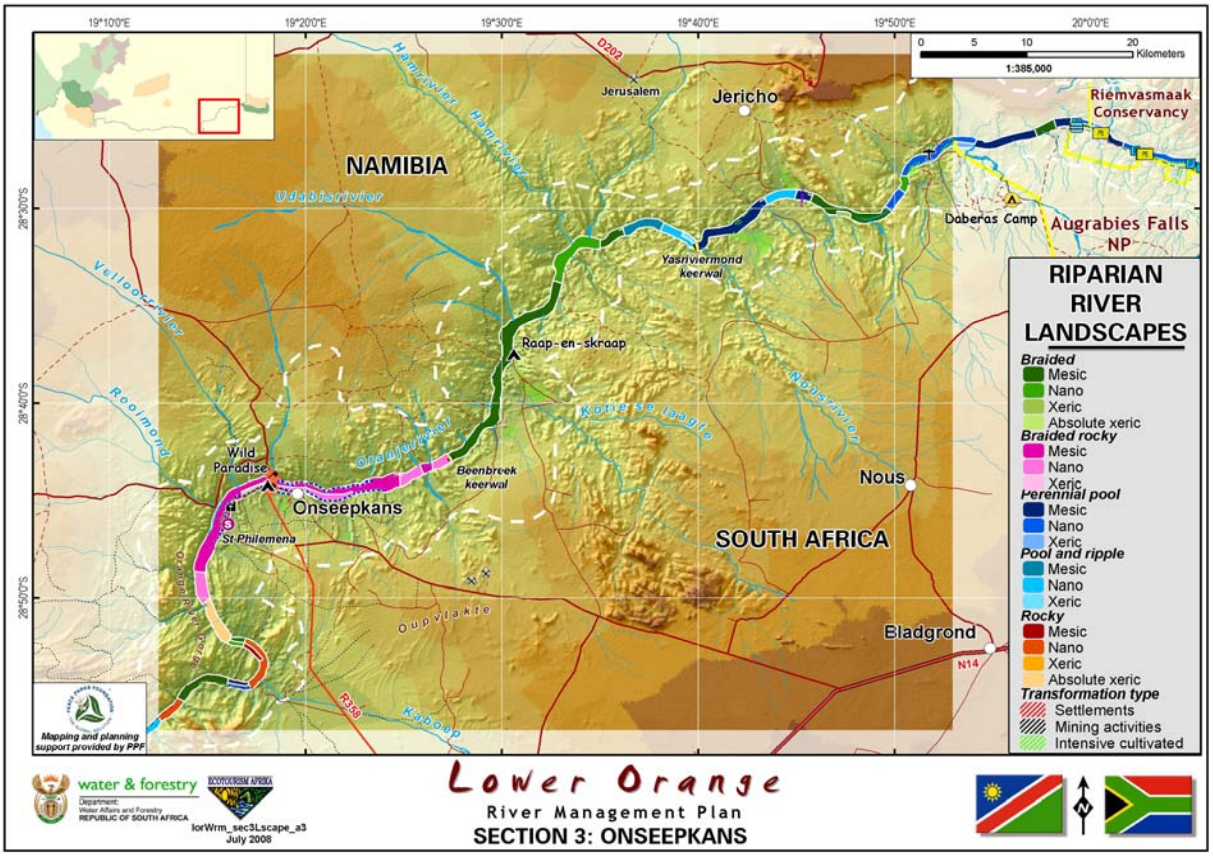
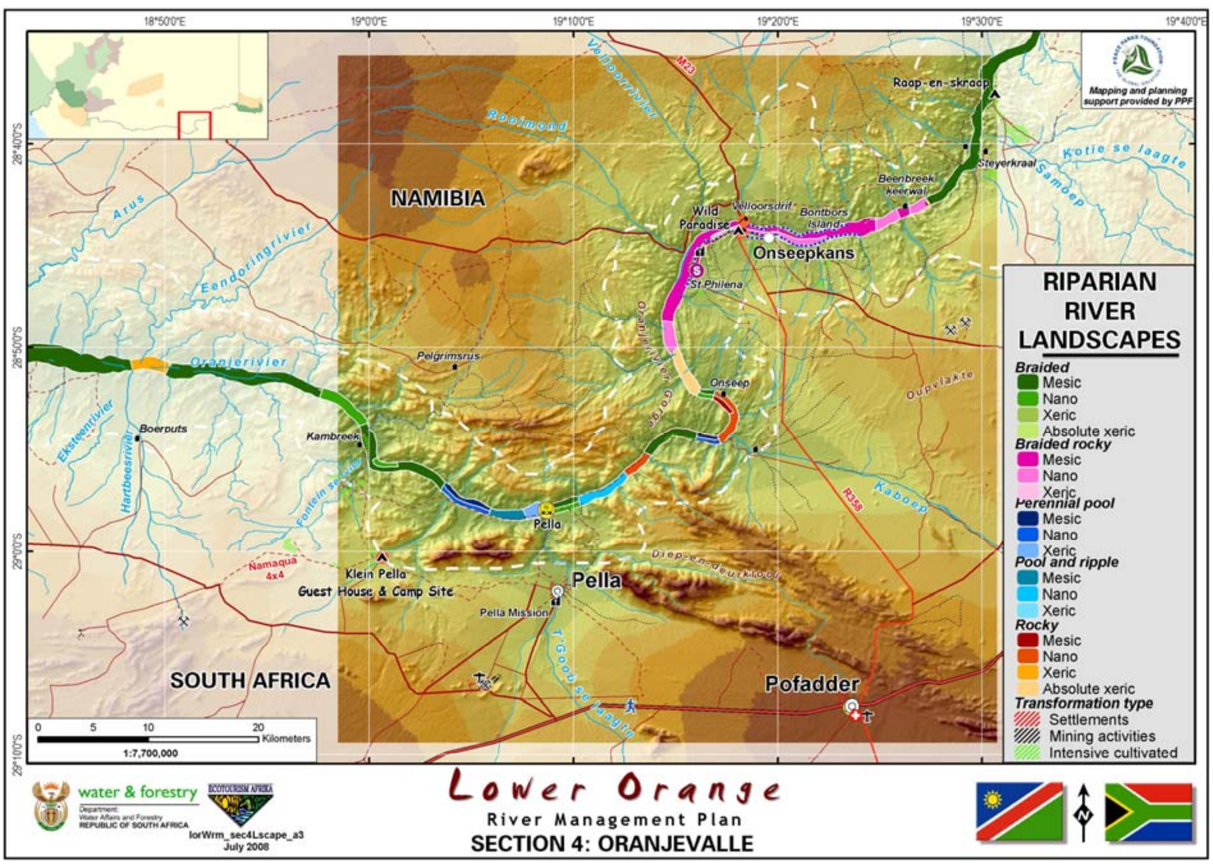
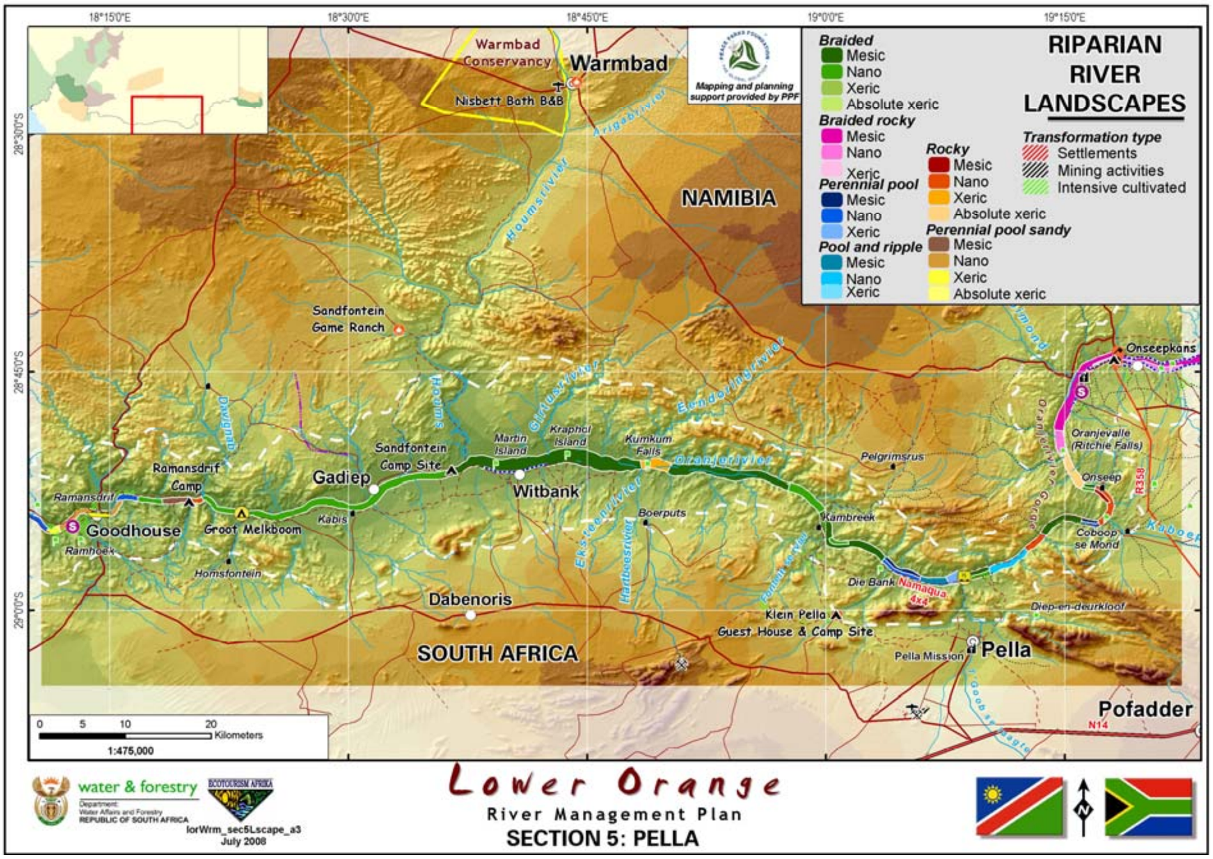


