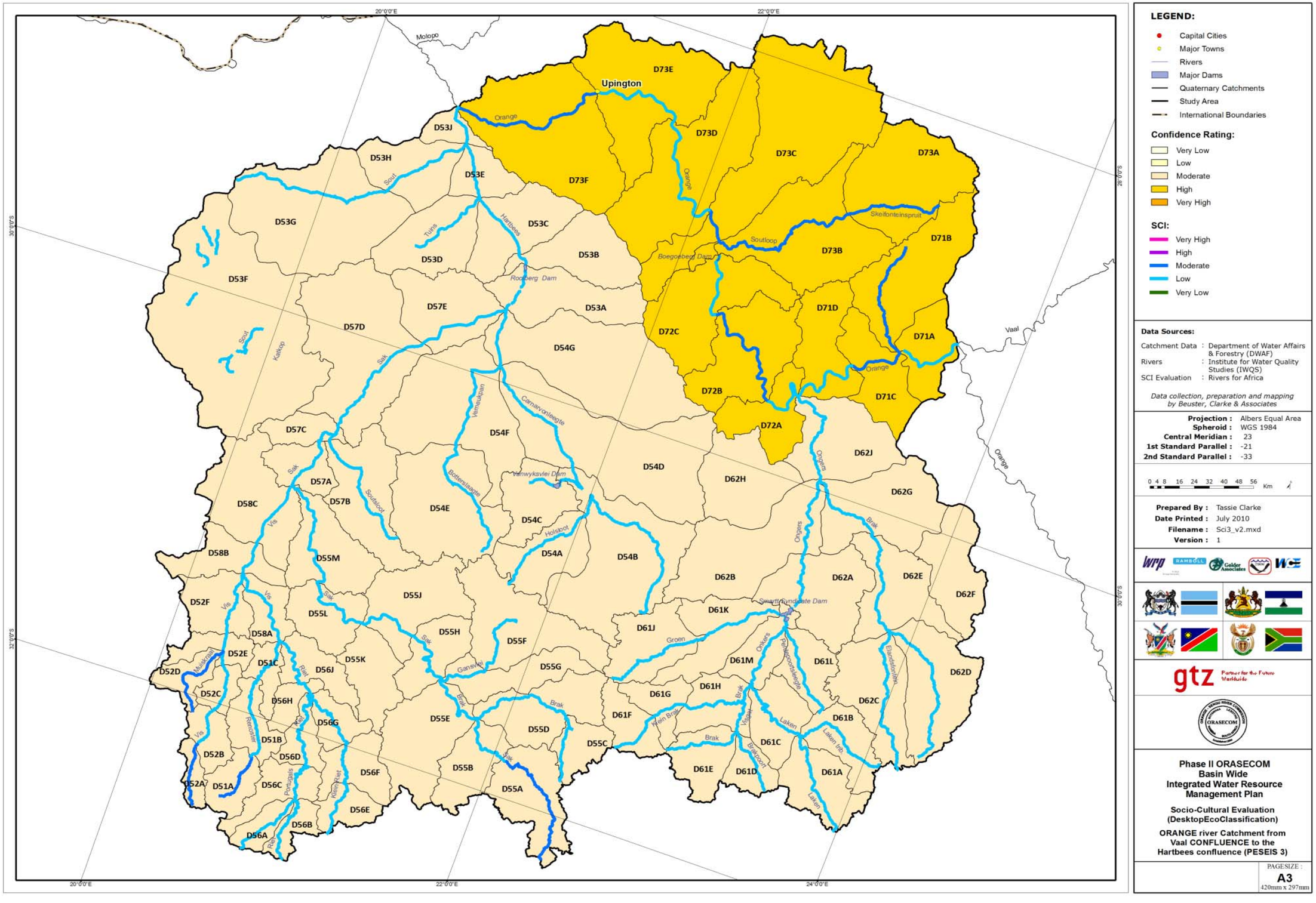
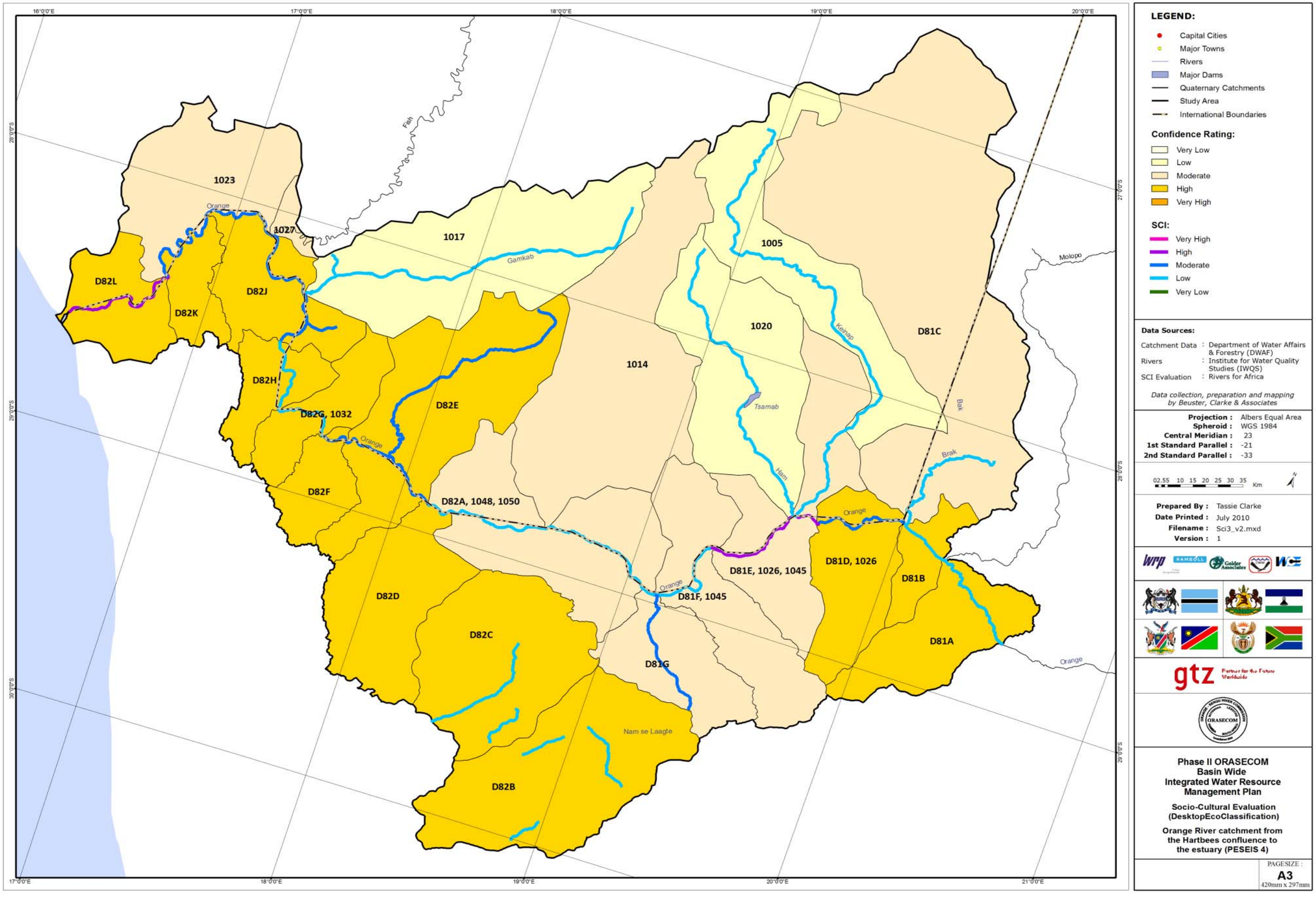


Figure 7.12 BASIN 3 map illustrating the SCI results



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Confidence Rating:

- Very Low
- Low
- Moderate
- High
- Very High

SCI:

- Very High
- High
- Moderate
- Low
- Very Low

Data Sources:

Catchment Data	:	Department of Water Affairs & Forestry (DWAF)
Rivers	:	Institute for Water Quality Studies (IWQS)
SCI Evaluation	:	Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

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Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Sci3_v2.mxd
Version : 1

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Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Socio-Cultural Evaluation (DesktopEcoClassification)

Orange River catchment from the Hartbees confluence to the estuary (PESEIS 4)

PAGESIZE : **A3** 420mm x 297mm

Figure 7.13 BASIN 4 map illustrating the SCI results

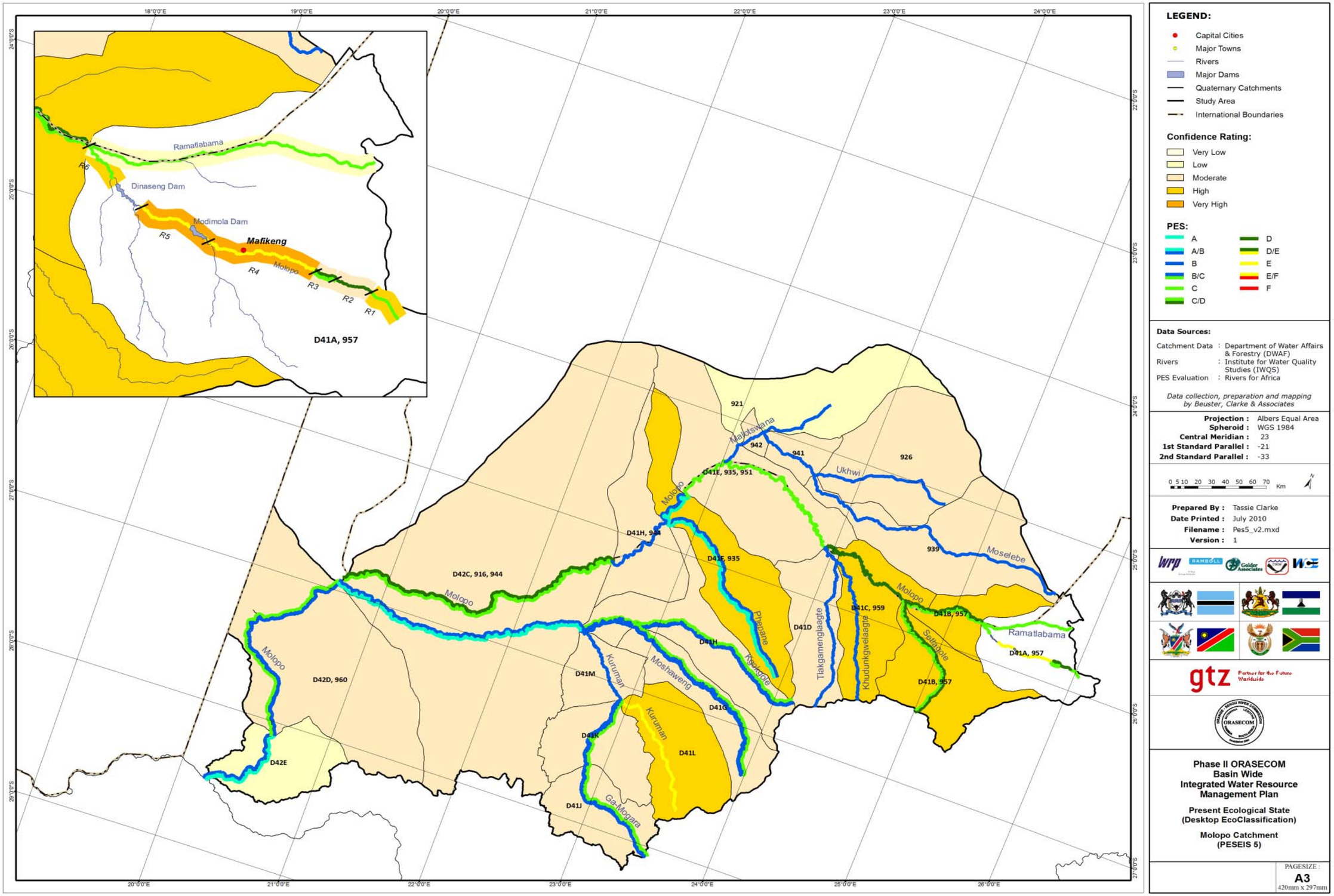


Figure 7.14 BASIN 5 map illustrating the SCI results

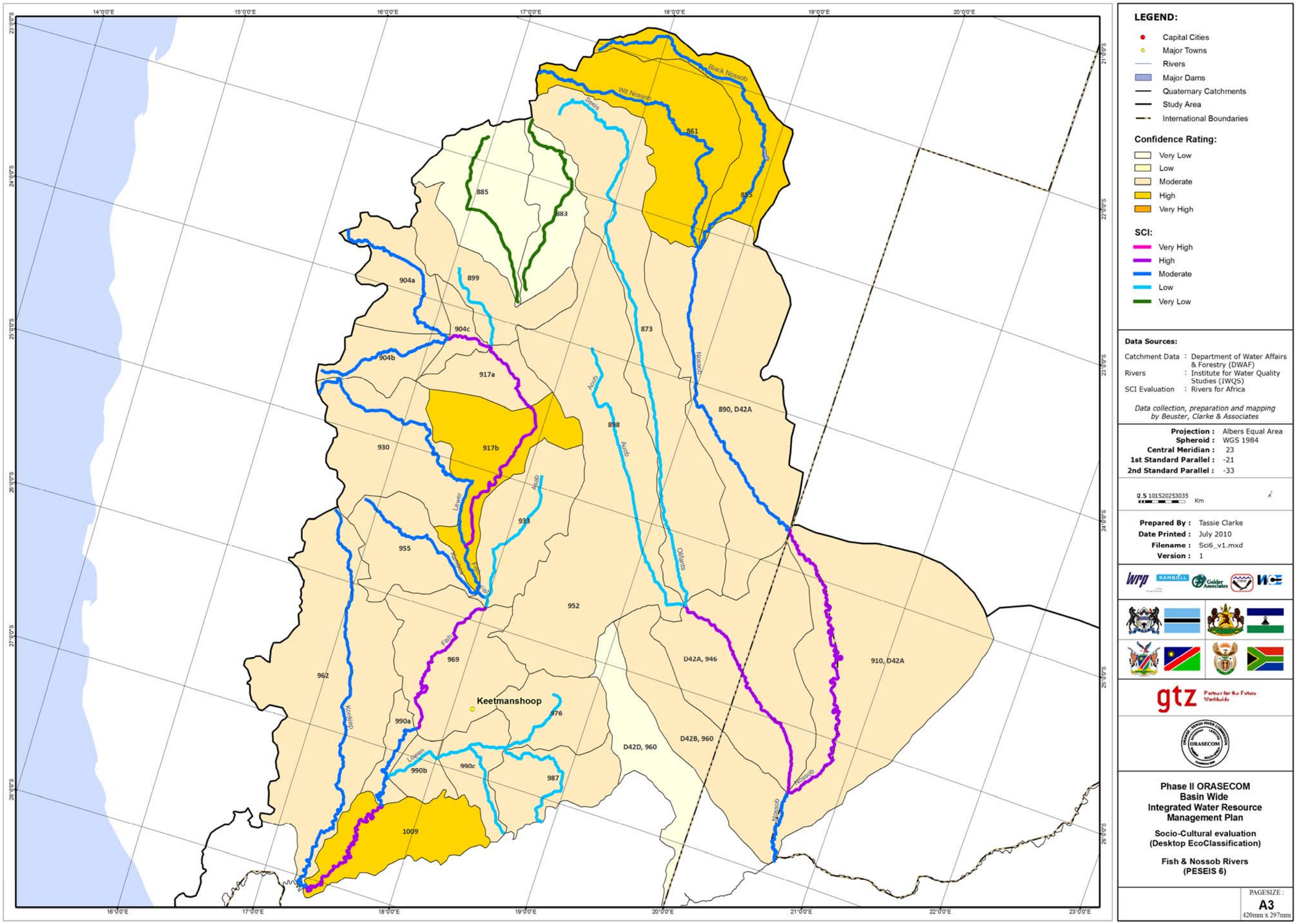


Figure 7.15 BASIN 6 map illustrating the SCI results

7.8 SUMMARY

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai
In the Lesotho highlands the Socio-Cultural Importance ratings are mostly High. The marginal nature of the Lesotho Highland society is one that dictates that there is close dependence on the resources of the area.

In the Caledon and Kraai River Basin s, characterised by farmlands and rural settlements combined with the subsistence farming areas of some of the former homelands and Lesotho, the influence of the Lesotho areas and rural settlements elevates many of the scores to Moderate (in fact the higher end of the Moderate range). However, the generally degraded nature of the Caledon and Kraai Rivers and associated riparian zones and in particular the perceived water quality issues, mean that the utilisation of the area (from a socio-cultural perspective) is not as high as it may have been historically.

In the remaining section of this unit includes the farmlands of the Eastern Cape and Free State, combined with the subsistence farming areas of some of the former homelands. As with the Caledon, the degraded nature of the area means that the utilisation of the area (from a socio-cultural perspective) is not as high as it may have been historically.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence
The quaternary areas and associated river reaches vary from Low to Moderate in the catchment section and are similar in many respects to BASIN 3, even though population densities are somewhat higher. Scores are dominated by those in the Low category as the area is generally utilised for farming (predominately extensive but with some intensive irrigation) and ancillary associated economic activities. With Low dependence on the riverine resources for livelihood, subsistence agriculture, combined with Low to relatively Moderate population densities; very few of the quaternary catchments display characteristics that would elevate the scores.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence
The SCI varies from Low to Moderate. Ratings are dominated by a Low category as the area is generally utilised for farming (predominately extensive but with some intensive irrigation) and ancillary associated economic activities. With Low dependence on the riverine resources for livelihood, subsistence agriculture combined with Low to relatively Moderate population densities, very few of the quaternary catchments display characteristics that would elevate the scores.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary
The SCI varies from Low to Moderate. The exception is the Orange River Mouth that scores High with respect to recreational usage, aesthetic value as well as historical and cultural value. The relatively low population densities of the rest of the catchment mean that socio-cultural importance is generally low.

Basin 5: Molopo River
The SCI varies from Low to Moderate in the catchment section. The reasons for this are mainly the relatively low population densities, the generally low intermittent nature of the riverine sections and the commercial nature of the area. The exception is the Kuruman Eye that has high recreational value (given the surrounding park area) and also scored relatively high with respect to aesthetic quality.

Basin 6: Fish and Nossob catchments

The SCI varies from Low to Moderate. This is not surprising given the relatively intermittent flows that generally preclude socio-cultural dependencies, combined with low population densities and overall utilisation. Two notable exceptions are D42A (910 - Nossob) and 1009 (Fish). The Fish River section scored very high in terms of recreational and aesthetic values. The Nossob section scored very high in terms of recreational usage and scored relatively high in terms of aesthetic value and resource dependence.

8 PRESENT ECOLOGICAL STATE RESULTS

8.1 ELECTRONIC DATABASE

The electronic database is provided on a CD.

The columns are explained below:

- Column A: Quaternary catchment;
- Column B: River name;
- Column C - R: Quick Habitat Integrity metrics (rating provided from 0 (no change from reference conditions) to 5 (critical changes from reference condition));
- Column V: Quick Habitat Integrity (calculated in spreadsheet);
- Column W: Desktop Invertebrate rating (value provided from 0 – 5);
- Column X: Desktop Invertebrate % (calculated in spreadsheet);
- Column Z: Desktop Fish rating (value provided from 0 – 5);
- Column AA: Desktop Fish % (calculated in spreadsheet);
- Column AC: Instream EC % (calculated in spreadsheet);
- Column AE: Instream EC (calculated in spreadsheet);
- Column AF: Desktop Riparian vegetation rating (value provided from 0 – 5);
- Column AG: Desktop Riparian vegetation % (calculated in spreadsheet);
- Column AI: EcoStatus percentage (calculated in spreadsheet);
- Column AK: EcoStatus EC (calculated in spreadsheet);
- Column AL: Confidence evaluation out of 5;
- Column AM: Source and comments relevant; and
- Column AN to AZ: Represents columns to provide the exact percentage if models were used during previous studies associated with Level 3 and 4 EcoClassification.

8.2 ORANGE CATCHMENT EIS UPSTREAM OF GARIEP DAM (BASIN 1)

This basin has been divided in to four smaller units for the purposes of tabulated and graphical information. The graphs and tables display results for the four sub-basins as follows:

- Basin 1_LesothoOrange: The Orange River within Lesotho (Table 8.1; Figure 8.1);
- Basin 1_Orange: The Orange River outside Lesotho (Table 8.2; Figure 8.2);
- Basin 1_Caledon: The Caledon River catchment (Table 8.3; Figure 8.3);
- Basin 1_Kraai: The Kraai and Stormbergspruit catchments (Table 8.4; Figure 8.4);

The map showing the results of the PES assessment (Figure 8.10) displays the results for the whole of BASIN 1.

8.2.1 Orange River EIS within Lesotho (BASIN 1_LesothoOrange)

Table 8-1 Summarised PES results per quaternary catchment (BASIN 1_LesOrange)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D11A	Tholatzi	A/B	4
D11B	Malibamatso	C	4
D11C	Motete	C	4
D11F	Bokong (Section not inundated by Katse)	B	2.5
D11G	Matsoku	C	4
D11H	Matsoku (includes the portion in D11J to the Orange confluence)	C	4
D11J	Malibamatso	D	4
D11K	Malibamatso	C	4
D15A	Makhaleng (source to Likolobeng)	A/B	2.5
D15A	Makhaleng (DS of Likolobeng confl)	B/C	2
D15B	Makhaleng	C	2
D15C	Makhaleng tributary	C	1
D15D	Makhaleng	C/D	1
D15E	Makhaleng	C	4
D15F	Ohoqhoane	C	1
D15G	Makhaleng	D	1.5
D15H	Makhaleng	D	1.5
D16A	Khubelu	A/B	4
D16B	Khubelu	A/B	4
D16C	Khubelu	B/C	2
D16D	Senqu	A/B	4
D16E	Senqu	C	3
D16F	Sanqebethu upper source area	A/B	1
D16F	Sanqebethu lower grazed area	C	2
D16G	Mokhotlong (upper source area)	A/B	1
D16G	Mokhotlong (lower more disturbed - agriculture - area)	C	2.5
D16H	Mokhotlong	C	3
D16H	Bafali	A/B	2
D16J	Sehonghong (upper undisturbed section)	A/B	1
D16J	Sehonghong (lower disturbed section)	C	1
D16K	Sani (focussing on Sani River from the border post that includes the large wetland	C	2.5
D16 L	Linaheng	D	1
D16M	Senqu	C	3
D17A	Senqunyane	B	2.5
D17B	Senqunyane (DS of Mohale)	C	4
D17C	Senqunyane	B/C	4
D17D	Mantsonyana	B/C	2
D17 E	Lesobeng	C	2
D17 F	Senqunyane	C	4

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D17 G	Senqu (incl Mashai confl)	B/C	4
D17 H	Senqu (Orange)	B/C	4
D17 J	Tsoelike (Sehlabathebe, disturbed areas assessed in lower quat).	A	5
D17 K	Tsoelike	C	2
D17 L	Senqu (Orange)	B/C	4
D17 M	Senqu (Orange)	B/C	4
D18A	Maletsanyane	C	1
D18B	Qhoali (undisturbed section - lower disturbed section same as D18C	A/B	1
D18C	Qhoali	E	1
D18C	Orange	C/D	2
D18D	Ketane	C	1
D18E	Quithing (undisturbed section - lower disturbed section same as D18F	A/B	1
D18F	Quithing	E	1
D18F	Orange	D	3
D18G	Sebapala (undisturbed section - lower disturbed section same as D18H	A/B	1
D18H	Sebapala	E	1
D18J	Orange	D	3
D18K	Blikana	D	2
D18L	Orange	D	3

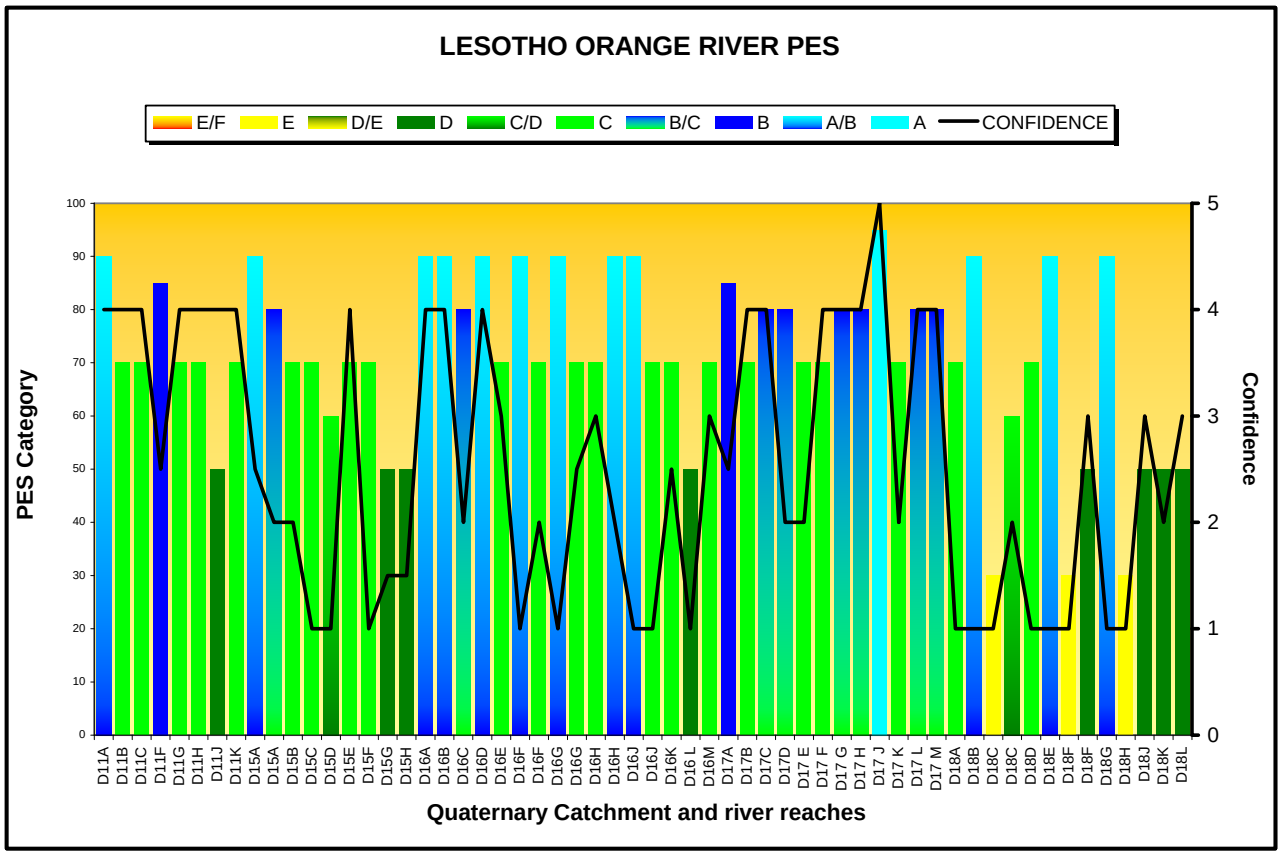


Figure 8.1 PES and confidence evaluation illustrated as bar graphs (BASIN 1_LesOrange)

