



ORASECOM Document No. 010/2010



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

Work Package 5:

Assessment of Environmental Flow Requirements

Goods and Services Report



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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ORASECOM Document No.

010/2010

Date of Publication:

December 2010

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Status:

Final Report

APPROVALS

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Study Name	Support to Phase 2 of the ORASECOM Basin-wide Integrated Water resources Management Plan		
Report Title:	<i>Goods and Services Report</i>		
Submitted by:	WRP Consulting Engineers in association with Golder Associates, DMM, PIK, RAMBOLL and WCE		
REPORTS, WPS AND OTHER DELIVERABLES SUBMITTED	TYPE	No.	
Overall Study			
Inception Report	Report	004/2010	
Overall 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 & WP	001/2011	
Modelling software and datasets	Software	None	
Capacity Building and Setting up the Models in each Country; Process of Continuous Review	WP	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	WP	005/2011	
Extension of Hydrological Records	Report	006/2011	
Hydrological Database	Database	None	
Work Package 3: INTEGRATED WATER RESOURCES QUALITY MANAGEMENT PLAN			
<i>Development of Water Quality Monitoring programme and Data Management Framework</i>	<i>Report</i>	<i>007/2011</i>	
Development of Specifications for the Water Quality Model	WP	006/2010	
Work Package 4: CLIMATE CHANGE IN THE ORANGE-SENQU RIVER BASIN			
Downscaling Methodology and Ongoing Climate Modelling Initiatives	WP	007/2010	
GCC Downscaling for the Orange-Senqu River Basin	Report	008/2011	
Projection of impacts and Guidelines on Climate Change Adaptation Strategies	WP	009/2011	
Work Package 5: ASSESSMENT OF ENVIRONMENTAL FLOW REQUIREMENTS			
Literature survey and Gap Analysis	WP	008/2010	
Delineation of Management Resource Units	WP	009/2010	
Desktop EcoClassification Assessment	Report	016/2010	
<i>Goods and Services Report</i>	<i>WP</i>	<i>010/2010</i>	
Environmental Flow Requirements	Report	010/2011	
Work Package 6: WATER CONSERVATION AND WATER DEMAND IN THE IRRIGATION SECTOR			
The Promotion of Water Conservation and Water Demand Management in the Irrigation Sector	Report	011/2011	
Irrigation GIS Database, Interactive Database and Irrigation Scenario Tools	WP	012/2011	
Irrigation GIS Database and Interactive Classification Tool	Software	None	
Irrigation Scenario Generation Tool	Software	None	

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ACRONYMS

AEC	Alternative ecological category
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EFR	Environmental Flow Requirements
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FROC	Frequency of occurrence
IFR	Instream Flow Requirements
LHWP	Lesotho Highlands Water Project
MDG	Millennium development goals
MRU	Management resource unit
NWA	National Water Act
NWRS	National Water Resource Strategy
ORASECOM	Orange-Senqu River Commission
PAI	Physico Chemical Driver Assessment Index
PES	Present Ecological State
REC	Recommended ecological category
RSA	Republic of South Africa
SCI	Socio Cultural Importance
ToR	Terms of Reference
WMA	Water management area

1 ENVIRONMENTAL GOODS AND SERVICES IN THE CATCHMENT

1.1 Study Area

The Orange-Senqu Basin spans four Southern African countries (Botswana, Lesotho, Namibia and South Africa) and is one of the largest river basins in Southern Africa, covering an area of 985,000 km². Almost 59% of the basin falls within South Africa, 26% in Namibia, 12% in Botswana and 3% in Lesotho. The relatively scarce surface and groundwater resources in the Orange-Senqu Basin are critical for the sustainable social and economic development of each country. Existing patterns of land and water use have reached the point where great care is needed to ensure that the scarce and vulnerable water resources are not over-exploited.

The focus of this “Goods and Services Report” is on the parts of the catchment that are central to a consideration of delivery of usage to people that is not part of the formal market economy. The first part of the report considers an overall contextual background to the Goods and Services in the catchment, while the second part is a more detailed consideration of the Goods and Services in specific parts of the catchment. These have been allied to the Environmental Flow Requirements (EFR) sites selected as part of the overall Environmental Flow Requirements study.

1.2 Overview and Approach

Natural habitats and ecosystems provide a huge range of environmental Goods and Services that contribute enormously – and are even essential – to human well-being. Protecting these areas is essential in order to achieve sustainable development. River systems and their associated use values are of particular importance.

Use values associated with environmental Goods and Services accrue to humans from the use of the environment consumptively or productively. They are classified into direct-use values, indirect-use values and option values.

The direct-use values refer to values associated with direct consumption, production, viewing of landscapes, bird watching, or even viewing of photographic images. Hunting and slaughter of wildlife for meat or skins constitute direct consumption of species from the environment. Grazing by livestock, harvesting medicinal plants and animals, and harvesting indigenous or endemic plants for road-side sale constitute productive activities whose economic values are realised in the form of profits from sale of final goods such as livestock, medicinal services, and the natural resources themselves.

The indirect-use values refer to ecological or ecosystem values such as production of nutrients, maintenance of well-functioning riverine ecosystems, water purification,

maintenance of specific gaseous qualities and hydrological cycles, and formation of soil and organic matter. These values do not accrue directly to users but support production of resources that bear direct use to people. Very important in the context of the Orange River Catchment is the capacity of a water body to assimilate or dilute wastes. This represents a real economic value when the costs of water-quality impacts are considered. Water managers rely on dilution flows in maintaining water-quality standards in rivers. The release of water from storage for low-flow augmentation is a recognised use of multiple-purpose reservoirs. The value of water for this use is related to the variation in natural stream flows. The value of water for waste dilution is usually calculated as either the waste-treatment costs foregone or downstream damages avoided. However, damages are difficult to estimate reliably.

Option values are values attached by individuals to the maintenance and preservation of environmental goods in order to reserve an option to use them, directly or indirectly, in the future. A different notion of option value known as vicarious value relates to creating use-options for contemporary generations. Value is not derived from use but from creating an option for use by others in the same generation. It is in this vicarious sense that option value is also seen as a non-use value.

Although all three use values make up the range of Goods and Services that are pertinent to our work, option values are not directly considered within the context of this present study. Although it is theoretically possible to generate option values, this is both a time-consuming as well as, given the size of the catchment, a very expensive task.

A consideration of Goods and Services is however an exercise that is of considerable importance to development planning for resource utilisation in the context of the poverty and vulnerability that pervades much of the catchment. As King 2007 points out:

Environmental Goods and Services are typically public goods, many of which are also managed under common property systems. Difficulty arises in realising the value of these Goods and Services in such a way that allows them to be included in the decision-making framework so as to mitigate adverse impacts on these resources as government actions are implemented. This has adverse implications for the national economy and the vulnerable poor. Social welfare and livelihoods can only be sustained through a policy environment that reduces the vulnerability of society and nature to resource-scarcity threats.

This requires technical and food security interventions as well as interventions that offset market, policy and institutional failures.

A poor understanding of the value of environmental Goods and Services will continue to encourage their overuse and degradation, the poor internalisation of the associated costs

and benefits of their use, and sub-optimal allocation among competing users, thus further exacerbating development constraints¹.

Further, the 2005 Millennium Ecosystem Assessment² concluded that the degradation of environmental services is a significant barrier to achieving the Millennium Development Goals (MDGs) – and that this impediment could grow significantly worse over the next 50 years. It also found that the harmful effects of environmental service degradation are often the principal drivers of poverty and social conflict.

Based on the literature research, as well as an initial site visit, the key Goods and Services that form a part of community reliance, livelihoods and subsistence, or provide key non-market related economic functions, have been examined and form part of this report. The list of Goods and Services were then further scrutinised to generate an overview of the likelihood that they will change given anticipated trajectories of modification to the system once scenarios are developed. If no change is expected, then further research into the value of these Goods and Services will not be pursued.

The method that was employed is essentially linked to EFR sites and then scenario-based. Assessment of the impacts of the various scenarios – in this case largely hypothetical notions of deviation from Present Ecological State (PES) at the EWR sites – essentially identifies the direction of change (either positive or negative), and estimates the “relative magnitude” of the change in benefits and costs that may be experienced within the Orange River System. The process adopted is as follows:

- The analysis of potential economic changes is based on the present-day situation, that is, the value of the Goods and Services currently provided by the water in the Orange River system.
- The biophysical specialists then identified the potential change that each of the key Goods and Services may undergo in each of the scenario clusters. The potential change is noted as a factor, and used in later calculations. For example, no change = 1, a 50% increase = 1.5, and a 20% decrease = 0.8.

1.3 Catchment Overview and Importance of Goods and Services

As previously mentioned, the Upper Orange-Senqu River includes the Senqu River in Lesotho and the Orange River in South Africa above the Vaal River confluence. The Lower Orange River includes the South African stretch, below the Vaal River confluence, and the Botswana and Namibia sections. Not all of the sections of the catchment and associated

¹ See King N.A (2007) Economic Valuation of Environmental Goods and Services in the Context of Good Ecosystem Governance, Water Policy 9 (Supplement 2)

² See www.millenniumassessment.org

riparian zones are equally critical with respect to the utilisation of Goods and Services. Large sections of the catchment are dominated by commercial farming and land use that relates to the formal market economy. The Orange River plays a major role in supporting agriculture, industry and mining. Two large water schemes have been created, the Orange River Project and the Lesotho Highlands Water Project. Agriculture employs more than half of the basin's population while a considerable portion is also employed in the industrial sector. Distribution of water use differs substantially between the Vaal River and the Orange River. While most of South Africa's heavy industry and mining activities are situated within the Vaal catchment, making urban and industrial consumption most important, irrigation gains more significance in the middle section of the basin, and ultimately accounts for 94% of water use on the Lower Orange River.

Along the Senqu River in Lesotho, extensive sheep and cattle farming are characteristic throughout the upper reaches. An estimated 70% of rural households produce vegetables in their home gardens and most of these gardens are rain-fed, supplemented with irrigation from household and/or community domestic water supplies. Produce from home gardens is mainly consumed at home, with small quantities sold at village markets. The Lesotho Highlands Water Project in the Upper Orange-Senqu water management area (WMA), and the huge investment associated with it are having a significant impact on Lesotho's political economy.

In the Upper Orange River WMA in South Africa the scale and magnitude of population and infrastructure is much greater than in Lesotho. The main economic activity is livestock farming and there are extensive areas under dry-land cultivation. Mining activities used to be a dominant sector in the Upper Orange but have declined in recent years and salt works and small diamond operations are the remaining operations.

The Lower Orange River is home to far fewer people than the Upper Orange-Senqu and Vaal River basins. This is driven mainly by climatic, physiographic and historical socio-economic factors. Economic activity is focused mostly around the small- to medium-sized towns located along or close to the river.

The major economic sectors in the Lower Orange River region are government, mining, agriculture and trade. Cultivation takes place along a fertile strip of alluvial soils in the Orange River valley and also in areas of locally higher rainfall. Most of the agricultural land is irrigated, using water extracted from the river and from groundwater. Crops grown in this region include high-value crops, e.g. dates, raisins and flowers, and vegetable and grain crops. Many of the high-value crops are exported to Europe. While these activities are localised along the river channel, sheep and goat livestock farming is prevalent across the entire region.

Mining activities do play a role in economic activities in the region, but much of it is alluvial diamond mining, located along the coast to the north and south of the Orange River Mouth. Other minerals extracted in the region include: copper (around Springbok, Nababeep and Aggenys), asbestos, Tiger's eye, aluminium silicate, limestone and dolomite.

Given that the central issue with respect to a consideration of Goods and Services is to ensure that vulnerable social groupings are not prejudiced by development trajectories, the social categories and economic activities largely linked to the formal market economy are not considered. This is not to say that all groupings linked to the formal economy are necessarily buffered against scenario-induced change. Indeed an argument could be made that farming communities and associate labour forces are potentially highly vulnerable to changes in river management regimes, particularly in the context of the Orange River system. However, these changes and allied impacts are represented in more formal economic analyses, while those dependent on Goods and Services and who are perceived as being outside of the formal market economy, are often overlooked.