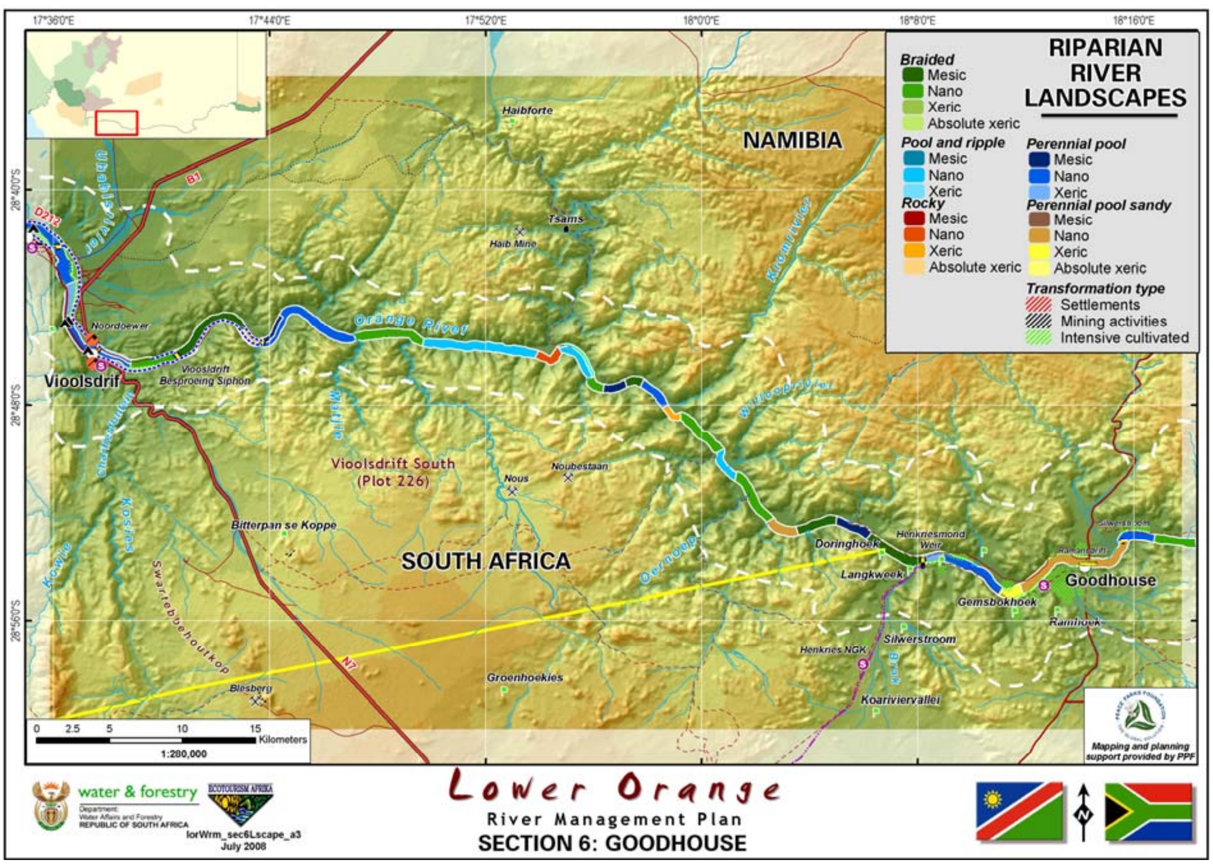
Map 11: River Landscape, Section 3 (Onseepkans)



Map 12: River Landscape, Section 4 (Oranjevalle)

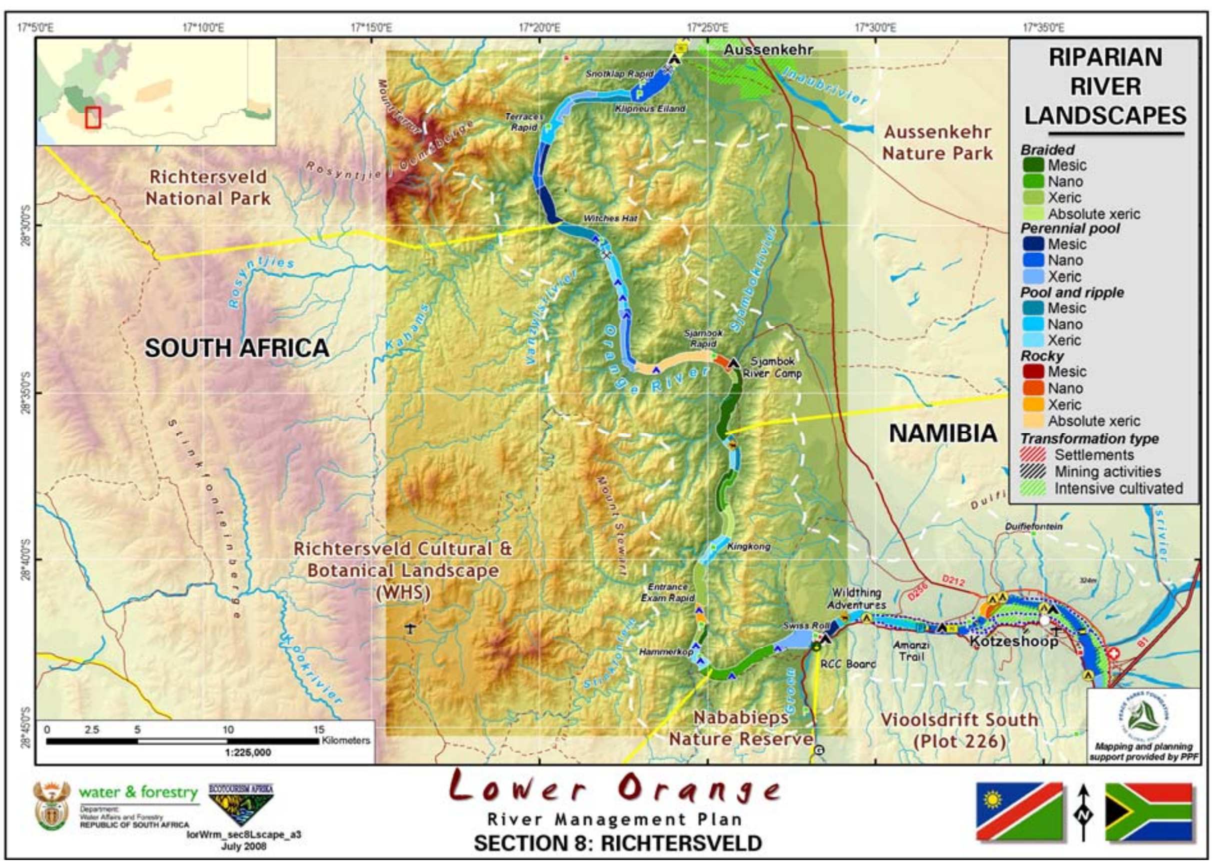


Map 13: River Landscape, Section 5 (Pella)

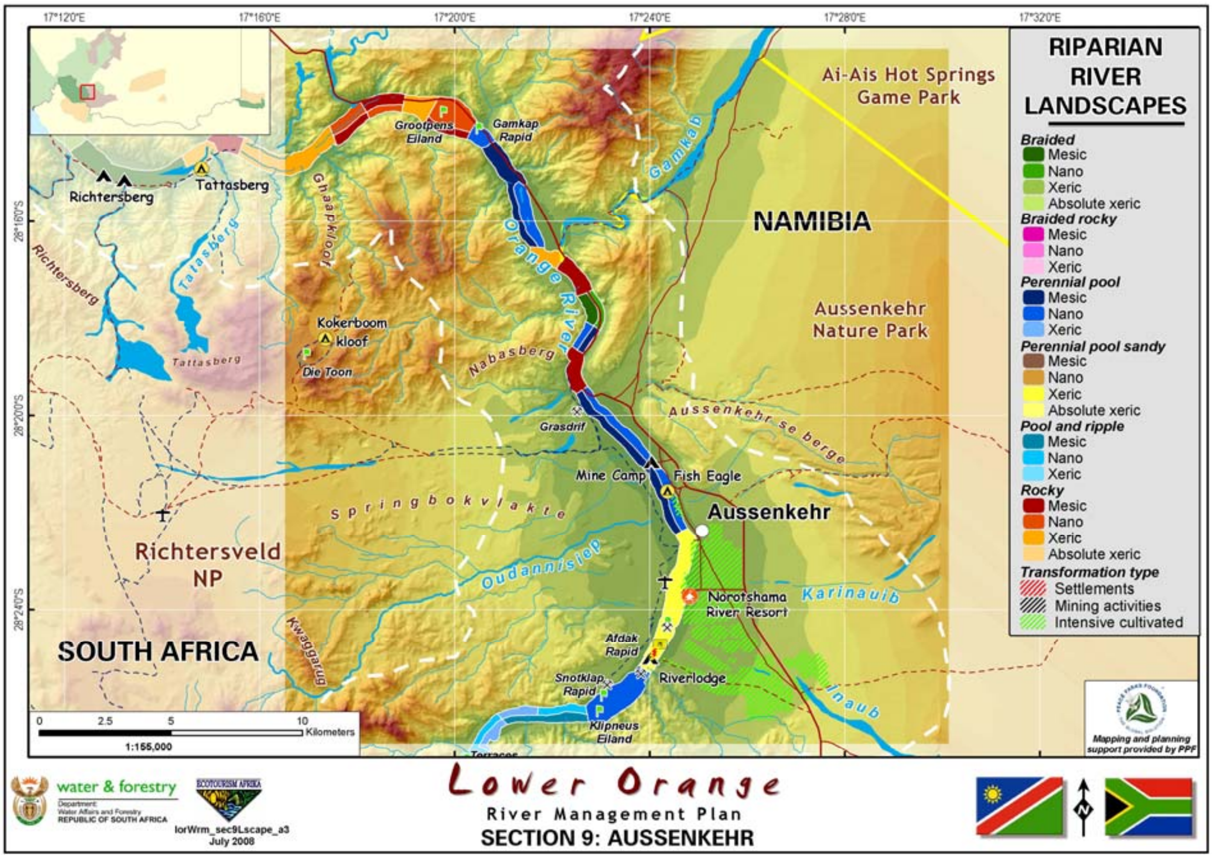


Map 14: River Landscape, Section 6 (Goodhouse)