8.2.2 Orange River PES outside Lesotho (BASIN 1_Orange)

Table 8-2 Summarised PES results per quaternary catchment (BASIN 1_Orange)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D12A	Orange	D	2
D12B	Kromspruit	C	2
D12C	Orange	C	2
D12D	Trib.	C/D	2
D12E	Orange	C/D	2
D12F	Orange	C/D	2
D14A	Orange	D	2
D14B	Stormbergspruit/Trib	D	2
D14C	Stormbergspruit/Trib	D	2
D14D	Bamboesbergspruit	D/E	2
D14E	Bamboesbergspruit	D/E	2
D14F	Lower Stormbergspruit	D	2
D14G	Witkopspruit	C/D	2
D14H	Lower Stormbergspruit	D	2
D14J	Orange (main stem)	C/D	2
D14K	Orange (main stem)	C	3

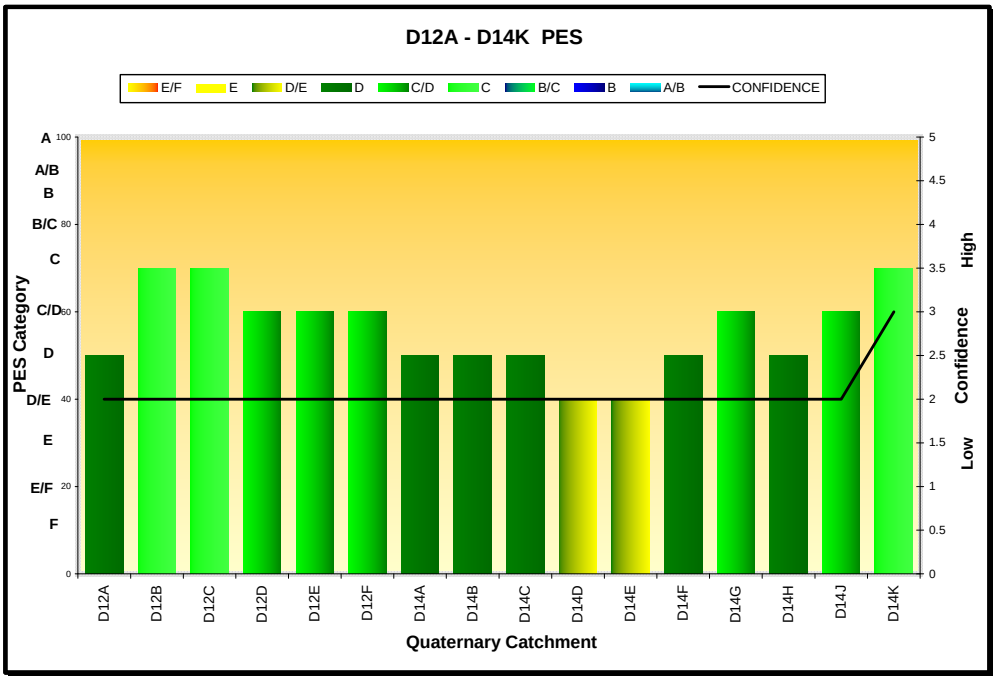


Figure 8.2 PES and confidence evaluation illustrated as bar graphs (BASIN 1_Orange)

8.2.3 Caledon River PES (BASIN 1_Caledon)

Table 8-3 Summarised PES results per quaternary catchment (PESIES 1_Caledon)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D21A	Caledon	C	3
D21B	Hololo (Lesotho)	C/D	2
D21C	Caledon (main stem)	D	3
D21D	Little Caledon	C	3.5
D21E	Little Caledon	D	2
D21F	Brandwater	D	3
D21G	Brandwater	C/D	3
D21H	Caledon (main stem)	D	3
D21J	Hlotse Trib	C	2
D21K	Morotong	D	2
D21L	Hlotse	D	2
D22A	Meulspruit	D	2
D22B	Meulspruit	D	2
D22C	Caledon (main stem)	D	2
D22D	Caledon (main stem)	E	2
D22E	Liotioaneng	D	2
D22F	Phuthiatsana	D	2
D22G	Mopeli	E	2
D22H	Main stem Caledon	D	2
D22J	Phutiatsane	C	3
D22K	Korokara	D	2
D22L	Phutiatsane - lower (outside of gorge)	C/D	2
D22L	Main stem Caledon	D/E	2
D23A	Main stem Caledon	D	2
D23B	Tsoaneng	E	2
D23C	Leeuspruit (US of Armenia Dam)	D	2
D23D	Leeuspruit	D	2
D23E	Main stem Caledon	D/E	2
D23F	Tsa-Kholo	D	2
D23G	Sandspruit	D/E	2
D23H	Rietspruit (US of Knelpoort)	D	2
D23J	Caledon (main stem) (US of the Rietspruit confluence)	D	2
D24A	Witspruit US from Egmont Dam	C/D	2
D24B	Blaasbalkspruit	C	2
D24C	Caledon (main stem)	D	2

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D24D	Wilgeboomspruit	C	2
D24E	Caledon (main stem)	D	2
D24F	Caledon (main stem)	D	2
D24G	Caledon (main stem)	D	2
D24H	Skulpspruit (trib Caledon)	C	2
D24J	Caledon (main stem)	D	2
D24K	Slykspruit	C	2
D24L	Slykspruit	C	2

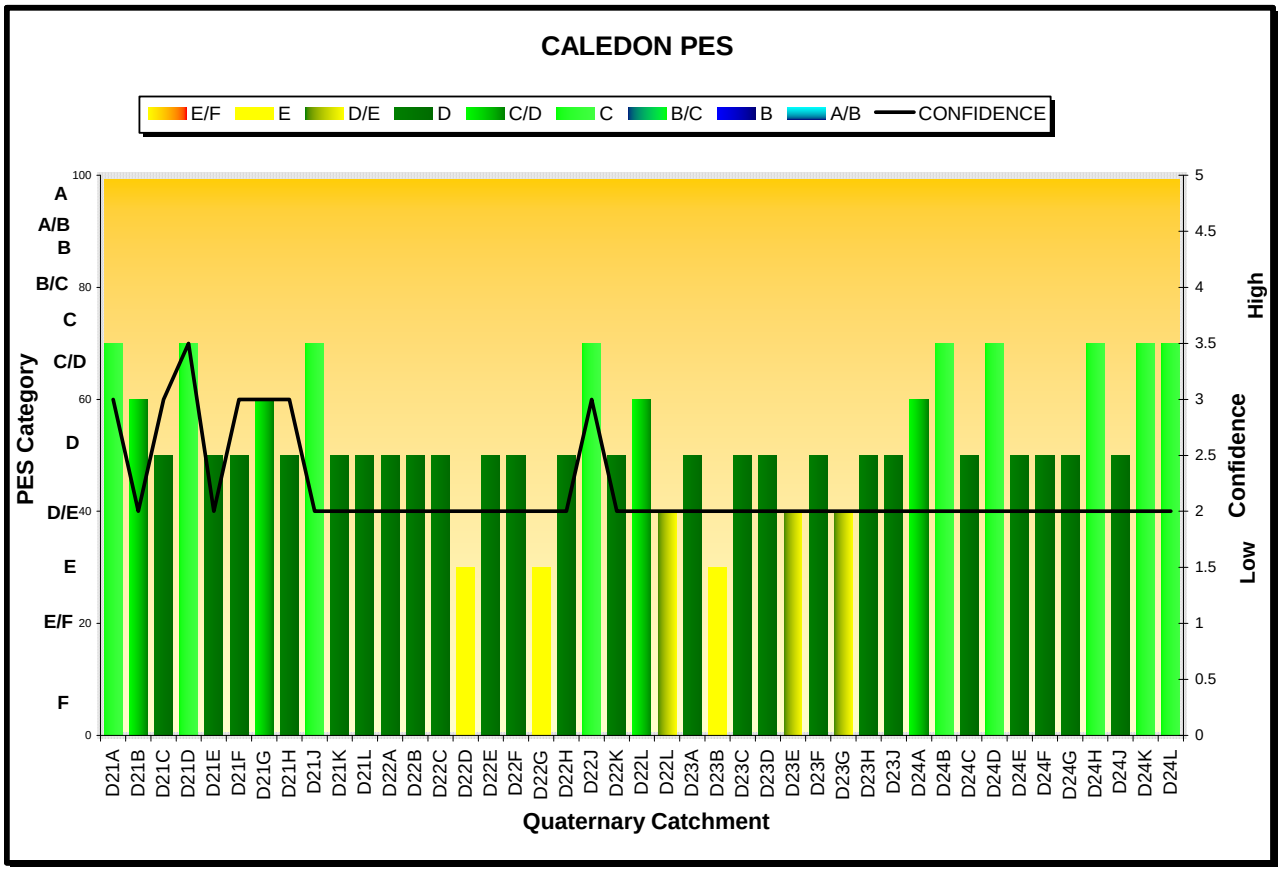


Figure 8.3 PES and confidence evaluation illustrated as bar graphs (PESIES 1_Caledon)

8.2.4 Kraai and Stormbergspruit PES (BASIN 1_Kraai)

Table 8-4 Summarised PES results per quaternary catchment (BASIN 1_Kraai)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D13A	Bokspruit	B/C	3
D13B	Kraai (goes into D13E)	B/C	4
D13C	Sterkspruit	C	2
D13D	Langkloof	C	2
D13E	Kraai (main stem)	C	2
D13F	Kraai (main stem)	C	2
D13G	Kraai (main stem)	B/C	2
D13H	Holspruit	C	2
D13J	Holspruit	C	2
D13K	Kraai trib	C	2
D13L	Kraai (main stem)	C	3
D13M	Kraai (main stem)	D	4

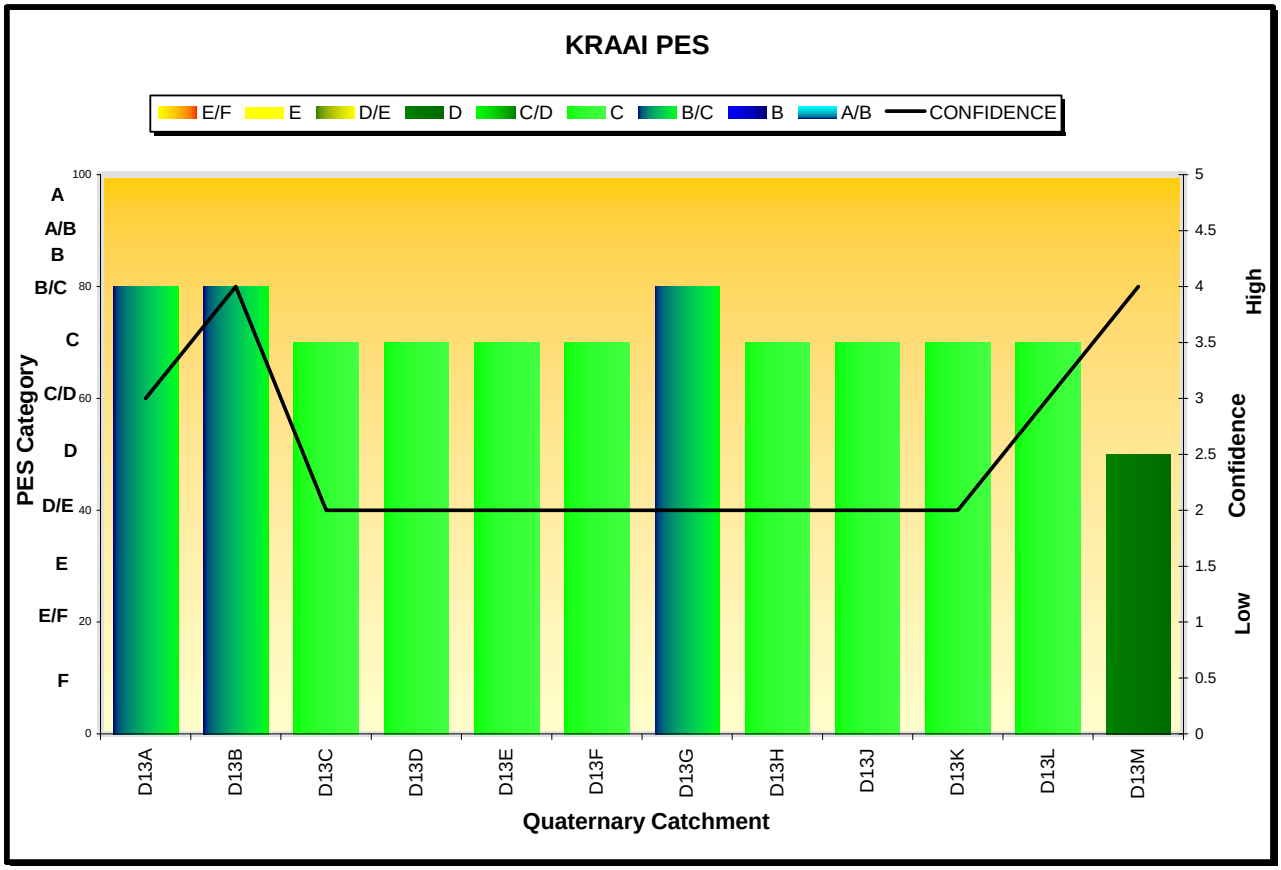


Figure 8.4 EIS and confidence evaluation illustrated as bar graphs (BASIN 1_Kraai)

8.3 ORANGE CATCHMENT FROM GARIEP DAM TO THE VAAL CONFLUENCE (BASIN 2)

This area includes the D3 catchments.

The results are provided as follows:

- Summarised PES per river reach (Table 8-5);
- Bar graphs (Figure 8.5); and
- Maps (Figure 8.11).

Table 8-5 Summarised PES results per quaternary catchment (BASIN 2)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D31A	Knapsak	B	2
D31B	Hondeblaf	B	2
D31C	Hondeblaf	B	2
D31D	Berg	B	1.5
D32A	Elandskloof	C	1
D32B	Klein Seekoei	C	1
D32C	Klein Seekoei	C	1
D32D	Trib of Seekoei	B	1
D32E	Trib of Seekoei	B	1
D32F	Seekoei	B	1
D32G	Noupoortspruit	D	2
D32H	Elands	B	2
D32J	Seekoei (incl D32G of Seekoei)	B	2
D32K	Seekoei (excl backup from Dam)	B	2
D34A	Main stem Orange	D/E	3
D34B	Oorlogspoort	A/B	2
D34C	Oorlogspoort	B/C	2
D34D	Oorlogspoort	B/C	2
D34E	Main stem Orange	D/E	3
D34F	Vanderwaltsfonteinspruit	B	2
D34G	Orange	D/E	3
D35A	Trib draining into Gariep dam (evaluated to US of backup)	B	1
D35B	Oudagspruit	A/B	1
D35C	Broekspruit	A/B	1
D35D	Broekspruit	A/B	1
D35E	Broekspruit (excluding backup)	B	1
D35F	Bossiespruit (excl backup)	B	1
D35G	Swarthoekspruit	B	1
D35J	Suurbergspruit	A/B	1
D33A	Orange (main stem)	E	3
D33B	Unnamed trib of Orange	B	2
D33C	Lemoenspruit	B/C	2
D33D	Orange	D/E	3
D33E	Orange	D/E	3
D33F	Orange trib	B	2
D33G	Orange (main stem)	D	3
D33H	Orange (main stem)	D	3

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D33J	Orange trib	A	2
D33K	Orange (main stem)	D	3

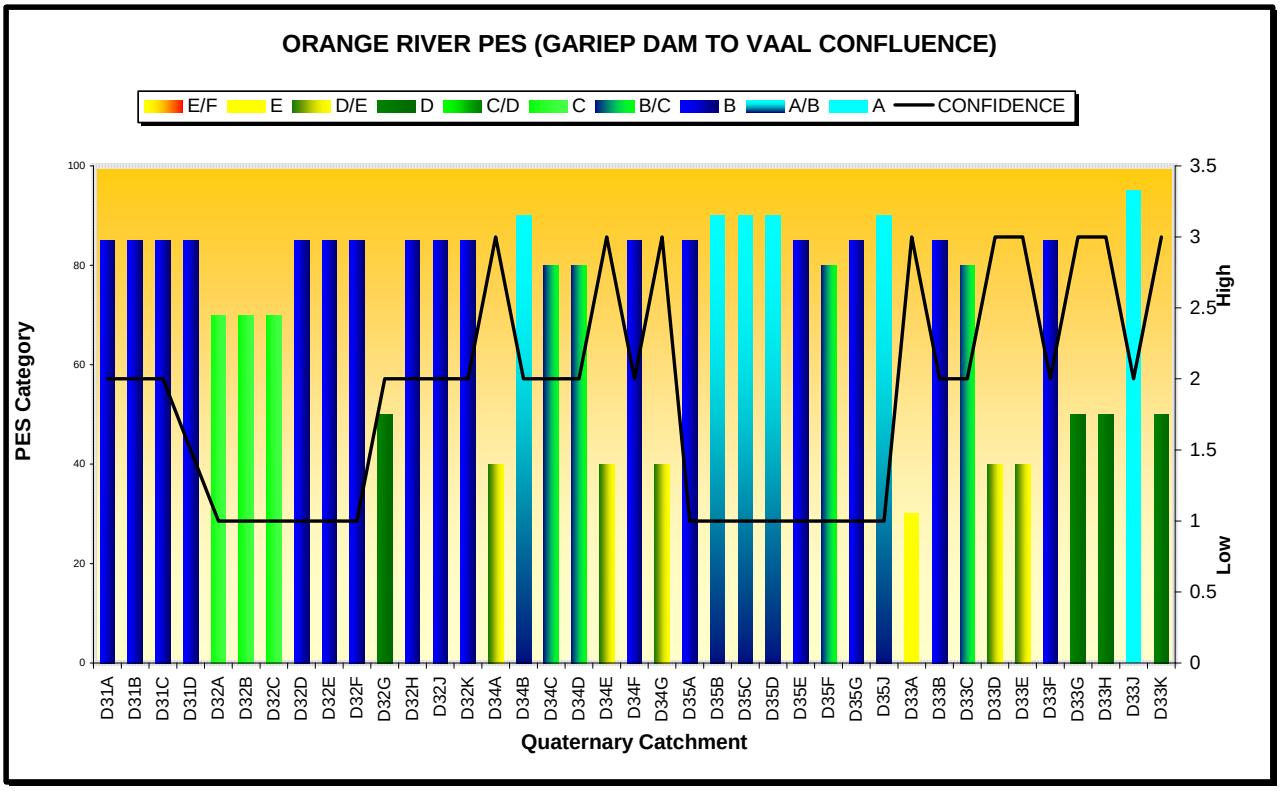


Figure 8.5 PES and confidence evaluation illustrated as bar graphs (BASIN 2)

8.4 ORANGE RIVER CATCHMENT FROM VAALCONFLUENCE TO THE HARTBEES CONFLUENCE (BASIN 3)

This area includes the D5, D6 and D7 catchments.

The results are provided as follows:

- Summarised PES per river reach (Table 8-6);
- Bar graphs (Figure 8.6); and
- Maps (Figure 8.12).

Table 8-6 Summarised EIS results per quaternary catchment (BASIN 3)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D51A	RENOSTER RIVER	B	2

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D51B	RENOSTER RIVER: Onderplaas to Sterkfontein	B/C	2
D51C	RENOSTER RIVER	B/C	2
D52A	Vis	C	2
D52B	Vis	C	2
D52C	Vis	C	2
D52D	Muiskraal	B/C	2
D52E	Vis	C	2
D52F	Vis	C	2
D53A	Hartbees	B	2
D53B	Hartbees	D	2
D53C	Hartbees: kenhardt to Tuins R confl.	B	2
D53D	Tuins	A	3
D53E	Hartbees	A/B	2
D53F	(ENDORHEIC)	A	3
D53G	Sout	A	2
D53H	Sout	A	3
D53J	Hartbees	A/B	2.5
D54A	Holsloot	B	2.5
D54B	Carnaveronleegte	B	2.5
D54C	Van Wyksvlei	A/B	2
D54D	Carnaveronleegte	B	2.5
D54E	Botterslaagte	A/B	2
D54F	Verneukpan	B	1
D54G	Hartbeespoort	B	1
D55A	SakRiver	C	2.5
D55B	SakRiver	C	2.5
D55C	BrakRiver	B	2
D55D	BrakRiver	B	2
D55E	Brak River	B/C	2
D55F	GansvleiRiver	C	2
D55G	GansvleiRiver	C	2
D55H	Sak River	B	2
D55J	Sak River	B/C	2
D55K	Klein Sak	B	2
D55L	Sak River	B/C	2
D55M	Sak River	B	2
D56A	Portugals River	A/B	2.5
D56B	Riet River	A/B	2.5
D56C	PortugalsRiver	B	2.5
D56D	PortugalsRiver	B	2.5
D56E	Klein Riet	B	2.5
D56F	Klein Riet	B	2.5
D56G	Klein Riet	B	2.5
D56H	Riet	B	2.5

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D56J	Riet	B	2.5
D57A	Sak River	C	2
D57B	Soutloot	B/C	1.5
D57C	Sak	B/C	2
D57D	Sak	B	2
D57E	Sak	B	2
D58A	Vis	B/C	2
D58B	Vis	B	2
D58C	Vis	A/B	2
D61A	Laken	C	2
D61B	Laken	C	2
D61C	Laken	C	2
D61D	Brakpoort	A/B	2
D61E	Brak	C	2.5
D61F	Klein Brak	C	2
D61G	Klein Brak	C	2
D61H	Brak	B/C	2
D61H	Visgat	A/B	2
D61J	Groen	B	2
D61K	Groen	B	2
D61L	Perdepoortsleegte	B	2
D61M	Ongers	A/B	2
D62A	Ongers	C	2
D62B	Ongers	B	2
D62C	Elandsfontein	B/C	2
D62D	Brak	B/C	2
D62E	Brak	B	2
D62F	Pans	B/C	2
D62G	Brak	A/B	2
D62H	Pans	A/B	1
D62J	Ongers	B/C	2.5
D71A	Orange	D	3
D71B	Orange trib	B	2
D71C	Orange	D	3
D71D	Orange	D	3
D72A	Orange	D	3
D72B	Orange	C	4
D72C	Orange	D/E	4
D73A	Skeifonteinspruit	A/B	2
D73B	Soutloop	A/B	2
D73C	Orange	D	4
D73D	Orange	D	4
D73E	Orange	D	4
D73F	Orange	C	4

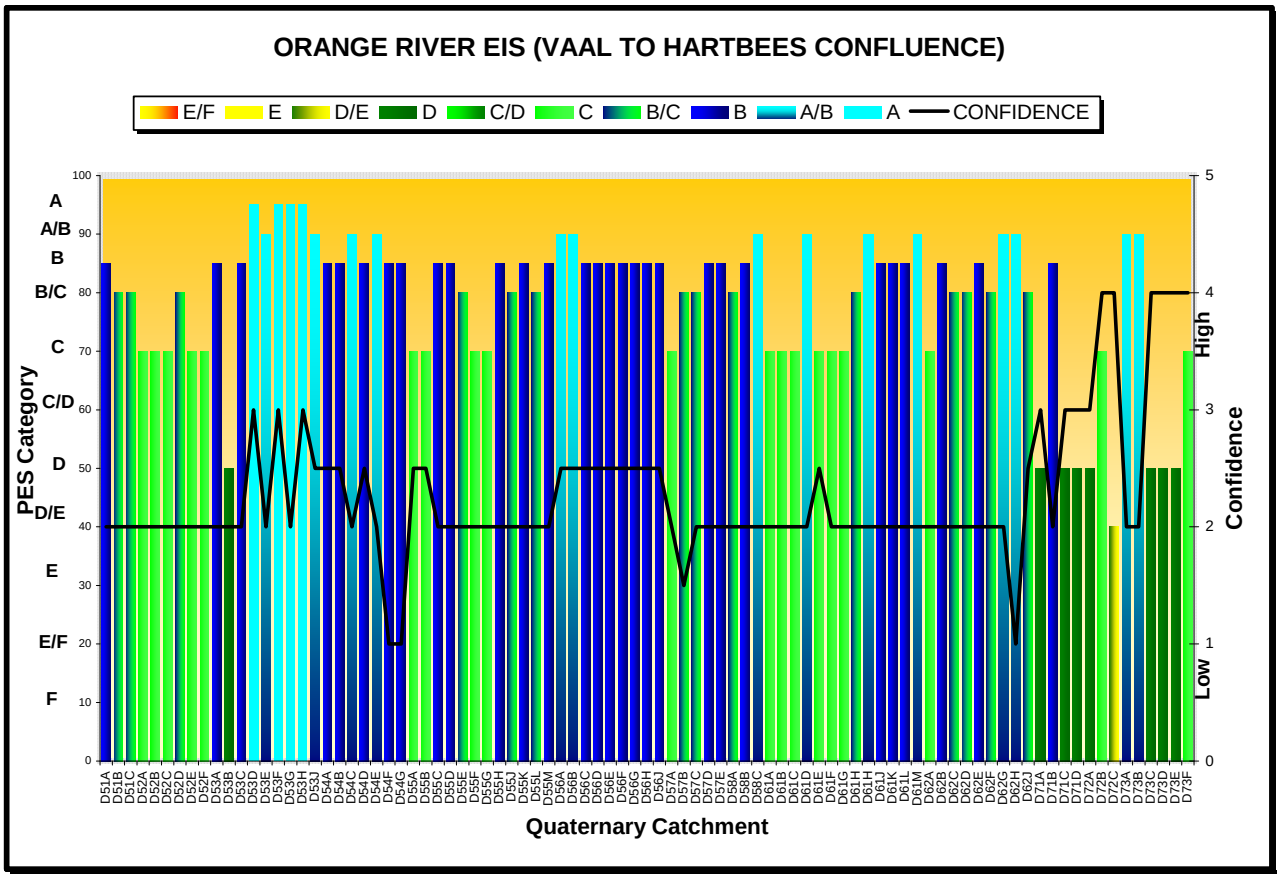


Figure 8.6 PES and confidence evaluation illustrated as bar graphs (BASIN 3)

8.5 ORANGE RIVER CATCHMENT FROM THE HARTBEES CONFLUENCE TO THE ESTUARY (BASIN 4)

This section includes the D8 catchments in South Africa and the Namibian tributaries excluding the Fish River.