The critical areas within which the utilisation of Goods and Services intersects with the potential for non-market related vulnerability to change among social groups have been identified as:

- The bulk of the Orange River (Senqu) in Lesotho
- Parts of the Caledon River – Lesotho is more relevant than the South African side of the river, which is dominated by commercial agriculture
- Parts of the Molopo River area in Botswana and South Africa
- Parts of the Nossob River in Namibia, South Africa and Botswana
- Aspects of the Fish River in Namibia
- Parts of the middle and lower Orange River in South Africa and its border with Namibia, in particular areas associated with the Namaqualand Region and the river mouth.

Preliminary results are presented by country in the section that follows.

2 OVERVIEW CONTEXTUAL ANALYSIS OF ECOSYSTEM GOODS AND SERVICES

2.1 Botswana

The southern parts of Botswana in the Nossob and Molopo River Basin host a very low rural population density confined to the sparsely populated Kgalagadi District and the moderately populated Southern District. Some 2.8% of Botswana's population lives within the Molopo Basin area. Goodhope, Mmathethe, Digawana and Khakhea are considered major villages in the Molopo River Basin.

Given the low population densities and the generally arid nature of the area, the relationship between the riparian resources and Goods and Services in this part of Botswana might initially appear to be tenuous. However, in this area the relationship between people and water has great cultural significance. Rain, water and river form a strong cultural idiom among the Tswana people and it is no accident that the name for the national currency "Pula" also means "rain". Furthermore, the river and water resources are linked to the primary subsistence economy in the area i.e. livestock farming. Traditional livestock rearing, which requires large expanses of land, is the main form of land use for the majority of the people in the Basin.

It is also reported that the Molopo and Nossob Rivers and their fossil river tributaries – even though these palaeo-river systems have no surface water flow nowadays – supply groundwater and as a result, soil moisture in the valleys is comparatively high. These areas tend to support relatively unique habitats and plant species in the region. The plant species are reportedly used for medicinal purposes. Some usage by the Khoisan people is reported, although the portions of the Orange River Basin considered here are only peripherally home to people claiming these ethnic allegiances.

The Molopo River Basin has pans associated with it. Some of the villages, e.g. Tabong, are built around the pans. The pans are spectacular geomorphological features in the region and are useful water sources for wildlife and domestic livestock, particularly after heavy rainfall - due to the compact structure of their calcareous soils.

Finally, the Nossob River is a key aesthetic feature of the Gemsbok National Park and the associated wildlife management areas.

2.2 Lesotho

Of the four riparian countries that make up the Orange River Basin, Lesotho is the only one where the entire population falls within the catchment of the Senqu-Orange River. It is also the area that is likely to display the greatest linkage between the population and its

dependence on environmental Goods and Services. While the urban and peri-urban centres may increasingly make up the bulk of the population in Lesotho, a considerable number of people still live in areas where dependence on Goods and Services is of paramount importance. Central to this dependence are riparian zones.

In particular, the riparian zones of the highland rivers are typically used by villagers on a daily basis for grazing animals, growing crops, catching fish and harvesting reeds, thatching grass, grass for handicrafts, wild vegetables, trees, medicinal plants and sand. This has been widely acknowledged, and of the four basin countries it is probably Lesotho that has the best information on the dependence between people and riparian systems. This is in no small part due to the research conducted for the Lesotho Highland Water Project to determine the compensation costs due to rural communities based on the impacts that the dams had on the availability of Goods and Services. In particular, Contract 648 *Consulting Services for the Establishment and Monitoring of the Instream Flow Requirements for River Courses Downstream of LHWP Dams* included an economic report that details the use and value of Goods and Services provided by the river. The following resources (Lesotho Highlands Development Authority (2007)) were recorded and examined for the purposes of costing.

- Fish (rock catfish, small mouth yellow fish, trout)
- Medicinal Plants on the wet and dry banks
- Shrubs and Debris
- Trees (poplars and willows)
- Vegetables (wet and dry banks)

Table 1

Table 1 shows the resources which were identified, but then excluded for the reasons given in the table.

Table 1: Goods and Services excluded; Senqu River Lesotho

Resource/ Service	Reason for Exclusion
Agriculture	Current flow believed to have no significant importance
Boat/Pedestrian crossings	Revenue loss to boat operators considered insignificant. Pedestrians will generally find river easier to cross after transformations in most areas.
Leloli (<i>Cyperus marginatus</i>)	Supply predicted to increase in all reaches and scenarios.
Medicinal animals	Current household use insignificant. Supply is sparse.
Reeds (<i>Phragmites australis</i>)	Supply predicted to increase in all reaches and scenarios.
River aesthetics/ Recreation	Not reliably measurable in the context of this study.
River for drinking water	Drinking water guaranteed from dam releases.
River serpent	Not reliably measurable.
Sand	Impact on households is judged as if sand is in plentiful supply.
Thatch grasses/shrubs	The supply of the main thatch grass increases.
Wild life	Current household use insignificant. Supply is sparse.

The methodology used provides a good basis for understanding how the issue may be tackled with respect to the greater Orange River Basin, and as such is set out in some detail below.

In the case of Contract 648, scenarios of impact were developed. For each scenario, the data on resource use, the prices attached to those resources and the midpoints of the biophysical consequences were combined to derive the monetary impact of flow changes as follows:

- resource values were first derived by multiplying resource use by prices,
- Monetary impacts were then isolated by weighting resource value using biophysical consequences, which provide both the direction and the magnitude of the predicted change (as a percentage).

However, the magnitudes of the biophysical changes were given as ranges of percentage changes within which there is a 95 % probability of outcome. The normal probability distribution was considered suitable for characterising the biophysical predictions. In order to reflect this for each IFR reach and scenario, the total household use value was weighted by a range of percentage changes for each resource in order to arrive at the value that would be lost due to alterations in flows.

Research that accompanied Contract 648 showed that plants are the riparian resources most used by the households affected by flow changes. These include wild vegetables, medicinal plants, shrubs, and trees. Shrubs, which are used mainly as a source of firewood, constituted

the largest value harvested by households. Fish was also a significant resource that was liable to decline due to flow changes.

The study also recognised that as resources decline in abundance, their use might well cease long before they have disappeared because of the poor returns to harvesting efforts. Thus, after the initial calculations had been done, the compensation costs were recomputed using the notion of a threshold beyond which the resource was effectively lost. The assumption used was that any resource that had a baseline mean reduction (threshold) of 50% or more would be treated as if its abundance had fallen by 100%.

For Contract 648 it was recognised that reduction in resource supplies could increase the prices of remaining resources, i.e., the same products could cost more. Thus, households may not be able to afford the same volume of resources and could either suffer welfare losses or seek substitute goods from markets.

Public and animal health studies provided information relating to the health of the population and their livestock. Baseline and future probabilities of contracting diseases or facing health risks were assessed. The predicted future probability of contracting diseases includes the baseline probability and the difference was termed 'flow-induced incremental risk'. In addition, mitigation programmes aimed at reducing the future risk were provided.

An overview of the Caledon River indicates that profiles of resource usage may loosely mimic those of the Highlands but there are three major differences. These are:

- The population densities are generally higher in the areas abutting the Caledon and although usage of Goods and Services may appear to be greater, in fact the intensity of usage has impacted negatively on availability to the extent that few resources of consequence appear to remain
- Water quality issues have also had a negative impact on resource availability
- Households in the Caledon catchment tend to be more tied to the urban and formal economy and less reliant on resources provided by the natural environment.

2.3 Namibia

Part of three of Namibia's regions, Omaheke, Karas and Hardap, make up Namibia's portion of the Orange River Basin. As is the case in Botswana, the population densities are low. The Namibian part of the basin is home to 11% of Namibia's total population, residing on 355,478 km² (43%) of Namibia's total area of 824,116 km².

While the Omaheke Region experiences a population growth rate of 2.5% per annum, the Karas and Hardap regions experience a mere 1.3% and 0.3% respectively. This is partially due to out-migration from the south, arising from the decline in job opportunities and the pull of urban centres for job seekers. However, it is also due to two other factors: 1) the number

of in-migrant households to the south which are small; and 2) the lower natural population growth rates among populations in the south compared to other parts of Namibia.

While quite small, the population of the Hardap and Karas Regions would be significantly lower if it were not for urban settlements, mining activities and irrigation schemes, as the hyper-arid, arid and semi-arid climate in the south can only support a sparsely distributed rural population. Vast parts of the south, as well as the Omaheke Region, consist of extremely large but sparsely populated commercial farms.

In the Karas Region, 54% of the population lives in urban areas, compared to only 46% in the Hardap Region and 28% in the Omaheke Region. The low figure of the Omaheke Region could be explained as a result of the predominant extensive farming areas. The regions continue to rapidly urbanise, especially in the Karas Region where more and more of the population is concentrated in the following four settlements: the regional capital of Keetmanshoop; the mining town of Oranjemund; the port of Lüderitz; and the rapidly growing mining town of Rosh Pinah. Of these three - Keetmanshoop, Oranjemund, and Rosh Pinah – are closely related to the Orange River.

There is a growing awareness about the economic potential of tourism in all three regions. As a result, the many emerging tourism enterprises may finally stabilise the exodus of the population from the rural areas. With the exception of Mariental, where the Hardap Irrigation Scheme is found, little economic activity other than extensive sheep and cattle farming is present in the Hardap Region. Utilisation of river-related Goods and Services is, however, generally low.

A potential exception is the tourism sector. Tourism, which is now Namibia's fastest growing sector after mining and agriculture, holds potential in further developing the southern and eastern parts of the Orange River catchment area, especially along the Konkiep, Fish River Canyon and the Karas Mountain area. Recognition must also be given to the fast-growing cultural tourism sector which can capitalise on the culture and tradition of the Nama who inhabited Namibia's south during the 1740's, generally entering the country from South Africa at the Velloorsdrift area, or the Orlam Nama (1800's) and Rehoboth Baster (1870) tribes following the Nama but penetrating even further north. High-value tourism in the Naukluft/Sossus Vlei area is also important.

Studies are currently being conducted to introduce olive and date farming along the northern banks of the Orange River near Oranjemund while the possibility of introducing cash-crop farming and a horticulture project at Rosh Pinah is also being investigated. The town of Rosh Pinah has probably almost tripled in size because of the development of the Skorpion Zinc Mine. Alternatively, the reduction in land-based mining activities over the past ten years near

Oranjemund has resulted in a decline in the town's population, although this appears to have been halted by off-shore developments.

Most of the land in the catchments consists of freehold and communal farmland. The communal areas are centred on Aminuis, Bersiba, near Karasburg and Warmbad. Apart from some very limited and intensive crop production under irrigation near Mariental (Hardap Dam), at Naute Dam, along the Orange River and along the ephemeral Auob River near the village of Stampriet, the vast majority of the land is used for extensive rangeland livestock and wildlife farming within indigenous ecosystems. Cattle-farming predominates in the north around Gobabis, Khomas and Okahandja areas, while mainly sheep and goats are farmed in the more arid south.

Traditionally, livelihoods have been based on the use of natural resources through livestock husbandry and cultivation of land. Land management practices had evolved to adapt to the physical conditions of Namibia's climate and historically, resource use is considered to have been largely sustainable. Today, people on Namibia's communal – particularly the Nama – land still largely lead subsistence lifestyles, due to the absence of employment and other significant monetary incomes. As affordable alternatives are not available, food, fuel, housing materials, and even medicines are extracted directly from the land, in most cases barely covering the needs of the respective resource users. Dependence on the exploitation of natural resources sometimes locks residents into a cycle of short-term overexploitation of resources.

In general the Nama practise a policy of communal land ownership. Music, poetry and storytelling are very important in Nama culture, and many stories have been passed down orally through the generations. They are known for crafts which include leatherwork, skin karosses and mats, musical instruments (such as reed flutes), jewellery, clay pots, and tortoiseshell powder containers. Water and its value is a powerful idiom in Nama culture.

As with the Nossob River in Botswana, the Fish River and its canyon is an important aesthetic feature. It is, however, unlikely that any of the potential development scenarios that could be associated with the Orange River would impact negatively on the aesthetic qualities of the Fish River and as such detract from its value. Developments scenarios in the Fish River may well impact negatively on the aesthetic qualities of the Fish River as large pools are an important feature in the river, but an analysis of such lies outside the scope of this report.

