AQUATIC PES ASSESSMENT OF THE AQUATIC RESOURCES ON THE ORANGE RIVER IN THE VICINITY OF A PROPOSED POWER LINE CROSSING

Prepared for:

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Executive Summary

Scientific Aquatic Services (SAS) was requested to undertake a riverine PES assessment as part of the project planning for the proposed development of a power line crossing on the Orange River. The subject property is situated in the Northern Cape Province towards the southwest side of the town of Upington.

The riverine PES assessment was confined to the area in the immediate vicinity of the crossing and did not include the surrounding properties.

Based on the findings of this assessment several conclusions can be drawn on the Ecological Importance and Sensitivity and Present Ecological State of the system. Conclusions were drawn on the sensitivity of each proposed crossing alternative and the suitability of each crossing alternative for the construction of the crossing.

The study then identified nine potential impacts that the construction of the proposed power line crossing will have on the receiving aquatic environment. The report then highlighted the key mitigation measures deemed necessary in order to prevent and mitigate impacts on the receiving aquatic environment.

The Orange River is considered to be a tolerant system that is adapted to constantly changing substrate and bankside conditions as well as constant variation in flow. The system is also tolerant to changes in water quality with special mention of temperatures, dissolved salt and turbidity levels as water constituents change through the system.

The aquatic communities of the system are however intact with more sensitive aquatic macro-invertebrate and fish populations still present and as such as much as the system is considered to be tolerant, it must also be considered to be sensitive to impacts that occur on the system.

It is therefore deemed essential that any proposed activities which could affect the system be comprehensively assessed to define and understand the impacts and in order to ensure that suitable and sufficient mitigation measures are put in place to protect the system throughout the life of the project and associated infrastructure.

Based on the consideration of habitat integrity and the characteristics of the crossing points with special mention of riverine structure and stream braiding, riparian zone integrity and instream habitat, two suitable crossing point alternatives were identified and three sites were identified which were considered less suitable as crossing points as follows:

- Crossing alternative 1: highly suitable for proposed crossing
- Crossing alternative 2: not suitable as a crossing point
- Crossing alternative 3: moderately suitable as a crossing point however the crossing should take place to the west of the existing road bridge
- Crossing alternative 4: suitable as a crossing point provided that care is taken with tower placement to prevent impacts on riparian vegetation
- Crossing alternative 5: suitable as a crossing point provided that care is taken with tower placement to prevent impacts on riparian vegetation

Based on the impact assessment it is evident that there are nine possible impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the proposed Orange River Power line crossing. From the impact analyses it is evident that prior to mitigation, most of the impacts are low to medium high level impacts, while if mitigation takes place the majority of the impacts can be reduced to very low level impacts while the impacts on form alien vegetation encroachment and increased turbidity can be reduced to low levels.

The report highlights key management and mitigation measures in order to prevent and minimise impacts on the receiving aquatic environment.

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1 Introduction & Terms of Reference

Scientific Aquatic Services (SAS) was appointed by Jones and Wagener Consulting Civil Engineers to to undertake a riverine PES assessment as part of the environmental assessment and authorisation process and project planning for the proposed development of a power line crossing on the Orange River between Keimoes and Upington. A core component of the study was to identify the most suitable crossing points based on the assessment of five proposed crossing alternative corridors, from an aquatic and riparian ecological perspective. The subject property is situated in the Northern Cape Province towards the southwest side of the town of Upington.

The proposed development activity would entail the following activities:

- site preparation and clearing of the servitude;
- construction of the power line crossing with special mention of support towers;
- rehabilitation activities in the vicinity of the crossing and areas affected by construction; and
- maintenance during the operational phase of the development.

The riverine PES assessment was confined to the area in the immediate vicinity of the crossing alternatives on the Orange River and did not include the surrounding properties.

The purpose of the aquatic ecological assessment was to determine the Ecological Importance and Sensitivity (EIS) and the Present Ecological Sate (PES) as well as risks to the receiving environment associated with the proposed project. The study area is located within the Nama Karoo aquatic ecoregion (quaternary catchment D73F). This report serves to document the condition at the time of sampling to indicate the state of the riverine ecological integrity in early spring, at a time when low flows were being experienced.