The results are provided as follows:

- Summarised PES per river reach (Table 8-7);
- Bar graphs (Figure 8.7); and
- Maps (Figure 8.13).

Table 8-7 Summarised PES results per quaternary catchment (BASIN 4)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D81A	Orange	C	4
D81B	Orange	C/D	4
D81C	Brak R (SA &Namibia)	A	4
D81D,1026	Orange	C	4
D81E (1026_45)	Orange	C	4
D81F (1045)	Orange	C	4

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D81G	Orange	C	3.5
D82A (1048_50)	Orange	C	3
D82B	Endorheic pans	A	3
D82C	Endorheic pans	A	3
D82D	Orange	C	3.5
D82E	Orange	C	3.5
D82F	Orange	C	4.5
D82G	Orange	C	4
D82H	Orange	C	4
D82J	Orange	C	4
D82K	Orange	C	4
D82L	Orange	C	4
1005 (1)	Keinab	A/B	2.5
1005 (2)	Keinab	A/B	2.5
1017	Gamkab	A/B	2.5
1020	Ham	A/B	2.5
1032	Haib	A/B	2.5
1014	Hom	A/B	2.5

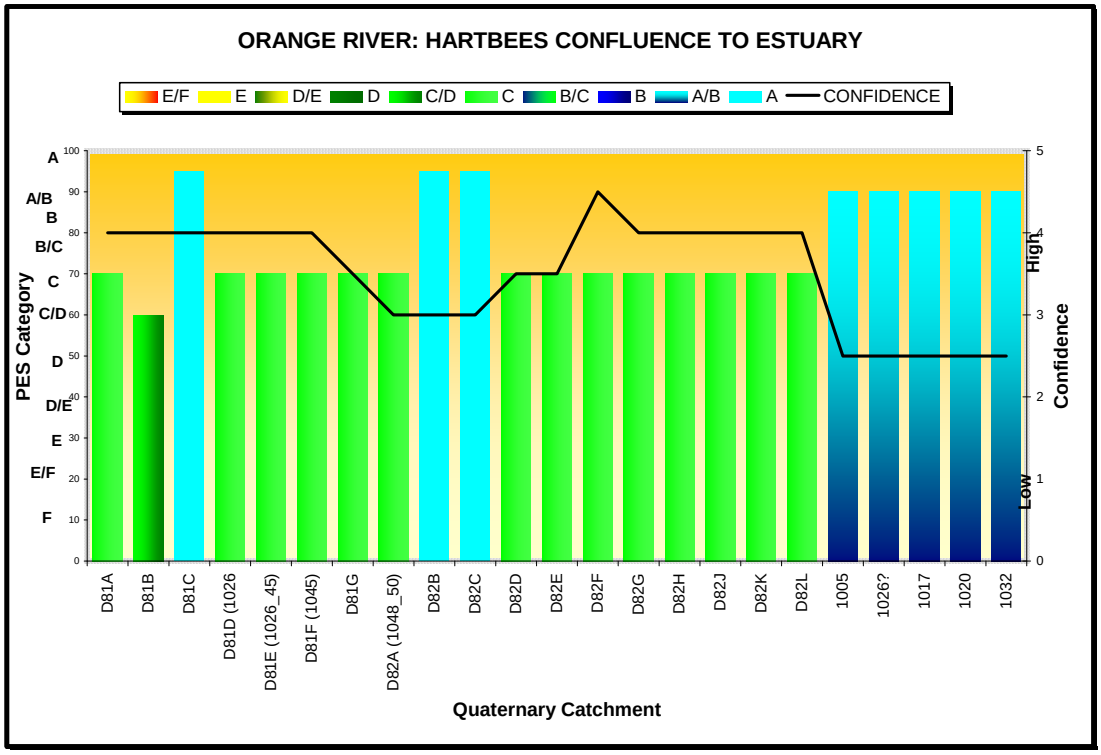


Figure 8.7 PES and confidence evaluation illustrated as bar graphs (BASIN 4)

8.6 MOLOPO CATCHMENT (BASIN 5)

This area excludes the Nossob River and includes the D4 catchments in South Africa and the Botswana tributaries.

The results are provided as follows:

- Summarised PES per river reach (Table 8-8);
- Bar graphs (Figure 8.8); and
- Maps (Figure 8.14).

Table 8-8 Summarised PES results per quaternary catchment (BASIN 5)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
D41A_R1	Molopo: From Source (eye) to barrier:	C	4
D41A_R2	Molopo: R1 end to R2 end:	D	3
D41A_R3	Molopo: R2 end to start of Mafikeng	D/E	3
D41A_R4	Molopo: From R3 end to start of Modimola Dam	E	4
D41A_R5	From Modimola Dam wall to start of Dinaseng Dam	E	4
D41A_R6	From Dinaseng Dam wall to end of D41A (Ramatlabama confluence on Botswana border)	C	4
D41A_Ramat.	Ramatlabama confluence	C	2
D41B (957)	Molopo	C/D	3
D41B	Setlagoli	C/D	3
D41C (959)	Molopo	D	3
D41C	Wildebeeshoringlaagte	B	3
D41D	Thakgamenglaagte	B	2
D41E	Molopo	C	2
939	Mosolebe	B	2
941	Mosolebe	B	2
942 to confl	Mosolebe	B	2
926	Ukhwi	B	2
921	Malotswana	B	2
D41F (935)	Molopo	A/B	3
D41F	Phepane	A/B	3
D41G	Moshaweng	B/C	2.5
D41H	Kgokgole	B/C	2.5
D41H(944)	Molopo	B	3
D41J	Ga-Mogana	B/C	2
D41K	Ga-Mogana	B/C	2
D41L	Kuruman Eye	E	3
D41M	Kuruman	B	2.5
D42C	Kuruman	A/B	3
D42C	Molopo	C/D	3
D42D	Molopo	B/C	3
D42E	Molopo	A/B	1.5

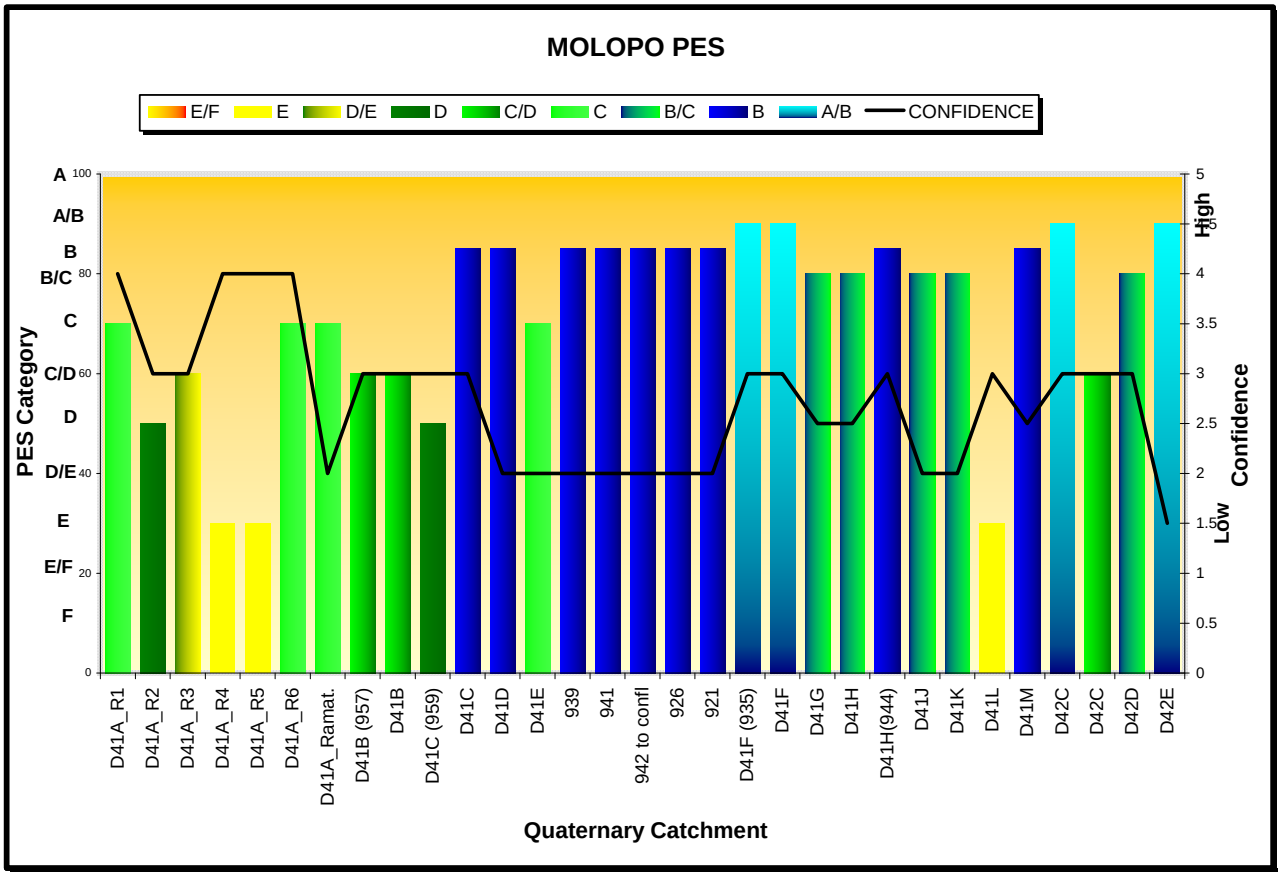


Figure 8.8 PES and confidence evaluation illustrated as bar graphs (BASIN 5)

8.7 FISH AND NOSSOB RIVERS (BASIN 6)

The results are provided as follows:

- Summarised PES per river reach (Table 8-9);
- Bar graphs (Figure 8.9); and
- Map (Figure 8.15).

Table 8-9 Summarised PES results per quaternary catchment (BASIN 6)

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
855	Black Nossob	C	3.5
861	Wit Nossob	C	3.5
890	Nossob	E	3
D42A (910)	Nossob	B	4
D42B (960)	Nossob	C	4
873	Olifants	B	4
898	Auob	C/D	3.5
D42A (946)	Auob	B	4
899	Nabob	A/B	3.5
904b	Fish to Kam confl	A/B	4

QUAT	RIVER	PES ECOSTATUS	CONFIDENCE (0 - 5)
904a	Kam to Fish confl	A/B	3
904c	Fish DS from Kam confl to Goma-Aub	A/B	4
917 a	Fish to Hardap Dam	A/B	4
917 b	Fish: Dam wall to Hudob-Lewer confl	C	3.5
930	Hudob to Fish confidence	A/B	4
933	Asab	A/B	4
955	Kannibes	A	3
969	Fish	B	4
976	Naute	A/B	3.5
987	Lowen	A/B	3.5
990c	Lowen to Naute Dam	B	4
990b	Lowen DS of Naute Dam	B/C	3.5
990a	Fish (Aub to start of Canyon	A/B	4
962	Konkipe	A	4
1009	Fish (Canyon to confluence)	A/B	4
885	Osib	A/B	3
883	Skaap	A/B	3
969	Aub	B	3

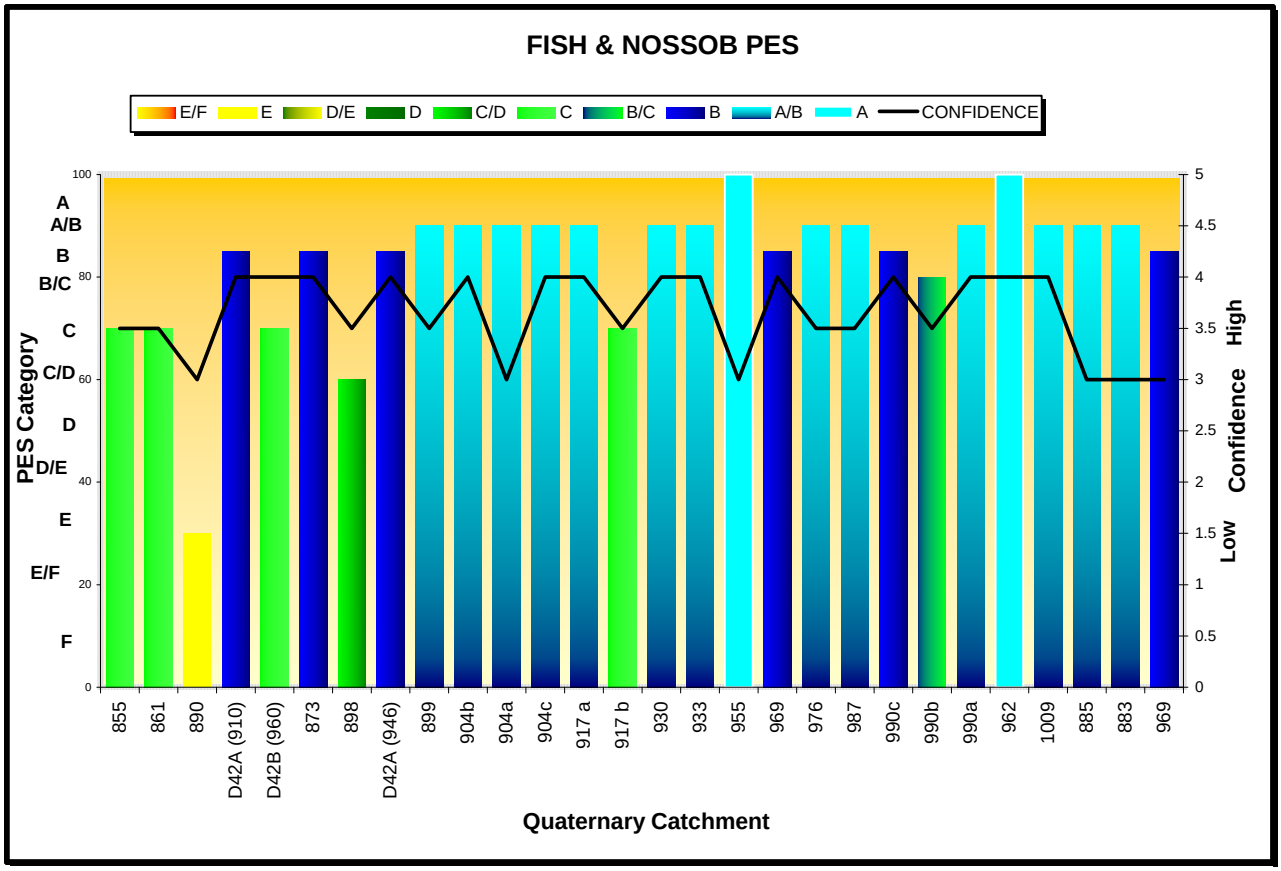


Figure 8.9 PES and confidence evaluation illustrated as bar graphs (BASIN 6)

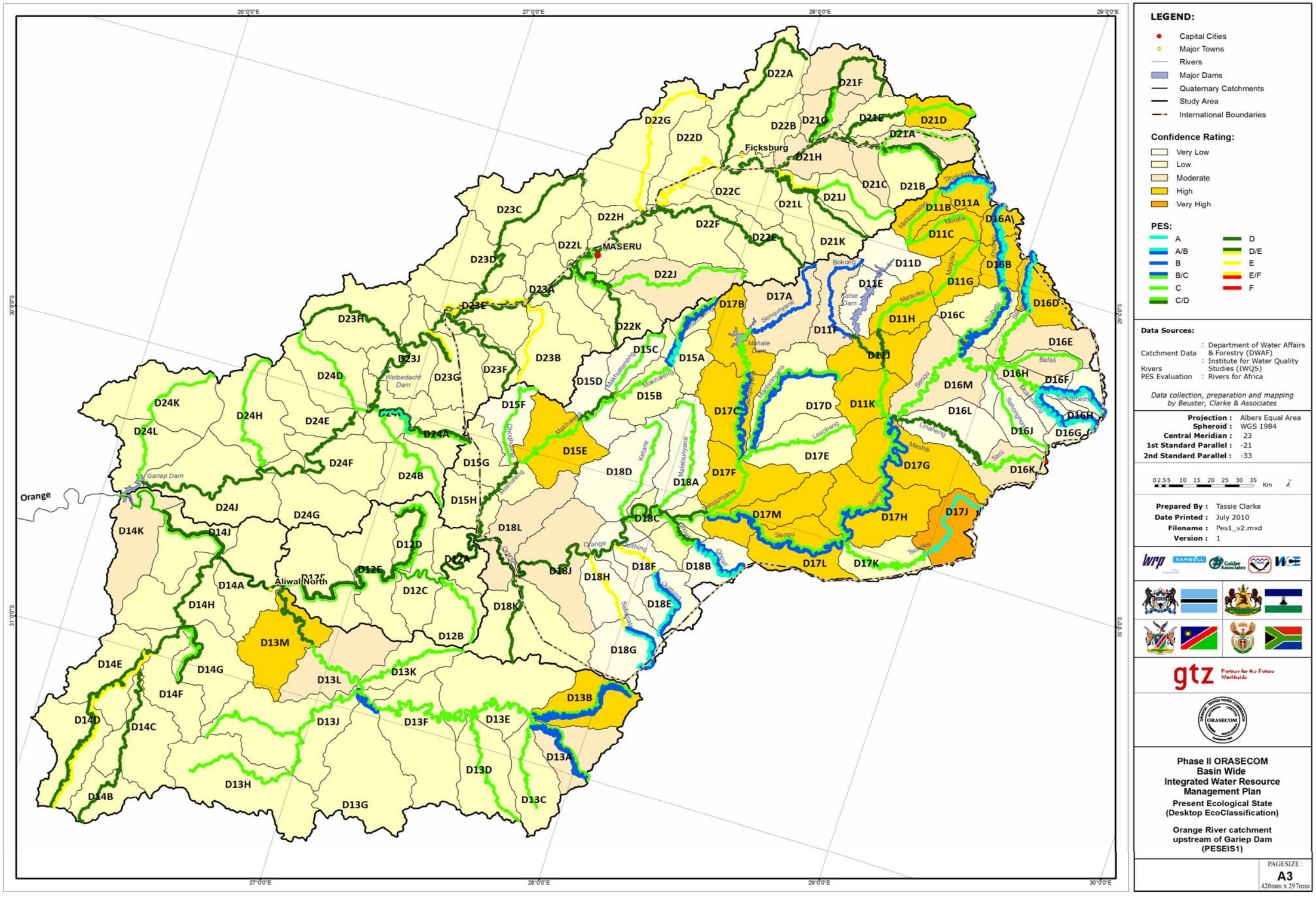


Figure 8.10 BASIN 1 map illustrating the PES results

Figure 8.11 BASIN 2 map illustrating the PES results

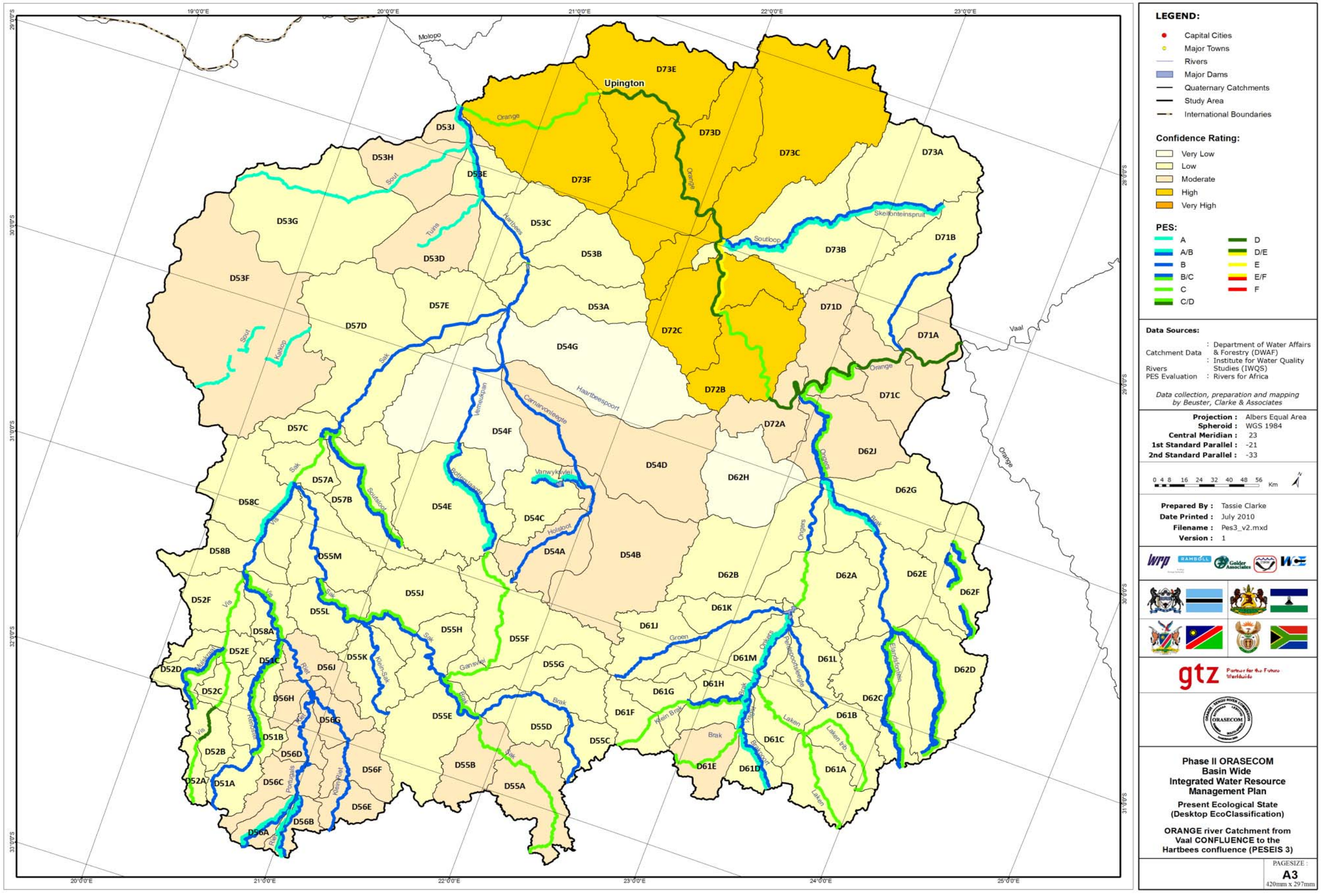
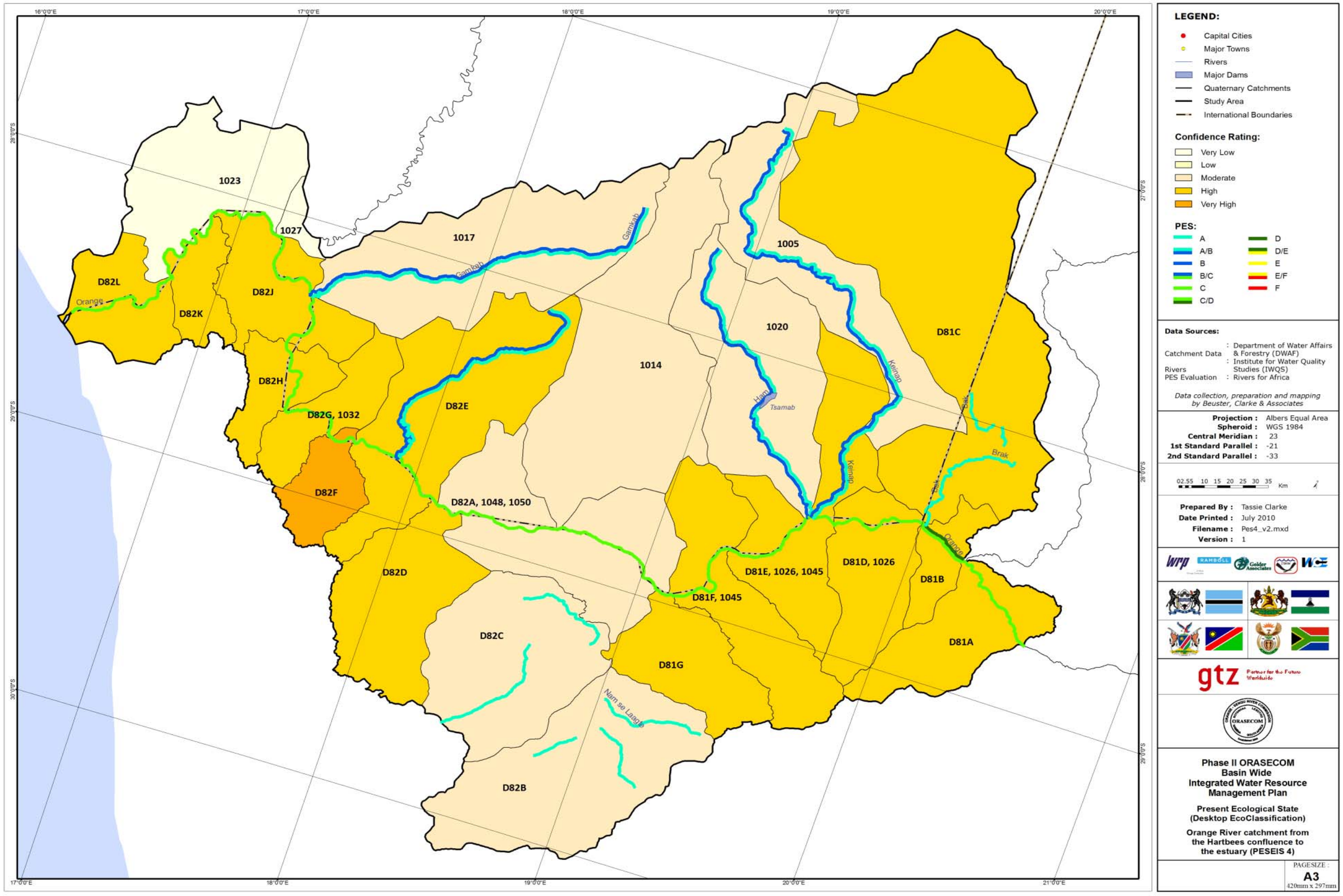


Figure 8.12 BASIN 3 map illustrating the PES results



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Confidence Rating:

- Very Low
- Low
- Moderate
- High
- Very High

PES:

- A
- A/B
- B
- B/C
- C
- C/D
- D
- D/E
- E
- E/F
- F

Data Sources:

Catchment Data : Department of Water Affairs & Forestry (DWAF)
Rivers : Institute for Water Quality Studies (IWQS)
PES Evaluation : Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

02.55 10 15 20 25 30 35 Km

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Pes4_v2.mxd
Version : 1

gtz Partner for the Future Worldwide

Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Present Ecological State (Desktop EcoClassification)

Orange River catchment from the Hartbees confluence to the estuary (PESEIS 4)