2.4 South Africa

The Orange River basin is by far the largest catchment area in South Africa and covers a considerable extent of the country, including most of the densely populated Gauteng province as well as the sparsely populated areas of the Northern Cape. With respect to the Orange River Basin, the socio-economic dynamics differ from one area to another. In general, the following trends are observed:

- The already sparsely populated areas of the lower Orange River Basin are experiencing significant out-migration, particularly of those with skills in the economically active age groups.
- The rural areas in general experience significant out-migration.
- The larger and more economically robust urban areas experience the most significant in-migration.
- Within the basin, particularly in the Northern Cape and North West, there is a tendency to migrate from poorer municipalities to those with urban nodes based on mines. For example 46% of those who migrated into the Dikgatong LM (Francis Baard DM north-west of Kimberley) are from the North West Province.
- The bulk of the catchment outside of the urban areas is given over to commercial farming. Much of the most valuable commercial farming is associated with the large irrigation schemes in close proximity to the Orange River.
- There are only small pockets of communities that might be identified as vulnerable and as dependent on the environmental Goods and Services that are associated with the greater Orange River Basin.

While the greater part of the catchment and its people would be excluded from consideration in terms of this report there are a few notable examples. These include:

- Recreational fishing – which takes place at many points along the river and associated tributaries.
- The Ai-Ais/Richtersveld Transfrontier National Park - a harsh and desolate area where water is scarce and life-sustaining moisture comes in the form of early-morning fog which rolls in from the cold waters of the Atlantic Ocean. It is prized for its remote aesthetic appeal. The local community, which owns the entire area located in South Africa, manages the National Park in conjunction with South African National Parks and is entirely responsible for management of the World Heritage Site. Both areas are used by traditional nomadic herders to practice their ancient lifestyle and culture. It is the last place where the traditional way of life of the KhoiKhoi (of whom the Nama are the surviving clan), who once occupied the entire south-western part of Africa, survives to any great extent.
- The Kgalagadi Transfrontier Park. Located across the border of South Africa and Botswana, this park comprises an area of over 3.6 million hectares – one of very few conservation areas of this magnitude left in the world.

- Augrabies Falls National Park. Water drops 56 m over the Augrabies Waterfall in the Orange River. The 28 000 hectares on both the northern and southern sides of the Orange River provides a sanctuary to a diversity of species. The aesthetic appeal of the Orange River is key to the Augrabies National Park.
- The Orange River Mouth is an increasingly desirable tourist destination.
- Rafting expeditions take place at various points along the river.

3 SITE-SPECIFIC ANALYSIS

A total of eight EFR sites representing river reaches (Management Resource Units) were examined in more detail in terms of the functioning of their Goods and Services, and analysed against potential changes. The sites are listed in Table 2. The sites and their ecological scores are discussed in the relevant associated Work Package 5 report on the EFR sites.

Table 2: Environmental Flow Requirement Sites

EFR site number	EFR site name	River	Geozone	Quaternary
EFR O1	Hopetown	Orange	Lowland	D33G
EFR O2	Boegoeberg	Orange	Lowland	D73C
EFR O3	Augrabies	Orange	Lowland	D81B
EFR O4	Vioolsdrift	Orange	Lowland	D82F
EFR C5	Upper Caledon	Caledon	Lower Foothills	D21A
EFR C6	Lower Caledon	Caledon	Lowland	D24J
EFR K7	Lower Kraai	Kraai	Lowland	D31M
EFR M8	Molopo Wetland	Molopo	Lower Foothills	D41A

3.1 EFR 1 – Hopetown

The reach under consideration includes 100 km of river from the bridge upstream of Hopetown to the Orange and Vaal River confluence. The stretch includes substantial areas of commercial farming activity. Agriculture is focussed around irrigation, cattle, and mixed farming. Population densities are relatively low, but public access to the water and its resources is restricted by land ownership patterns. Most land is private farmland. The only significant settlement is Hopetown at the top end of the reach. Canoeing is a popular recreational activity in this part of the river, as is fishing. The numbers of people who derive direct benefit from the Goods and Services produced by the river and its associated resources is negligible, and restricted largely to farm workers and their immediate families.

3.1.1 Scenarios

3.1.1.1 Present Ecological State (PES)

The Present Ecological State (PES) is characterised by decreased frequency of large floods as the river is highly regulated. The main reasons behind the change from reference conditions are the releases for hydropower, barrier effects of the dams, water-quality problems and the destruction and removal of vegetation on floodplains for agriculture. The dominant factor seems to be the hydro-electric releases. The PES was found to be a C Ecological Category.

The study did not set flow requirements for an alternative scenario to the PES for this reach as the major problem would be the hydro-electric pulses that are required. These are strategic imperatives, and as such there were no alternative operational possibilities that could have been considered. The Goods and Services are therefore considered only with regard to their current importance.

3.1.2 Ecological Goods and Services Associated with the Present Ecological State

A range of ecological Goods and Services have been considered for the river reach. These are detailed below.

3.1.2.1 Subsistence Fishing

Subsistence fishing is important in the context of the river, but only to a small number of people. These are largely the people associated with farming activities in the area. The species targeted for subsistence fishing are the larger species, including carp, barbel/catfish, and yellowfish. Both species of yellowfish are present.

3.1.2.2 Recreational Fishing

Recreational fishing in the area is largely restricted to fly-fishing with some “spinner” fishing also practiced. Again, utilisation is low and restricted to landowners or occasional opportunistic fishermen. Yellowfish is the most important recreational fishing species.

3.1.2.3 Riparian Fauna Hunting and Poaching

Recreational hunting in the area is not part of a larger enterprise and mostly small-scale and restricted. Recreational hunting and poaching (mainly geese and ducks) are further limited by the lack of access.

3.1.2.4 Riparian vegetation

Usage includes the following:

- Cyprus: *Cyperus marginatus*. Usage is low even though they are available.
- Reeds: *Phragmites australis*. Usage is low.
- Grazing: *Cynodon dactylon*, Usage is generally low.
- Geophytes: Include *Crinum bulbispermum*. These are important aspects of the area and may be used for floral decoration and medicinal purposes but usage is low.
- Timber and fuel woods: These are *Acacia erioloba*, *A. karoo*, *Prosopis glandulosa*, *Ziziphus mucronata*. Usage is very low.

3.1.2.5 Waste Assimilation and Dilution

Water quality is low but has an assimilation and dilution function that is important but probably not as critical as at some of the other Orange River sites.

3.1.2.6 Wetland Cultivation

Commercial cultivation of flood terraces ("floodplain pockets") is widespread. Increased floods (under Recommended Ecological Category (REC)) (Score 0.9) or decreased floods (Alternative Ecological Category (AEC)) (Score 1.1) could make less or more of the terraces available for cultivation respectively.

3.1.2.7 Recreational Canoeing

This occurs in the river reach but again is not as important as at some of the other reaches that are under consideration. Most of the utilisation is white-water adventure based rather than the more eco-tourism recreational-based canoeing that dominates other reaches.

3.1.2.8 Ritual Use

This is low given the densities of people and restricted access.

3.1.2.9 Aesthetic Attraction

The river is an attraction in the area but again, given the nature of the land use and the topography, it has no critical central features that act as a draw card. Bird watching does take place, but the area is not particularly noteworthy.

3.1.2.10 Flood attenuation and bank protection

There is some degree to which the river acts to attenuate floods but overall this is not regarded as particularly important. The banks of the river are however well vegetated and the bank protection function of the river is in good condition.

3.1.2.11 Summary Discussion

Production and utilisation of Goods and Services is not considered to be of critical importance at this site. There is little in the way of operational management scenarios that would alter flow states to impact the delivery of these Goods and Services in either a positive or negative manner.

3.2 EFR 2 – Boegoeberg

The reach under consideration includes 300 km of river from the Boegoeberg Dam to the start of the Augrabies National Park. The stretch includes substantial areas of high-value commercial farming activity. Agriculture is focussed around irrigation from the river and the nature of the riparian and adjacent zones have been extensively altered to support irrigation. A network of canals to serve irrigation has been constructed (see Figure 1). A variety of crops are produced, many for high-value export markets. Of particular importance are the large irrigation projects in and around the Upington area. Population densities are relatively low, and public access to the water and its resources is restricted by land ownership patterns. Most land is private farmland. The significant settlements are Groblershoop, Upington, Louisvale, Keimos, and Kakamas. Fishing is an important recreational activity in the area, and a number of small camp sites and lodges have been developed.



Figure 1: Irrigation Canal from the Orange River

Regulation of the river has changed the natural flow regime to be more consistent throughout the year. The flow has been regulated to support the agricultural activities on the South African side. Black Fly (*Simulium* spp.) is a significant problem in the area. The elevated water base flows in winter, due to regulation efforts, have created the conditions necessary for their proliferation to pest levels.

3.2.1 Scenarios

3.2.1.1 Present Ecological State (PES)

The PES is characterised by decreased frequency of large floods as the river is highly regulated. Agricultural return flows, agricultural activities and associated water-quality impacts are important considerations. As a result of river regulation, there are higher low flows than naturally occur in the dry season and the natural variability caused by droughts and dry periods has been greatly reduced. Presence of alien fish species and barrier effects of dams and alien vegetation is noticeable. Release of sediment and the barrier effect of the large dams have altered the geomorphology of the river. The PES was found to be a C EC.

3.2.1.2 Recommended Ecological Category (REC)

The Ecological Importance and Sensitivity (EIS) was HIGH and the recommendation was to improve the PES to a B/C. However, as in-stream improvement was not possible due to constraints imposed by operational considerations, no EFR was set for the REC. Improvement would need to be managed by non-flow-related measures.

3.2.1.3 Alternative Ecological Category (AEC)

The AEC that was considered was a D. This would be characterised by decreased low flows in the wet and dry seasons. It would further include decreased floods and decreased dilution resulting in worse water quality. Reduced low flows will result in less light penetration (increased turbidity) which will result in algal and benthic growth.

3.2.2 Ecological Goods and Services associated with PES and Scenarios

A range of ecological Goods and Services have been considered for the river reach. These are detailed below.

3.2.2.1 Subsistence Fishing

Subsistence fishing is important in the context of the river, but only to a small number of people. Non-flow related recommendations that could manage the fishing production of the river towards a B/C status include removing or addressing migration barriers and eradication of alien fish species. Alien carp species were, however, noted as important subsistence fish species. Under the AEC, reduced abundance of yellowfish & carp is expected, leading to reduced catches of large species.

- AEC Score: 0.8

3.2.2.2 Recreational Fishing

Recreational fishing in the area is largely restricted to fly-fishing. Again non-flow-related recommendations that could manage the fish production of the river towards a B/C status include removing or addressing migration barriers and eradication of alien fish species. Under the AEC, reduced abundance of yellowfish & carp is expected, leading to reduced catches of large species under the AEC. A reduced abundance of yellowfish, particularly largemouth yellowfish, may have a significant impact on fly-fishing yields, and the associated recreational value.

- AEC Score: 0.5

3.2.2.3 Riparian Fauna Hunting and Poaching

Recreational hunting in the area is not part of a larger enterprise but mostly small-scale. There are limited riparian animals that are utilised for hunting. Under the AEC, it is likely that there will be fewer habitats for waterfowl. This will further decrease the riparian fauna (waterfowl) available for hunting and poaching.

- AEC Score: 0.9

3.2.2.4 Sedges

These include *Cyperus marginatus*. Usage is low even though they are available. Under the AEC, reduced wet-season base flows and flooding disturbance will facilitate increased cover and density. Therefore, as base flows and small floods are reduced, an increase will occur as additional habitat becomes available for colonisation.

- AEC Score: 1.2

3.2.2.5 Reeds

These include *Phragmites australis*. Usage is important in terms of building temporary structures for seasonal labourers (See Figure 3.2). Under the AEC, reduced wet-season base flows and flooding disturbance will facilitate increased reed cover and density. This is due to fewer disturbances which maintain open patches and patch dynamics, and a small amount of additional available habitat for rheophytes to colonise on the water's edge.