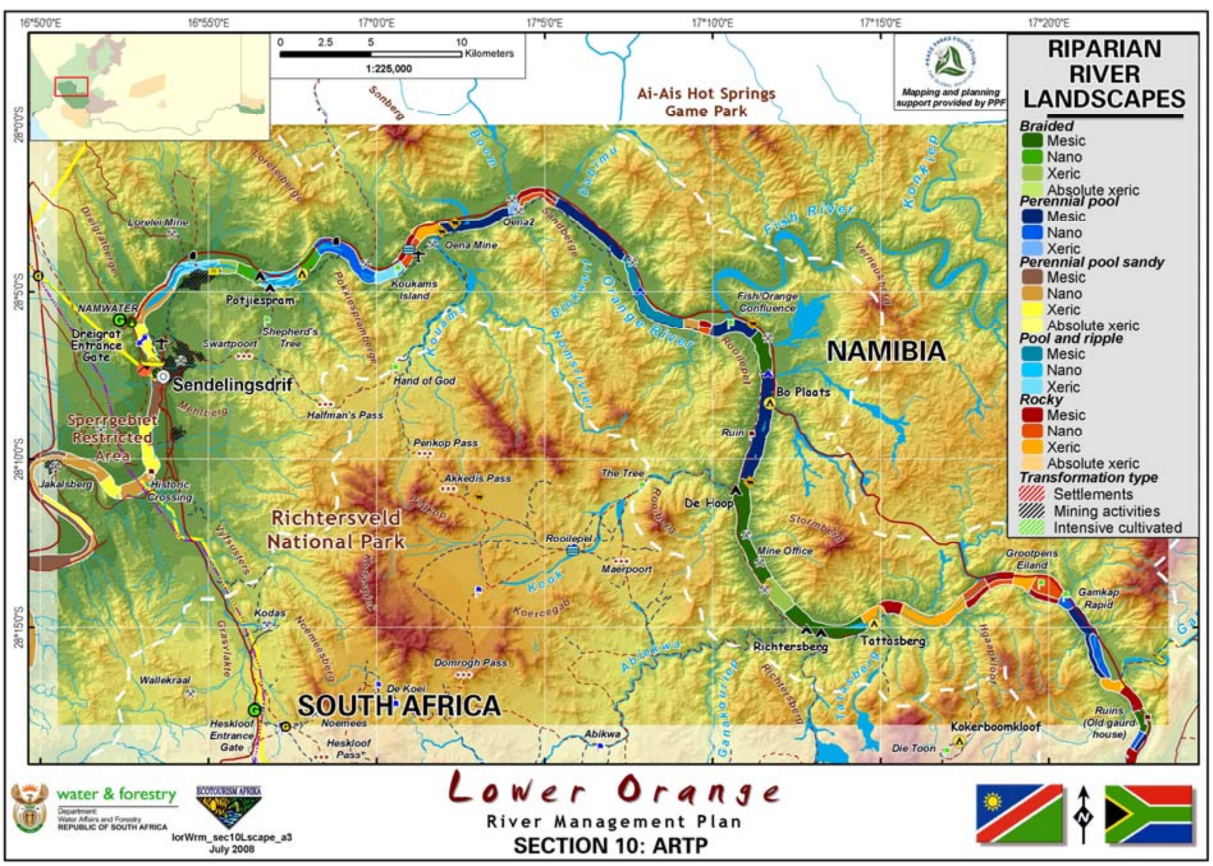
Map 15: River Landscape, Section 7 (Vioolsdrift)



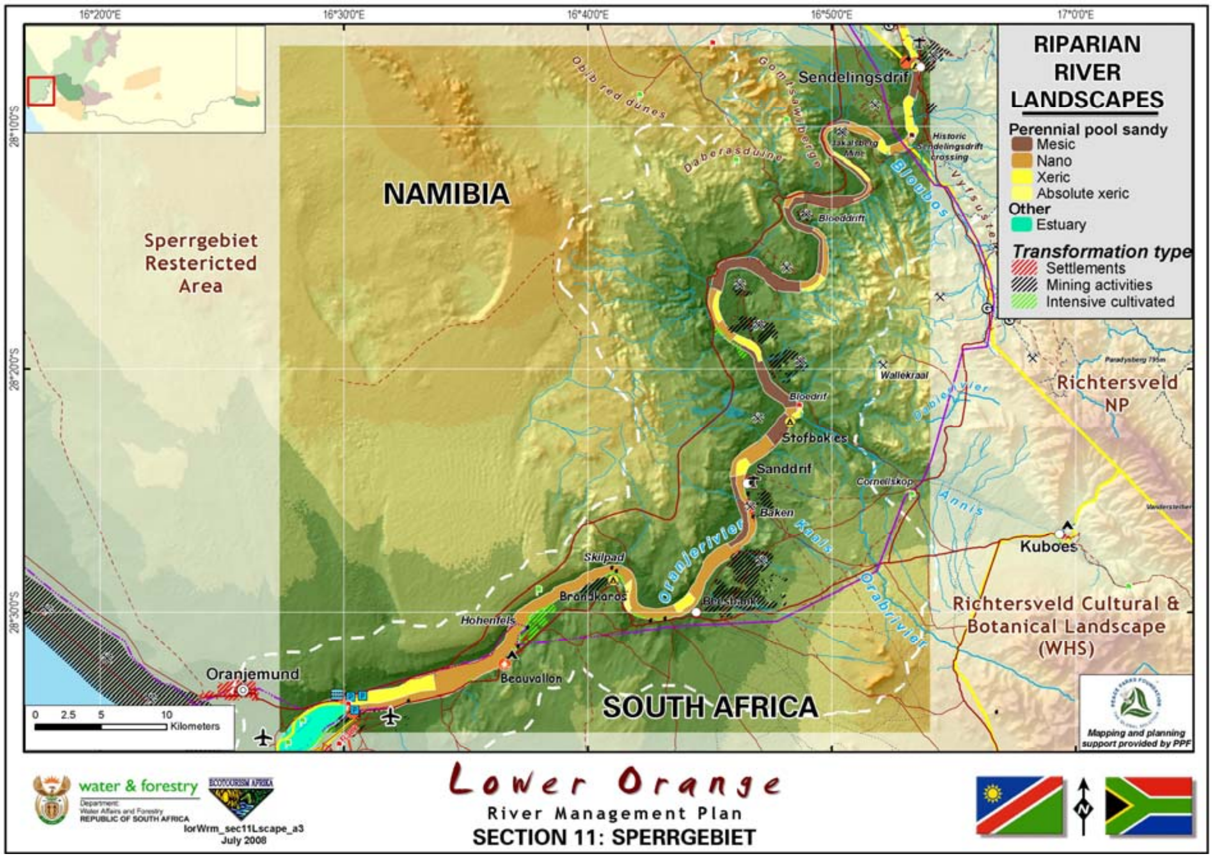
Map 16: River Landscape, Section 8 (Richtersveld)



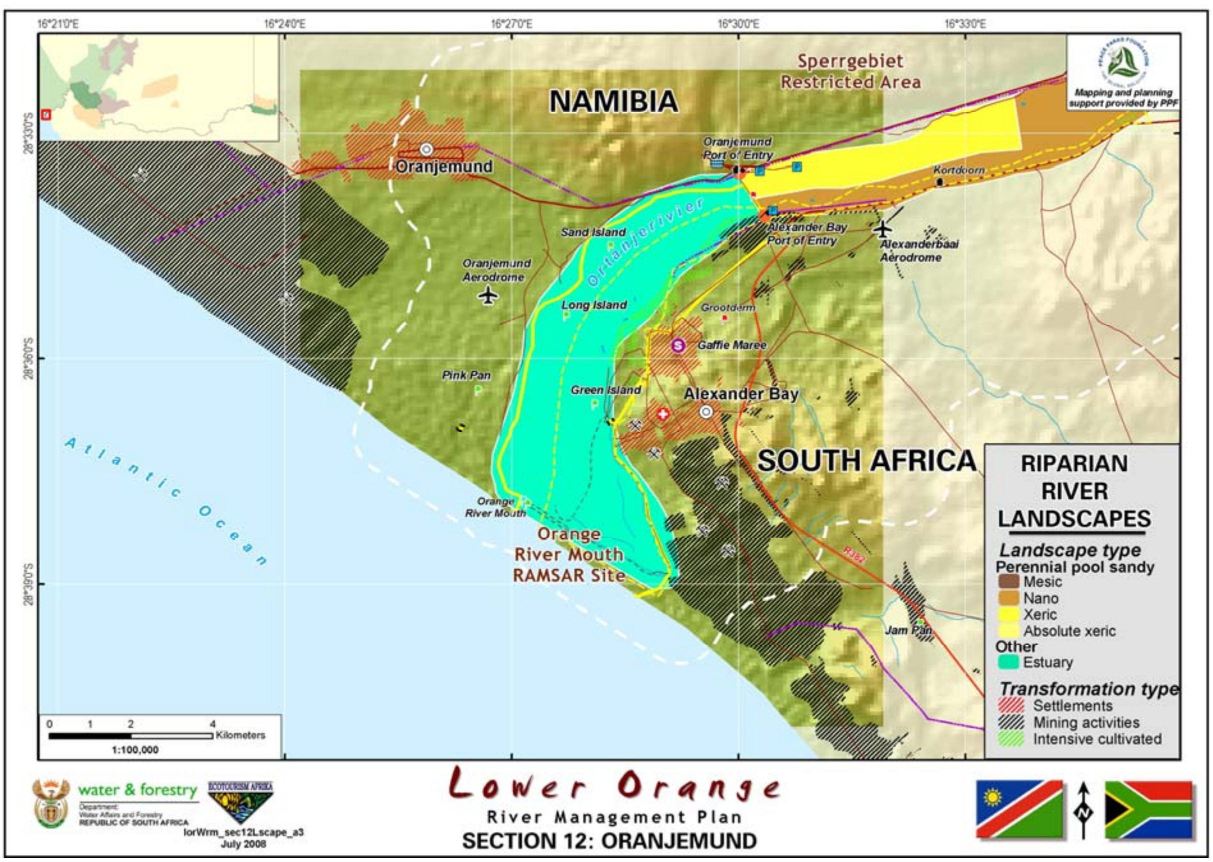
Map 17: River Landscape, Section 9 (Aussenkehr)