PAGESIZE : **A3** 420mm x 297mm

Figure 8.13 BASIN 4 map illustrating the PES results

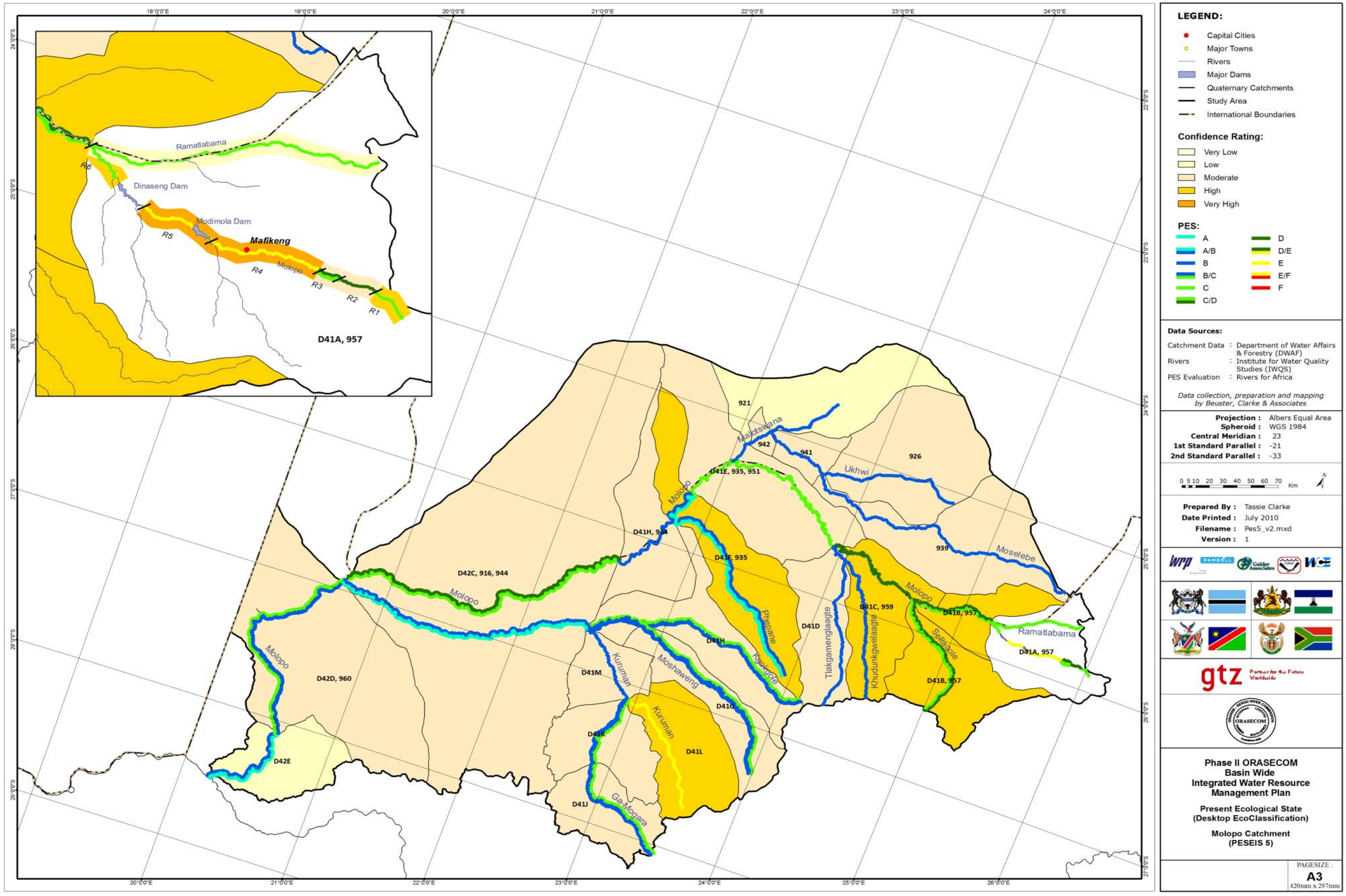


Figure 8.14 BASIN 5 map illustrating the PES results

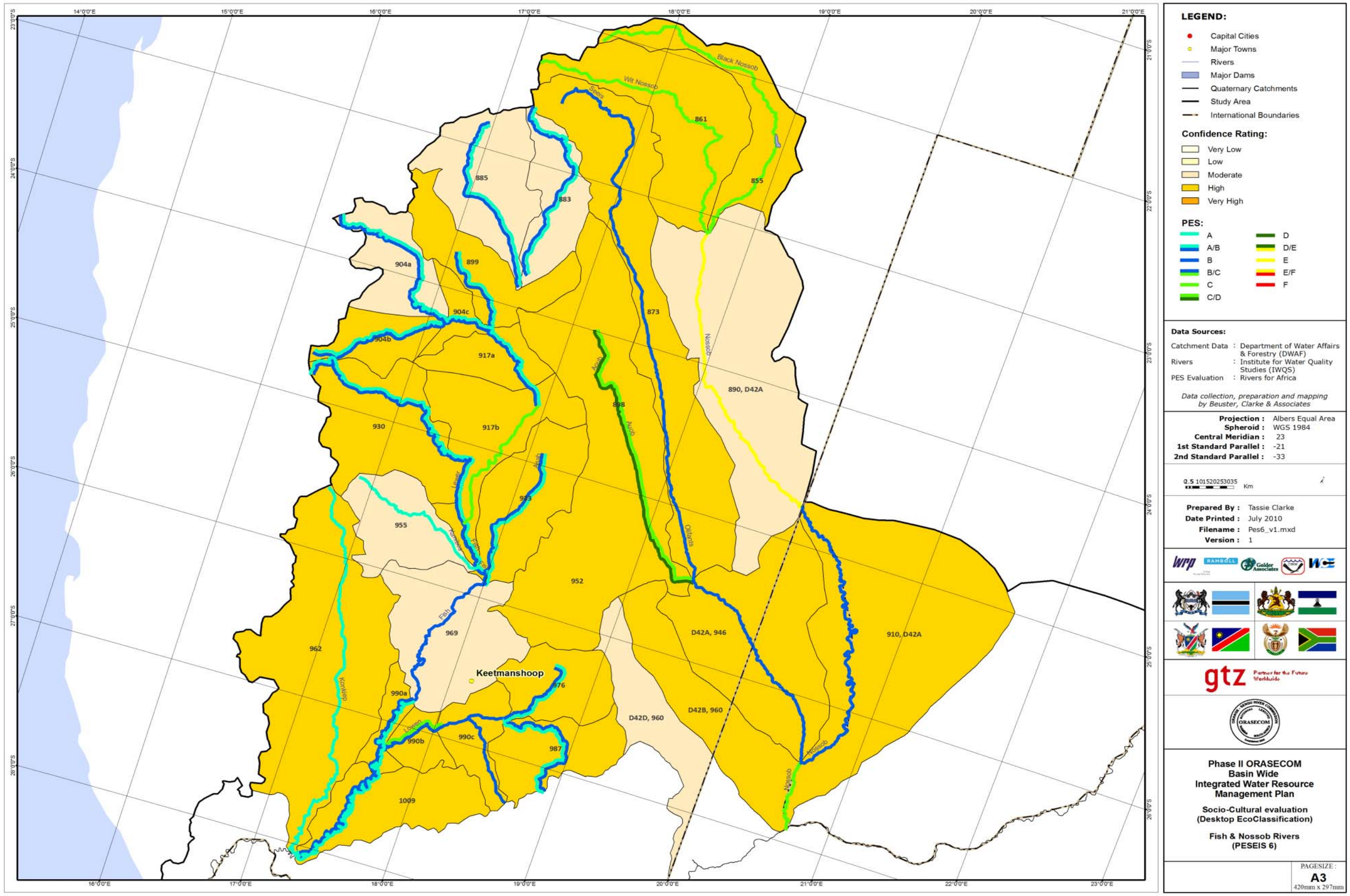


Figure 8.15 BASIN 6 map illustrating the PES results

8.8 SUMMARY

Basin 1: Lesotho-Orange, Orange, Caledon, Kraai

In the upper Lesotho areas, only one river section, namely the upper Tsoelike, has a PES in an A Ecological Category (EC). This is largely due to its protective status and the inaccessibility of the area. A number of rivers with A/B status occur in the source areas. These sections are in a good condition due to inaccessibility and some measure of protection. The majority of the rivers are however in a C and B/C state. Impacts are mostly related to overgrazing, erosion, sedimentation, terracing, removal of riparian vegetation and the presence of alien vegetation. Below Katse and Mohale Dam, changes in the flow regime also plays a role. The three river sections falling within an EC of E is mostly due to the same impacts as mentioned above, with increased intensity and extent.

Further downstream along the Orange in South Africa, most of the rivers are in a C/D and a D state. This is due to extensive utilisation, as well as the cumulative effects of impacts originating in Lesotho. The Bamboesbergspruit is in a D/E PES where there are extensive dams in the tributaries and significant erosion in places.

Along the Caledon River and its tributaries, EC's range from a C to an E. The majority of the quaternary catchments are in a D EC. The E PES river flowing from Botswana is due to agriculture to the river's edge and extensive erosion and sedimentation. The E section in the Caledon River is due to the riparian bank conditions and estimated riparian state, as well as sedimentation and flow modification. The Mopeli tributary flowing to the Caledon from South Africa, is in an E state due to the extensive number of dams in the tributary, as well as the presence of exotic vegetation.

The impacts in the Kraai Basin are associated with agriculture, abstraction and farm dams, as well as exotic vegetation. PES scores range from a C to C/D with one section (the lowest Kraai River quaternary catchment) in a D PES, but the majority of the quaternary catchments have a C PES.

Basin 2: Orange Catchment from Gariep Dam to Vaal River confluence

The main Orange River falls in a D and D/E state. These impacts are all associated with the flow regulation and operation due to the presence of ESCOM's hydro-electric schemes. The tributaries range from an A to a C PES with the majority being in an A/B and B PES. The moderate to good states of the tributaries are related to the fact that most of these rivers are seasonal (ephemeral) and therefore there is limited development associated with the rivers.

Basin 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

The Orange River is still mostly in a D PES due to the same reasons mentioned above, as well as the presence of irrigation schemes. There are two sections in a C state of which D72B is not as accessible as the rest of the Orange River and D72 F (downstream of Upington) which is very wide and anatomising. Levees in this section do therefore not have the same impact as in the single channel sections. The tributaries range also from an A to a C PES with the majority being in a B PES. Reasons are similar to those mentioned under BASIN 2.

Basin 4: Orange Catchment from the Hartbees confluence to the estuary

The main Orange River is in a C PES. This improvement is due to the fact that the river is inaccessible or protected in many sections and the increasing abstractions of flow upstream, has lessened the impact of the flow releases for hydro-power and agriculture.

All the tributaries from Namibia are in an A/B PES as there is no development apart from tracks and crossings. The absence of other activities is likely due to the extremely ephemeral nature of the system.

Basin 5: Molopo River

Two large quaternary catchments of the Molopo River around Mafikeng are in an E PES. The poor state is due to the abstraction of water from the Eye, the extensive abstraction for agriculture-irrigation practices, the inadequate sewage system in Mafikeng and the associated water quality problems. The Kuruman River downstream from the Eye is also in an E PES. This is due to the extensive abstraction of flow from the Eye, as well as the canalisation of the river.

The tributaries from Botswana are in a B state, as there is limited development due to their ephemeral nature.

In the South African portion there are three A/B PES quaternary catchments:

- The lower Kuruman (which is ephemeral and not developed);
- The Phephane River (which mostly flows through the Molopo Game Reserve and is referred to as a 'relic' river); and
- The Lowest Molopo quaternary catchment which flows through the Riemvasmaak protected area.

Other quaternary catchments in South Africa range from a B to a D PES. The lower evaluations are mostly due to extensive presence of dams, physical disturbance and the presence of *Prosopys sp* (an aggressive invader plant species).

Basin 6: Fish and Nossob catchments

The upper Nossob River is in a C PES due to the extensive presence of dams and abstraction in the area. The Nossob is in an E PES in the area upstream of where it flows into South Africa, due to the channel being completely overgrown by *Prosopys sp* and the impact of decreased flooding. Within the Kgalagadi in South Africa, both the Nossob and the Auob Rivers are in a B PES.

The main Fish River ranges from an A/B to a C PES. The C PES is due to the impacts of Hardap Dam, as well as the presence of *Prosopys sp*. The A/B PES is due to protection through National Parks or, as in the upper area, absence of development. Many of the tributaries are also in an A/B state which is due to the limited development association with its ephemeral state.

9 DESKTOP ECOCLASSIFICATION OF WETLANDS IN THE CATCHMENT

Author: Mark Rountree, Fluvius Consultants

The assessment thus far focussed on the main rivers in the quaternary catchment. However, an additional assessment was made to identify quaternary catchments where potentially important wetlands could occur. This additional assessment was at a purely desktop scale and the focus was only on the areas in the lower reaches where it is known that large and important wetlands (such as endorheic pans not associated with the rivers) could occur. Lesotho (BASIN 1) was therefore not assessed, as wetland studies have been undertaken and the information is available. The Fish and Nossob (BASIN 6) were also not assessed. This decision was based on practical considerations (time and budget) and both these areas will not be further considered during the next steps within this study.

This assessment therefore follows a rapid desktop assessment to identify priority wetland areas in the Orange River Basin . No field verification has been undertaken and the results are of low confidence.

9.1 APPROACH

An initial screening of all quaternary catchment areas in BASIN 2 to BASIN 5 was undertaken to rank catchments according to their expected wetland importance. This screening was based on visual assessments of the available desktop wetland distributions derived from the SANBI wetlands probability map (South Africa) and MapSource maps (Botswana and Namibia).

The initial screening assessed wetland density and wetland size examined at the 1: 500 000 scale, as well as the rarity of the expected wetland type/s present in the area. Catchments were scored according to expected wetland importance on a 0 to 3 scale as indicated below. Catchments that were scored as 0 (not significant) imply that there are no wetlands expected in the catchment, or that there are very few and that these are not expected to be large, regionally rare or regionally significant systems.

Category	Expected Wetland Importance
0	No significant wetlands expected
1	Low expected importance
2	Moderate expected importance
3	High expected importance

For all quaternaries rated as a 2 or 3 (Moderate or High), subsequent verification of wetland presence, size, extent and description of the wetland types was undertaken using high resolution Google Earth, 1:50 000 maps and available desktop information.

Those confirmed or upgraded to expected “high” importance were then investigated in more detail. Desktop assessments of the wetland PES and EIS at the quaternary catchment scale for these catchments were undertaken using desktop tools developed for the Department of Water Affairs by Rountree (cf. DWA, 2009; DWA, 2010).

9.2 RESULTS: INITIAL SCREENING TO IDENTIFY QUATERNARIES WITH EXPECTED WETLANDS OF IMPORTANCE

The initial screening covered 184 catchments. Subsequent verification of the expected medium and high importance catchments was undertaken to confirm the presence, size, density and types of wetlands expected to be present. The second verification round was necessary since the available desktop sources of wetland size and distribution, over-estimate wetland size and extent in arid areas (such as most of the Orange Basin), Farm dams and irrigated lands are often incorrectly designated as wetlands on the available databases of wetland distribution.

The verification process identified 12 catchments as having expected high wetland importance; 27 with medium expected importance; 114 with expected low importance and 31 being regarded as not significant in terms of expected wetland importance (Table 9-1 and Figure 9.1). The desktop PES and EIS assessments were undertaken for the 12 priority catchments in which wetland importance was expected to be high (at the Basin scale).

Table 9-1 Identification of wetlands with expected importance

Catchment No.	Characteristics of the wetlands in the catchment	Expected Importance
921	no significant wetlands.	**0**
926	no significant wetlands.	**0**
939	no significant wetlands.	**0**
941	no significant wetlands.	**0**
1005	no significant wetlands.	**0**
1014	no significant wetlands.	**0**
1017	no significant wetlands.	**0**
1020	no significant wetlands.	**0**
1032	no significant wetlands.	**0**
1005 (2)	no significant wetlands.	**0**
942 to confluence	no significant wetlands.	**0**
D31A	moderate density of small wetlands - seeps and eroded drainage lines.	**2**
D31B	moderate density of small wetlands - large valley-bottom (VB) wetlands, good condition.	**2**
D31C	moderate density of small wetlands – VBs.	**2**
D31D	moderately high density of small wetlands.	**1**
D31E	some wetlands (VBs), but most have been drowned by the dam.	**1**
D32A	moderate density of small wetlands.	**1**
D32B	moderate density of small wetlands.	**1**
D32C	moderately high density of small wetlands.	**1**
D32D	moderate density of small wetlands.	**1**
D32E	moderate density of small wetlands.	**1**
D32F	moderately high density of small wetlands.	**1**
D32G	moderate to low density - seeps, VBs, farm dams and irrigated lands.	**1**

Catchment No.	Characteristics of the wetlands in the catchment	Expected Importance
D32H	moderate to low density - seeps, VBs, farm dams and irrigated lands.	1
D32J	moderate density - large VBs.	2
D32K	moderate to low density - seeps, VBs, farm dams and irrigated lands.	1
D33A	extensive irrigated lands.	1
D33B	moderate density of small wetlands.	1
D33C	moderate density of small wetlands.	1
D33D	moderate density of small wetlands.	1
D33E	some large pans, also irrigated lands.	2
D33F	moderate density of small wetlands.	1
D33G	moderate density of small wetlands.	1
D33H	numerous small wetlands along river, also some irrigation.	2
D33J	moderate density of small wetlands.	1
D33K	some wetlands, but large scale irrigation of lands.	1
D34A	moderately high density of small wetlands.	1
D34B	moderately high density of small wetlands.	1
D34C	moderately high density of small wetlands.	1
D34D	mod density - seeps, VBs, but also irrigated lands.	1
D34E	moderately high density of small wetlands.	1
D34F	moderate density - seeps, VBs, but also irrigated lands.	1
D34G	moderate density - seeps, VBs, but also irrigated lands.	1
D35A	moderate density - seeps, VBs, but also irrigated lands.	1
D35B	moderately high density of small wetlands.	1
D35C	moderate density - seeps, VBs, but also irrigated lands.	2
D35D	moderate density - seeps, VBs, but also irrigated lands.	2
D35E	moderate density of small wetlands.	1
D35F	moderate density of small wetlands.	1
D35G	moderate density - seeps, VBs, but extensive cultivation and dams.	1
D35J	moderate density of small wetlands.	1
D41A_R1	un-channelled valley bottom wetlands - Peat system.	3
D41A_R2	un-channelled valley bottom wetlands - Peat system.	3
D41A_R3	un-channelled valley bottom wetlands - probably naturally more seasonal and thus less sensitive.	2
D41A_R4	no significant wetlands.	1
D41A_R5	no significant wetlands.	1
D41A_R6	few wetlands in upper catchment.	1
D41A_Ramat.	no significant wetlands.	1
D41B	few wetlands in upper catchment.	1
D41B (957)	no significant wetlands.	1
D41C	no significant wetlands.	0
D41C (959)	no significant wetlands.	0
D41D	few small pans.	0
D41E	few small pans.	1

Catchment No.	Characteristics of the wetlands in the catchment	Expected Importance
D41F	few small pans.	1
D41F (935)	few small pans.	1
D41G	few wetlands in upper catchment.	0
D41H	few wetlands in upper catchment.	0
D41H(944)	few small pans.	1
D41J	some small pans.	1
D41K	few small pans.	1
D41L	few wetlands in upper catchment.	1
D41M	some pans - primarily endorheic.	1
D42C	some pans - primarily endorheic.	1
D42C	few small pans.	1
D42D	numerous large pans and washouts - groundwater linked.	3
D42E	some wetlands in upper catchment, washout before Orange confluence.	1
D51A	seepage wetlands in the upper catchment.	1
D51B	seepage wetlands in the upper catchment.	1
D51C	no significant wetlands expected.	0
D52A	seepage wetlands in the upper catchment.	1
D52B	seepage wetlands in the upper catchment.	1
D52C	no significant wetlands expected.	0
D52D	large wetlands in the upper catchment.	2
D52E	no significant wetlands expected.	0
D52F	no significant wetlands expected.	0
D53A	few interdune wetlands and pans (?) present.	1
D53B	few interdune wetlands and pans (?) present.	1
D53C	interdune wetlands and pans (?) present.	1
D53D	large washout VB at top of catchment.	2
D53E	wide VB drainage line - seasonal river, not wetland.	1
D53F	high density of endorheic large pans, washouts, within the catchment.	3
D53G	moderately high density of large pans.	2
D53H	no significant wetlands expected.	0
D53J	no significant wetlands expected.	0
D54A	seepage wetlands in the upper catchment.	1
D54B	seepage wetlands in the upper catchment.	1
D54C	very large pans present.	3
D54D	some large pans, numerous interdune wetlands present	3
D54E	some large washout/pan areas.	2
D54F	extremely large pan present.	3
D54G	small wetlands present.	1
D55A	high density of small wetlands in the upper catchment.	2
D55B	seepage wetlands in the upper catchment.	1
D55C	high density of small wetlands in the upper catchment.	2
D55D	high density of small wetlands in the upper catchment.	2
D55E	high density of small wetlands in the upper catchment.	2

Catchment No.	Characteristics of the wetlands in the catchment	Expected Importance
D55F	seepage wetlands in the upper catchment.	1
D55G	seepage wetlands in the upper catchment.	1
D55H	seepage wetlands in the upper catchment.	1
D55J	wetlands in the lower catchment.	1
D55K	small wetlands across the catchment.	1
D55L	small wetlands across the catchment.	1
D55M	seasonal river with flood-out areas - not wetland.	1
D56A	small wetlands across the catchment.	1
D56B	small wetlands across the catchment.	1
D56C	small wetlands across the catchment.	1
D56D	small wetlands across the catchment.	1
D56E	seepage wetlands in the upper catchment.	1
D56F	small wetlands across the catchment.	1
D56G	small wetlands across the catchment.	1
D56H	small wetlands across the catchment.	1
D56J	small wetlands across the catchment.	1
D57A	number of large pans.	2
D57B	large pan.	2
D57C	number of large pans.	2
D57D	extremely large pans present.	3
D57E	extremely large pans present.	3
D58A	small wetlands across the catchment.	1
D58B	small wetlands across the catchment.	1
D58C	extremely large pans present.	3
D61A	few wetlands.	1
D61B	few wetlands.	1
D61C	few wetlands.	1
D61D	few wetlands.	1
D61E	numerous small wetlands.	2
D61F	wetlands in the upper catchment.	1
D61G	few wetlands.	1
D61H	few wetlands.	1
D61H	few wetlands.	1
D61J	seepage wetlands in the upper catchment.	1
D61K	few wetlands across the catchment.	1
D61L	numerous small wetlands.	2
D61M	large pan and large dam.	2
D62A	numerous large and small wetlands.	2
D62B	small wetlands across the catchment.	1
D62C	some wetlands, also farm dam, washouts along river.	2
D62D	some wetlands, large dams, irrigated lands.	1
D62E	some wetlands, large dams, irrigated lands.	1
D62F	large pan, some smaller pans.	2
D62G	numerous small wetlands.	1
D62H	numerous small and some large wetlands.	1

Catchment No.	Characteristics of the wetlands in the catchment	Expected Importance
D62J	numerous small wetlands.	**1**
D71A	numerous small wetlands and some small pans.	**1**
D71B	numerous small wetlands.	**1**
D71C	extensive irrigated lands in the catchment.	**1**
D71D	numerous small wetlands.	**1**
D72A	numerous small wetlands.	**1**
D72B	numerous small wetlands.	**1**
D72C	extensive irrigated lands in the catchment.	**1**
D73A	small wetlands across the catchment.	**1**
D73B	small wetlands across the catchment.	**1**
D73C	small wetlands across the catchment.	**1**
D73D	small wetlands across the catchment.	**1**
D73E	small wetlands across the catchment.	**1**
D73F	small wetlands across the catchment.	**1**
D81A	some small wetlands (or farm dams?).	**1**
D81B	some small wetlands (or farm dams?).	**1**
D81C	some large pans and many interdune pans - river linked.	**3**
D81D (1026	no significant wetlands.	**0**
D81E (1026_45)	no significant wetlands.	**0**
D81F (1045)	no significant wetlands.	**0**
D81G	no significant wetlands.	**0**
D82A (1048_50)	no significant wetlands.	**0**
D82B	number of pans - river linked.	**2**
D82C	no significant wetlands.	**0**
D82D	no significant wetlands.	**0**
D82E	some very small wetlands (or farm dams?).	**1**
D82F	large washouts - ephemeral river.	**1**
D82G	no significant wetlands.	**0**
D82H	some very small wetlands (or farm dams?).	**1**

9.3 EIS AND PES RESULTS

The above screening identified 12 catchments with an expected high importance. Only these were further evaluated.

The EIS assessments conducted for these catchments identified one Very High, five High and six Moderate catchments (Table 9-2 and Figure 9.1). The average PES scores of most of the priority wetland quaternary catchments was High (A), as these are primarily seasonally to episodically inundated pans and are consequently exposed to little impact in these arid parts of the country. The catchment with Very High EIS (the Orange River estuary, a RAMSAR site) only has a PES of a C. This is primarily due to the extensive flow reductions and the consequent impacts for the wetlands associated with the estuary.

Table 9-2 Wetland EIS and PES results

Quat	Map zones	Characteristics	EIS Score	EIS	PES Score	PES
D53F	BASIN 3	high density of endorheic large pans, washouts (Commisioner's Salt Pan, Rietfontein SE Pan, Bitterputs SE Pan).	1.7	MODERATE	4.8	A
D54C	BASIN 3	very large pans present (Van Wyksvlei).	2.0	MODERATE	4.1	B/C
D54D	BASIN 3	some large pans, numerous interdune wetlands present (Carnaveron Leegte).	1.8	MODERATE	4.7	A
D54F	BASIN 3	extremely large pan present (Vernieuk Pan).	2.2	HIGH	4.9	A
D57D	BASIN 3	extremely large pans present (Grondvloer Pan).	2.2	HIGH	4.8	A
D57E	BASIN 3	extremely large pans present (Grondvloer Pan etc).	2.0	MODERATE	4.9	A
D58C	BASIN 3	extremely large pans present (Grondvloer Pan).	2.1	HIGH	4.6	A
D81C	BASIN 4	some large pans and many interdune pans - river linked (Brak River).	1.4	MODERATE	4.6	A
D82L	BASIN 4	RAMSAR wetland - Orange River mouth.	3.2	VERY HIGH	3.4	C
D41A_R1	BASIN 5	Un-channelled valley bottom wetlands - regionally very rare and thus provide critical habitat especially. for birds; Peat system - very sensitive to flow reduction (Molopo Eye and wetland).	2.2	HIGH	4.6	A
D41A_R2	BASIN 5	Un-channelled valley bottom wetlands - regionally very rare and thus provide critical habitat especially. for birds; Peat system - very sensitive to flow reduction (Molopo Eye and wetland).	2.0	MODERATE	3.9	B/C
D42D	BASIN 5	Numerous large pans and washouts - groundwater linked (Hakskeen, Koppieskraal and other pans).	2.7	HIGH	4.8	A

9.4 INTEGRATED ECOLOGICAL IMPORTANCE

The same approach applied to determine Integrated Environmental Importance was used to determine the integrated wetland importance. In this case, it is referred to as Integrated Wetland Importance, as the SCI was not directly considered. The results are provided in the Table 9-3 and Figure 9.1.