- AEC Score: 1.2



Figure 2: Temporary Structure made from Reeds

3.2.2.6 Grazing

Important here is *Cynodon dactylon*. Under the AEC, reduced wet-season base flows and flooding disturbance will facilitate increased *C. dactylon*. This is due to fewer disturbances which maintain open patches and patch dynamics, and a small amount of additional available habitat.

- AEC Score: 1.1

3.2.2.7 Geophytes

These include *Crinum bulbispermum*. There is a high abundance at the site, but utilization remains low. These are protected bulbs, used medicinally and collected by plant enthusiasts. Under AEC, desiccation is likely to reduce population size, especially along upper limits of species distribution pattern.

- AEC Score: 0.9

3.2.2.8 Exotics

These include *Prosopis glandulosa*, *Eucalyptus camuldensis*, *Nicotiniana glauca* which are used for timber and fuelwood. *Prosopis glandulosa* is a category 2 exotic and is used for fodder (pods) and firewood. It may be decreased as a good if clearing of exotics occurs, but the exact degree of decrease depends on the effort made. Under the AEC, allowing *Prosopis glandulosa* and other perennial exotic species to increase by 10%, (a likely scenario if exotic invasion is left unchecked) could occur.

- AEC Score: 1.1

3.2.2.9 Indigenous Timber and Fuel Woods

At this site, some timbers are present, but utilisation and collection are low given access issues. Fuelwood harvest is limited, but there is some evidence of a linkage to seasonal workers used in grape harvesting. Under the AEC, reduced flooding frequency will likely facilitate an expansion/better survival of some species.

- AEC Score: 1.1

3.2.2.10 Waste Assimilation and Dilution

Under the AEC, the ability to assimilate waste is reduced due to the poorer quality of water under a D category, i.e. a reduced assimilative capacity. Further, the ability to dilute toxics and salts reduced due to poor quality of water under the D category.

- AEC Score: 0.9

3.2.2.11 Flood attenuation and bank protection

There is some degree to which the river acts to attenuate floods, but overall this is not regarded as particularly important. The banks of the river are, however, well vegetated and the bank protection function of the river is in good condition. Although this good is currently very small, there is a limited increase possible if vegetation increases under the AEC.

- AEC Score: 1.05

3.2.2.12 Ritual Use

This is low given the densities of people, and in any case neither the REC nor the AEC will impact on usage as the river will not change enough to accelerate or preclude this usage.

3.2.2.13 Aesthetic Attraction

The river is not particularly critical in terms of aesthetic attraction, although there are parts of the reach considered to be attractive. Under the AEC reduced flows would reduce the attraction. The wader component of the bird species could decrease due to habitat loss - waders are always challenging to bird watchers and as such are prized.

- AEC Score: 0.8

3.2.2.14 Sand Winning

This is currently very small as a utilisation category, but possibly reduced flows under the AEC will allow further access to the bed.

- AEC Score: 1.1

3.2.2.15 Black Fly

These are an important pest on the river and their presence is a cost or a dis-service. Under the AEC, lower base flows during the dry season and increased agricultural development are likely to reduce the incidence of outbreaks of the pest blackfly *Simulium chutteri*, but increase problems associated with *Simulium impukane*.

- AEC Score: 0.8

3.2.2.16 Summary Discussion

Production and utilisation of Goods and Services is not considered to be of critical importance at this site. Only the AEC down was considered. Here the total score in terms of the AEC down was found to be -46. This reflects the fact that the AEC down would impact to a moderate extent on the production of Goods and Services.

3.3 EFR 3 - Augrabies

The reach includes 375 km of river from the uppermost part of the Augrabies National Park to Vioolsdrift (Figure 3.3). The stretch includes substantial areas of commercial farming activity on the South African side of the border, which has a favourable topography for farming. Agriculture is focussed around high value cash crops such as grapes and dates. In contrast, the Namibian side of the border is generally steeper and thus less suitable for farming. Furthermore, the desert strip on the Namibian side makes this area less accessible to migration down to the river. Regulation of the river has changed the natural flow regime to be more consistent throughout the year. The flow has been regulated to support the agricultural activities on the South African side. Black Fly (*Simulium* spp.) is a significant problem in the area. The elevated water base flows in winter, as a result of regulation, have created the conditions necessary for their proliferation to pest levels. Extensive modification of the floodplain has taken place as levees have been created to colonise the floodplain and protect the standing crop. Population densities are higher on the South African side than on the Namibian, but are relatively low at a national scale. The only significant settlement is Vioolsdrift at the bottom end of the reach. The next largest settlement is Onseepkans, a secondary settlement with a very low population. The Augrabies National Park occupies some 50 km of the river reach. The Park was developed around the Augrabies Waterfall, but also stocks some game and is home to a variety of water-dependant avifauna. Canoeing is a popular recreational activity in this part of the river.



Figure 3: Augrabies Falls

3.3.1 Scenarios

3.3.1.1 Present Ecological State (PES)

The PES is characterised by decreased frequency of large floods as the river is highly regulated. Agricultural return flows, agricultural activities and associated water-quality impacts are important considerations. As a result of river regulation, there are higher low flows than natural in the dry season and natural variability caused by droughts and dry periods has been greatly reduced. Presence of alien fish species and barrier effects of dams and alien vegetation is noticeable. Decreased sedimentation (lack of large floods and presence of upstream dams) has altered the geomorphology of the river. The PES was found to be a C EC.

3.3.1.2 Recommended Ecological Category (REC)

The REC is to improve the condition of this reach as its Ecological Importance and Sensitivity (EIS) is HIGH. The means by which this could be attained is to reinstate droughts (i.e. lower flows than presently during dry extremes of the dry season) and to improve the (higher) wet-season base flows. Non-flow-associated management measures could include clearing vegetation of alien species which will improve the vegetation condition in the marginal and lower zones. Improved agricultural practices will also reduce nutrient runoffs and return flows in the dry season. The REC is a B.

3.3.1.3 Alternative Ecological Category (AEC)

The hypothetical AEC is a D. This would be brought about via increased agricultural utilisation with associated negative impacts on water quality and decreased wet-season base flows. It would also see decreased floods. There may also be an increase in alien vegetation.

3.3.2 Ecological Goods and Services associated with PES and Scenarios

A range of ecological Goods and Services have been considered for the Augrabies river reach. These are detailed below.

3.3.2.1 Subsistence Fishing

Subsistence fishing is important in the context of the river, but only to a small number of people. These are largely the people associated with the farming activities in the area. The species targeted for subsistence fishing are the larger species including carp, barbel/catfish, yellowfish, and tilapia. Under the REC, increased abundance (Frequency of Occurrence - FROC) of larger fish species, particularly yellowfish (both species), is expected with higher catch yields. Under the AEC, reduced abundance of yellowfish & carp is expected, leading to reduced catches of large species.

- REC Score: 1.1
- AEC Score: 0.8

3.3.2.2 Recreational Fishing

Recreational fishing in the area is largely restricted to fly-fishing. Under the REC, increased abundance (FROC) of both yellowfish species is expected, which should improve conditions for recreational fishing (especially fly-fishing). Under the AEC, reduced abundance of yellowfish, particularly largemouth yellowfish, may have a significantly negative impact on fly-fishing yields and the associated recreational value.

- REC Score: 1.3
- AEC Score: 0.5

3.3.2.3 Riparian Fauna

Recreational hunting in the area is not part of a larger enterprise but mostly small-scale. The area is more accessible than the upstream area, so the incidence of small-scale recreational hunting and poaching (mainly geese and ducks) is likely to be higher in this area than sites in the upper reaches of the river. There are, however, limited riparian animals that are utilised for hunting. Under the REC, improved flows will eventually result in more open areas in the marginal and lower zones of the river stretch which will result in the return of faunal species that prefer grassy grazing lawns (ducks, geese), mudflats (waders), alluvial sandbars

(plovers) and shallow edge habitats for waders. This will lead to an improvement in this stretch of river for hunting and poaching. Under the AEC, it is likely that there will be fewer habitats for waterfowl. This will further decrease the riparian fauna (waterfowl) available for hunting and poaching.

- REC Score: 1.7
- AEC Score: 0.9

3.3.2.4 Sedges

Sedges are available but usage is low. *Cyperus marginatus* is one of the common sedge species found along the river stretch. Under the REC, a combination of improved wet-season base flows, improved small and moderate flooding, a reduction in fires in reed beds and reduced grazing pressure would improve the PES to 82.4%, with a REC state of B. The main changes to sedges under the REC would be reduced woody vegetation (flow-related) and reduced reed cover (flow-related) in the marginal and lower zones. There would be a reduction of fires in the marginal and lower zones and the reduced woody vegetation and reed cover would create more open areas. Under the AEC, reducing wet-season base flows and flooding disturbance would facilitate increased reed cover and density as well as more *Cyloдон dactylon* where fine sediments would be deposited along cobble bars. This would be due to fewer disturbances that would otherwise have maintained open patches and patch dynamics, and a small amount of additional available habitat for *Rheophytes* to colonise on the water's edge.

- REC Score: 0.9
- AEC Score: 1.1

3.3.2.5 Reeds

Reeds are important for building temporary structures for seasonal labourers. *Phragmites Australis* is one of the common reed species found that is used for this purpose. The main change to reeds under the REC would be reduced woody vegetation (flow-related) and reed cover (flow-related) in the marginal and lower zones. There would be a reduction of fires in the marginal and lower zones and the reduced woody vegetation and reed cover would create more open areas. Under the AEC, reducing wet-season base flows and flooding disturbance would facilitate increased reed cover and density as well as more *Cynodon dactylon* where fine sediments would be deposited along cobble bars. This would be due to fewer disturbances that would otherwise have maintained open patches and patch dynamics, and a small amount of additional available habitat for *Rheophytes* to colonise on the water's edge.

- REC Score: 0.9
- AEC Score: 1.1

3.3.2.6 Grazing

Cynodon dactylon is one of the important species for grazing on this river stretch. The REC is B as above. The main changes under the REC would be reduced woody vegetation (flow-related) and reed cover (flow-related) in the marginal and lower zones. There would be reduced fires in the marginal and lower zones and the reduced woody vegetation and reed cover would create more open areas. Under the AEC, reducing wet season base flows and flooding disturbance would facilitate increased reed cover and density as well as more *Cynodon dactylon* where fine sediments would be deposited along cobble bars. This would be due to fewer disturbances that would otherwise have maintained open patches and patch dynamics, and a small amount of additional available habitat for *Rheophytes* to colonise on the water's edge.

- REC Score: 0.9
- AEC Score: 1.1

3.3.2.7 Geophytes

Geophytes are important for floral decoration and medicinal purposes. Floral decorative value would be linked to aesthetics of the area as well as decorative purposes in tourism accommodation but it is likely that many substitutes to geophytes are available. Medicinal usage would be limited to seasonal agricultural labourers in the area. *Crinum bulbispermum* is one of the most common geophytes in this river stretch. There would be no change to geophytes under the REC. Under the AEC, desiccation is likely to reduce the population size of geophytes, especially along the upper limits of the species distribution pattern (Score 0.9).

- REC Score: 1
- AEC Score: 0.9

3.3.2.8 Timber and Fuel Woods

The main indigenous timber and fuel wood species are *Acacia erioloba*, *Acacia karoo*, *Prosopis glandulosa*, and *Ziziphus mucronata*. The main uses of exotics in the area are timber and fuel wood. Common exotic species in the area include *Prosopis glandulosa*, *Eucalyptus camuldensis* and *Nicotiniana glauca*. Under the REC, a combination of improved wet-season base flows, improved small and moderate flooding, reduced fires in reed beds, and reduced grazing pressure would improve the PES to 82.4%, with a REC state of B. The main changes under the REC would be reduced woody vegetation (flow-related) and reed cover (flow-related) in the marginal and lower zones. There would be a reduction of fires in the marginal and lower zones and the reduced woody vegetation and reed cover would create more open areas. This would lead to a small decrease in the availability of timber and fuel wood. Under the AEC, allowing *Prosopis glandulosa* and other perennial exotic species to increase by 15% (a likely scenario if exotic invasion is left unchecked) would reduce the

PES from 78% to 77.2% (a small change but this does constitute a change from B/C to C). This would lead to an increase the availability of timber and fuel wood.