Map 18: River Landscape, Section 10 (ARTP)



Map 19: River Landscape, Section 11 (Sperrgebiet)



Map 20: River Landscape, Section 12 (Oranjemund)

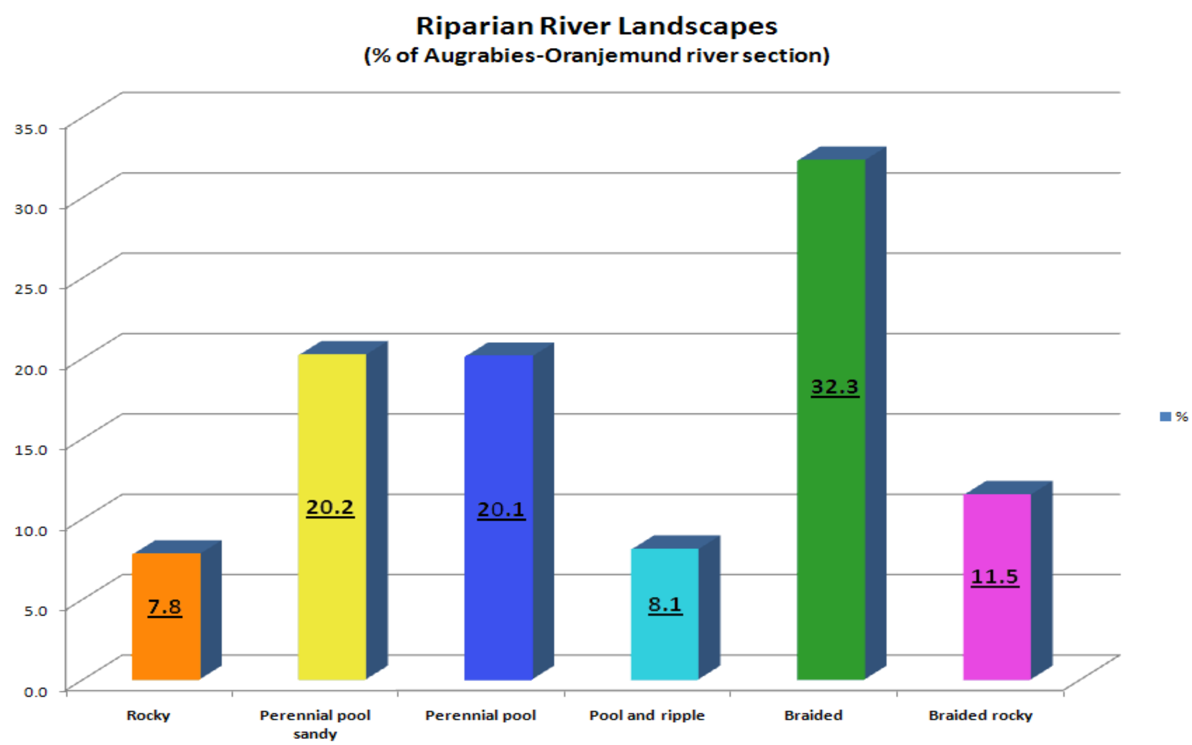


Figure 10: **Graph indicating Percentages Riparian River Landscapes**

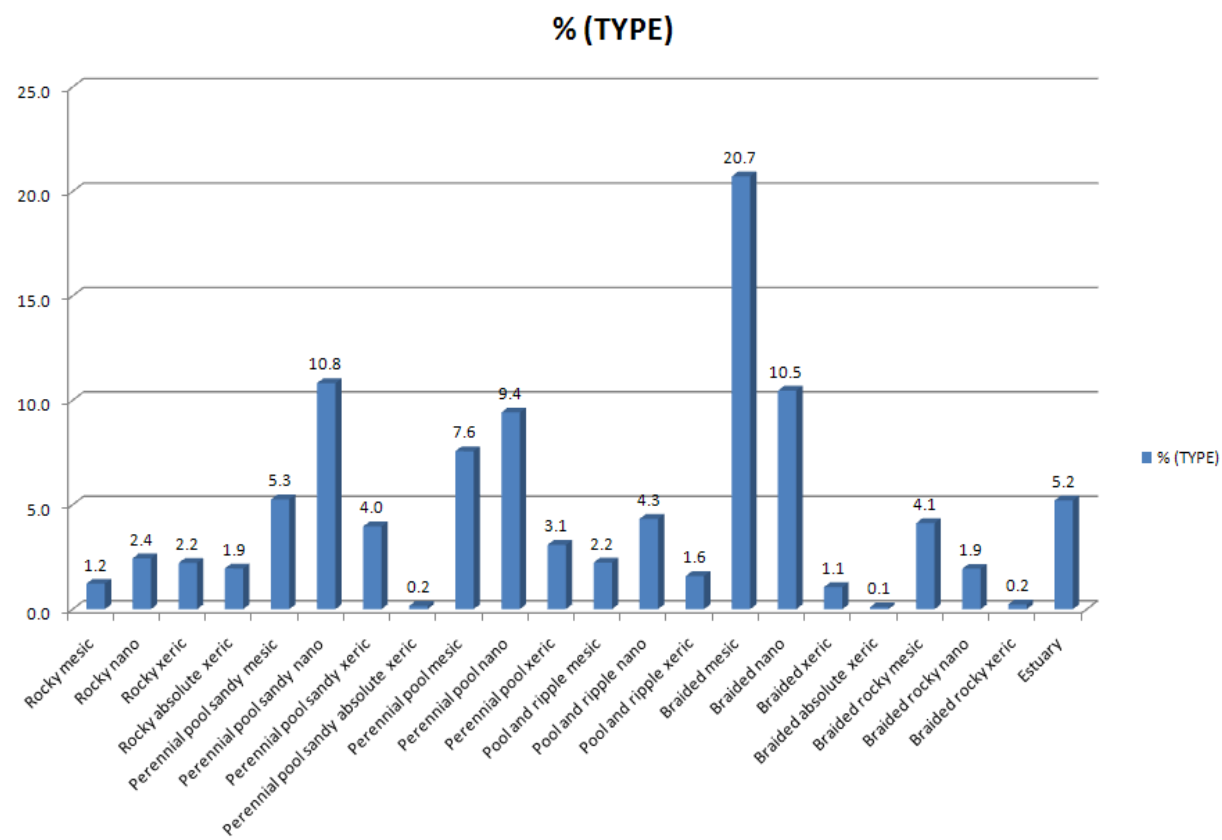


Figure 11: **Graph indicating Percentages Riparian River Landscapes and Associated Vegetation Cover**

2.1.5 Riverine and Riparian Ecology

According to PWC, 2005a, 2005f and 2005g the aquatic and riparian ecosystems of the LOR evolved in response to the natural seasonal flow pattern, inclusive of the flood regime. This regime has however increasingly been modified, principally due to the construction of large dams. It is anticipated that the aquatic ecosystem has and will continue to respond to this change over time. A number of aquatic microphytes and aquatic and semi-aquatic macrophytes are present in the LOR. Filamentous Phycophyta are fairly abundant in the side streams of the LOR and the blue-green algae occur in the lower stretches of the river. A number of relatively pristine stretches of shoreline and island vegetation have been observed in the mountainous and less accessible areas; however, these areas are under threat. The exotic tree, *Prosopis* species has invaded large areas of the riparian forest, while reeds are the dominant semi-aquatic macrophyte along the whole of the river. This indigenous plant can reach pest proportions, especially downstream of irrigation areas, due to increased disturbance and possibly an increase in nutrients.

Invertebrate populations appear to be rather homogenous through the entire length of the river. This is likely to be due to the natural unpredictable, erratic nature of the flow regime. Freshwater shrimp and freshwater mussel are found in the river. The LOR downstream of the Augrabies Falls is very important with regard to fish species, with 12 of the 15 indigenous freshwater fish of the Orange River found in the LOR. These include one unique Red Data listed endemic and other unique and vulnerable indigenous species. A gradual downstream increase in the occurrence of freshwater fish being infested by parasites, as well as increase in fish parasite diversity has been observed, possibly due to a deterioration in water quality.

The present ecological status of the river has been generally assessed as being largely modified and its condition is deemed to be on a negative trajectory. Controlling the present mechanical manipulation of the river bed, banks and floodplain is extremely important as these factors are major contributors towards the decline in the condition of the riverine ecosystem, which together with the current manipulation of the flow regime will eventually lead to its complete collapse. Particular attention should be given to maintaining the few remaining and relatively undisturbed braided or anastomosed sections, e.g. upstream of Onseepkans. These areas are considered to be ecologically important.

The ORM wetland is a RAMSAR site (a wetland of international importance) – in September of 1995 this site was placed on the Montreaux Record as a result of severely degraded state of the salt marsh on the south bank – the LORMS study concluded that its present ecological state is largely modified. Along the entire length of the Lower Orange River, a high percentage of the riparian habitat is transformed (63.8%), with high levels of transformation totaling 34.9%, moderately transformed 19.1%, and totally transformed 9.8%. Low levels of transformation total 25%, while only 11.2% can be classified as pristine, yet most of this is not in formally proclaimed protected areas, and therefore under threat. Attempts must be made to formally protect these, through conservation or custodianship agreements with the relevant landowners (refer Fig. 12).