The following was considered in the selection of suitable sites for assessing the level of aquatic ecological integrity on the Orange River:

- The site location in relation to the existing infrastructure and activities in the area;
- The site location was assessed as close as possible to the middle of each crossing corridor alternative in order to be as representative as possible of each crossing alternative;
- Consideration was given to the position of the proposed development site in order to assist in defining the Present Ecological State and any impacts in this area;

- Accessibility with a vehicle in order to allow for the transport of assessors and equipment;
- Sites were selected where there were good habitat conditions with a good level of diversity, suitable for supporting a diverse aquatic community.

The five assessment points within each crossing corridor are presented in the table below as well as the figure below.

Table 1: Geographic information pertaining to the assessment site

Site	Description	GPS co-ordinates	
		South	**East**
CO1	Downstream point in the Orange River.	S28°46'10.41"	E20°42'15.57"
CO2	Representative of the Orange River.	S28°45'31.62"	E20°48'56.03"
CO3	Aquatic biomonitoring site.	S28°42'51.97"	E20°59'20.67"
CO4	Representative of the Orange River.	S28°35'47.32"	E20°59'20.67"
CO5	Upstream point below Upington.	S28°30'32.79"	E20°11'12.32"

Figure 1: Aerial photograph depicting the biomonitoring site selected in the vicinity of the study area.