- REC Score: 0.9
- AEC Score: 1.15

3.3.2.9 Natural Salt Licks

Tamarix usneoides is the indigenous plant species that is used by cattle and game as a natural salt lick. Under the REC, *Tamarix usneoides* will benefit slightly from increased floods, leading to a marginal increase in natural salt licks for cattle and game. Under the AEC, the abundance of *Tamarix usneoides* is unlikely to change with decreased wet-season base flows and decreased floods unlikely to have an effect on species abundance.

- REC Score: 1.1
- AEC Score: 1

3.3.2.10 Waste Assimilation and Dilution

The river has waste assimilation and dilution attributes linked closely to base flows and flooding. Under the REC, there is more assimilation and dilution as higher floods mitigate the effect of agricultural runoff. Under the AEC, the ability to assimilate waste is reduced due to the poorer quality of water under a D category i.e. a reduced assimilative capacity. Furthermore, the ability to dilute toxics and salts is reduced due to reduced wet-season base flows and decreased flooding under the D category.

- REC Score: 1.1
- AEC Score: 0.8

3.3.2.11 Wetland Cultivation

Commercial cultivation of flood terraces ("floodplain pockets") is widespread. Increased floods under the REC or decreased floods under the AEC could make less or more of the terraces available for cultivation, respectively.

- REC Score: 0.9
- AEC Score: 1.1

3.3.2.12 Recreational Canoeing

Recreational canoeing is important in the river sections under consideration. Under the REC, the canoeing experience would improve with reduced outbreaks of blackflies and with increased high flows, but would deteriorate with reduced low-flows. Overall a slight improvement would be expected. Under the AEC, the canoeing experience will deteriorate with reduced flows.

- REC Score: 1.2
- AEC Score: 0.7

3.3.2.13 Ritual Use

Ritual use is low, given the low densities of people. Furthermore, neither the REC nor the AEC will impact on usage as the river will not change enough to accelerate or preclude this usage.

- REC Score: 1
- AEC Score: 1

3.3.2.14 Aesthetic Attraction

The river is central to the Augrabies area and the aesthetic attraction is largely linked to the amount of water flowing over the falls. Under the REC, low winter flows would have a negative rather than positive impact on aesthetic attraction. The same would apply to the AEC as reduced flows reduce the aesthetic attraction of the falls.

- REC Score: 0.8
- AEC Score: 0.8

3.3.2.15 Bird Watching

Bird watching is an important recreational activity and tourism draw card in the area. Under the REC, improved flows would eventually result in more open areas in the marginal and lower zone. This will lead to the return of avifaunal species that prefer grassy grazing lawns (ducks, geese), mudflats (waders), alluvial sandbars (plovers) and shallow edge habitats for waders. Increased abundance and diversity of bird species would improve the value of the area for bird watching. Under the AEC, the wader component of bird species occupying the area would decrease due to habitat loss. Furthermore, waders are always a challenge to bird watchers. Value of the area for bird-watching would decrease.

- REC Score: 2
- AEC Score: 0.8

3.3.2.16 Eco-tourism

The main eco-tourism activity in the area is riparian game viewing associated with water holes. Under the REC, open areas would increase with higher flows in the summer months and lower flows in the winter months (more variation in the river system). This would lead to improved game viewing. Under the AEC, denser riparian vegetation due to lower flows might obscure game viewing, with more places for game to hide and increased difficulty in spotting game.

- REC Score: 1.1
- AEC Score: 0.9

3.3.2.17 Floodplain Deposition

Increased floods under the REC will lead to more deposition of fine sediments on the terraces. This will lead to improved soil quality for agriculture. Conversely decreased floods under the AEC will lead to less deposition of fine sediments on the terraces which will lead to poorer soil quality for agriculture on the terraces.

- REC Score: 1.1
- AEC Score: 0.9

3.3.2.18 Pathogens

These exist largely as blue-green algae. Under the REC, abundance of blue-green algae is unlikely to change. Under the AEC, some increase in blue-green algae is expected based on evidence of blue-green toxic algae coming down river from Uington (MRU D). The increased score is a cost as this is a disservice, and not a benefit.

- REC Score: 1
- AEC Score: 1.2

3.3.2.19 Black Fly (Spp. Simulium)

These have become a major pest on the river, and their presence is a cost or a disservice. Under the REC, lower base flows during the dry season and a wider seasonal range of base flows is expected to reduce the incidence of outbreaks of the species *Simulium Chutteri*. Under the AEC, lower base flows during the dry season and increased agricultural development are likely to reduce the incidence of outbreaks of the species *Simulium chutteri*, but increase outbreaks of *Simulium Impukane*.

- REC Score: 0.7
- AEC Score: 0.8

3.3.2.20 Summary Discussion

Production and utilisation of Goods and Services is of moderate importance at this site. It would be of high importance if population densities were higher. Both an AEC up and down were considered. Here the total score in terms of the AEC up was found to be 126 and the AEC down was found to be -59. This reflects the fact that the AEC down would impact to a

moderate extent on the production of Goods and Services but the AEC up scenario would improve the delivery of Goods and Services to a relatively large extent.

3.4 EFR 4 - Vioolsdrift

The reach under consideration includes 150 km of river from Vioolsdrift to the confluence with the Fish River. The river marks the border between South Africa and Namibia. The river sections include the Richtersveld National Park. Downstream of Vioolsdrift and upstream of the Park there are pockets of irrigated agriculture developed in close proximity to the river. Irrigation appears on both sides of the river, in both South Africa and Namibia. The Richtersveld National Park is a harsh and barren area where the Orange River is the central water feature. It is prized for its remoteness and aesthetic appeal. The local community, which owns the entire area located in South Africa, manages the National Park in conjunction with South African National Parks and is entirely responsible for management of the World Heritage Site. Both sides of the river are used by traditional nomadic herders to practice their ancient lifestyle and culture. It is the last place where the traditional way of life of the KhoiKhoi (of whom the Nama are the surviving clan), who once occupied the entire south-western part of Africa, survives to any great extent.



Figure 4: Richtersveld part of the Orange River

Canoeing is a popular recreational activity in this part of the river. As with the upstream parts, regulation of the river has changed the natural flow regime to be more consistent throughout the year. Black Fly (*Simulium* spp.) is a significant problem in the area.

3.4.1 Scenarios

3.4.1.1 Present Ecological State (PES)

The PES is characterised by decreased frequency of large floods as the river is regulated. Agricultural return flows, agricultural activities, mining and associated water-quality impacts are important considerations in terms of water quality. As a result of river regulation, there are higher low flows than natural in the dry season and the natural variability has been significantly reduced. Presence of alien fish species and vegetation is noticeable. Decreased sedimentation (lack of large floods and presence of upstream dams) has altered the geomorphology of the river. The PES was found to be a C.

3.4.1.2 Recommended Ecological Category (REC)

The REC is to improve the condition of this reach as its Ecological Importance and Sensitivity (EIS) is high. The means by which this could be attained is to improve (higher) wet season base flows, clear vegetation aliens – this will improve the vegetation condition in the marginal and lower zones – and control grazing and trampling. The REC is a B/C.

3.4.1.3 Alternative Ecological Category (AEC)

The hypothetical AEC is a D. This would be brought about via increased mining with associated impacts on water quality and decreased wet season base flows. Decreased wet season floods would also impact negatively on managing the river, towards a D category. Increased vegetation aliens (*esp. Prosopis sp.*) would also be part of the AEC consideration.

3.4.2 Ecological Goods and Services associated with PES and Scenarios

A range of ecological Goods and Services have been considered for the river reach downstream of Violsdrift. These are detailed below.

3.4.2.1 Subsistence Fishing

Subsistence fishing is important in the context of the river but only to a small number of people in the Violsdrift – Richtersveld area. Poaching of fish is highly evident (See Figure 4). The species targeted for subsistence fishing are the larger species, including carp, barbel/catfish, yellowfish, and tilapia. Under the REC, increased abundance (Frequency of Occurrence - FROC) of larger fish species, particularly yellowfish (both species), is expected with higher catch yields. Under the AEC, reduced abundance of yellowfish & carp is expected, leading to reduced catches of large species.

- REC Score: 1.1
- AEC Score: 0.8



Figure 5: Fish Poached from the Orange River in Richtersveld

3.4.2.2 Recreational Fishing

Recreational fishing in the area is largely restricted to fly-fishing. Under the REC, increased abundance (FROC) of both yellowfish species is expected, which should improve recreational fishing success (especially fly-fishing). Under the AEC, reduced abundance of yellowfish, particularly largemouth yellowfish, may have significant impact on fly-fishing yields and the associated recreational value.

- REC Score: 1.3
- AEC Score: 0.5

3.4.2.3 Riparian Fauna

Recreational hunting in the area is not part of a larger enterprise but mostly small-scale. The area is more accessible than some up-stream sections, so small-scale recreational hunting and poaching (mainly geese and ducks) are likely to be higher in this area than at some sites

in the upper reaches of the river. There are, however, limited riparian animals that are utilised for hunting. Under the REC, improved flows will eventually result in more open areas in the marginal and lower zones of the river stretch, which will result in the return of faunal species that prefer grassy grazing lawns (ducks, geese), mudflats (waders), alluvial sandbars (plovers) and shallow edge habitats for waders. This will lead to an improvement in this stretch of river for hunting and poaching. Under the AEC, it is likely that there will be fewer habitats for waterfowl. This will further decrease the riparian fauna (waterfowl) available for hunting and poaching.

- REC Score: 1.7
- AEC Score: 0.9

3.4.2.4 Sedges

Sedges are available but usage is low. *Cyperus Marginatus* is one of the common sedge species found along the river stretch. Under the REC, a combination of improved wet-season base flows, improved small and moderate flooding, a reduction in fires in reed beds and reduced grazing pressure would improve the PES to 80.9%, with an ecological state of B/C. Improvements include slightly reduced sedge and annual exotic cover. Under the AEC, reducing wet-season base flows and flooding disturbance would facilitate increased reed cover and density. This would be due to fewer disturbances, which would otherwise have maintained open patches and patch dynamics, and a small amount of additional available habitat for *Rheophytes* to colonise on the water's edge.

- REC Score: 0.9
- AEC Score: 1.1

3.4.2.5 Reeds

Under the REC, a combination of improved wet season-base flows, improved small and moderate flooding, a reduction in fires in reed beds and reduced grazing pressure would improve the PES to a state of B/C. Under the AEC, reducing wet-season base flows and flooding disturbance would facilitate increased reed cover and density.

- REC Score: 0.9
- AEC Score: 1.1

3.4.2.6 Grazing

Cynodon dactylon is one of the important species for grazing in this river stretch. Under the REC, improved wet-season base flows would improve the PES to 82.4%, with an ecological state of B/C. Under the AEC, reducing wet-season base flows and flooding disturbance would facilitate increased *Cynodon Dactylon* where fine sediments would be deposited along cobble bars. This would be due to fewer disturbances that would otherwise have maintained

open patches and patch dynamics, and a small amount of additional available habitat for *Rheophytes* to colonise on the water's edge.

- REC Score: 0.9
- AEC Score: 1.1

3.4.2.7 Exotics

The main uses of exotics in the area are timber and fuel wood. Common exotic species in the area include *Prosopis glandulosa*, *Eucalyptus camuldensis* and *Nicotiniana glauca*. Under the REC, removal of all existing perennial exotic species at the site and allocation to woody riparian and terrestrial species would improve the PES. This would lead to a reduction in available timber and fuel wood. Under the AEC, perennial exotic species would increase by 20%, (a likely scenario if exotic invasion is left unchecked). This would reduce the PES from 78% to 77.2% (a small change but this does constitute a change from B/C to C). This would increase the availability of timber and fuel wood.

- REC Score: 0.9
- AEC Score: 1.2

3.4.2.8 Timber and Fuel Woods

The main indigenous timber and fuelwood species are *Acacia erioloba*, *Acacia karoo*, *Prosopis glandulosa*, and *Ziziphus mucronata*. Under the REC, a combination of improved wet-season base flows and improved small and moderate flooding, would improve the PES. The main changes under the REC would be reduced woody vegetation (flow-related) and reed cover (flow-related) in the marginal and lower zones. This would lead to a small decrease in the availability of timber and fuel wood. Under the AEC, there would be an increase in the availability of timber and fuel wood.