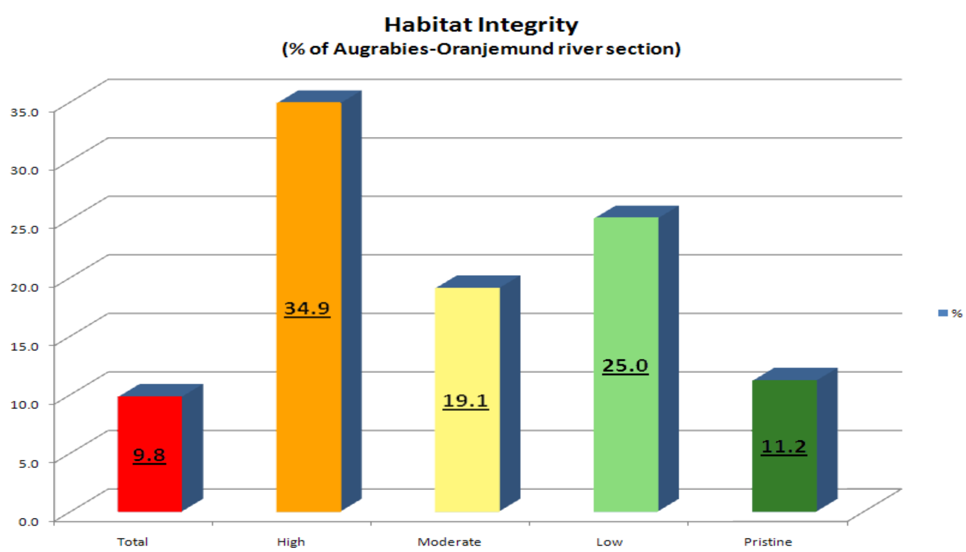


Figure 12: Graph indicating Percentages Habitat Integrity

2.1.6 Terrestrial Ecology

The focus area of the proposed LOR TFCA lies within the semi-arid Nama Karoo and Succulent Karoo Biomes, the latter of which is the most diverse desert system in the world. Although the eco-region contains many endemic plants, the fauna of the Nama Karoo is relatively species-poor. Grazing pressure from sheep and goats have impacted on the vegetation and altered habitat for native wildlife in many areas (PWC, 2005g).

The main vegetation types (refer Map 21) associated with the river include, *inter alia* vegetation from the following bioregions in South Africa:

- Bushmanland Bioregion;
- Gariep Desert Bioregion; and,
- Southern Namib Desert Bioregion;

and from Namibia:

- Orange River Valley;
- Edaphic dry sparse shrubland;
- Dwarf Shrub Savanna;
- Mountain succulent dwarf shrubland; and,
- Plains dwarf shrubland.

The ORM, as an estuary has vegetation associated with salt marshes, recognised as a Ramsar site, this is a wetland of international significance.

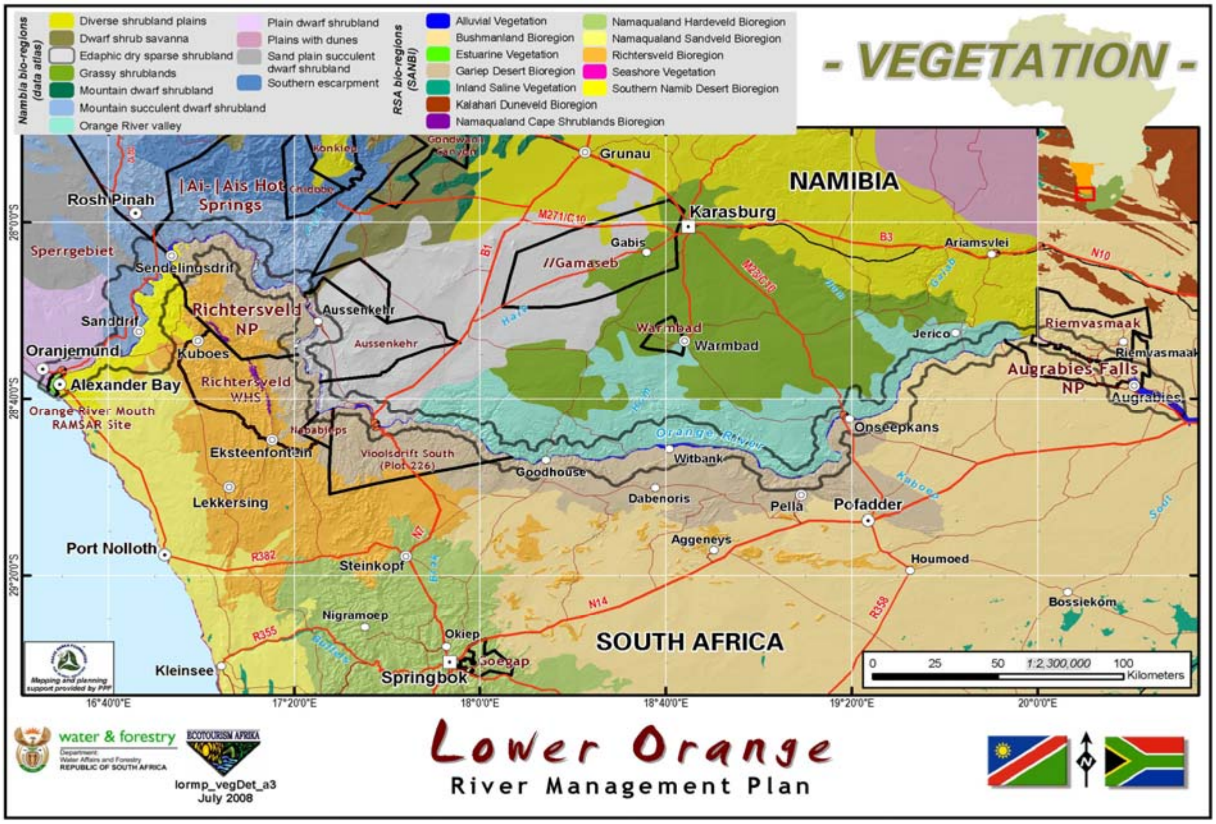
Despite the significant role that the Richtersveld National Park (RNP) and World Heritage Site (WHS), and the AFNP play in providing protection to the vegetation of this region, most of the vegetation along the LOR is not protected, with only a few portions poorly or hardly protected at a national level (refer Map 22).

Through collaborative efforts between the Namibia and South Africa additional areas such as the portion between Henkries and Vioolsdrift/Noordoewer could form part of a transboundary conservation initiative incorporating state land on both sides of the river. Other partnerships between the public, private and communal sectors could see the protection of large portions of areas not currently afforded any protection status.

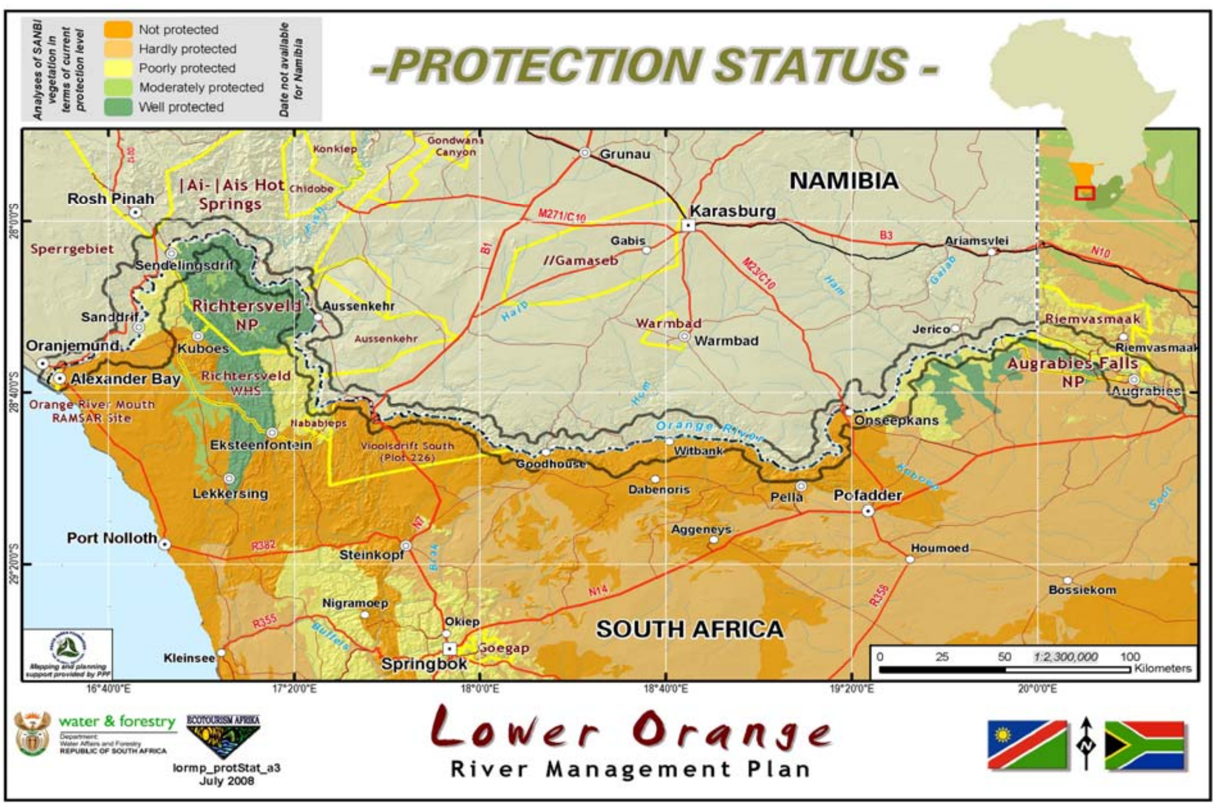
This could be undertaken between the landowners all along the LOR from AFNP to the Richtersveld complex on the South African side, and from Ariamsvlei in the east to the Ai-Ais Hot Springs Game Park and the Sperrgebiet in the west on the Namibian side. Numerous private conservation initiatives such as Sandfontien, Aussenkehr, and the Greater Fish River Canyon Complex (GFRCC) could be linked with communal initiatives to establish TFCAs where state land does not exist. These initiatives could contribute significantly to the protection of vegetation types that currently are not meeting national targets.