Table 9-3 Wetland Integrated Ecological Importance

Quat	Map zones	EIS	PES	Integrated Wetland Importance
D53F	BASIN 3	MODERATE	A	VERY HIGH
D54C	BASIN 3	MODERATE	B/C	HIGH
D54D	BASIN 3	MODERATE	A	VERY HIGH
D54F	BASIN 3	HIGH	A	VERY HIGH
D57D	BASIN 3	HIGH	A	VERY HIGH
D57E	BASIN 3	MODERATE	A	VERY HIGH
D58C	BASIN 3	HIGH	A	VERY HIGH
D81C	BASIN 4	MODERATE	A	VERY HIGH
D82L	BASIN 4	VERY HIGH	C	HIGH
D41A_R1	BASIN 5	HIGH	A	VERY HIGH
D41A_R2	BASIN 5	MODERATE	B/C	HIGH

D42D	BASIN 5	HIGH	A	VERY HIGH

The wetland Integrated Ecological Importance was used as a modifier in the determination of the river IEI results. Wherever the above wetlands resulted in a higher Integrated Ecological Importance, this result then overrode the river IEI results (Chapter 10).

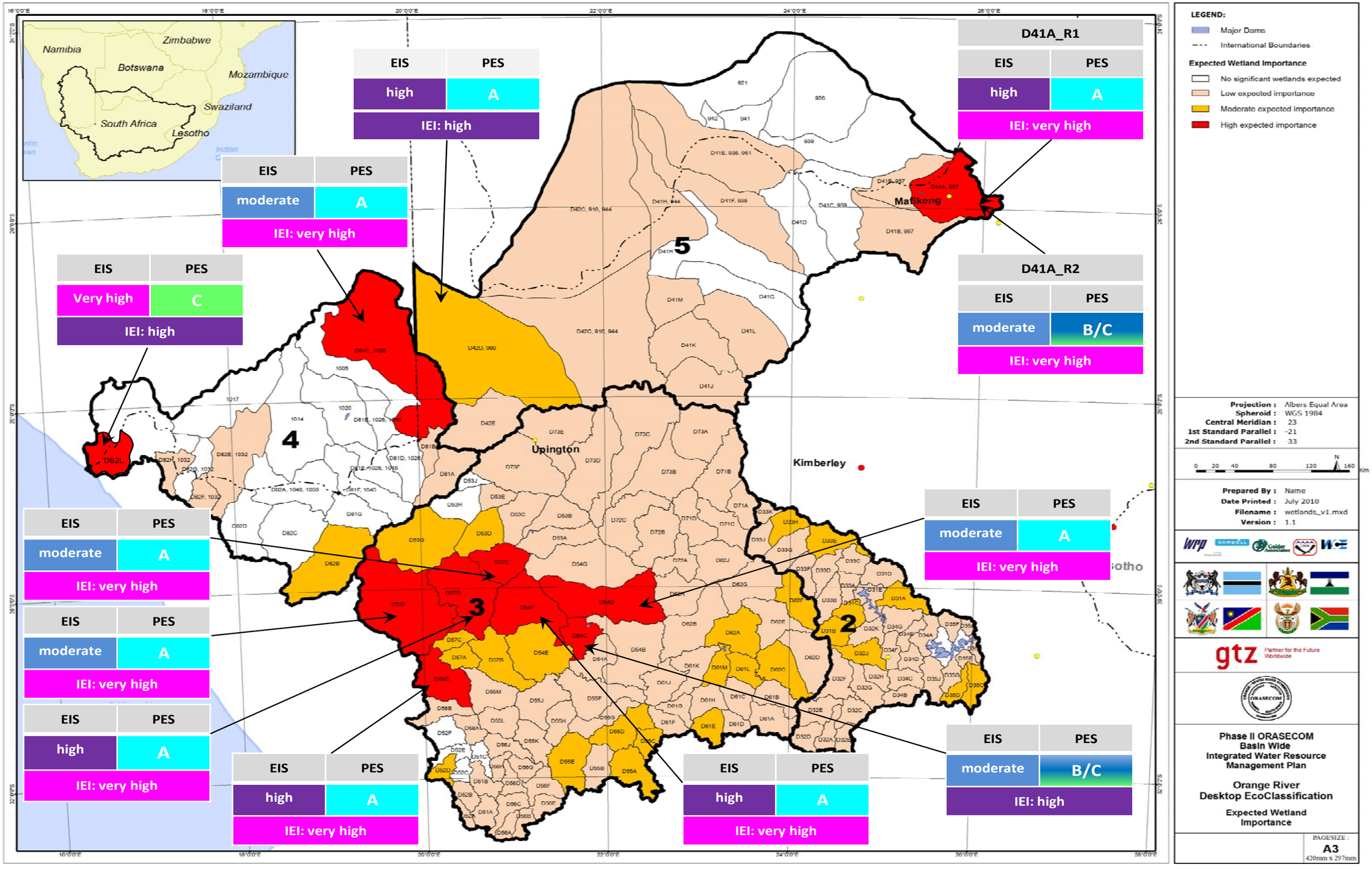


Figure 9.1 Wetlands of expected importance indicating PES, EIS and IEI for key quaternary catchments

10 INTEGRATED ENVIRONMENTAL IMPORTANCE RESULTS

As explained in Chapter 3, EIS, SCI and PES are compared and an Integrated Environmental Importance (IEI) rating derived. The results are provided in the tables below and the appropriate maps.

10.1 INTEGRATED ENVIRONMENTAL IMPORTANCE: ORANGE CATCHMENT UPSTREAM OF GARIEP DAM (BASIN 1)

Table 10-1 BASIN 1: Integrated Environmental Importance of the river reaches assessed

.Quat	EIS	SCI	PES	IEI Rating (0-4)
D11A	HIGH	HIGH	A/B	3
D11B	LOW	HIGH	C	3
D11C	LOW	HIGH	C	3
D11F	MODERATE	HIGH	B	3
D11G	LOW	HIGH	C	2.5
D11H	LOW	HIGH	C	2.5
D11J	MODERATE	HIGH	D	2
D11K	HIGH	HIGH	C	3
D15A	LOW	HIGH	A/B	3
D15A	LOW	HIGH	B/C	3
D15B	MODERATE	HIGH	C	3
D15C	LOW	HIGH	C	3
D15D	MODERATE	HIGH	C/D	2
D15E	MODERATE	HIGH	C	2.5
D15F	LOW	HIGH	C	2.5
D15G	LOW	HIGH	D	2
D15H	LOW	HIGH	D	2
D16A	HIGH	HIGH	A/B	3
D16B	MODERATE	HIGH	A/B	3
D16C	MODERATE	HIGH	B/C	3
D16D	HIGH	HIGH	A/B	3
D16E	MODERATE	HIGH	C	2.5
D16F	LOW	HIGH	A/B	3
D16F	MODERATE	HIGH	C	2.5
D16G	LOW	HIGH	A/B	3
D16G	MODERATE	HIGH	C	2.5
D16H	MODERATE	HIGH	C	2.5
D16H	LOW	HIGH	A/B	3
D16J	LOW	HIGH	A/B	3
D16J	MODERATE	HIGH	C	2.5
D16K	MODERATE	HIGH	C	3
D16 L	MODERATE	HIGH	D	2
D16M	MODERATE	HIGH	C	2.5
D17A	MODERATE	HIGH	B	3

D17B	HIGH	HIGH	C	3
D17C	HIGH	HIGH	B/C	3
D17D	HIGH	HIGH	B/C	3
D17 E	HIGH	HIGH	C	2.5
D17 F	HIGH	HIGH	C	3
D17 G	MODERATE	HIGH	B/C	3
D17 H	MODERATE	HIGH	B/C	3
D17 J	HIGH	HIGH	A	4
D17 K	LOW	HIGH	C	3
D17 L	MODERATE	HIGH	B/C	3.5
D17 M	MODERATE	HIGH	B/C	3.5
D18A	MODERATE	HIGH	C	3.5
D18B	HIGH	HIGH	A/B	4
D18C	LOW	HIGH	E	2.5
D18C	MODERATE	HIGH	C/D	3
D18D	MODERATE	HIGH	C	3.5
D18E	HIGH	HIGH	A/B	4
D18F	LOW	HIGH	E	2.5
D18F	MODERATE	HIGH	D	2.5
D18G	MODERATE	HIGH	A/B	4
D18H	LOW	HIGH	E	2.5
D18J	MODERATE	HIGH	D	2.5
D18K	MODERATE	HIGH	D	2.5
D18L	MODERATE	HIGH	D	2.5
D13A	MODERATE	HIGH	B/C	3
D13B	MODERATE	HIGH	B/C	3
D13C	MODERATE	HIGH	C	2.5
D13D	MODERATE	MODERATE	C	1
D13E	MODERATE	MODERATE	C	1
D13F	MODERATE	MODERATE	C	1
D13G	MODERATE	MODERATE	B/C	2
D13H	MODERATE	MODERATE	C	2
D13J	MODERATE	MODERATE	C	1
D13K	LOW	MODERATE	C	1
D13L	LOW	MODERATE	C	1
D13M	LOW	MODERATE	D	1
D12A	LOW	HIGH	D	2
D12B	LOW	MODERATE	C	2
D12C	LOW	MODERATE	C	1
D12D	LOW	MODERATE	C/D	1
D12E	LOW	MODERATE	C/D	1
D12F	LOW	MODERATE	C/D	1
D14A	LOW	MODERATE	D	1
D14B	LOW	MODERATE	D	1
D14C	LOW	MODERATE	D	1
D14D	LOW	MODERATE	D/E	1
D14E	LOW	MODERATE	D/E	1
D14F	LOW	MODERATE	D	1
D14G	LOW	MODERATE	C/D	1
D14H	LOW	MODERATE	D	1

D14J	LOW	MODERATE	C/D	1
D14K	LOW	MODERATE	C	1
D21A	MODERATE	MODERATE	C	2
D21B	LOW	MODERATE	C/D	1
D21C	LOW	MODERATE	D	2
D21D	MODERATE	MODERATE	C	2.5
D21E	LOW	MODERATE	D	1
D21F	LOW	MODERATE	D	1
D21G	LOW	MODERATE	C/D	1
D21H	LOW	MODERATE	D	2
D21J	LOW	HIGH	C	2.5
D21K	LOW	HIGH	D	2
D21L	LOW	HIGH	D	2
D22A	LOW	MODERATE	D	1
D22B	LOW	MODERATE	D	1
D22C	LOW	MODERATE	D	1
D22D	LOW	MODERATE	E	1
D22E	LOW	HIGH	D	2
D22F	LOW	HIGH	D	2
D22G	LOW	MODERATE	E	1
D22H	LOW	HIGH	D	2
D22J	LOW	HIGH	C	2.5
D22K	LOW	HIGH	D	2
D22L	LOW	MODERATE	C/D	1
D22L	LOW	MODERATE	D/E	1
D23A	LOW	MODERATE	D	1
D23B	LOW	MODERATE	E	1
D23C	LOW	MODERATE	D	1
D23D	LOW	MODERATE	D	1
D23E	LOW	MODERATE	D/E	1
D23F	LOW	HIGH	D	2
D23G	LOW	HIGH	D/E	2
D23H	LOW	MODERATE	D	1
D23J	LOW	MODERATE	D	1
D24A	LOW	MODERATE	C/D	1
D24B	LOW	MODERATE	C	1
D24C	LOW	MODERATE	D	1
D24D	LOW	MODERATE	C	1
D24E	LOW	MODERATE	D	1
D24F	LOW	MODERATE	D	1
D24G	LOW	MODERATE	D	1
D24H	LOW	MODERATE	C	1
D24J	LOW	MODERATE	D	1
D24K	LOW	MODERATE	C	1
D24L	LOW	MODERATE	C	1

10.2 INTEGRATED ENVIRONMENTAL IMPORTANCE: ORANGE CATCHMENT FROM GARIEP DAM TO THE VAAL CONFLUENCE (BASIN 2)

Table 10-2 BASIN 2: Integrated Environmental Importance of the river reaches assessed

Quat	EIS	SCI	PES	IEI Rating (0-4_
D31A	LOW	LOW	B	3
D31B	LOW	LOW	B	3
D31C	LOW	LOW	B	3
D31D	MODERATE	LOW	B	3
D32A	LOW	LOW	C	1
D32B	LOW	LOW	C	2
D32C	LOW	LOW	C	2
D32D	LOW	LOW	B	3
D32E	LOW	LOW	B	3
D32F	LOW	LOW	B	3
D32G	LOW	LOW	D	1
D32H	LOW	LOW	B	3
D32J	LOW	LOW	B	3
D32K	LOW	LOW	B	3
D34A	MODERATE	MODERATE	D/E	1
D34B	LOW	LOW	A/B	3
D34C	LOW	LOW	B/C	3
D34D	LOW	LOW	B/C	2
D34E	MODERATE	MODERATE	D/E	1
D34F	LOW	LOW	B	3
D34G	MODERATE	MODERATE	D/E	1
D35A	LOW	LOW	B	3
D35B	LOW	LOW	A/B	3
D35C	LOW	LOW	A/B	3
D35D	LOW	LOW	A/B	3
D35E	LOW	MODERATE	B	3
D35F	LOW	MODERATE	B	3
D35G	LOW	MODERATE	B	3
D35J	LOW	LOW	A/B	3
D33A	MODERATE	LOW	E	1
D33B	LOW	LOW	B	3
D33C	LOW	LOW	B/C	2
D33D	MODERATE	LOW	D/E	1
D33E	MODERATE	LOW	D/E	1.5
D33F	LOW	LOW	B	3
D33G	MODERATE	LOW	D	1.5
D33H	MODERATE	LOW	D	1.5
D33J	LOW	LOW	A	3
D33K	MODERATE	LOW	D	1.5

10.3 INTEGRATED ENVIRONMENTAL IMPORTANCE: ORANGE RIVER CATCHMENT FROM VAAL CONFLUENCE TO THE HARTBEES CONFLUENCE (BASIN 3)

Table 10-3 BASIN 3: Integrated Environmental Importance of the river reaches assessed

Quat	EIS	SCI	PES	IEI Rating (0-4_
D51A	LOW	MODERATE	B	3
D51B	LOW	LOW	B/C	2
D51C	LOW	LOW	B/C	2
D52A	LOW	MODERATE	C	2
D52B	LOW	LOW	C	2
D52C	LOW	LOW	C	2
D52D	LOW	MODERATE	B/C	3
D52E	LOW	LOW	C	2
D52F	MODERATE	LOW	C	2
D53A	LOW	LOW	B	3
D53B	LOW	LOW	D	1
D53C	LOW	LOW	B	3
D53D	LOW	LOW	A	3
D53E	LOW	LOW	A/B	3
D53F	LOW	LOW	A	3
D53G	LOW	LOW	A	3 (wetland 4)
D53H	LOW	LOW	A	3
D53J	LOW	LOW	A/B	3
D54A	LOW	LOW	B	3
D54B	LOW	LOW	B	3
D54C	LOW	LOW	A/B	3 (wetland 3)
D54D	LOW	LOW	B	3 (wetland 4)
D54E	LOW	LOW	A/B	3
D54F	LOW	LOW	B	3 (wetland 4)
D54G	LOW	LOW	B	3
D55A	LOW	MODERATE	C	2
D55B	LOW	LOW	C	2
D55C	LOW	LOW	B	3
D55D	LOW	LOW	B	3
D55E	LOW	LOW	B/C	3
D55F	LOW	LOW	C	2
D55G	LOW	LOW	C	2
D55H	LOW	LOW	B	3
D55J	LOW	LOW	B/C	3
D55K	LOW	LOW	B	3
D55L	LOW	LOW	B/C	3
D55M	LOW	LOW	B	3
D56A	LOW	LOW	A/B	3
D56B	LOW	LOW	A/B	3
D56C	LOW	LOW	B	3
D56D	LOW	LOW	B	3

Quat	EIS	SCI	PES	IEI Rating (0-4_
D56E	LOW	LOW	B	3
D56F	LOW	LOW	B	3
D56G	LOW	LOW	B	3
D56H	MODERATE	LOW	B	3
D56J	MODERATE	LOW	B	3
D57A	MODERATE	LOW	C	2
D57B	LOW	LOW	B/C	3
D57C	MODERATE	LOW	B/C	2
D57D	MODERATE	LOW	B	3 (wetland 4)
D57E	LOW	LOW	B	3 (wetland 4)
D58A	LOW	LOW	B/C	3
D58B	LOW	LOW	B	3
D58C	MODERATE	LOW	A/B	3 (wetland 4)
D61A	LOW	LOW	C	1
D61B	LOW	LOW	C	1
D61C	LOW	LOW	C	1
D61D	LOW	LOW	A/B	3
D61E	LOW	LOW	C	2
D61F	LOW	LOW	C	1
D61G	LOW	LOW	C	1
D61H	LOW	LOW	B/C	2
D61H	LOW	LOW	A/B	3
D61J	LOW	LOW	B/C	3
D61K	LOW	LOW	B	3
D61L	LOW	LOW	B	3
D61M	LOW	LOW	A/B	3
D62A	LOW	LOW	C	2
D62B	LOW	LOW	B	3
D62C	LOW	LOW	B/C	3
D62D	LOW	LOW	B/C	3
D62E	LOW	LOW	B	3
D62F	LOW	LOW	B/C	2
D62G	LOW	LOW	A/B	3
D62H	LOW	LOW	A/B	3
D62J	LOW	LOW	B/C	2
D71A	MODERATE	LOW	D	1.5
D71B	LOW	MODERATE	B	3
D71C	MODERATE	MODERATE	D	1.5
D71D	MODERATE	LOW	C/D	1.5
D72A	MODERATE	LOW	D	1.5
D72B	MODERATE	MODERATE	C	2
D72C	MODERATE	LOW	D/E	1
D73A	LOW	MODERATE	A/B	3
D73B	LOW	MODERATE	A/B	3
D73C	MODERATE	MODERATE	D	1.5

Quat	EIS	SCI	PES	IEI Rating (0-4_
D73D	MODERATE	LOW	D	1.5
D73E	MODERATE	LOW	D	1.5
D73F	HIGH	MODERATE	C	2.5

10.4 INTEGRATED ENVIRONMENTAL IMPORTANCE: ORANGE RIVER CATCHMENT FROM THE HARTBEES CONFLUENCE TO THE ESTUARY (BASIN 4)

Table 10-4 BASIN 4: Integrated Environmental Importance of the river reaches assessed

Quat	EIS	SCI	PES	IEI Rating (0-4)
D81A	HIGH	LOW	C	2.5
D81B	HIGH	LOW	C/D	2
D81C	LOW	LOW	A	3
D81D (1026	MODERATE	LOW	C	2
D81E (1026_45)	HIGH	MODERATE	C	2.5
D81F (1045)	MODERATE	LOW	C	2.5
D81G	MODERATE	MODERATE	C	3
D82A (1048_50)	HIGH	LOW	C	3.5
D82B	LOW	LOW	A	3
D82C	LOW	LOW	A	3
D82D	HIGH	LOW	C	3
D82E	MODERATE	MODERATE	C	2.5
D82F	HIGH	MODERATE	C	2.5
D82G	HIGH	LOW	C	2.5
D82H	HIGH	LOW	C	3.5
D82J	HIGH	MODERATE	C	3.5
D82K	MODERATE	MODERATE	C	3.5
D82L	MODERATE	HIGH	C	3
1005 (1)	LOW	LOW	A/B	3
1005 (2)	LOW	LOW	A/B	3
1017	LOW	LOW	A/B	3
1020	LOW	LOW	A/B	3
1032	LOW	LOW	A/B	3
1014	LOW/MARGINAL	LOW	A/B	3

10.5 INTEGRATED ENVIRONMENTAL IMPORTANCE: MOLOPO CATCHMENT (BASIN 5)

Table 10-5 BASIN 5: Integrated Environmental Importance of the river reaches assessed

Quat	EIS	SCI	PES	IEI Rating (0-4)
D41A_R1	HIGH	HIGH	C	3 (wetland 4)
D41A_R2	LOW	MODERATE	D	2 (wetland 3)
D41A_R3	LOW	LOW	D/E	1
D41A_R4	LOW	LOW	E	1
D41A_R5	LOW	LOW	E	1
D41A_R6	LOW	LOW	C	1

Quat	EIS	SCI	PES	IEI Rating (0-4)
D41A_Ramat.	LOW	LOW	C	1
D41B (957)	LOW	MODERATE	C/D	1
D41B	LOW	MODERATE	C/D	2.5
D41C (959)	LOW	MODERATE	D	1.5
D41C	LOW	LOW	B	3
D41D	LOW	LOW	B	3
D41E	MODERATE	MODERATE	C	2
939	LOW	LOW	B	3
941	LOW	LOW	B	3
942 to confl	LOW	MODERATE	B	3
926	LOW	LOW	B	3
921	LOW	LOW	B	3
D41F (935)	MODERATE	LOW	A/B	3
D41F	LOW	LOW	A/B	3
D41G	LOW	LOW	B/C	2
D41H	LOW	LOW	B/C	2
D41H(944)	HIGH	LOW	B	3
D41J	LOW	LOW	B/C	2
D41K	LOW	LOW	B/C	2
D41L	LOW	MODERATE	E	1
D41M	LOW	LOW	B	3
D42C	LOW	MODERATE	A/B	3
D42C	LOW	LOW	C/D	1
D42D	LOW	LOW	B/C	3 (wetland 4)
D42E	HIGH	LOW	A/B	4

10.6 INTEGRATED ENVIRONMENTAL IMPORTANCE: FISH AND NOSSOB RIVERS (BASIN 6)

Table 10-6 BASIN 6: Integrated Environmental Importance of the river reaches assessed

Quat	EIS	SCI	PES	IEI Rating (0-4)
855	MODERATE	MODERATE	C	2
861	MODERATE	MODERATE	C	2
890	LOW	MODERATE	E	1
D42A (910)	VERY HIGH	HIGH	B	4
D42B (960)	HIGH	MODERATE	C	2.5
873	LOW	LOW	B	3
898	LOW	LOW	C/D	1
D42A (946)	VERY HIGH	HIGH	B	4
899	LOW	LOW	A/B	3
904b	HIGH	MODERATE	A/B	4
904a	MODERATE	MODERATE	A/B	4
904c	HIGH	HIGH	A/B	4
917 a	HIGH	HIGH	A/B	4
917 b	HIGH	HIGH	C	3.5

Quat	EIS	SCI	PES	IEI Rating (0-4)
930	HIGH	MODERATE	A/B	4
933	LOW	LOW	A/B	3
955	LOW	MODERATE	A	3
969	HIGH	HIGH	B	4
976	LOW	LOW	A/B	3
987	LOW	LOW	A/B	3
990c	MODERATE	LOW	B	3
990b	HIGH	LOW	B/C	3
990a	HIGH	MODERATE	A/B	4
962	LOW	MODERATE	A	3
1009	HIGH	HIGH	A/B	4
885	LOW	VERY LOW	A/B	3
883	LOW	VERY LOW	A/B	3
969	LOW	VERY LOW	B	3

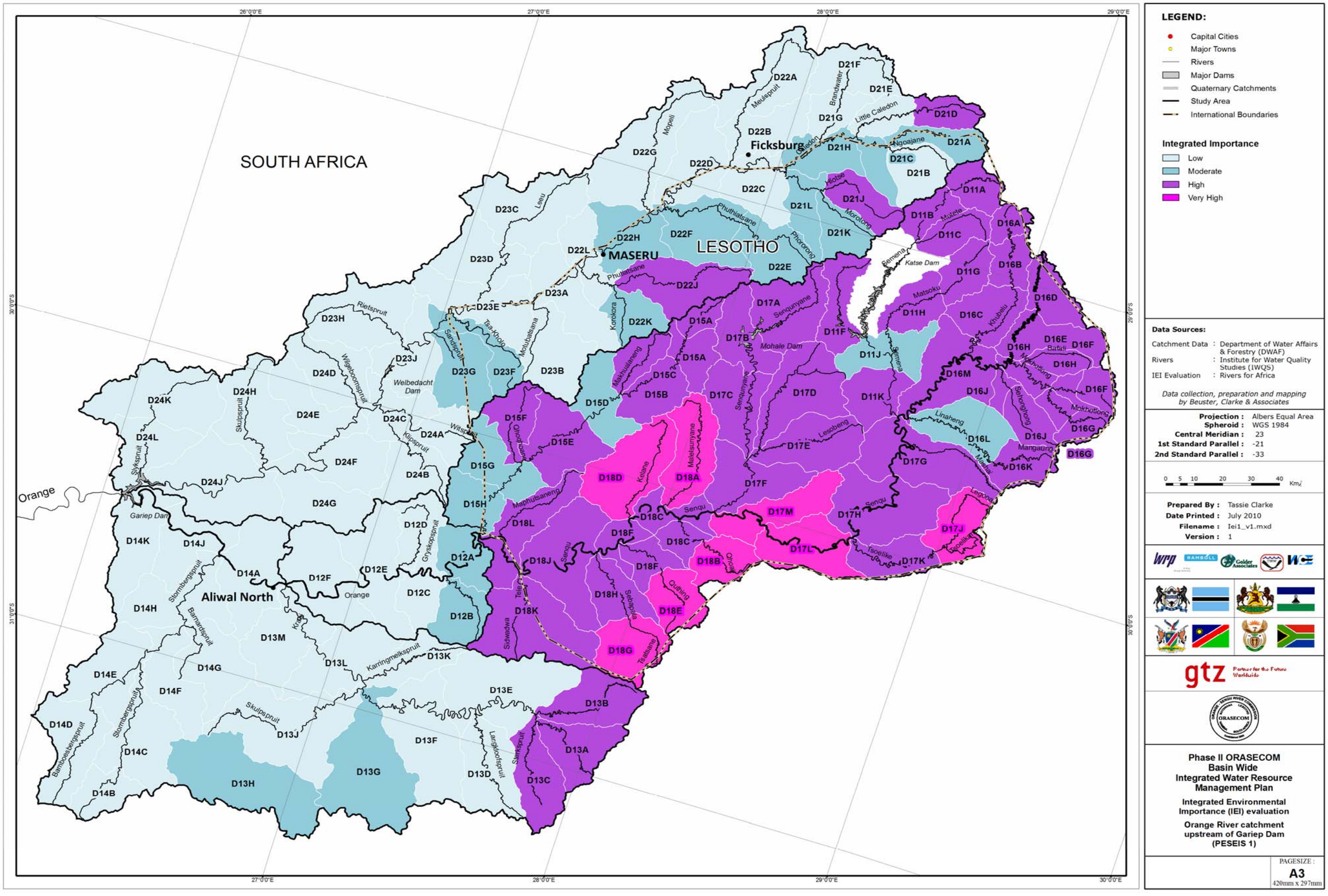


Figure 10.1 BASIN 1 map illustrating areas of high Integrated Environmental Importance