- REC Score: 0.9
- AEC Score: 1.2

3.4.2.9 Browsing

At present there is indiscriminate browsing by goats, but *Seasia pendulina*, *Diospyros lycioides* and *Acacia karoo* are the main plant species grazed. Under the REC this would be reduced due to removal of exotics. Under the AEC, this would see a slight increase due to increase in exotic component.

- REC Score: 0.95
- AEC Score: 1.05

3.4.2.10 Natural Salt Licks

Tamarix Usneoides is the indigenous plant species that is used by cattle and game as a natural salt lick. Under the REC, *Tamarix Usneoides* will benefit slightly from increased floods, leading to a marginal increase in natural salt licks for cattle and game. Under the AEC, the abundance of *Tamarix Usneoides* is unlikely to change with decreased wet-season base flows and decreased floods are unlikely to have an effect on species abundance.

- REC Score: 1.1
- AEC Score: 1

3.4.2.11 Waste Assimilation and Dilution

The river has waste assimilation and dilution attributes linked closely to base flows and flooding. Even at this point the impacts associated with the upstream farming and mining-related water-quality issues are evident. Under the REC, there is more assimilation and dilution as higher floods mitigate the effect of agricultural runoff. Under the AEC, the ability to assimilate waste is reduced due to the poorer quality of water under a D category i.e. a reduced assimilative capacity. Furthermore, the ability to dilute toxins and salts is reduced due to reduced wet-season base flows and decreased flooding under the D category.

- REC Score: 1.1
- AEC Score: 0.8

3.4.2.12 Recreational Canoeing

Recreational canoeing is an extremely important activity in these river sections. Many canoe-tour operators base their operations in the area. Under the REC, the canoeing experience would improve with reduced outbreaks of blackflies and with increased high flows, but would deteriorate with reduced low-flows. Overall, a slight improvement would be expected. Under the AEC, the canoeing experience will deteriorate with reduced flows.

- REC Score: 1.2
- AEC Score: 0.7

3.4.2.13 Ritual Use

Ritual use in terms of magnitude of use is low given the low densities of people. However, the makeup of the area is such that the significance of ritual use, for those people resident in and around the area, is high. However, neither the REC nor the AEC will impact on usage as the river will not change enough to accelerate or preclude this usage.

- REC Score: 1
- AEC Score: 1

3.4.2.14 Aesthetic Attraction

The river is central to the Richtersveld National Park and to the Fish River section of Namibia. Under the REC, lower winter flows (that are more natural) would arguably have a positive impact on aesthetic attraction, but the converse would apply to the AEC as reduced flows reduce the aesthetic attraction.

- REC Score: 1.2
- AEC Score: 0.95

3.4.2.15 Bird Watching

Bird watching is an important recreational activity and tourism drawcard in the area. Under the REC, improved flows would eventually result in more open areas in the marginal and lower zone. This will lead to the return of avifaunal species that prefer grassy grazing lawns (ducks, geese), mudflats (waders), alluvial sandbars (plovers) and shallow edge habitats for waders. Increased abundance and diversity of bird species would improve the value of the area for bird watching. Under the AEC, the wader component of bird species occupying the area would decrease due to habitat loss. Furthermore, waders are always a challenge to bird watchers. Value of the area for bird-watching would decrease.

- REC Score: 2
- AEC Score: 0.8

3.4.2.16 Eco-tourism related to game viewing

The main eco-tourism activity in the area is riparian game viewing. Under the REC, open areas would increase with higher flows in the summer months and lower flows in the winter months (higher variability). This would lead to improved game viewing. Under the AEC, denser riparian vegetation due to lower flows might obscure game viewing, with more places for game to hide and increased difficulty in spotting game.

- REC Score: 1.1
- AEC Score: 0.9

3.4.2.17 Floodplain Deposition

Increased floods under the REC will lead to more deposition of fine sediments on the terraces. This will lead to improved soil quality for agriculture. Conversely decreased floods under the AEC will lead to less deposition of fine sediments on the terraces which will lead to poorer soil quality for agriculture on the terraces.

- REC Score: 1.1
- AEC Score: 0.9

3.4.2.18 Pathogens

These exist largely as blue-green algae, and two outbreak incidents were reported in 2008. Under the REC, abundance of blue-green algae is unlikely to change. Under the AEC, some increase in blue-green algae is expected based on evidence of blue-green toxic algae coming down the river. The increased score is a cost as this is a disservice, and not a benefit.

- REC Score: 1
- AEC Score: 1.1

3.4.2.19 Black Fly

These have become a large pest on the river and their presence is a cost or a disservice. Under the REC, lower base flows during the dry season and a wider seasonal range of base flows is expected to reduce the incidence of outbreaks of the species *Simulium chutteri*. Under the AEC, lower base flows during the dry season and increased agricultural development are likely to reduce the incidence of outbreaks of the species *Simulium chutteri*, but increase outbreaks of *Simulium impukane*.

- REC Score: 0.7
- AEC Score: 0.8

3.4.2.20 Summary Discussion

Production and utilisation of Goods and Services is of moderate to high importance at this site. It would be of high importance if population densities were higher. Both a REC and AEC down were considered. Here the total score in terms of the REC was found to be 146 and of the AEC down was found to be -87. This reflects the fact that the AEC down would impact to a moderate extent on the production of Goods and Services but the REC state would improve the delivery of Goods and Services to a relatively large extent.

3.5 EFR 5 – Upper Caledon

The reach runs from the source to the Welbedacht dam, a stretch of about 500 km of river along the entire length of Lesotho's western border with South Africa. The stretch includes substantial areas of commercial farming activity on the South African side of the border, while on the Lesotho side the agriculture is more subsistenceorientated. The agricultural activities are mainly focussed around grain crops such as maize and sorghum, but fruit trees also commonly occur. The Lesotho side is considerably more densely populated with a series of small settlements. On both sides of the river there are also several small- to medium-sized towns, primarily in the northern half, while in the southern half of the stretch the Lesotho side is significantly more sparsely populated. The most significant settlements

are Butha-Buthe, Leribe, Maputsoe and Maseru on the Lesotho side and Fouriesburg, Ficksburg, Ladybrand, Hobhouse and Wepener on the South African side. Flow regulation is not a major issue as no large dams exist. There are no protected areas along this stretch of river but the Golden Gate highlands national park is associated with a tributary in the uppermost section of the catchment. Recreational activities associated with the river are very limited, non-commercial and consisting mainly of fishing and swimming. The river suffers from quite severe degradation of its ecological status, mainly caused by active soil erosion, mainly on the Lesotho side of the river, and the concomitant sediment production. This has led to a degradation of the river-bed substrate, hence also of the preconditions for the fish fauna. From a socio-cultural point of view the influence of the Lesotho areas elevates many of the scores to the higher end of the Moderate range. However, the generally degraded nature of the Caledon and associated riparian zones, and in particular the perceived water-quality issues, means that the utilisation of the area, from a socio-cultural perspective, is not as high as it may have historically been.

3.5.1 Scenarios

3.5.1.1 Present Ecological State (PES)

The PES is characterised by overgrazing and trampling by livestock, causing extensive problems with erosion of rangelands, fields and river banks. This leads to degradation of the river bed's substrate from coarse material to finer alluvium, mainly sand. The land use results in elevated nutrient content and potential toxicant loads due to fertiliser and pesticide use. Presence of alien fish species and alien vegetation is noticeable. The PES was found to be a C/D.

3.5.1.2 Recommended Ecological Category (REC)

N/A - the EIS is low, providing no motivation for improvement.

3.5.1.3 Alternative Ecological Category (AEC down)

The hypothetical AEC is a D. The main causes for the PES were non-flow related and therefore an improved AEC of the PES was not considered (i.e., increased flows will not improve the EcoStatus). An AEC down was, however, assessed and the scenario includes:

- Decreased flows due to increased abstraction.
- Continued sedimentation due to continued erosion.
- Reduced flows will result in reduced dilution, which will affect the water-quality variables such as temperature and oxygen.
- Habitat loss for a large percentage of time.
- Vegetation – increased sedges due to increased sedimentation.

3.5.2 Ecological Goods and Services associated with PES and Scenarios

A range of ecological Goods and Services have been considered for the Upper Caledon river reach. These are detailed below.

3.5.2.1 Subsistence Fishing

Under present conditions, most species are very scarce. Catches are, therefore, expected to be very low. Under the AEC scenario, a further decrease in the abundance and occurrence of smallmouth yellowfish can be expected. This will further decrease the potential utilisation of large fish for subsistence purposes, as this will be the primary species targeted in most of the reach.

- AEC Score: 0.6

3.5.2.2 Recreational Fishing

Under present conditions, most species are very scarce. The catches are, therefore, expected to be very low and provide very limited attraction value for anglers (trout is not expected to occur in reach under investigation, with a low possibility of occurring in the upper reaches). Under the AEC scenario, a further decrease in the abundance and occurrence of smallmouth yellowfish can be expected to further decrease the potential utilisation of large fish for angling purposes, as this is the primary species targeted.

- AEC Score: 0.6

3.5.2.3 Sedges

Cyperus marginatus is likely to be favoured by additional sediments (geomorphology trend with reduced flows) and will increase from this perspective, although grazing and trampling pressure is likely to mitigate this increase to a large extent. This species has a cover which is already higher than expected under reference state, due to reduced flows and increased sediments, and this trend is likely to continue.

- AEC Score: 1.1

3.5.2.4 Grazing

All non-woody vegetation, especially grasses (site is in the Grassland Biome) is utilised. Utilisation rates are very high, with associated trampling. Slightly reduced flows in the AEC will allow a small amount of habitat to be colonised and become available to grazers (but the response is mainly from sedges - see above).

- AEC Score: 1.05

3.5.2.5 Medicinal plants

The environmental service is important as such, but is non-flow related and therefore scores 1 in the AEC.

- AEC Score: 1

3.5.2.6 Exotics

These include *Pyracantha angustifolia*, *Salix babylonica* and *Rubus spp*, but are generally non-flow related.

- AEC Score: 1

3.5.2.7 Timber and Fuel Woods

The environmental service is important as such, but is non-flow related and therefore scores 1 in the AEC.

- AEC Score: 1

3.5.2.8 Waste Assimilation and dilution

Reduced flows will result in lower dilution capacities, thereby increasing the impact of toxicants available in the system. Slightly higher sediment loads are expected, as well as increased temperatures and reduced oxygen concentrations. Nutrient conditions will deteriorate; the extent to which will depend on how much the flows are reduced, and for how long. The impact of reduced flows will likely be minimal due to the current state of the system.

- AEC Score: 0.9

3.5.2.9 Wetland Cultivation

Cultivation of riparian banks is common. The decreased flows under the AEC results in a slightly elevated score.

- AEC Score: 1.05

3.5.2.10 Ritual Use

This is high, given the densities of people, but is not likely to change much in the AEC unless the river dries up completely.

- AEC Score: 0.9

3.5.2.11 Bank protection

It is an important issue since over-grazing and trampling have affected the banks. The area also is affected by fires at the wrong time of the year. AEC will, however, not affect the issue, yielding an unchanged score.

- AEC Score: 1

3.5.2.12 Groundwater recharge

The issue is not that important on the Lesotho side, but extraction of water from boreholes is more common on the South African side. This results in a slight reduction in score.

- AEC score is 0.95.

3.5.2.13 Eco-tourism

The Golden Gate national park is partly located in the catchment but the river stretch is not accessible from the park side - ecotourism is high but not river-linked, hence no change in score for the AEC.

- AEC Score: 1

3.5.2.14 Snail-related livestock liver disease

A snail (*Lymnaea spp.*) is the carrier of livestock liver fluke (*Fasciola spp.*), which is a big issue for local livestock, especially the small-scale subsistence stock on the Lesotho side. Reduced flows are expected to reduce habitat availability for host snails.