Due to its ecological significance, the possibility exists for the establishment of a world heritage site focusing on the Succulent Karoo biome within the region, yet this would require collaboration between the two countries. Possibly this could form the basis for an expanded TFCA within the area, and should include the portions of the Nama Karoo, specifically the Gariep Desert Bioregion (Orange River Brokenveld); the Bushmanland Bioregion (grassy shrublands); and the alluvial vegetation in the Orange River Valley, all vegetation types that require additional protection, both in Namibia and South Africa.

This protection status could be bolstered by incorporating aspects such as the cultural landscape unique to the region, drawing on the successes of the Richtersveld Cultural Landscape which achieved World Heritage Status. By combining the significant natural features with the cultural heritage of the region the protection can be made ensured from both sides, and lead to a broadening of the understanding of the cultural utilisation of the region's natural resources, and the influence that the region has had on the cultural heritage of the people who call this home.



Map 21: Vegetation



Map 22: Protection Status of Vegetation (RSA)

2.1.7 Climate

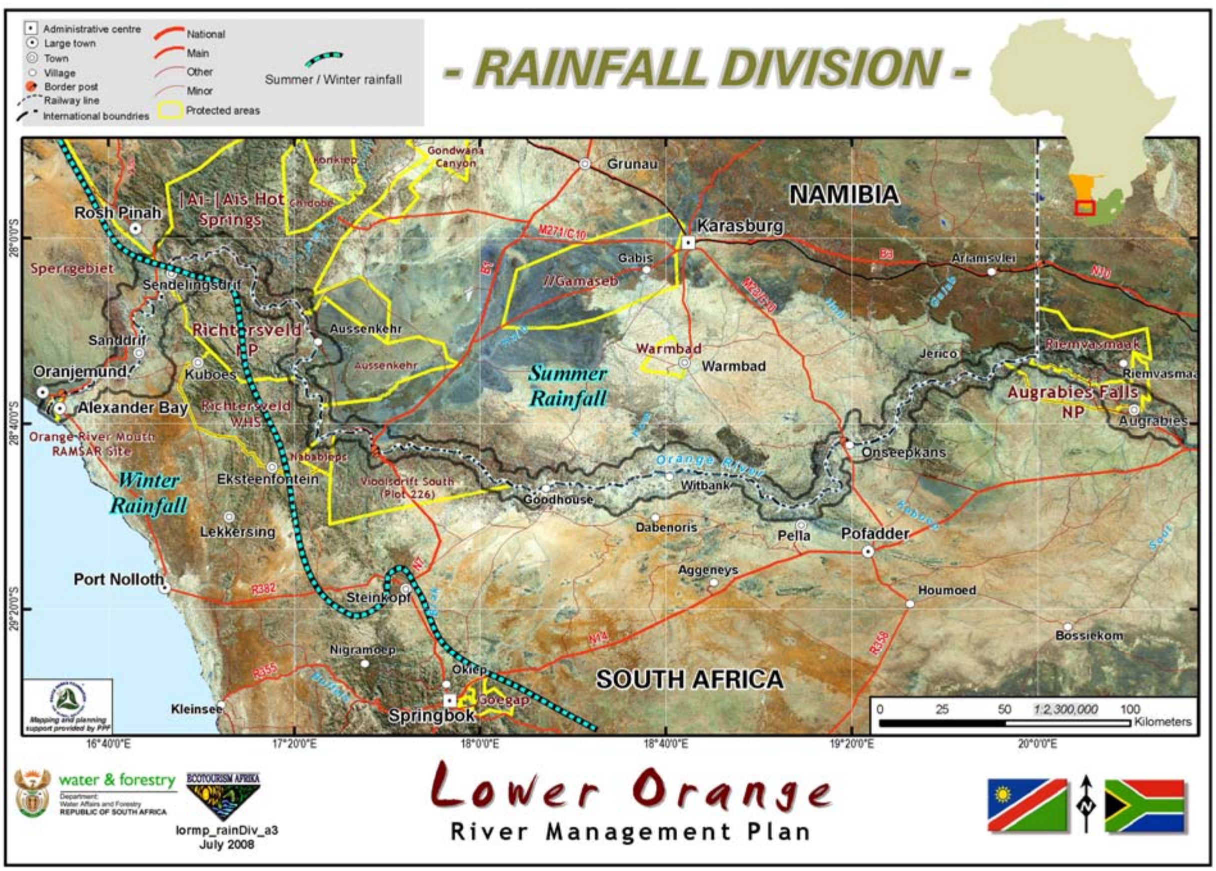
2.1.7.1 Rainfall

Two desert systems are drained by the catchments of the Lower Orange, the Succulent Karoo in the extreme west of the study area, consisting of the 'winter rainfall' area from Luderitz south to the Orange River and on into South Africa, representing the area where rainfall occurs with almost equal improbability throughout the year; and the Nama Karoo, which receives mainly 'summer rainfall' and comprises a number of different vegetation types as discussed in subsection 2.1.6 of this plan (PWC, 2005g; ORASECOM, 2008). (Refer Maps 23 and 24.)

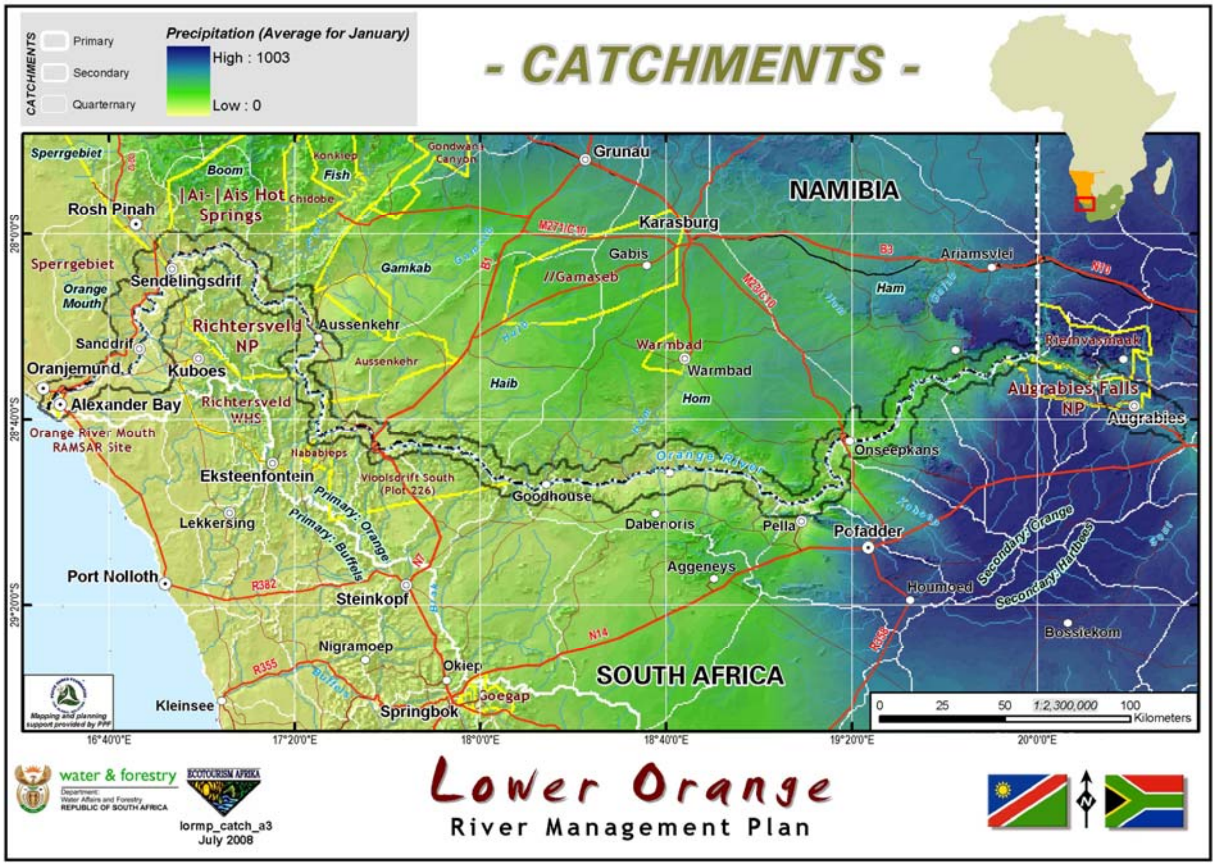
A clear distinction exists between the Succulent Karoo desert system which receives mainly rainfall during the winter months, while the Nama Karoo desert system mainly receives rainfall during summer. A rough line following the coastal plain and the north-south trending mountains forming the escarpment largely represents the division between winter and summer rainfall.

Rainfall within the study area is very low and unpredictable and varies from less than 50mm in the west to about 400mm per year in the east. Annual potential evaporation exceeds 3,000mm in places, and with an average water deficit per year of about 2.6m resulting in harsh arid conditions. The area within the ARTP represents the driest portion within the entire study area, with less than 50mm annual precipitation, while the catchment around Springbok receives more than 100mm annually, as does the area close to Augrabies.

Despite the entire LOR area being classified as extremely dry, harsh and inhospitable, the altitudinal variation, from the coast to the escarpment, and that associated with the incised valley gouged by the Orange River has resulted in high biodiversity within the area as a result of the various landscapes that have been formed.



Map 23: Rainfall Division



Map 24: Rainfall per Catchment

2.1.7.2 Temperature

Mean maximum temperatures within the study area range from east to west, with higher temperatures in the east. Mid-summer (January) temperatures exceed 40^0C, whereas mean minimum mid-winter (July) temperatures are below freezing (PWC, 2005g).