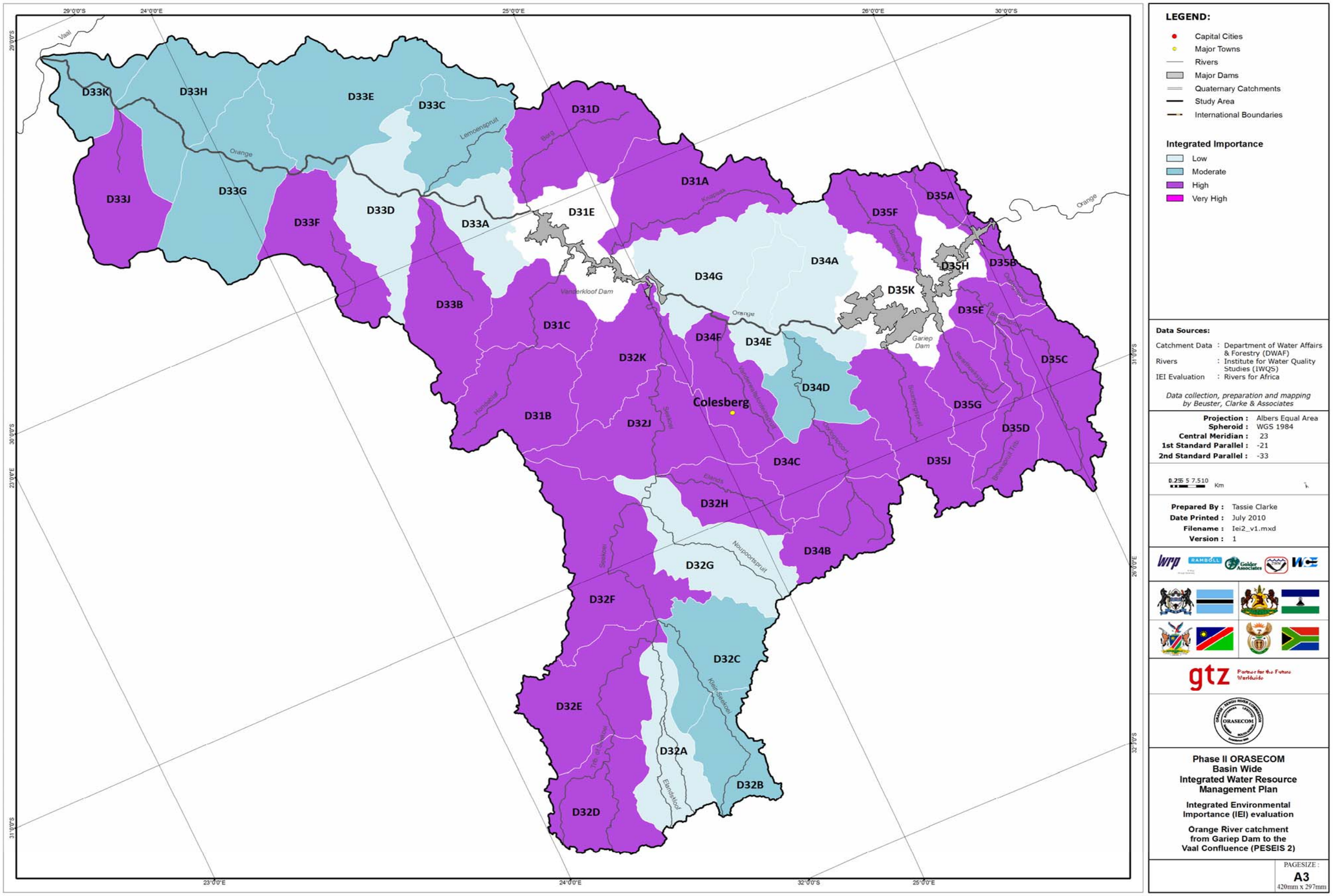


Figure 10.2 BASIN 2 map illustrating areas of high Integrated Environmental Importance

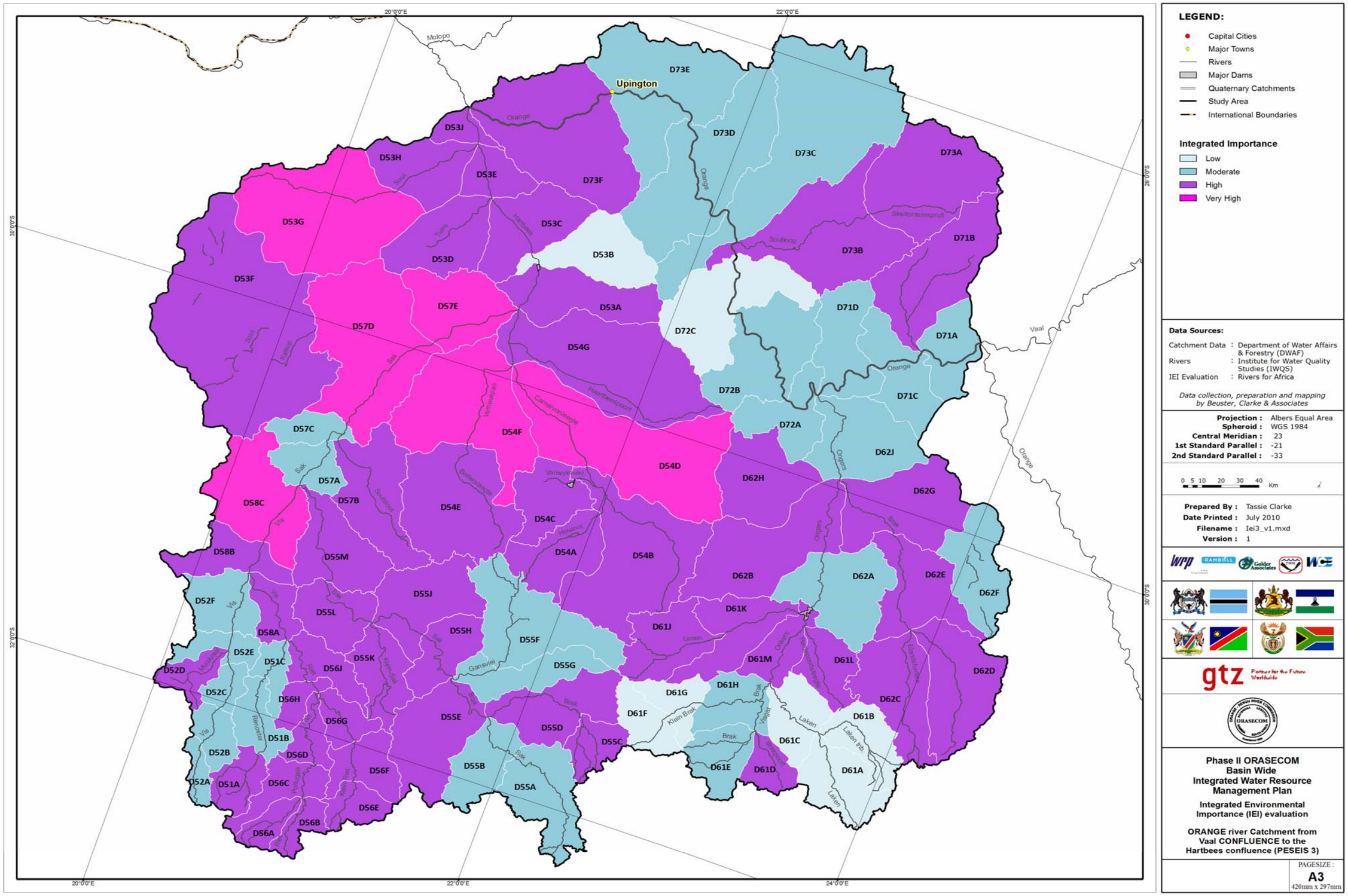


Figure 10.3 BASIN 3 map illustrating areas of high Integrated Environmental Importance

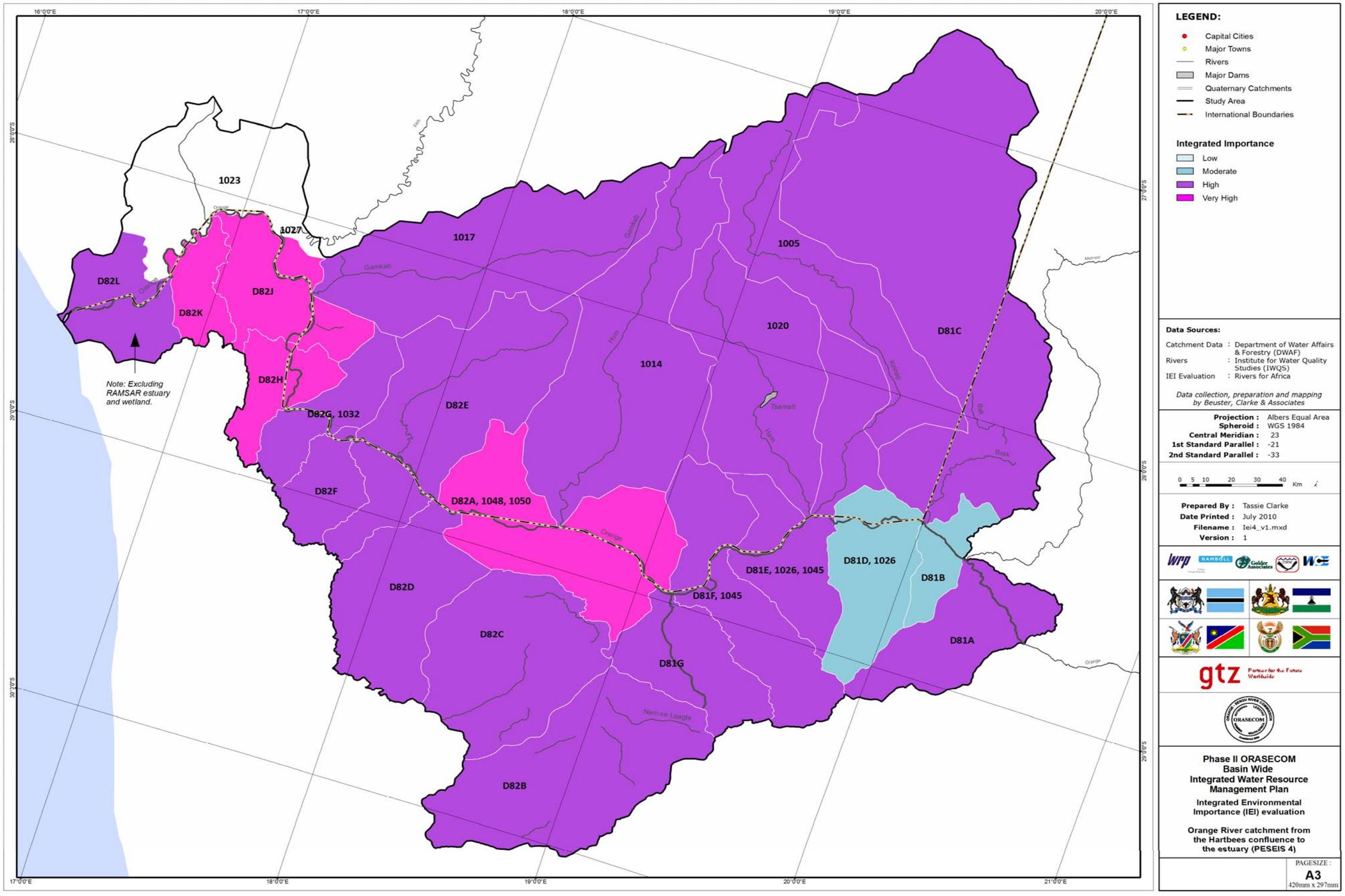
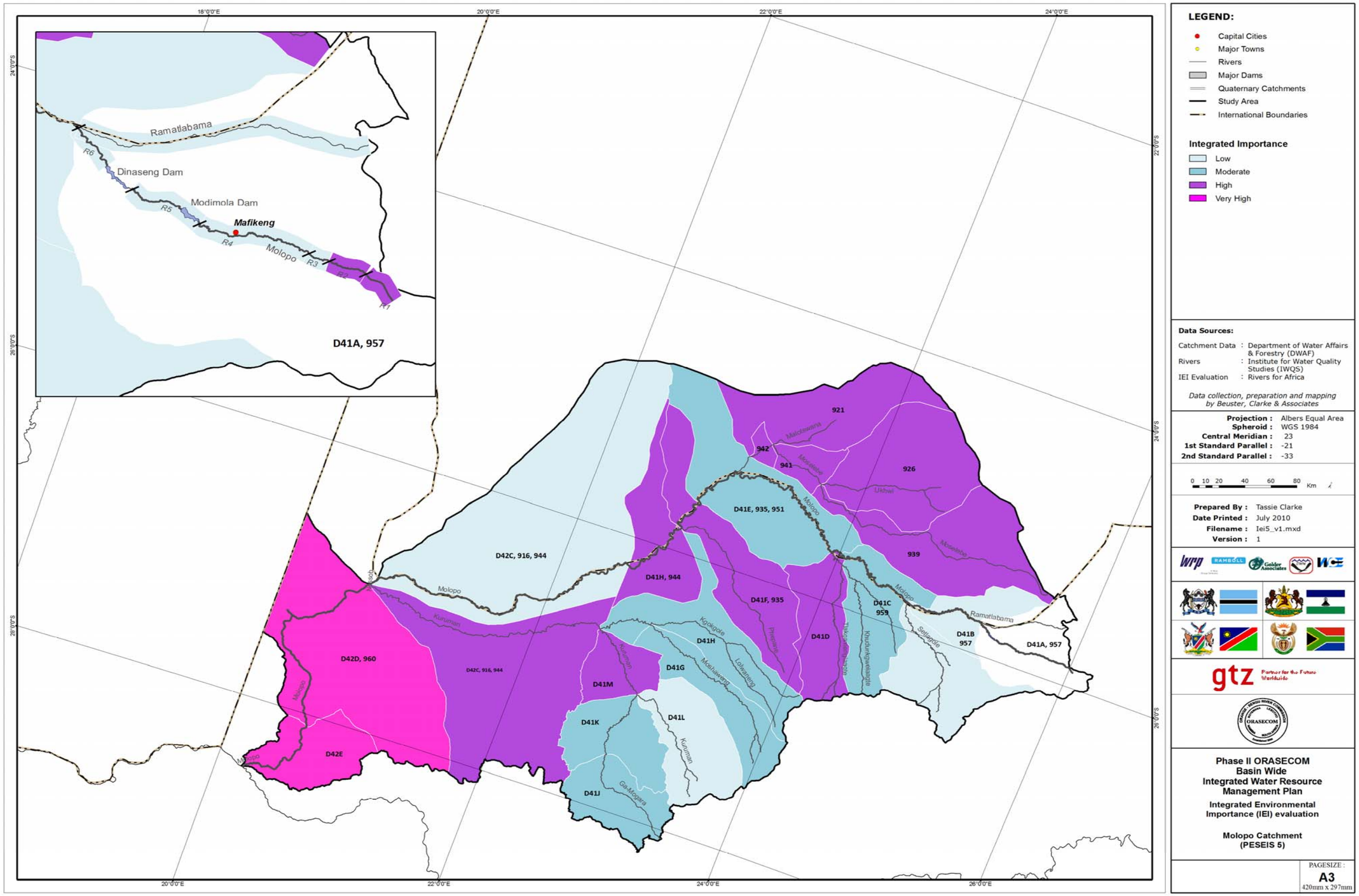


Figure 10.4 BASIN 4 map illustrating areas of high Integrated Environmental Importance



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Integrated Importance

- Low
- Moderate
- High
- Very High

Data Sources:

Catchment Data	:	Department of Water Affairs & Forestry (DWAF)
Rivers	:	Institute for Water Quality Studies (IWQS)
IEI Evaluation	:	Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

0 10 20 40 60 80 Km

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Iei5_v1.mxd
Version : 1

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ORASECOM

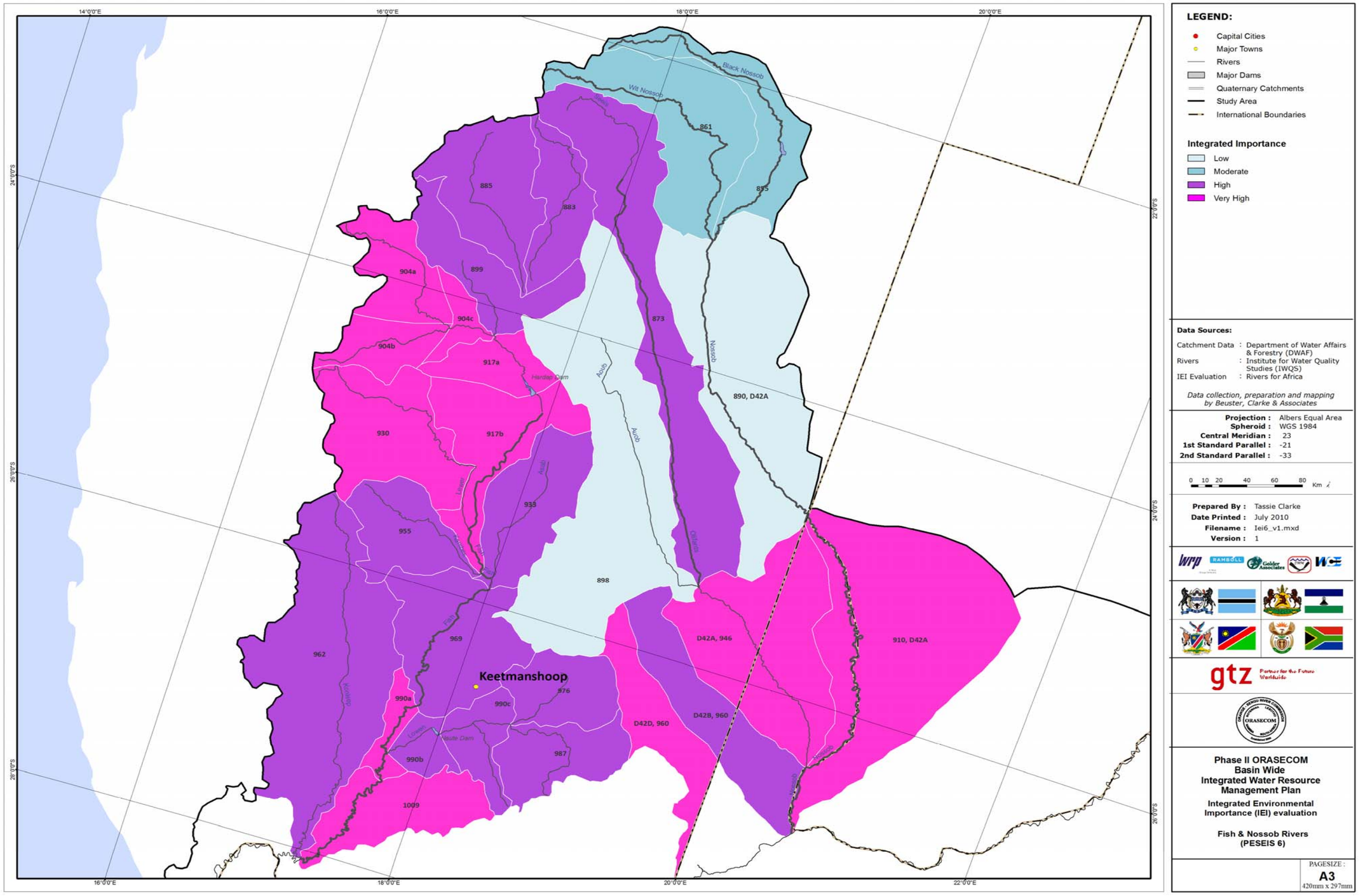
Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Integrated Environmental Importance (IEI) evaluation

Molopo Catchment (PESEIS 5)

PAGESIZE : **A3** 420mm x 297mm

Figure 10.5 BASIN 5 map illustrating areas of high Integrated Environmental Importance



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Integrated Importance

- Low
- Moderate
- High
- Very High

Data Sources:

Catchment Data	:	Department of Water Affairs & Forestry (DWAF)
Rivers	:	Institute for Water Quality Studies (IWQS)
IEI Evaluation	:	Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

0 10 20 40 60 80 Km

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Iei6_v1.mxd
Version : 1

gtz Partner for the Future Worldwide

Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Integrated Environmental Importance (IEI) evaluation

Fish & Nossob Rivers (PESEIS 6)

PAGESIZE : **A3** 420mm x 297mm

Figure 10.6 BASIN 6 map illustrating areas of high Integrated Environmental Importance

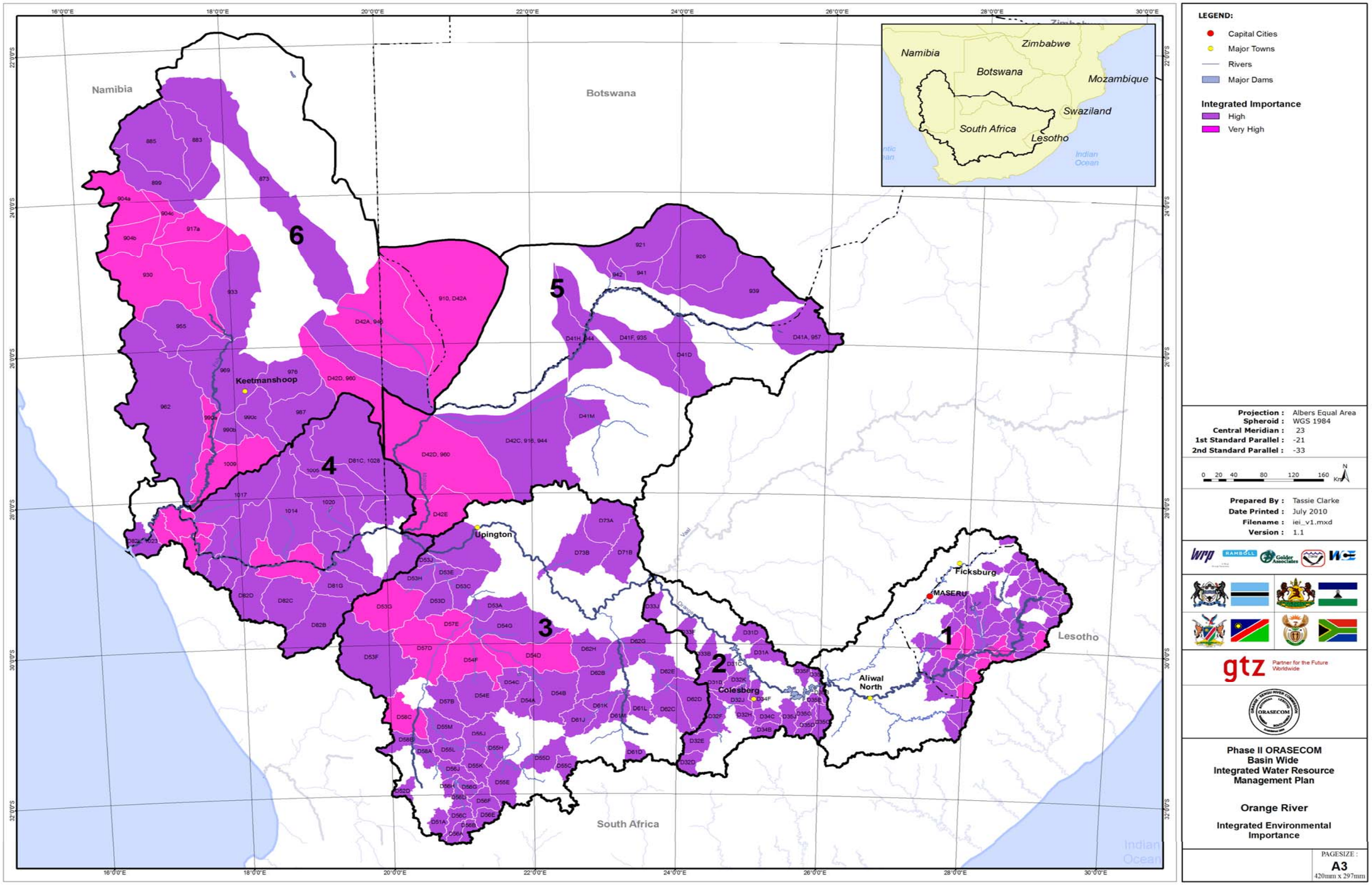


Figure 10.7 Identification of quaternary catchments of high IEI (Very High and High)

10.7 SUMMARY

BASIN 1

Most of the SCI in Lesotho is High which results in a high IEI. The IEI of the Senqu section in the east, downstream of D17L, is Very High as a result of a combination of a high SCI and a reasonably high PES. Apart from some High IEI ratings in the upper Kraai catchments, the rest of BASIN 1 quaternaries are all classified as having a Low IEI. This is due to a combination of a Low PES, EIS and SCI.

BASIN 2: Orange Catchment from Gariep Dam to Vaal River confluence

Most of the tributaries of the Orange are classified as having a High IEI. This is due to the high PES even though the EIS and SCI is low. The main Orange River has a Low IEI and this is due to the Low PES when compared to that of the tributaries.

BASIN 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

The situation is generally similar than above with the main Orange River however being mostly of Moderate IEI as the PES is higher than for BASIN 2 (due to the impact of the hydro-electric releases being minimised). There are six quaternaries with Very High IEI ratings, which is due to the important wetlands in these quaternary catchments.

BASIN 4: Orange Catchment from the Hartbees confluence to the estuary

There are 4 quaternaries (D82A, H, J, K) with a Very High IEI. These include the Orange River and are related to the high EIS and reasonably high PES. The rest of the area is mostly of High IEI, mostly due to the very high PES. The only two Moderate areas are the Orange River (D81B and D) and this is due to the lower PES originating from the upstream agricultural impacts.