- AEC Score: 0.8

3.5.2.15 Summary Discussion

Production and utilisation of Goods and Services is of moderate to high importance at this site. Only the AEC down was considered. Here the total score in terms of the AEC down was found to be -17. This reflects the fact that the system is under extreme pressure and even a category down does not affect the services very much. Further, most services are compromised by factors that are not directly flow-related.

3.6 EFR 6 – Lower Caledon

The reach runs from the Welbedacht Dam to the backwaters from the Gariep Dam, a stretch of about 200 km of river. It is mainly located in the Free State Province of the RSA, with commercial farming activities dominating land use on both banks of the river. The agricultural activities are mainly focussed around grain crops and livestock farming. Tussen Die Riviere nature reserve is located on the left bank of the river, with game farming and some hunting

activities. Hence the aesthetic and recreational aspects are of importance to a consideration of Goods and Services. The river suffers from quite severe degradation of its ecological status, mainly caused by sedimentation and the strongly altered hydrological regime. Sediment flushing from a bottom outlet at the Welbedacht dam is a problem. The generally degraded nature of the Caledon and associated riparian zones, and in particular the perceived water-quality issues, means that the utilisation of the area, from a socio-cultural perspective, is only moderate.

3.6.1 Scenarios

3.6.1.1 Present Ecological State (PES)

The PES is characterised by a severely degraded hydrology mainly associated with decreased base flows and the sediment flushing from the Welbedacht dam. The turbidity is high, nutrient content elevated and there is a potential for toxicant loads due to fertiliser and pesticide use. Geomorphology is moderately to highly modified. Most of the fish species expected to occur are still found in the section, but their status is quite deteriorated. The PES was found to be a C.

3.6.1.2 Recommended Ecological Category (REC)

N/A - the EIS is low, providing no motivation for improvement

3.6.1.3 Alternative Ecological Category (AEC up)

No AEC down was evaluated as an EC lower than a D does not represent a sustainable river. Instead, an AEC up was evaluated. The AEC up is a B/C and the scenario includes:

- Bottom releases take place during the wet season and not during low-flow conditions.
- Improvement of low flows.
- Limited duration of zero flows or preferably no zero flows.

These conditions would lead to improvement in the fish and macro-invertebrate components, as well as the marginal riparian vegetation zone due to an increase in Gomphostigma.

3.6.2 Ecological Goods and Services associated with PES and Scenarios

A range of ecological Goods and Services has been considered for the Lower Caledon river reach. These are detailed below.

3.6.2.1 Subsistence Fishing

There is a low abundance of most large species. In combination with the increased turbidity, this reduces the potential for high catches utilising bait (however, the opposite would be true when using gill nets). Under the AEC scenario, improved conditions for especially large-mouth yellowfish may result in increased catches, and therefore improved utilisation for subsistence fishing.

- AEC Score: 1.2

3.6.2.2 Recreational Fishing

The situation strongly resembles that for subsistence fishing above. Under the AEC scenario, the improved conditions for large-mouth yellowfish may result in increased attraction to fishermen, especially fly-fishermen, since the yellowfish is a sought-after species.

- AEC Score: 1.3

3.6.2.3 Fauna

There are some geese and ducks in the area, with a certain hunting and poaching pressure. The situation is, however, unlikely to change under the AEC.

- AEC Score: 1

3.6.2.4 Sedges

Cyperus marginatus occurs, but the use is low. Increased base flows and small floods will likely reduce the cover of the population.

- AEC Score: 0.9

3.6.2.5 Grazing

Commercial use for game in the reserve, and heavily utilised for stock and game in the winter months. The utilisation will, however, not be affected by the AEC, yielding an unchanged score.

- AEC Score: 1

3.6.2.6 Medicinal plants

Crinum bulbispermum is collected outside the reserve, mainly by farm workers. Additional recruiting opportunities and water availability when reproductive demands are high are likely to favour the population.

- AEC Score: 1.1

3.6.2.7 Exotics

The dominating species are *Salix babylonica*, *Populus X* and *Pyracantha angustifolia*. These are common outside the reserve, but rare inside it. Since the concerned species' abundance is non-flow related, the score under the AEC remains unchanged.

- AEC Score: 1

3.6.2.8 Timber and Fuel Woods

There is no real usage in the reserve, and outside the reserve the primary species are *Acacia karoo* and *Celtis Africana*. The riparian woody species are unsuitable as a source of timber. Since the concerned species' abundance is non-flow related, the score under the AEC remains unchanged.

- AEC Score: 1

3.6.2.9 Waste Assimilation

Water quality is an issue with significant impacts from agriculture and high sediment loads, exacerbated by the flushing at Welbedacht dam. The AEC would cause an improvement in the nutrient status, due to improved low flows and this would result in a greater assimilative capacity.

- AEC Score: 1.2

3.6.2.10 Waste dilution

It is still functional in the reach, but is under stress. The PES is better than in the Upper Caledon since the population density is lower. Under the AEC scenario, improved low flows would result in a dilution of farming-related pesticides.

- AEC Score: 1.3

3.6.2.11 Wetland Cultivation

No significance in this reach, hence the score doesn't change under the AEC.

- AEC Score: 1

3.6.2.12 Ritual Use

This is low, given the densities of people, and is not likely to change much under the AEC, unless the river dries up completely.

- AEC Score: 0.9

3.6.2.13 Flood attenuation

It is of importance in the reach, but there are no floodplains and the function is largely fulfilled by the dams. This means nothing will change under the AEC.

- AEC Score: 1

3.6.2.14 Bank protection

The well-vegetated banks offer good bank protection, which will not be affected under the AEC.

- AEC Score: 1

3.6.2.15 Eco-tourism

The river is an important aspect of the game reserve, and the Caledon River guest farm is linked to fishing. The AEC will, however, not change the score.

- AEC Score: 1

3.6.2.16 Pathogens

None identified as yet.

3.6.2.17 Snail-related livestock liver disease

A snail (*Lymnaea spp.*) is the carrier of livestock liver fluke (*Fasciola spp.*). The snail is present in this section, but is not as big an issue as upstream. Increased flows under the AEC will provide additional habitat for the host snails.

- AEC Score: 1.2 (increased dis-service)

3.6.2.18 Summary Discussion

Production and utilisation of Goods and Services is of moderate importance at this site. Only an AEC up was considered. Here the total score in terms of the AEC up was found to be 32. This reflects the fact that the number of people relying on Goods and Services is low, and the actual range of services used is also restricted.

3.7 EFR 7 –Kraai

The reach under consideration includes the entire Kraai River, from the source to the confluence with the Orange, a stretch of about 350 km. This sub-catchment is dominated by the farmlands of the Eastern Cape and some near-river settlements together with some subsistence-farming areas of the former homeland of the Transkei. In particular the influence of the nearby settlement areas elevates many of the scores to the higher end of the

Moderate range. The degraded nature of the area means that the utilisation of services, from a socio-cultural perspective, is not as high as it may have historically been.

3.7.1 Scenarios

3.7.1.1 Present Ecological State (PES)

The PES is characterised by a near-undisturbed hydrology and only slightly modified geomorphology. Base flows are only slightly reduced by the small farm dams and weirs in the upstream sections of the river. High flows and floods are relatively unaffected by the changes in the catchment, and the geomorphology at the EFR site – dominated by larger cobble/gravel bed elements – is not sensitive to the small changes in base flows. There is alien vegetation present throughout the section. All the fish species expected for the reference state are still present. There is good abundance of the large fish species, especially in the lower reaches. Two trout species are found in the middle/upper reaches, and yellowfish in the middle/lower sections. Water quality is generally good, in spite of some farming-related impacts. The PES is C.

3.7.1.2 Recommended Ecological Category (REC)

The REC is a C - the EIS is moderate, providing no motivation for improvement, so the REC is to maintain the PES.

3.7.1.3 Alternative Ecological Categories (AEC up and down)

The AEC up is a B and the AEC down remains a C, but with deterioration to in-stream ecological parameters.

The AEC up scenario includes:

- Decreased abstraction, i.e. higher base flows.
- No zero flows.
- The above-mentioned flow changes will result in improved water quality.
- Land use changes and catchment management will also improve water quality.
- Alien vegetation should be cleared.

The AEC down scenario includes:

- Increased abstraction.
- More frequent periods of zero flows.
- Increased abstraction and associated increase in farming activities will have a negative impact on water quality.
- Decrease in small floods (e.g. an increase of dams in the tributaries).

- Slightly higher sedimentation in some areas.

3.7.2 Ecological Goods and Services associated with PES and Scenarios

A range of ecological Goods and Services have been considered for the Kraai River. These are detailed below.

3.7.2.1 Subsistence Fishing

The usage in the traditional areas is close to zero due to taboos against the eating of fish. In the lower reaches of the river there is moderate usage by farm workers. The improved conditions under the AEC up scenario would result in improved abundance of larger species, especially in the middle and lower areas, which should yield higher catches for the purpose of subsistence utilisation. Under the AEC down scenario, species most probably utilised for subsistence fishing (esp. yellowfish, labeos and catfish) will be reduced and a decrease in the catches can be expected.

- AEC Up Score: 1.4
- AEC Down Score: 0.6

3.7.2.2 Recreational Fishing

The two trout species present in the middle and upper reaches under present conditions are intensely utilised by fly-fishermen, while yellowfish in the middle and lower area may be targeted to a lesser degree. Some other large species may also be caught by anglers.

Under AEC up scenario, some improvement in especially yellowfish should increase the value of angling in the middle and lower reaches (especially for fly-fishing). It is uncertain whether the status of the trout in the upper reaches will be improved under this scenario, and therefore recreational fishing in the upper reaches may not be altered significantly. Under AEC down scenario, species targeted especially for fly-fishing in the middle and lower reaches (yellowfish) will be reduced, resulting in decreased value of this service. Trout in the upper reaches can also be expected to be negatively influenced by an overall decrease in flow, and therefore angling activities in the upper reaches can also be expected to be influenced negatively.

- AEC Up Score: 1.3
- AEC Down Score: 0.4

3.7.2.3 Fauna

The diversity of riparian fauna is low. The area is cold Highveld and the utilisation is low. Under AEC up scenario, there will be a marginal improvement. Under AEC down scenario, there will be a marginal deterioration.

- AEC Up Score: 1.1
- AEC Down Score: 0.9

3.7.2.4 Sedges

Utilisation is restricted to the old homeland areas. Under the AEC up scenario, there will be a reduced cover due to improved base flows and more frequent small floods. Under the AEC down scenario, the reduced base flows and small floods would cause the sedges to increase (sediment).

- AEC Up Score: 0.9
- AEC Down Score: 1.1

3.7.2.5 Reeds

There is utilisation, but it is restricted to the old homeland areas. Under the AEC up scenario, there will be reduced cover due to improved base flows and small floods. Under the AEC down scenario, the deteriorated flow regime means that the density of reed beds is likely to increase.

- AEC Up Score: 0.95
- AEC Down Score: 1.05

3.7.2.6 Grazing

Grazing is high in the subsistence-orientated segments. Under the AEC up scenario, the grazing will improve as perennial exotics are removed, but this is not flow related. Under the AEC down scenario, we can expect the situation to remain unchanged.

- AEC Up Score: 1.1
- AEC Down Score: 1

3.7.2.7 Exotics

The present situation is dominated by agricultural weeds and poplars, but usage is low, almost negligible. Under the AEC up scenario, removal of aliens to a max of 20% is a non-flow related reduction. Under the AEC down scenario, there is no actual alteration, but there is a negative trend which is non-flow related.

- AEC Up Score: 0.7
- AEC Down Score: 1

3.7.2.8 Timber and Fuel Woods

There is low usage of tree-related services and the future impacts would be non-flow related.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.9 Waste Assimilation

There are farming-related impacts, mainly in the lower sections, but generally the water quality is good with limited sediments. Under the AEC up scenario, there would be an improvement in land management as well as improved base flows leading to a greater assimilative capacity. Under the AEC down scenario, there will be more farming and increases in abstraction which will result in higher nutrient loads and lower assimilative capacity.