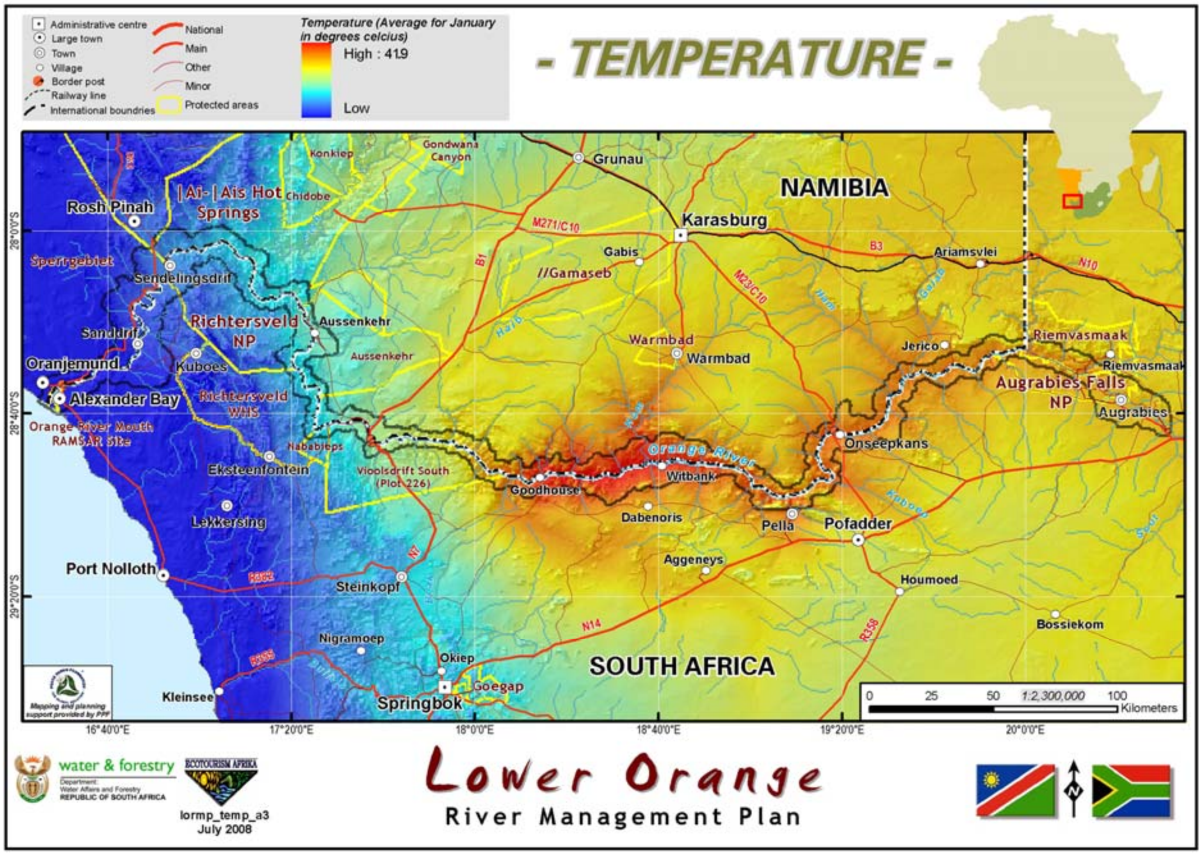
The high lying areas around Springbok, the Richtersveld mountains, and the Hunsberge illustrate the cooling effect of altitude, while the coastal plain shows the moderating effect of the Benguella current, while the impact of the Central Kalahari High Pressure System is evident in the eastern side of the study area. (Refer Map 25.)

2.1.8 Water

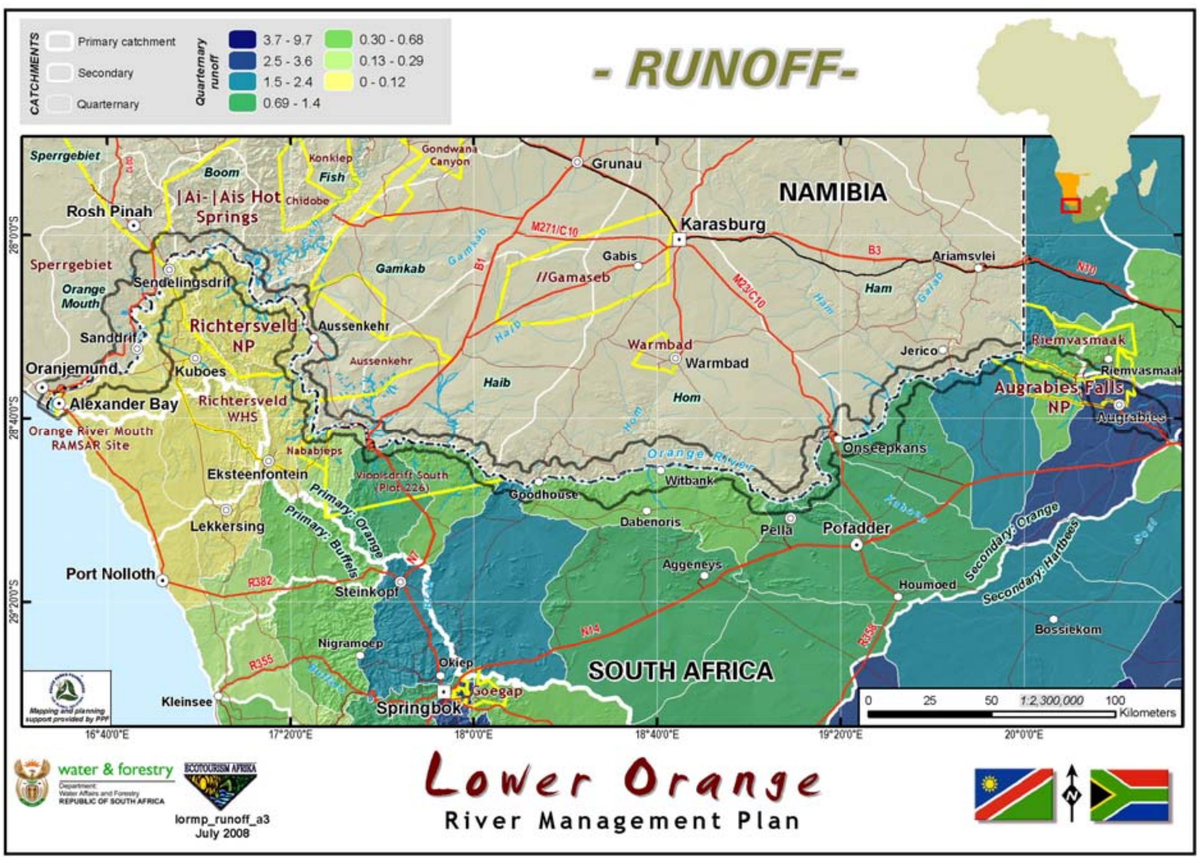
2.1.8.1 Hydrology

Namibia has 7 quaternary catchments (refer Map 24) that drain into the LOR, while 14 drain the South African side. The north-south oriented escarpment edge separates the primary catchment of the Orange River from the Buffels River catchment, while the watershed south of the river divides the secondary Orange River catchment from the Hartbees catchment.

The catchment around Augrabies drains has the highest quaternary runoff, while the catchments around Springbok have the highest runoff, albeit lower than Augrabies, for the western portion, clearly indicating the dry, harsh conditions on this side. (Refer Map 26.)



Map 25: Temperature



Map 26: Runoff

Before the construction of the major impoundments (i.e. Gariep and Vanderkloof Dams, 1400km from the river mouth) the flow in LOR was known to stop. These low-flow or no-flow periods coincided with the dry periods in the catchment area and normally occurred during August and September. Since construction, the dams and river flow has been regulated with more constant flow throughout the year in order to ensure a high assurance of supply to users as far downstream as the estuary. Releases from the Vanderkloof Dam take approximately one month to reach the river mouth. In addition to modifying the low flow regime, the dams attenuate the medium sized floods and absorb the smaller floods. Future water demand from the Upper Orange River System will reduce the availability of water in the LOR even further (PWC, 2005a; PWC 2005g).

PWC, 2005d states that the runoff originating from the Orange River downstream of the Orange Vaal confluence is highly erratic and cannot be relied upon to support the various downstream demands. Further storage is thus required. A study undertaken and completed in 2005 by the Permanent Water Commission (a joint water resource management structure established by the Governments of Namibia and South Africa) resulted in the choice of a dam site a few kilometres upstream of Vioolsdrift/Noordoewer, with current planning seeing completion of the new impoundment by 2015.

The Orange River has become highly regulated by virtue of more than 20 major dams and numerous weirs within its catchment. Abstraction and regulation of the Orange River has resulted in changed flow patterns, from a pronounced seasonal flow (a 82:18 summer to winter flow) to a nearly even flow distribution (a 59:41 summer to winter flow) throughout the year (refer Figure 13).

The sustained release of water from the large dams even in winter (mainly for hydro-electricity generation and agriculture) means the elimination of water deficits in the lower reaches of the river and the mouth now remains open almost permanently. The sustained flows in winter prevent mouth closing and back-flooding which is regarded a crucial part of the ecological functioning of especially the saltmarsh at the ORM.

The various large impoundments notably the Gariep and Vanderkloof Dams in South Africa and the Naute and Hardap on the Fish River in Namibia, have also significantly reduced summer flood peaks in the LOR and ORM by as much as 50%. The flow regime of the Orange River and ORM will be further altered as the increase in water demands further inland are accommodated.

LOR is a largely managed system but for inputs from the uncontrolled tributaries such as the Fish River. From the schematic below (refer Figure 14), one can see that some demands are supplied directly from the Gariep and Vanderkloof Dams and some by means of releases into the river. For this set up, the inflows from the Vaal are not entering the Orange River at the Orange/Vaal confluence. This is to prevent the users along the Orange River to utilise these inflows. This is in line with the current operating procedure where inflows from the Vaal are not taken into account. The Vaal inflows are, however, available to supply the river evaporation along the river, as well as environmental requirements at Augrabies and the river mouth. Inflows from the Fish River (Namibia) are only utilised to supply the river mouth environmental requirements. If the Vaal inflows are not sufficient to meet the evaporation and environmental requirements, additional water is released from Vanderkloof Dam to ensure that these requirements are fully met.