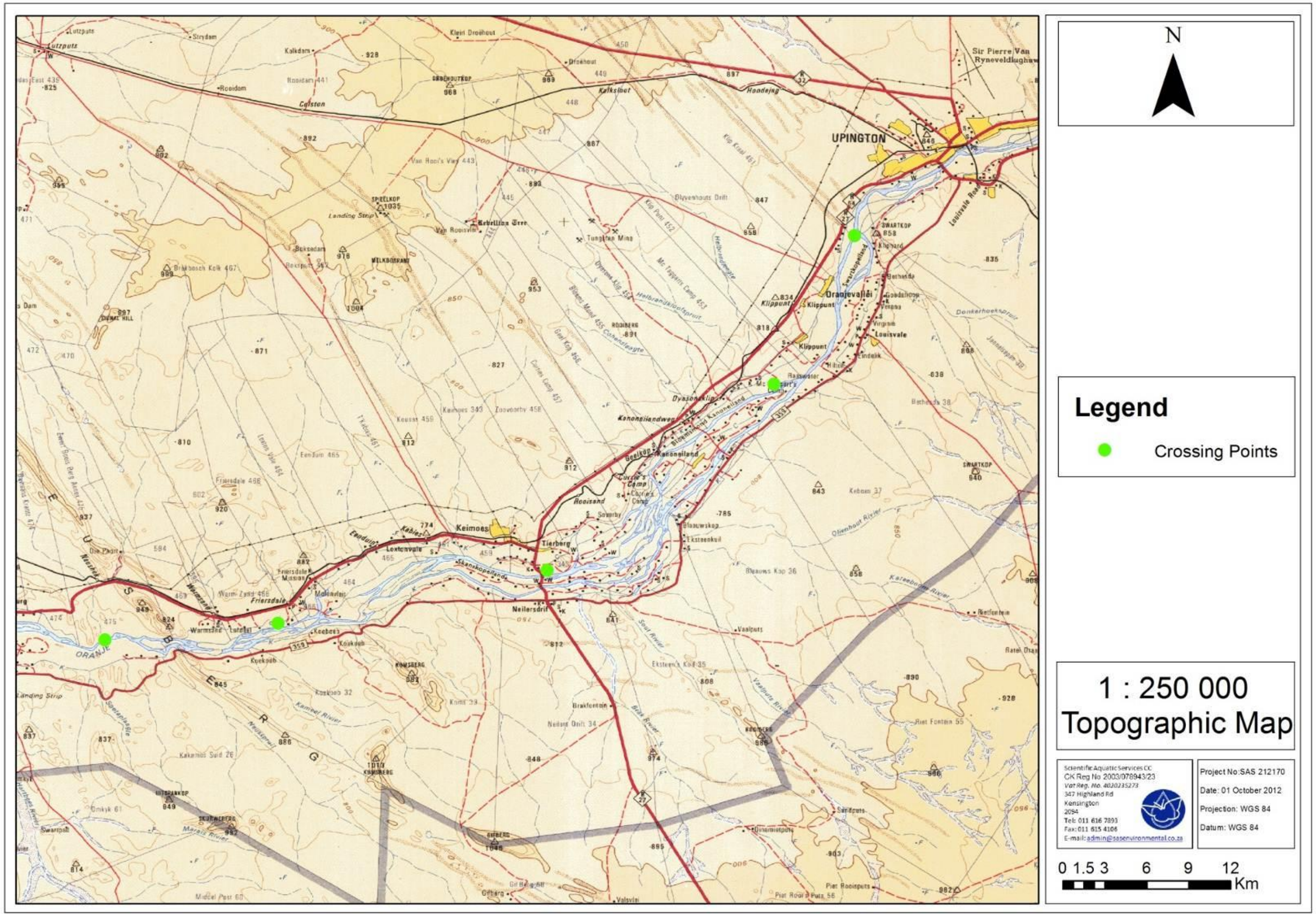

Figure 2: Crossing points presented on a 1:50 000 topographic map.

2. Scope of Work

2.1 Aims

Specific outcomes required from this report include the following:

- define the Present Ecological State of the aquatic and riparian zone resources in the study area;
- define the habitat and riparian zone conditions of the Orange River in the vicinity of the five crossing alternative corridors;
- determine most suitable crossing alternative over the Orange River;
- define the impacts associated with the proposed development;
- document the mitigatory measures deemed necessary to minimise the impact on the Orange River as a result of the proposed development

2.2 Assumptions and limitations

The following points serve to indicate the assumptions and limitations of this study.

- ***Reference conditions are unknown:*** The composition of aquatic biota in the study area prior to disturbance is unknown. For this reason, reference conditions are hypothetical, and are based on professional judgement and/or inferred from data available.
- ***Temporal variability:*** The data presented in this report are based on a single site visit, undertaken in spring (19 September 2012). The effects of natural seasonal and long-term variation in the ecological conditions and aquatic biota found in the streams are therefore unknown except for data available from desktop sources for some aspects of the aquatic ecology.
- ***Ecological assessment timing:*** *A*quatic and terrestrial ecosystems are dynamic and complex; it is likely that aspects, some of which may be important, could have been overlooked. A more reliable assessment of the biota would require seasonal sampling with sampling being undertaken under both low flow and high flow conditions.
- **Access and proximity:** The ecological assessment is confined to representative points within each crossing corridor and does not include an assessment of the system upstream and downstream of the corridor areas and therefore some aspects, some of which may be important, could have been overlooked.

3. Aquatic Ecological Description

3.1 Ecoregions

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the study area is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment to guide the assessment.

The study area falls within the Nama Karoo aquatic Ecoregion, which can be considered to contain a relatively high level of aquatic biodiversity and a relatively sensitive aquatic community. The study area falls within the D73F quaternary catchment. Refer to Figure 2.

3.2 Ecostatus

Water resources are generally classified according to the degree of modification or level of impairment. The classes used by the South African River Health Program (RHP) are presented in the table below and will be used as the basis of classification of the systems in this field and desktop study, as well as the field studies.

Table 2: Classification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural.
B	Largely natural, with few modifications.
C	Moderately modified.
D	Largely modified.
E	Extensively modified.
F	Critically modified.

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC), were defined and serve as useful guidelines in determining the importance and sensitivity of aquatic ecosystems, prior to assessment, or as part of a desktop assessment.

This database was searched for the quaternary catchment of concern (C21C) in order to define the EIS, PEMC and DEMC. The findings are based on a study undertaken by Kleynhans (1999) as part of "A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers". The results of the assessment are summarised in the table below.