BASIN 5: Molopo River

A similar situation was observed for BASIN 5 where the tributaries are ephemeral which usually results in a high PES and therefore a High IEI. This cluster also included two Very High IEI quaternary catchments namely D42D (due to wetlands) and D42E (due to the good condition of the Molopo River and the presence of protected areas). The Low IEI evaluations for the rest of the areas are mostly due to a low PES related to agricultural and domestic use activities as well as the presence of alien vegetation such as *Prosopys sp*.

BASIN 6: Fish and Nossob catchments

The Very High IEI evaluations in the Nossob and Auob (D42A) is due to the high PES and EIS which is a result of the protected status afforded by the Kgalagadi Transfrontier Park. The Very High IEI in the Fish Catchments are in the upper sections (inaccessible and therefore high PES) and the lower sections which is due to the Fish River National Park and the high EIS, SCI and reasonable PES. The rest of the BASIN 6 is of High IEI apart from the Auob (898) and Nossob (890) which is low due to the low PES and EIS as a result of the excessive growth of *Prosopys sp*.

11 IDENTIFICATION OF PRIORITY AREAS AND HOTSPOTS

The matrix was used to compare the Integrated Environmental Importance with the Water Resource Use importance and the results are provided in the tables and figures below.

11.1 PRIORITY AREAS FOR DETAIL STUDIES: ORANGE CATCHMENT UPSTREAM OF GARIEP DAM (BASIN 1)

Table 11-1 BASIN 1: Hotspots and priority areas for detail assessment

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
D11A	Upstream from Katse Dam, no formal use. However, contribution flow to yield of Katse dam very important. Water quality needs to be protected for dam.	4	3	4
D11B	Upstream from Katse Dam, no formal use. However, contribution flow to yield of Katse dam very important. Water quality needs to be protected for dam. Water quality needs to be protected for the Katse dam.	4	3	4
D11C	See above.	4	3	4
D11F	See above.	4	3	4
D11G	Upstream of Matsoko weir - contributes high flows for diversion.	2	2.5	2.5
D11H	Matsoko weir - diversion weir to Katse.	3	2.5	3.5
D11J	Downstream of Katse. Only water released is for environmental purposes. No further development planned. Important in terms of contributing to yield of Gariep and Vanderkloof.	3	2	3
D11K	See above.	3	3	4
D15A	Protection of water quality as possible off take point for bulk drinking water supply in the Lesotho Lowlands.	3	3	4
D15A	See above.	3	3	4
D15B	See above.	3	3	4
D15C	See above.	3	3	4
D15D	See above.	3	2	3
D15E	Downstream of proposed off take point for Lesotho Lowlands.	3	2.5	3.5
D15F	See above.	3	2.5	3.5
D15G	See above.	3	2	3
D15H	See above.	3	2	3
D16A	Contributing to future Polihale Dam's yield and water quality.	4	3	4
D16B	See above.	4	3	4
D16C	See above.	4	3	4
D16D	See above.	4	3	4
D16E	See above.	4	2.5	4
D16F	See above.	4	3	4
D16F	See above.	4	2.5	4
D16G	See above.	4	3	4
D16G	See above.	4	2.5	4
D16H	See above.	4	2.5	4
D16H	See above.	4	3	4
D16J	See above.	4	3	4

D16J	See above.	4	2.5	4
D16K	Contributing to Orange River yield.	3	3	4
D16 L	See above.	3	2	3
D16M	Locality of future Polihale Dam.	4	2.5	4
D17A	Contributing to Mohale Dam's yield and water quality.	4	3	4
D17B	Downstream of Mohale. Only water released is for environmental purposes. No further development planned. Important in terms of contributing to yield of Gariep and Vanderkloof.	3	3	4
D17C	See above.	3	3	4
D17D	See above.	3	3	4
D17 E	See above.	3	2.5	3.5
D17 F	See above.	3	3	4
D17 G	See above.	3	3	4
D17 H	See above.	3	3	4
D17 J	See above.	3	4	4
D17 K	See above.	3	3	4
D17 L	See above.	3	3.5	4
D17 M	See above.	3	3.5	4
D18A	Contribution to Orange River.	3	3.5	4
D18B	Contribution to Orange River / Van der Kloof Dam and water quality.	3	4	4
D18C	See above.	3	2.5	3.5
D18C	See above.	3	3	4
D18D	See above.	3	3.5	4
D18E	See above.	3	4	4
D18F	See above.	3	2.5	3.5
D18F	See above.	3	2.5	3.5
D18G	See above.	3	4	4
D18H	See above.	3	2.5	3.5
D18J	See above	3	2.5	3.5
D18K	See above.	3	2.5	3.5
D18L	See above.	3	2.5	3.5
D12A	Contributes to Gariep Dam's yield and water quality.	4	2	4
D12B	Jozanna's Hoek Dam - Rural and town supply.	4	2	4
D12C	Contributes to Gariep Dam's yield and water quality.	4	1	3
D12D	See above.	4	1	3
D12E	See above.	4	1	3
D12F	BosBerg Dam, future unlikely Dam.	4	1	3
D14A	Contributes to Gariep Dam's yield and water quality.	4	1	3
D14B	Locally very important for water supply and water quality. Very dry. Not that important as contribution to the Orange.	3	1	2
D14C	Chiappini Klip Dam 1 and 2. Supplies Burgersdorp. Water quality needs protection.	3	1	2
D14D	Locally very important for water supply. Water quality needs protection. Very dry. Not that important as contribution to the Orange.	3	1	2
D14E	See above.	3	1	2
D14F	JL de Bruyn Dam.	3	1	2
D14G	Locally very important for water supply and water quality. Very dry. Not that important as contribution to the Orange.	3	1	2
D14H	See above.	3	1	2

D14J	Contributes to Gariep Dam's yield and water quality.	4	1	3
D14K	See above.	4	1	3
D13A	Contributing to Gariep Dam's yield and water quality.	4	3	4
D13B	See above.	4	3	4
D13C	See above.	4	2.5	4
D13D	See above.	4	1	3
D13E	See above.	4	1	3
D13F	See above.	4	1	3
D13G	See above.	4	2	4
D13H	See above.	4	2	4
D13J	See above.	4	1	3
D13K	See above.	4	1	3
D13L	See above.	4	1	3
D13M	Boskraai Dam - not a likely option and far in future.	4	1	3
D21A	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems. Water quality important as possible offtake in Hololo River as part of the Lesotho Lowlands project.	4	2	4
D21B	See above.	4	1	3
D21C	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	2	3
D21D	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	2.5	3.5
D21E	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D21F	See above.	3	1	2
D21G	See above.	3	1	2
D21H	See above	3	2	3
D21J	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems. Water quality important as possible off-take in Hlotse River as part of the Lesotho Lowlands project.	4	2.5	4
D21K	See above.	4	2	4
D21L	See above.	4	2	4
D22A	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D22B	See above.	3	1	2
D22C	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems. Maseru Water Treatment works and drinking water supply.	3	1	2
D22D	See above.	3	1	2
D22E	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems. Maseru Water Treatment works and drinking water supply.	3	2	3
D22F	See above.	3	2	3
D22G	See above.	3	1	2
D22H	See above.	3	2	3

D22J	Upper catchment of the Phuthiatsana River in which the Metolong Dam will be built. Catchment management important for water quality and treatability of the WTW. Maseru water supply supplement and part of the Lesotho Lowlands project.	4	2.5	4
D22K	See above.	3	2	3
D22L	Upper catchment of the Phuthiatsana River in which the Metolong Dam will be built. Catchment management important for water quality and treatability of the WTW. Maseru water supply supplement and part of the Lesotho Lowlands project.	4	1	3
D22L	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D23A	See above.	3	1	2
D23B	See above.	3	1	2
D23C	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems. Armenia Dam used for irrigation and towns - many such and smaller dams in area. Water quality management upstream important.	3	1	2
D23D	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D23E	See above.	3	1	2
D23F	See above.	3	2	3
D23G	See above.	3	2	3
D23H	Contributes to yield of Knelpoort.	3	1	2
D23J	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems. Welbedacht Dam used for drinking water supply to Bloemfontein.	3	1	2
D24A	Contributes to yield of Egmont.	3	1	2
D24B	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D24C	River used for conduit for extensive irrigation (pivots) ds to the Game Reserve at the confluence with the Orange.	4	1	3
D24D	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D24E	River used for conduit for extensive irrigation (pivots) ds to the Game Reserve at the confluence with the Orange.	4	1	3
D24F	See above.	4	1	3
D24G	See above.	4	1	3
D24H	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D24J	River used for conduit for extensive irrigation (pivots) ds to the Game Reserve at the confluence with the Orange.	4	1	3
D24K	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2
D24L	Whole Caledon highly utilised and stressed. Many small dams, mostly off-channel due to sedimentation problems.	3	1	2

11.2 PRIORITY AREAS FOR DETAIL STUDIES: ORANGE CATCHMENT FROM GARIEP DAM TO THE VAAL CONFLUENCE (BASIN 2)

Table 11-2 BASIN 2: Hotspots and priority areas for detail assessment

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
D31A	Very dry, mostly local importance. Very little contribution to Orange.	1	3	2.5
D31B	See above.	1	3	2.5
D31C	See above.	1	3	2.5
D31D	See above.	1	3	2.5
D32A	See above.	1	1	1
D32B	See above.	1	2	1.5
D32C	See above.	1	2	1.5
D32D	See above.	1	3	2.5
D32E	See above.	1	3	2.5
D32F	See above.	1	3	2.5
D32G	See above.	1	1	1
D32H	See above.	1	3	2.5
D32J	See above.	1	3	2.5
D32K	See above.	1	3	2.5
D34A	Between Gariep and Van der Kloof Dams. Important conduit for hydro-electric releases.	4	1	3
D34B	Very dry, mostly local importance. Very little contribution to Orange.	1	3	2.5
D34C	See above.	1	3	2.5
D34D	See above.	1	2	1.5
D34E	Between Gariep and Van der Kloof Dams. Important conduit for hydro-electric releases.	4	1	3
D34F	Very dry, mostly local importance. Very little contribution to Orange.	1	3	2.5
D34G	Between Gariep and Van der Kloof Dams. Important conduit for hydro-electric releases.	4	1	3
D35A	Very dry, mostly local importance. Very little contribution to Orange. Water quality contributes to Gariep dam.	2	3	3.5
D35B	See above.	2	3	3.5
D35C	See above.	1	3	2.5
D35D	See above.	1	3	2.5
D35E	See above.	1	3	2.5
D35F	Very dry, mostly local importance. Very little contribution to Orange. Water quality contributes to Gariep dam.	2	3	3.5
D35G	Very dry, mostly local importance. Very little contribution to Orange. Water quality contributes to Gariep dam and local influence to Orange-Fish transfer scheme.	2	3	3.5
D35J	Very dry, mostly local importance. Very little contribution to Orange. Water quality contributes to Gariep dam.	2	3	3.5
D33A	Extensive irrigation and other developments. River used as conduit to convey water. Also hydro-electric releases.	4	1	3

D33B	Very dry. Very little contribution to Orange.	1	3	2.5
D33C	See above.	1	2	1.5
D33D	Extensive irrigation and other developments. River used as conduit to convey water. Also hydro-electric releases.	4	1	3
D33E	See above.	4	1.5	3
D33F	Very dry. Very little contribution to Orange.	1	3	2.5
D33G	Extensive irrigation and other developments. River used as conduit to convey water. Also hydro-electric releases.	4	1.5	3
D33H	See above.	4	1.5	3
D33J	Very dry. Very little contribution to Orange.	1	3	2.5
D33K	Extensive irrigation and other developments. River used as conduit to convey water. Also hydro-electric releases.	4	1.5	3

11.3 PRIORITY AREAS FOR DETAIL STUDIES: ORANGE RIVER CATCHMENT FROM VAAL CONFLUENCE TO THE HARTBEES CONFLUENCE (BASIN 3)

Table 11-3 BASIN 3: Hotspots and priority areas for detail assessment

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
D51A	Very dry. Local use.	1	3	2.5
D51B	Very dry. Local use.	1	2	1.5
D51C	Very dry. Local use.	1	2	1.5
D52A	Very dry. Local use.	1	2	1.5
D52B	Very dry. Local use.	1	2	1.5
D52C	Very dry. Local use.	1	2	1.5
D52D	Very dry. Local use.	1	3	2.5
D52E	Very dry. Local use.	1	2	1.5
D52F	Very dry. Local use.	1	2	1.5
D53A	Influences Rooiberg Dam and water quality.	2	3	3.5
D53B	Endorheic pans, no importance.	1	1	1
D53C	See above.	1	3	2.5
D53D	See above.	1	3	2.5
D53E	See above.	1	3	2.5
D53F	See above.	1	4	2.5
D53G	See above.	1	3	2.5
D53H	See above.	1	3	2.5
D53J	See above.	1	3	2.5
D54A	Very dry. Local use.	1	3	2.5
D54B	Very dry. Local use.	1	3	2.5
D54C	Vanwyksvlei Dam - only has water in when rains. Potential water quality influence to dam.	2	3	3.5
D54D	Very dry. Local use.	1	3	2.5
D54E	Very dry. Local use.	1	3	2.5
D54F	Very dry. Local use.	1	3	2.5
D54G	Very dry. Local use.	1	3	2.5
D55A	Very dry. Local use.	1	2	1.5
D55B	Very dry. Local use.	1	2	1.5
D55C	Very dry. Local use.	1	3	2.5
D55D	Very dry. Local use.	1	3	2.5

D55E	Very dry. Local use.	1	3	2.5
D55F	Very dry. Local use.	1	2	1.5
D55G	Very dry. Local use.	1	2	1.5
D55H	Very dry. Local use.	1	3	2.5
D55J	Very dry. Local use.	1	3	2.5
D55K	Very dry. Local use.	1	3	2.5
D55L	Very dry. Local use.	1	3	2.5
D55M	Very dry. Local use.	1	3	2.5
D56A	Very dry. Local use.	1	3	2.5
D56B	Very dry. Local use.	1	3	2.5
D56C	Very dry. Local use.	1	3	2.5
D56D	Very dry. Local use.	1	4	2.5
D56E	Very dry. Local use.	1	3	2.5
D56F	Very dry. Local use.	1	4	2.5
D56G	Very dry. Local use.	1	3	2.5
D56H	Very dry. Local use.	1	3	2.5
D56J	Very dry. Local use.	1	3	2.5
D57A	Endorheic pans, no importance.	1	2	1.5
D57B	See above.	1	3	2.5
D57C	See above.	1	2	1.5
D57D	See above.	1	4	2.5
D57E	See above.	1	4	2.5
D58A	Very dry. Local use.	1	3	2.5
D58B	Very dry. Local use.	1	3	2.5
D58C	Very dry. Local use.	1	4	2.5
D61A	Upstream of Smart Syndicate Dam. Very dry. Some local impacts.	2	1	1.5
D61B	See above.	2	1	1.5
D61C	See above.	2	1	1.5
D61D	See above.	2	3	3.5
D61E	See above.	2	2	2
D61F	See above.	2	1	1.5
D61G	See above.	2	1	1.5
D61H	See above.	2	2	2
D61H	See above.	2	3	3.5
D61J	See above.	2	3	3.5
D61K	See above.	2	3	3.5
D61L	See above.	2	3	3.5
D61M	See above.	2	3	3.5
D62A	Very dry. Local use.	1	2	1.5
D62B	Very dry. Local use.	1	3	2.5
D62C	Very dry. Local use.	1	3	2.5
D62D	Very dry. Local use.	1	3	2.5
D62E	Very dry. Local use.	1	3	2.5
D62F	Endorheic pans, no importance.	1	2	1.5
D62G	Very dry. Local use.	1	3	2.5
D62H	Endorheic pans, no importance.	1	3	2.5
D62J	Very dry. Local use.	1	2	1.5
D71A	Extensive irrigation and other developments. River used as conduit to convey water.	4	1.5	3
D71B	Very dry. Local use.	1	3	2.5

D71C	Extensive irrigation and other developments. River used as conduit to convey water.	4	1.5	3
D71D	See above	4	1.5	3
D72A	Extensive irrigation and other developments. River used as conduit to convey water. Water quality possible influence to Boegoeberg Dam.	4	1.5	3
D72B	See above.	4	2	4
D72C	See above.	4	1	3
D73A	Very dry. Local use.	1	3	2.5
D73B	Very dry. Local use.	1	3	2.5
D73C	Extensive irrigation and other developments. River used as conduit to convey water. Water quality possible influence to Boegoeberg Dam.	4	1.5	3
D73D	Extensive irrigation and other developments. River used as conduit to convey water.	4	1.5	3
D73E	See above.	4	1.5	3
D73F	Extensive irrigation and other developments. River used as conduit to convey water. Water quality possible influence to local use in Kakamas and Keimos.	4	2.5	4

11.4 PRIORITY AREAS FOR DETAIL STUDIES: ORANGE RIVER CATCHMENT FROM THE HARTBEES CONFLUENCE TO THE ESTUARY (BASIN 4)

Table 11-4 BASIN 4: Hotspots and priority areas for detail assessment

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
D81A	Extensive developments and irrigations in sections right down to the mouth.	4	2.5	4
D81B		4	2	4
D81C	No use	0	3	1.5
D81D (1026	Extensive developments and irrigations in sections right down to the mouth.	4	2	4
D81E (1026_45)		4	2.5	4
D81F (1045)		4	2.5	4
D81G		4	3	4
D82A (1048_50)		4	3.5	4
D82B	Endorheic pans.	0	3	1.5
D82C		0	3	1.5
D82D	Extensive developments and irrigations in sections right down to the mouth.	4	3	4
D82E	Possible Vioolsdrift Dam (us of gauge).	4	2.5	4
D82F	Extensive developments and irrigations in sections right down to the mouth.	4	2.5	4
D82G		4	2.5	4
D82H		4	3.5	4
D82J		4	3.5	4
D82K		4	3.5	4
D82L	Extensive developments and irrigations in sections right down to the mouth. Water quality used by mining in Oranjemund and Alexander Bay.	4	3	4
1005 (1)	Very dry ephemeral rivers.	1	3	2.5
1005 (2)		1	3	2.5
1017		1	3	2.5
1020	Tsamab Dam, water quality control for dam.	2	3	3.5

1032	Very dry ephemeral rivers.	1	3	2.5
1014	No use	0	3	1.5

11.5 PRIORITY AREAS FOR DETAIL STUDIES: MOLOPO CATCHMENT (BASIN 5)

Table 11-5 BASIN 5: Hotspots and priority areas for detail assessment

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
D41A_R1	Heavy utilisation of the dolomitic eye. Assumed water is taken directly out of the eye. Contribute to various lower dam yields. Water quality management required for downstream dam usage.	4	4	4
D41A_R2		4	3	4
D41A_R3		4	1	3
D41A_R4	Heavy utilisation of the dolomitic eye. Assumed water is taken directly out of the eye. Contribute to various lower dam yields. Water quality management required for Modimola Dam usage.	4	1	3
D41A_R5	Heavy utilisation of the dolomitic eye. Assumed water is taken directly out of the eye. Contribute to various lower dam yields. Water quality management required for Dinaseng Dam usage.	4	1	3
D41A_R6	Heavy utilisation of the dolomitic eye. Assumed water is taken directly out of the eye. Contribute to various lower dam yields.	4	1	3
D41A_Ramat.	Dam in lower catchment. Some irrigation. Contribution to Ramatlabama Dam's yield.	3	1	2
D41B (957)	Large rural settlements and some instream dams.	3	1	2
D41B	Extensive local use, many small farm dams in main river and tributaries. No significant contribution in terms of flow downstream.	2	2.5	2.5
D41C (959)	Large rural settlements and some instream dams.	3	1.5	2.5
D41C	Very dry compared to e.g. D41B	1	3	2.5
D41D		1	3	2.5
D41E	No more instream dams or pools. Very dry.	1	2	1.5
939	In Botswana, not surface water, ephemeral. No real utilisation.	0	3	1.5
941		0	3	1.5
942 to confl		0	3	1.5
926		0	3	1.5
921		0	3	1.5
D41F (935)	No more instream dams or pools. Very dry.	1	3	2.5
D41F	No significant water use.	0	3	1.5
D41G		0	2	1
D41H		0	2	1
D41H(944)	No more instream dams or pools. Very dry.	0	3	1.5
D41J	No significant water use.	0	2	1
D41K		0	2	1
D41L	Use of eye and downstream river and water quality management for downstream users.	3	1	2

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
D41M	Downstream river very dry.	1	3	2.5
D42C	No surface water whatsoever.	0	3	1.5
D42C		0	1	1
D42D		0	4	1.5
D42E		0	4	2

11.6 PRIORITY AREAS FOR DETAIL STUDIES: FISH AND NOSSOB RIVERS (BASIN 6)

Table 11-6 BASIN 6: Hotspots and priority areas for detail assessment

Quat	WRUI motivations	WRUI	IEI	PRIORITY RATING
855	Various dams in system.	4	2	4
861		4	2	4
890	Mostly local dams, many with no yield.	2	1	1.5
D42A (910)	Ephemeral, in National Park mostly.	0	4	2
D42B (960)		0	2.5	1
873	Mostly groundwater schemes, many small dams.	4	3	4
898	Ephemeral.	4	1	3
D42A (946)	Ephemeral, in National Park mostly.	0	4	2
899	Role of catchment in yield of Hardap Dam and water quality.	0	3	1.5
904b		4	4	4
904a		4	4	4
904c		4	4	4
917 a		4	4	4
917 b		4	3.5	4
930	DS from Hardap Dam, very dry.	1	4	2.5
933		1	3	2.5
955		1	3	2.5
969	Potential Neckertal Dam.	3	4	4
976	Naute Dam - Catchment important for yield and water quality.	4	3	4
987		4	3	4
990c		4	3	4
990b		4	3	4
990a		0	4	2
962		0	3	1.5
1009		0	4	2
885		1	3	1.5
883		1	3	1.5
969		1	3	1.5

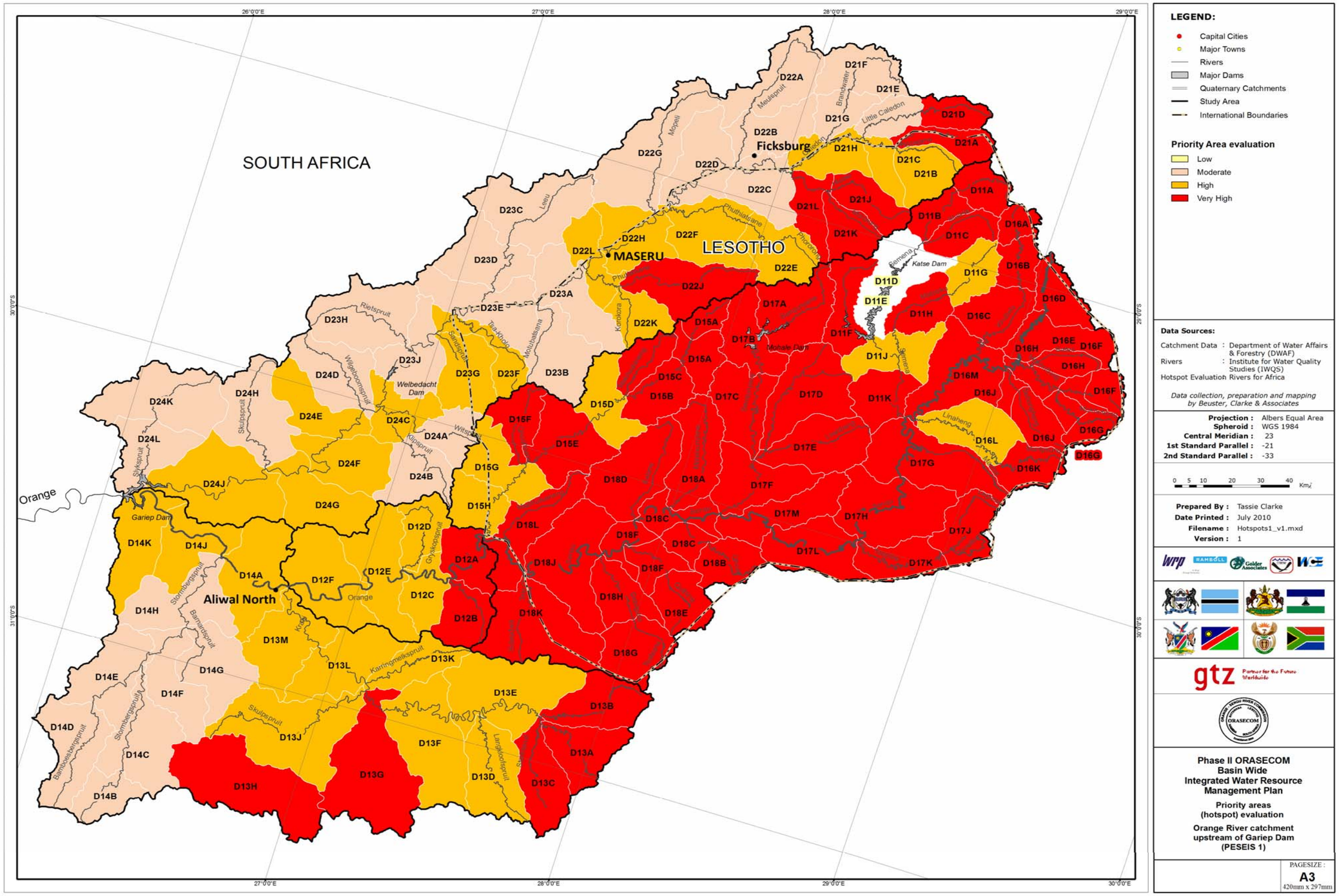


Figure 11.1 BASIN 1: Map illustrating hotspots and priority areas for detail assessment