- AEC Up Score: 1.4
- AEC Down Score: 0.8

3.7.2.10 Waste dilution

There are farming-related impacts, mainly in the lower sections, but generally the water quality is good with limited sediments. Under the AEC up scenario, improved base flows result in a dilution of farming-related pesticide use. Under the AEC down scenario, the additional farming and increases in abstraction will result in higher pesticide loads and less dilution.

- AEC Up Score: 1.2
- AEC Down Score: 0.7

3.7.2.11 Wetland Cultivation

No significance in this reach, hence the score doesn't change under the AECs.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.12 Ritual Use

Marginal in some areas, but not a key feature and no change is expected under either of the AEC scenarios.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.13 Flood attenuation

There is functionality, but not critical in light of the scenarios. There are no extensive floodplain reaches, so the role is small. No change is expected under either of the AEC scenarios.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.14 Bank protection

It is in good shape, banks are well protected and no change is expected under either of the AEC scenarios.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.15 Groundwater recharge

The middle sections of the catchment have a minor role. Dolerite dykes and sheets inhibit large aquifer development. No change is expected under either of the AEC scenarios.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.16 Eco-tourism

There are no gazetted protected areas, but the upper catchment has an aesthetic appeal. No change is expected under either of the AEC scenarios.

- AEC Up Score: 1.
- AEC Down Score: 1

3.7.2.17 Pathogens

None identified as yet.

3.7.2.18 Summary Discussion

Production and utilisation of Goods and Services is of moderate importance at this site. It would be of high importance if population densities were higher. Both an AEC up and down were considered. Here the total score in terms of the AEC up was found to be 42 and down was found to be -64. This reflects the fact that the AEC down would impact to a moderate to high extent on the production of Goods and Services but the AEC up state would improve the delivery of Goods and Services to a moderate extent. This is caused by the fact that the

number of people relying on Goods and Services is low, and the actual range of services used is also restricted.

3.8 EFR 8 - Molopo Wetland

The Molopo Wetlands and the Kuruman Oog have relatively high recreational value given the surrounding park areas. They are also relatively important with respect to aesthetic quality. The EFR site is in wetlands upstream of relatively dense settlement (Witkoppies and then Mafikeng). In this instance the Molopo Wetlands have been demarcated from a Goods and Services perspective, as the stretch below the weir to the Bosbokpark Road, about 1.3 km of wetland/riverine area. The road crossing was originally constructed during 1965 to link the two portions of the farm Trekdrift. This road crossing was upgraded by the farmer during March 2005. The upgrade involved raising the height of the road and inserting six pipes. The permanent inundation and subsequent loss of connectivity in this section of the wetland was raised as a concern at the North West Wetland Forum. Working for Wetlands volunteered to rehabilitate the road crossing during 2007. They inserted gabion structures but the upstream inundation problems and the downstream erosion caused by the discharge through the pipes remain a concern. Direct utilisation of Goods and Services from the wetlands is important as subsistence grazing takes place as well as some harvesting of sedges and reeds. Sand mining was observed as well. The wetland also plays an important role in water-quality control for human usage. The area has some important aesthetic qualities and the wetlands are considered relatively unique highland peat.

3.8.1 Scenarios

3.8.1.1 Present Ecological State (PES)

The PES is a C. The condition of the wetland is moderately modified but still maintains a well-vegetated valley bottom, although some sections are channelised, others are impacted by impoundments. Vegetation has changed due to desiccation of large sections of the wetland as a result of reduced flows, and through spraying and die-off of *Phragmites*. This has promoted terrestrialisation of the former areas, and invasion of more weedy species in the latter areas. It is estimated that all the expected fish species are still present in this river reach, albeit in reduced abundance. The primary changes responsible for deterioration in the fish assemblage are associated with the presence of alien predatory fish.

3.8.1.2 Recommended Ecological Category (REC)

As the EIS is HIGH, the REC is an improvement of the PES. A number of scenarios were considered. These are set out in Table 3.

Table 3: Scenarios Associated with EFR 8

SCENARIO	Expected Wetland EC (for EFR site)	DESCRIPTION
SCENARIO 1: Drop road crossing by 1.2 m (inflow remains at PD levels)	C	Although inflows will remain low, backup area should be reduced by 50%. Flows to the downstream wetland area will increase by 35%.
SCENARIO 2: Drop road crossing by 2 m (inflow remains at PD levels)	B	Although inflows will remain low, backup area should be reduced by 75%. Flows to the downstream wetland area will increase by 50%.
SCENARIO 3: Drop road crossing to original bed level (inflow remains at PD levels)	B	Although inflows will remain low, backup area should be reduced by 85%. Flows to the downstream wetland area will increase by 60%.
SCENARIO 4: Present day without spraying.	C	No significant change from PES expected. No change to the flows to the downstream wetland.
SCENARIO 5: Reduced inflows (50% of Present Day), no change to road crossing	D/E	Wetland at EFR 8 site becomes desiccated more frequently, and flows to the downstream wetland area will decrease by 94%
SCENARIO 6: Reduced inflows (75% of Present Day), no change to road crossing	D	Wetland at EFR 8 site becomes desiccated more frequently, and flows to the downstream wetland area will decrease by 50%

3.8.2 Ecological Goods and Services associated with PES and Scenarios

For the purposes of examining the Goods and Services, only the two most extreme positive and negative scenarios were considered. Scenario 3 is the most positive and would entail dropping the road crossing to the original level. The result would be a B Category and increase the wetland expanse in the section under consideration from about 28 ha to 47 ha of open waterway. The worst-case negative scenario would be Scenario 5, which would reduce flows by 50% and not alter the road crossing. This would result in a D/E category and reduce the water surface area from the current 28 ha to about 2 ha.

3.8.2.1 Subsistence Fishing

The usage is very low and related to farm workers and families. Damming of the reach under consideration has created favourable habitats for potential angling species that would not have been present (or very scarce) under reference condition, namely catfish. Due to the presence of deep pools in the wetland, favourable habitat was also created for the stocking of alien species for angling purposes (especially bass, but potentially also carp). Under Scenario 3, loss of the deep habitats will result in eradication or strong reduction of the large

species utilised for angling. Although this results in an overall improvement in ecological integrity (due to removal of unwanted species), it simultaneously results in a severe deterioration of angling potential. Under this scenario only catfish will be present in very low abundance. Under Scenario 5, fish species expected to be utilised for recreational fishing are not expected to change significantly.

- Scenario 3 score 0.1
- Scenario 5 score 1

3.8.2.2 Recreational Fishing

This is a small area under consideration so importance is moderate. It is a drawcard for the guest house in the area. Under natural conditions, this wetland would have had no value for recreational fishing, but due to the creation of a deep area associated with the weir, and the presence of recreational/tourism facilities, some recreational angling now occurs. The primary recreational angling species is expected to be the alien bass, which was introduced for this purpose. Other species caught by anglers include catfish and possibly also alien carp. As for subsistence fishing under Scenario 3, loss of the deep habitats will result in eradication or severe reduction of the large species utilised for recreational angling. Although this will result in an overall improvement in ecological integrity (due to removal of unwanted species), it will result in a deterioration of angling potential. Under this scenario only catfish will be present in very low abundance. Under Scenario 5, fish species expected to be utilised for recreational fishing are not expected to change significantly.

- Scenario 3 score 0.1
- Scenario 5 score 1

3.8.2.3 Riparian Fauna – hunting

Under Scenario 3, the area would increase from 28 ha to 47 ha and an increase in water will mean an positive increase of the open water habitat for water fowl. These are the only fauna worth hunting in the section under consideration. Under Scenario 5, the reduction of the 28 ha to 2 ha would mean less water and lack of open water habitat for water fowl.

- Scenario 3 score 1.3
- Scenario 5 score 0.5

3.8.2.4 Riparian Fauna – bird watching

Under Scenario 3, the area would increase from 28 ha to 47 ha. With more open water and less wetland habitat for wetland birds there would be a decline in this range of species, which are popular among birdwatchers. Under Scenario 5, the reduction of the 28 ha to 2 ha would mean less water and better wetland habitat for wetland birds. This would improve the species presence.

- Scenario 3 score 0.6
- Scenario 5 score 1.7

3.8.2.5 Reeds and Sedges

Under Scenario 3, hydrophilic grasses will increase along the edges of the wetland (with an associated thinning of *P. australis*) which increases the reed, non-woody and species composition rating slightly. This scenario has the danger of incising a channel because of the way that the water is routed through the section. Should this happen, the wetland will dry out from the edges inwards and species composition will completely change. The final EC would then likely be worse or similar to the current PES. Reed cover could increase by about 40%. There would be no expected change under Scenario 5.

- Scenario 3 score 1.4
- Scenario 5 score 1

3.8.2.6 Geophytes and Medicinal plants

There is some utilisation of geophytes e.g. *Crinum bulbispermum* in the area. Under Scenario 3 the conditions would marginally favour increase in the geophytes. Scenario 5 has no impact.

- Scenario 3 score 1.05
- Scenario 5 score 1

3.8.2.7 Grazing

Grazing is important in the stretch under consideration. The scenarios under consideration will change flows downstream and this should alter areas of wetland that can be maintained and thus grazing opportunities likewise maintained. Scenario 3 is expected to result in increased downstream flow of 63%, whereas Scenarios 5 is expected to cause a decline of 94%.

- Scenario 3 score 1.4
- Scenario 5 score 0.4

3.8.2.8 Groundwater Recharge

This is a critical function of the wetland in the greater area. The scenarios under consideration will change flows downstream and this should alter groundwater recharge. Scenario 3 is expected to result in increased downstream flow and associated re-charge, whereas Scenarios 5 is expected to cause a decline.

- Scenario 3 score 1.4
- Scenario 5 score 0.4

3.8.2.9 Recreational Canoeing

Recreational canoeing takes place, but is not a critical use. Under Scenario 5 there will be a major decline in the available area for this activity, while Scenario 3 will increase the available area.

- Scenario 3 score 1.3
- Scenario 5 score 0.3

3.8.2.10 Ecotourism Aesthetic

This aspect is still important even at the sections under consideration - open areas are of importance as an aesthetic attraction. Under Scenario 5, there will be a major decline in the available area for this activity while Scenario 3 will increase the available area.

- Scenario 3 score 1.2
- Scenario 5 score 0.9

3.8.2.11 Fire Risk from Reeds

Reeds pose a natural fire hazard. This is a cost. Under Scenario 3, reeds would spread, but they would decrease under Scenario 5.

- Scenario 3 score 1.6
- Scenario 5 score 0.1

3.8.2.12 Summary Discussion

Production and utilisation of Goods and Services is of low to moderate importance at this site. Two scenarios representing an improvement and degradation in ecological state were considered. Here the total score in terms of the positive scenario was found to be 13, and the negative scenario was found to be -41. The important issue to bear in mind is that the improved scenario would actually entail a major reduction in the recreational fishing aspect, as the present environment has been altered so as to improve this aspect of fishing. If this was discounted then the positive impacts of the improved scenario would be much greater.

4 GOODS AND SERVICES RELATED TO CHANGES IN ECOLOGICAL STATE

The range of Goods and Services available at the lower end of the Orange River ensures that these reaches are rendered more sensitive to management interventions. The converse is generally true for the upper sites. In addition, there are a body of users of Goods and Services in the lower part of the Orange whose dependence on these Goods and Services is of paramount importance to their livelihoods. Conversely for the Caledon, particularly the upper site, in spite of a dependency on Goods and Services, the highly impacted state of the river means that management interventions will not result in substantial changes to the delivery of Goods and Services. In addition, in these areas the most important management interventions will not be flow-related but will likely relate to a wider programme of catchment management. The Kraai is in many respects in a good state, and the usage relatively low. As such, management interventions will not yield dramatic results. Table 4.1 summaries the overall evaluation results. These were derived from modelling the results for each EFR site with the importance of each category of Goods and Services weighted. Those deemed to be most important at the site were given a weighting of 100. Those of marginal importance were given lesser weightings.

Table 4: Summary Results with Weighting

Site	AEC Up	AEC Down
Hopetown	NA	NA
Boegoeberg	NA	-45.5
Augrabies	125.5	-58.5
Vioolsdrift	146	-87
Upper Caledon	NA	-17
Lower Caledon	32.25	NA
Kraai	42	-64.25
Molopo	13.25	-40.5

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