Table 3: Summary of the ecological status of quaternary catchment D73F based on Kleynhans 1999

Catchment	Resource	EIS	PEMC	DEMC
D73F	Orange River	High	CLASS B (Class C based on desktop certainty)	Class B: Sensitive systems

The points below summarise the impacts on the aquatic resources in this quaternary catchment:

- The aquatic resources within this quaternary catchment have been highly affected by bed modification due to sedimentation and the Neusberg weir in the catchment (immediately upstream of Crossing alternative 5).
- Significant flow modifications have taken place due to the effects of water abstraction and urban runoff from surrounding farming practices.
- High impacts have occurred as a result of introduced in-stream biota with special mention of the fish *Cyprinus carpio*.
- Impact due to inundation from the Neusberg weir (immediately upstream of Crossing alternative 5) is high.
- Riparian zones and stream bank conditions are considered to be moderately impacted due to alien vegetation encroachment.
- An impact on the aquatic community, due to altered water quality, is deemed to affect the catchment to a moderate degree due to the effects of general urban and rural runoff as well as agricultural effluent discharge.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- The riverine systems in this catchment have a high diversity of habitat types, limiting the ecological sensitivity and importance of the resources in the area however pools runs sponge areas occur in the area and increase the biodiversity of the system.
- The site has a low importance in terms of conservation due to the proximity to the Neusberg weir (immediately upstream of Crossing alternative 5).
- The riverine resources have a low sensitivity to flow requirements.

- The area has a high importance in terms of migration of avifaunal species.
- The area is of high importance in terms of rare and endemic species conservation with special mention of the fish species *Labeobarbus kimberleyensis* and *Simulium gariepensis* a black fly species.
- The ecology of the area is considered to be moderately sensitive to changes in water quality.
- The area has a moderate importance as a source of refugia for aquatic species.
- The catchment has a moderate importance in terms of species richness in the area.
- The system is moderately important in terms of unique and endemic taxa conservation.