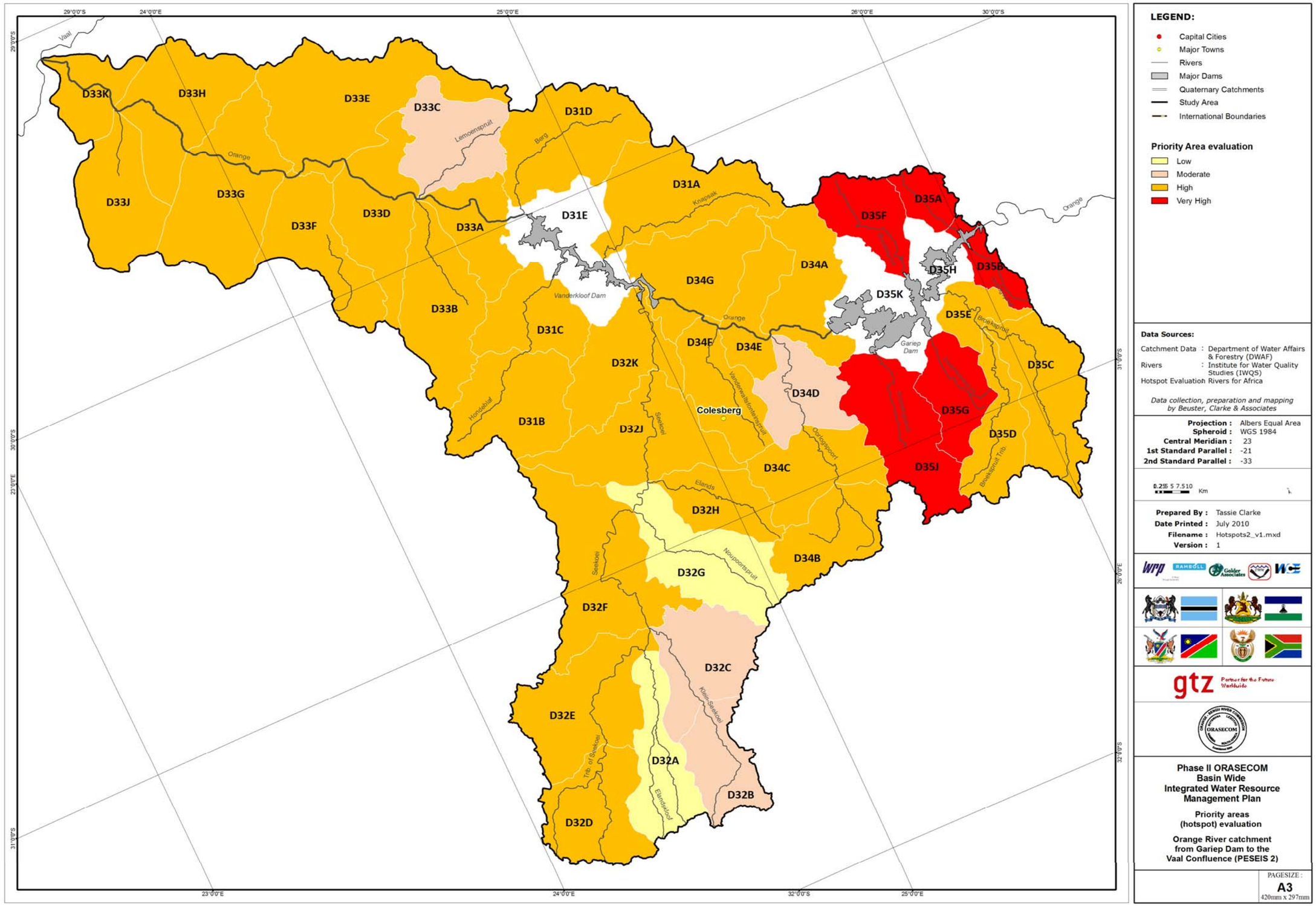
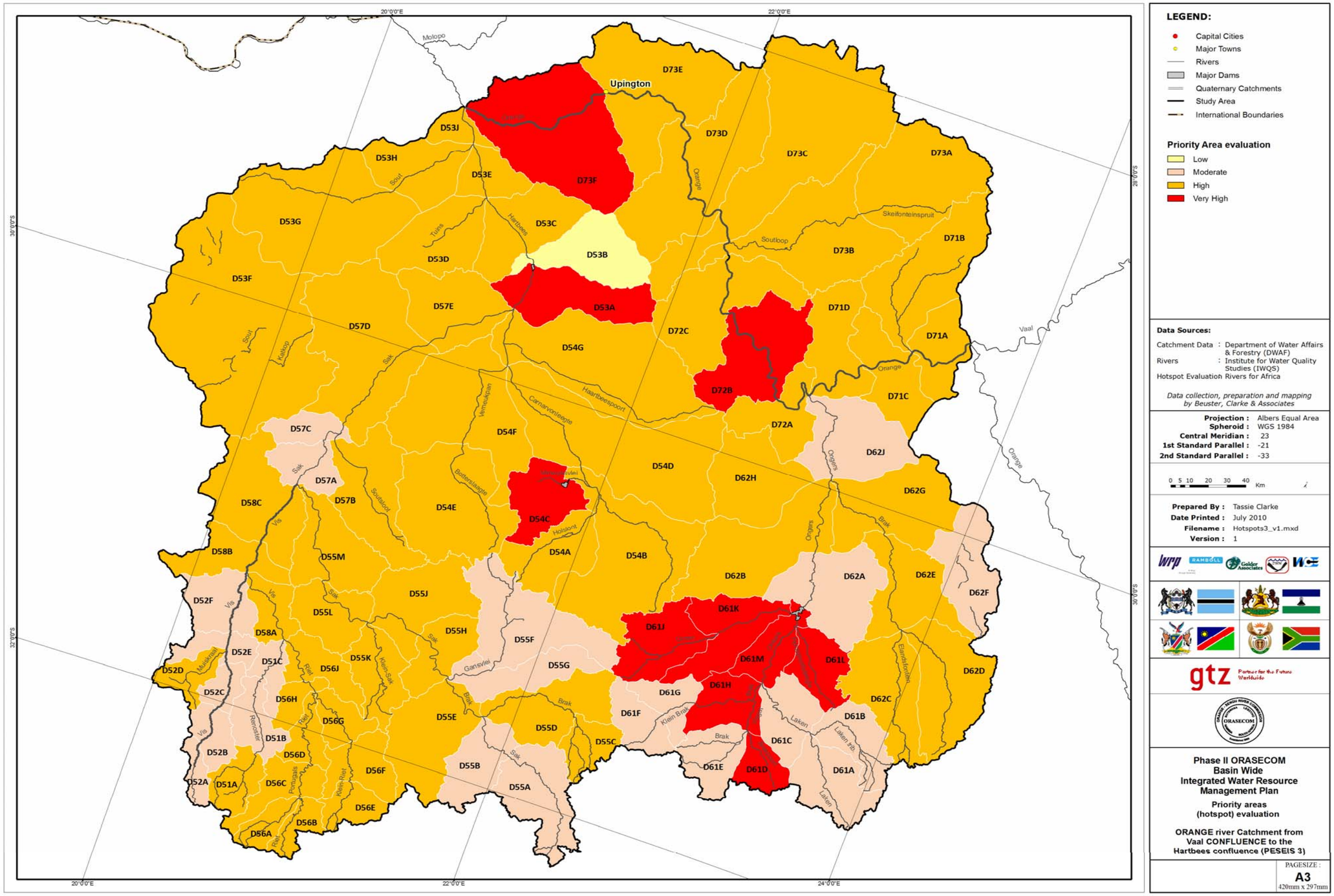


Figure 11.2 BASIN 2: Map illustrating hotspots and priority areas for detail assessment



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Priority Area evaluation

- Low
- Moderate
- High
- Very High

Data Sources:

Catchment Data : Department of Water Affairs & Forestry (DWAF)
Rivers : Institute for Water Quality Studies (IWQS)
Hotspot Evaluation Rivers for Africa

Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

0 5 10 20 30 40 Km

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Hotspots3_v1.mxd
Version : 1

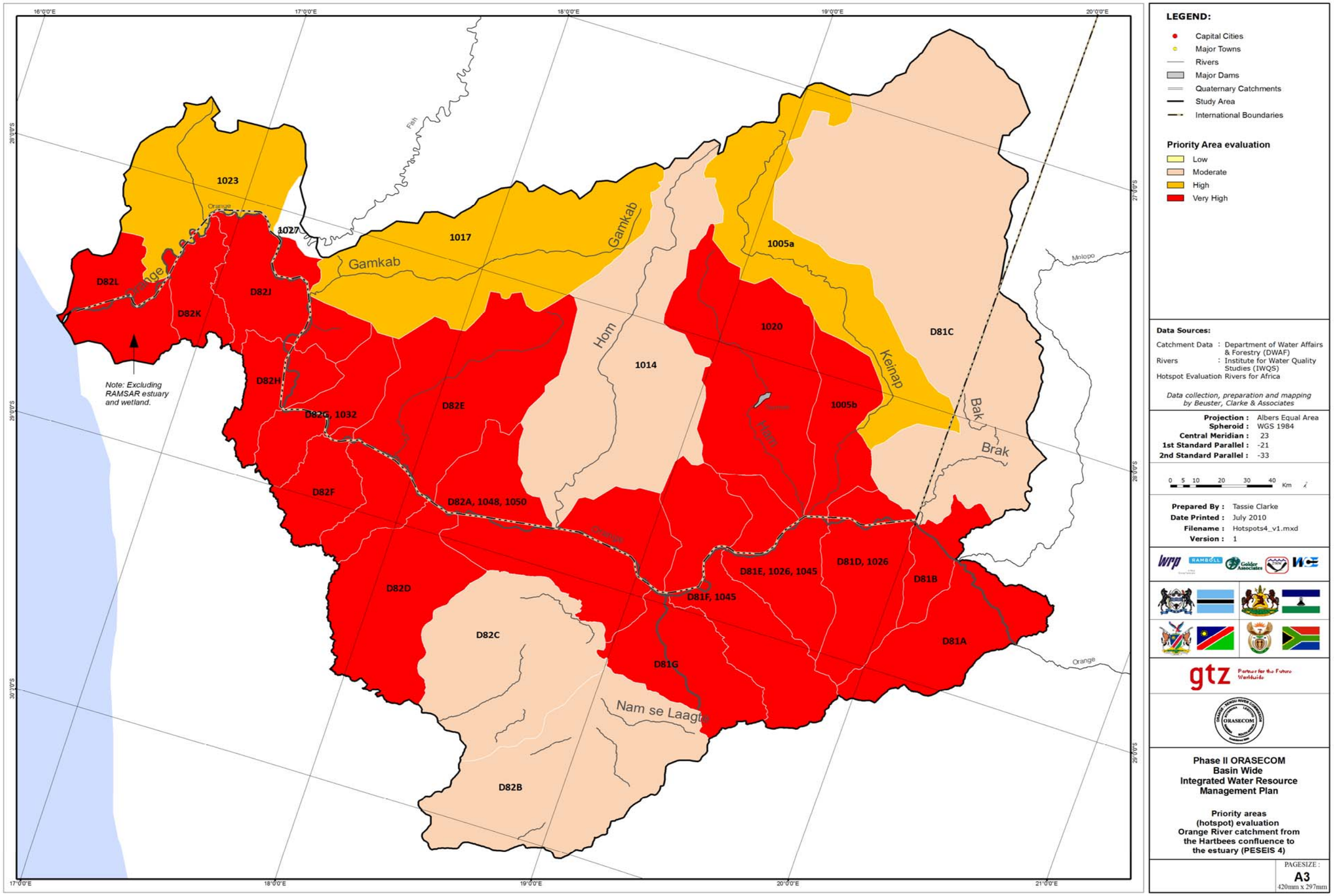
Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Priority areas (hotspot) evaluation

ORANGE river Catchment from Vaal CONFLUENCE to the Hartbees confluence (PESEIS 3)

PAGESIZE : **A3** 420mm x 297mm

Figure 11.3 BASIN 3: Map illustrating hotspots and priority areas for detail assessment



LEGEND:

- Capital Cities
- Major Towns
- Rivers
- Major Dams
- Quaternary Catchments
- Study Area
- International Boundaries

Priority Area evaluation

- Low
- Moderate
- High
- Very High

Data Sources:

Catchment Data : Department of Water Affairs & Forestry (DWAF)
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Data collection, preparation and mapping by Beuster, Clarke & Associates

Projection : Albers Equal Area
Spheroid : WGS 1984
Central Meridian : 23
1st Standard Parallel : -21
2nd Standard Parallel : -33

0 5 10 20 30 40 Km

Prepared By : Tassie Clarke
Date Printed : July 2010
Filename : Hotspots4_v1.mxd
Version : 1

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Phase II ORASECOM Basin Wide Integrated Water Resource Management Plan

Priority areas (hotspot) evaluation Orange River catchment from the Hartbees confluence to the estuary (PESEIS 4)

PAGESIZE : **A3** 420mm x 297mm

Figure 11.4 BASIN 4: Map illustrating hotspots and priority areas for detail assessment

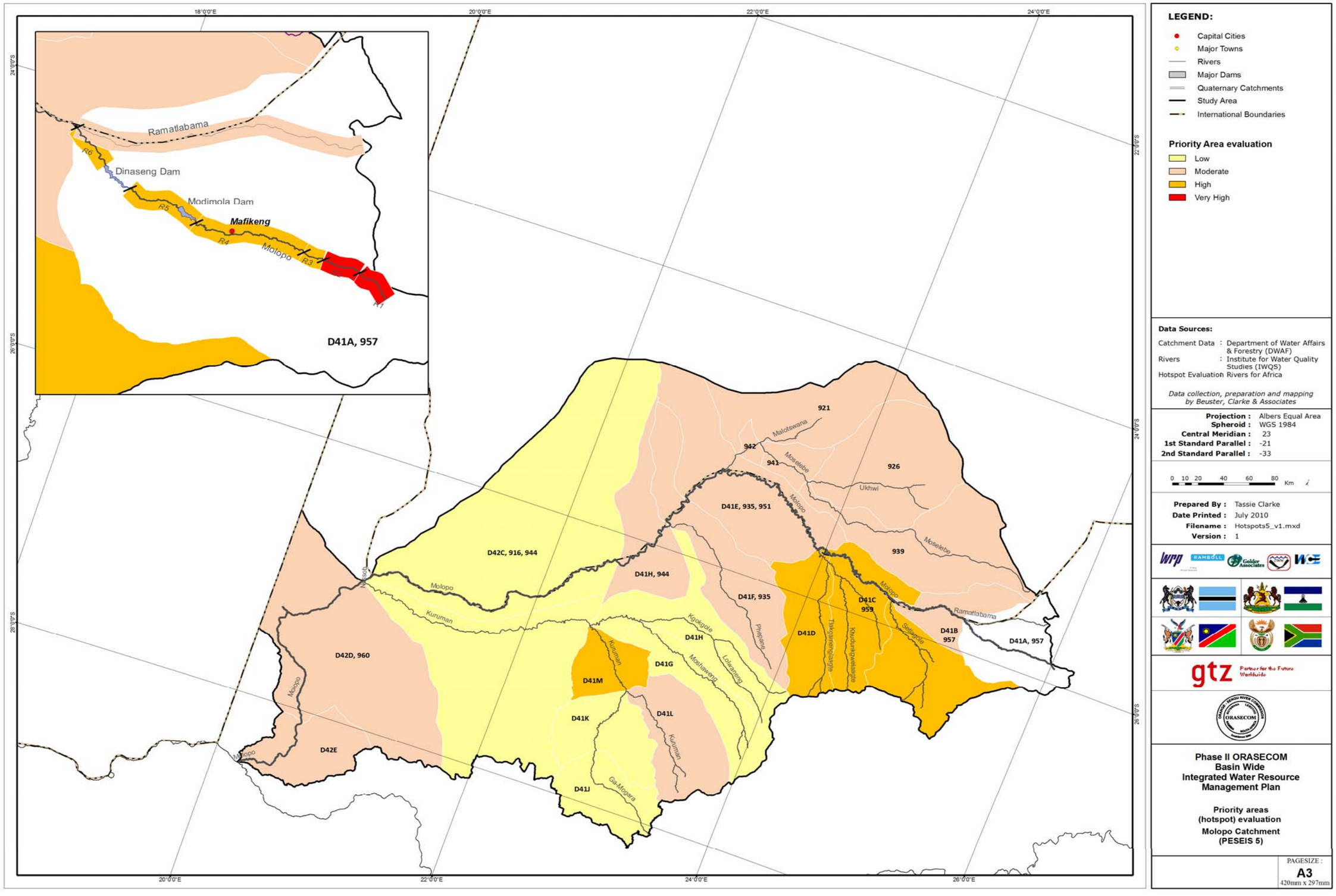

Figure 11.5 BASIN 5: Map illustrating hotspots and priority areas for detail assessment

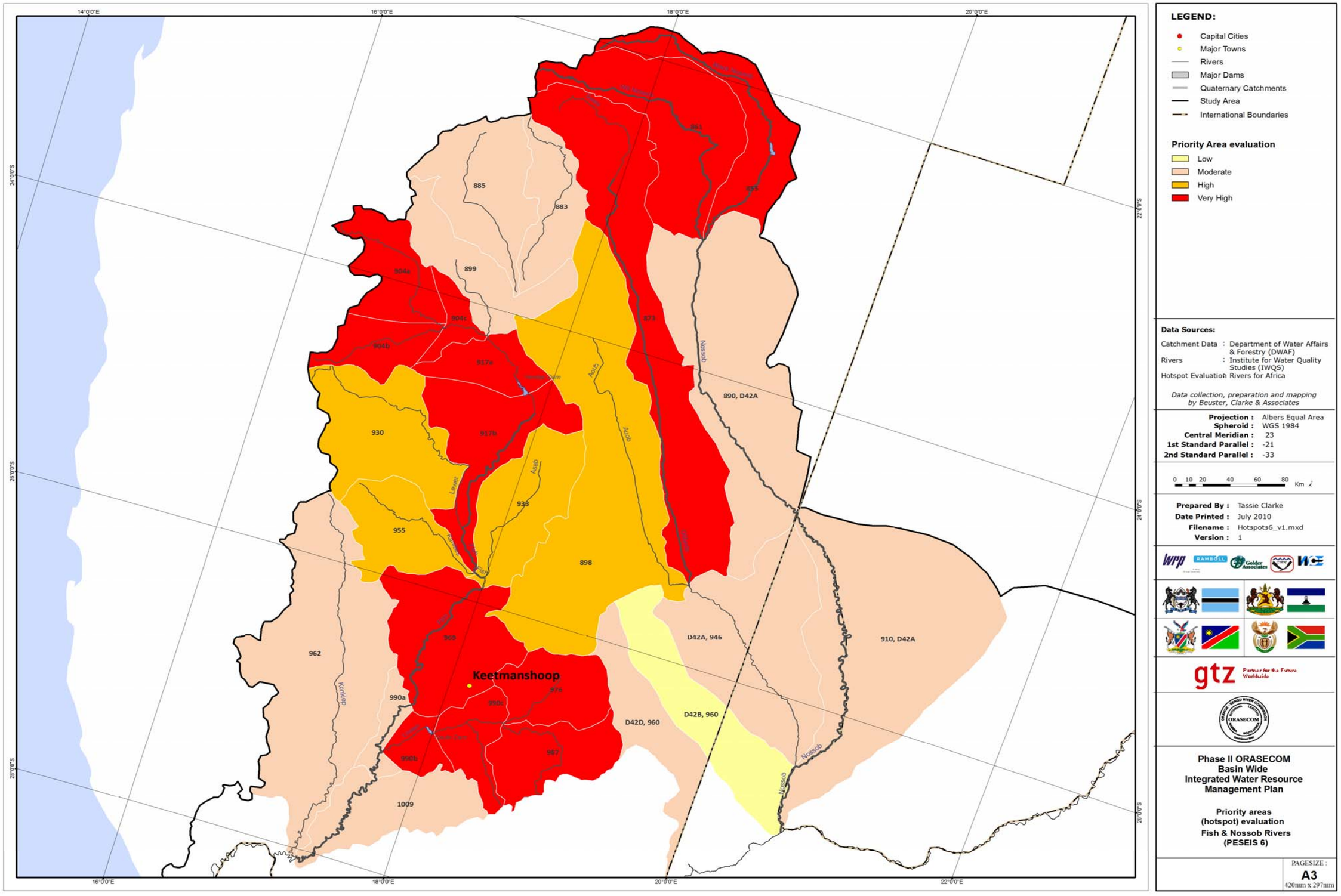

Figure 11.6 BASIN 6: Map illustrating hotspots and priority areas for detail assessment

11.7 CONCLUSIONS AND RECOMMENDATIONS

BASIN 1: Orange Catchment to Gariep Dam

Most of the priority areas (hotspots) are lying within Lesotho and are associated with the Senqu/Orange portion of Lesotho. This is due to the combination of a High IEI as well as the High WRUI. The WRUI is mainly high due to the importance of the yield to Gauteng (transfers) and to the lower Gariep Dam.

This is also the case for all the priority areas rated as a 3 (just less than the hotspot evaluation which is a 4). The WRUI is important in the Caledon system as supplying yield to Knelpoort and Welbedacht Dams and the suppliers from these dams.

BASIN 2: Orange Catchment from Gariep Dam to Vaal River confluence

The only hotspots (4 rating) are associated with tributaries to the Orange River that flows into the Gariep Dam. The reasoning is the relatively high WRUI due to the water quality function of these tributaries for the dam as well as the Orange-Fish transfer.

The rest of the tributaries are mostly rated as a 3 due to the high IEI and the relatively high WRUI related to the local importance of this resource for agriculture.

BASIN 3: Orange Catchment from the Vaal confluence to the Hartbees confluence

The hotspots in the tributaries of the Orange River are situated in the quaternary catchments that contribute to Van Wyksvlei Dam, and Rooiberg Dam. There are two hotspots in the Orange River with D72B due to the importance of Boegoeberg Dam and D73F due to the Kakemas and Keimoes irrigation schemes.

BASIN 4: Orange Catchment from the Hartbees confluence to the estuary

The extensive developments and irrigations in sections right down to the mouth have resulted in a high WRUI. This, in combination with the high IEI, has resulted to the whole Orange River within this cluster as being rated as a hotspot.

BASIN 5: Molopo River

There are only two hotspots in the D41A quaternary catchment associated with the high IEI as well as the high WRUI as the only supply of water to Mafikeng.

BASIN 6: Fish and Nossob catchments

Due to the water scarce nature of this area, the Fish River is a major resource and has resulted in most of the reaches upstream of Hardap Dam to be evaluated as a hotspot. The situation is similar in the upper Nossob reaches where the yield to the various dams is vital for Windhoek and other smaller towns.

The above results are summarised in Figure 11-7.

Recommendations

The information gained from this exercise and produced in this report should be used to indicate priority areas where more detailed studies should be undertaken. The Work Package 5 focuses on the determination of EFRs at an intermediate level which is considered relatively detailed. The key

to detailed EFR assessment is in selecting appropriate EFR sites at which the ecological flows will be determined. It therefore follows that the hotspot identification provides an indication of where detailed EFR results are required and therefore where the EFR sites should be selected.

The map in Figure 11-7 provides a visual assessment of the locality of the hotspots. Lesotho (section of BASIN 1) and BASIN 6 is excluded from further consideration as these areas are not included in the study area for EFR assessments.

The hotspots (considering the 4 and 3 ratings, i.e. red and orange) fall along the Orange, Caledon, Kraai and the upper Molopo Rivers. Where possible, EFR sites for this study should be situated on these rivers and in the hotspots if possible as these data provide an indication of the highest priority areas to investigate.

The selection of Management Resource Units and the EFR sites are documented in internal deliverable 8. The EFR sites are also indicated on Figure 11.7.

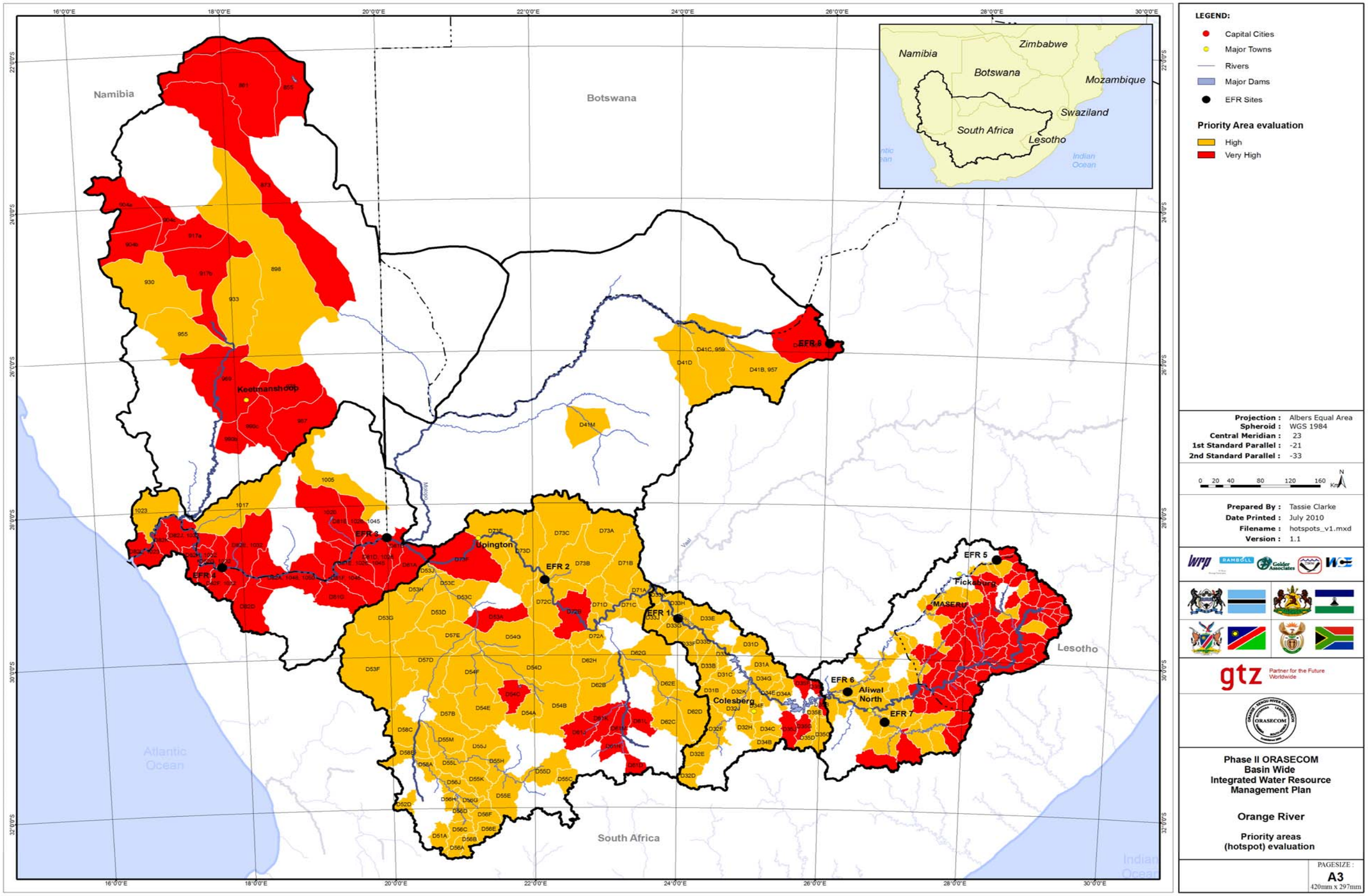

Figure 11.7 Identification of quaternary catchments of high priority (rating very High and High) for detailed EFR and other studies

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