Gariep and Vanderkloof Dams are the two largest reservoirs in South Africa and are used to supply all the water requirements along the Orange River from Gariep Dam to the ORM. These demands include all the irrigation, urban, mining, environmental requirements, river evaporation and operational losses. Large volumes of water are also transferred to other neighbouring catchments.

Except for the releases through the Orange-Fish tunnel and those into the Vanderkloof Canals, all the releases from Gariep and Vanderkloof Dams, to supply downstream users, are made directly into the Orange River. These river releases are also used to simultaneously generate hydropower. Any spills from the Vaal or Fish Rivers (Namibia) or any local runoff generated in the Lower Orange are not taken into account when releases are made from Vanderkloof Dam to supply the downstream users. It is, however, extremely difficult to compensate for Vaal, Fish or any other inflows into the Lower Orange by means of reduced releases from Vanderkloof Dam, as releases take approximately one month to reach the river mouth and the existing flow gauging structures in the Orange and Lower Vaal Rivers are inaccurate for the measuring of low flows (PWC.2005b).

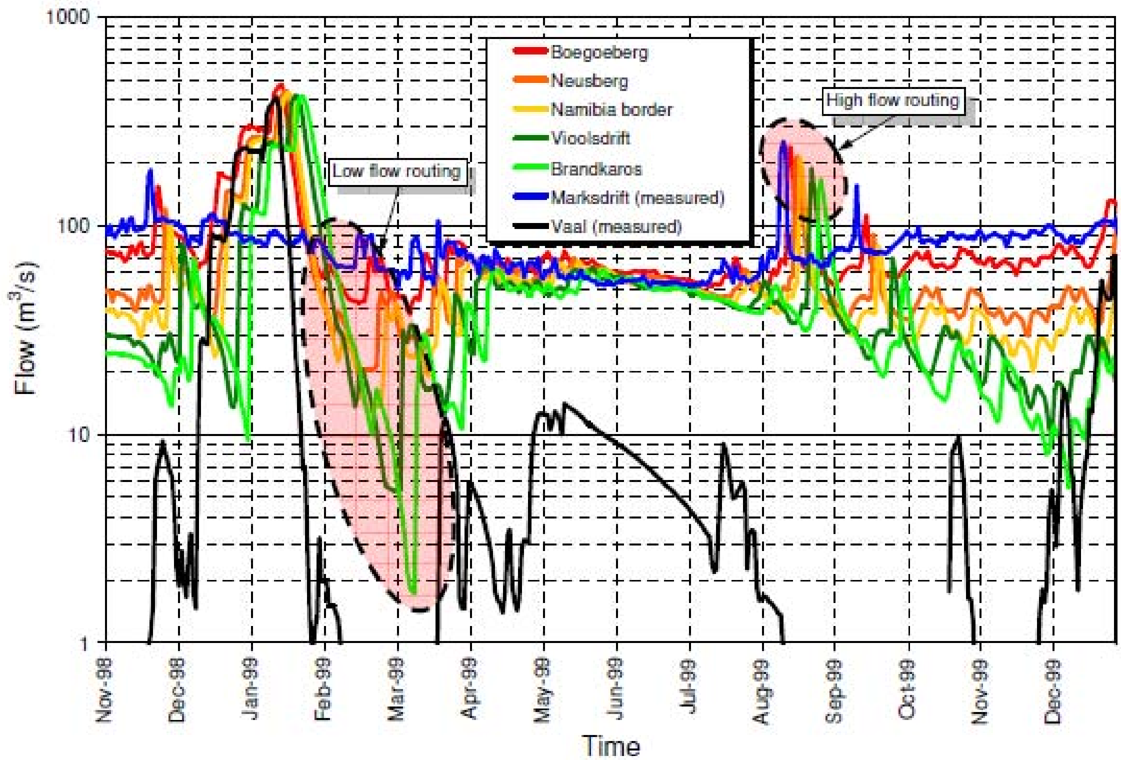


Figure 5.13: Time Lags During High and Low Flows

Figure 13: **Flow-Time Graph (Namibian Border, Vioolsdrift, Brandkaros - 1999)** (PWC, 2005b)

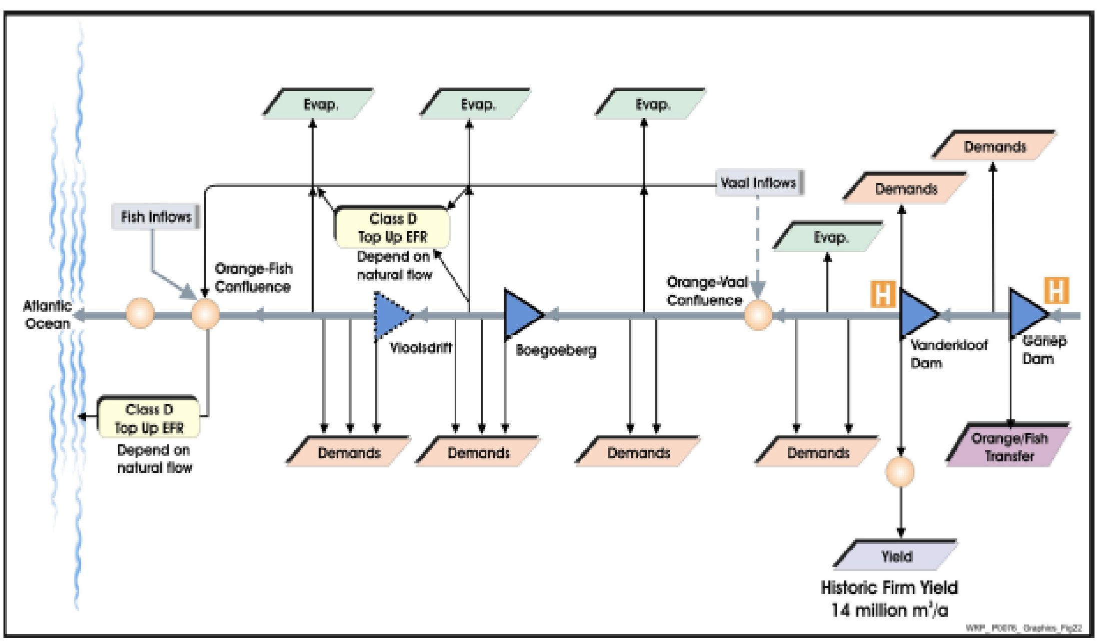


Figure 4.14: Historic Analyses Simplified System Schematic

Figure 14: **Simplified System Schematic** (PWC, 2005b)

2.1.8.2 *Water* Quality

The status of the water quality in the LOR was generally assessed to be 'moderately modified' in PWC, 2005b, however, the development of dams and impoundments on the Orange has resulted in a constant blackfly problem on the LOR as these dams promote eutrophication, the build up of suspended organic material which create ideal conditions for immature blackflies to increase, and changed the natural flow variation. The largest outbreaks usually occur during spring as the environmental conditions are not as harsh as experienced over summer months. During winter adult annoyance levels remains low. Although a blackfly control programme is in place along the LOR, however major outbreaks still occur (Myburgh, 2002).

The general water quality of the lower Orange River is fairly good, but the quality is deteriorating. The dissolved oxygen concentrations in the river is good (>70% saturation), the pH is relatively high (8.2), but acceptable and the general bacterial contamination is low (mean, E. coli <100 cfu/100 ml, acceptable for full-contact recreational use). The water turbidity is relatively low (clear water) and has decreased the past years because of a lower sediment load. The trace metal concentrations are low and pose apparently no threat to the biota in the river or to humans. Thus, the water quality is acceptable for agricultural, domestic, recreational, and industrial use.

However, the Dams have homogenized the flow regime in the river, thus the natural variability characteristics of the river have been greatly reduced. Because of fragmentation and flow regulation, the Orange River has been classified as strongly affected.

Major issues and concerns in the LOR are:

- *Increased loads of salts (salinity):* The average Total Dissolved Salts (TDS) in the lower Orange River is relatively low (270mg/ℓ), but is increasing with time (~4mg/ℓ/a) and space (downstream). These increases are mainly ascribed to irrigation return flows, poor quality from tributaries (e.g. Vaal River) and reduced flows. Special concern is between Boegoeberg Dam and Kakamas, which regularly exceeds 500mg TDS/ℓ. Impact on sustainability of agriculture is a concern. Salinisation of irrigated soil could lead to greater salt loads to the river, ultimately to the point where quality may be impaired and the uses of the water restricted.
- *Eutrophication (nutrient over-enrichment):* The nutrient concentrations (N & P) in the Orange River are relatively low, however, serious algal blooms have occurred in the lower Orange since 2000. Algal blooms are associated with low flows and clear water conditions. Cyanobacteria (blue-green algae) species (potential toxic) have also occurred in the central and Lower Orange River that poses a threat to water users.
- *Reduced flow:* Hydrology plays an important role, not only in the chemistry, but also in the biology, of the Orange River water. Mean annual discharge in the lower Orange River has been reduced by around 62% as a result of irrigation abstractions and reduced flow from the Vaal River. The average flow rate at Vioolsdrift is currently approximately $160m^3/s$.

The reduced flow and artificial flow regime have negative impacts upon the water quality and biota in the ecosystem in general; it enhances salinity and eutrophication (less dilution); increase residence times that promote opportunities for algal growth and water-bloom formation, contribute to the outbreak of pest blackflies – from Hopetown to Sendelingsdrift, reed encroachment of the channel (in the middle reaches) and the formation of sandbars in the river mouth.

In the long-term, increased pressures are expected from population increases and development in the Orange River catchment, through aspects such as allocation of additional irrigation water, will increase the pollution levels, which will probably necessitate additional measures and strategies to maintain acceptable water quality in the river.

Monitoring of system change is crucial, but more importantly the system must be audited against the resource water quality objectives, to ensure that the goals of management are met and the system is maintained in the desired state (Roos, Pers Comm, 2008).