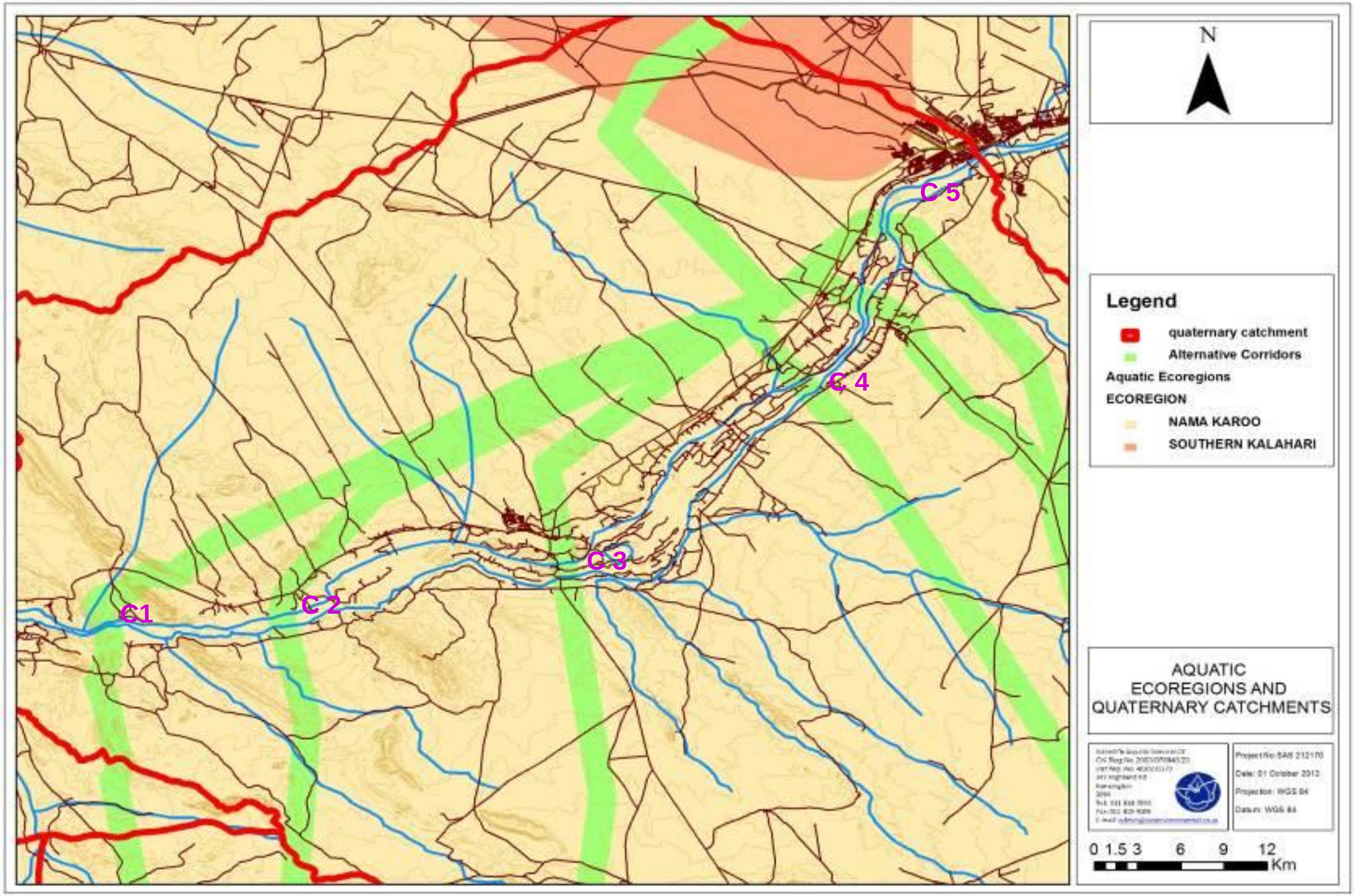

Figure 3: A map of the ecoregions of the area.

3.3 Riparian Zone Ecology

Each crossing point was evaluated and the riparian vegetation condition was established. A "walk-about" was undertaken to assess the species composition, community structures and the degree of exotic vegetation encroachment for each site during a field assessment in September 2012. The species composition was then compared to the *Lower Gariep Alluvial Vegetation* (Mucina & Rutherford, 2006) vegetation type in which the proposed crossings of the Orange River will occur. By comparing current vegetation composition to this baseline information will give an indication of the ecological integrity and level of transformation of the riparian zone.

Lower Gariep Alluvial Vegetation occurs in the Northern Cape Province. More specifically the vegetation is associated with broad alluvium (floodplains and islands) of the Orange (Gariep) River between Groblershoop and the mouth into the Atlantic Ocean at Oranjemund (Namibia). This river stretch is embedded within Desert vegetation types (Oranjemund to roughly Pofadder) and Nama-Karoo vegetation (further upstream as far as Groblershoop). Altitude ranging from
0-1 000m.

The vegetation type occurs on flat alluvial terraces and riverine islands supporting a complex of riparian thickets (dominated by *Ziziphus mucronata, Euclea pseadebenus* and *Tamarix usneoides*), reed beds with *Phragmites australis* as well as flooded grasslands and herb-lands populating sand banks and terraces within and along the river.

The vegetation type is considered endangered. A Target of 31% for conservation of the vegetation type has been defined. Only about 6% statutorily conserved in the Richtersveld and Augrabies Fall National Parks. Some 50% transformed for agricultural purposes (vegetables and grapes) or alluvial diamond mining. *Prosopis* species, *Nicotiana glauca* and *Argemone ochroleuca* are known to invade the alluvia in places.

The following species are dominant within the vegetation type:
Riparian thickets Small trees: *Acacia karoo* (d), *Euclea pseudebenus* (d), *Salix mucronata* subsp. *mucronata* (d), *Schotia afra* var. *angustifolia* (d), *Ziziphus mucronata* (d), *Acacia erioloba, Combretum erythrophyllum, Ficus cordata, Maerua gilgii, Prosopis glandulosa* var. *grandulosa, Rhus lancea.* Tall Shrubs: *Gymnosporia linearis* (d), *Tamarix usneoides* (d), *Ehretia rigida, Euclea undulate, Sisyndite spartea.* Low Shrub: *Asparagus laricinus.* Woody Climber: *Asparagus retrofractus.* Succulent Shrub: *Lycium bosciifolium.* Herb: *Chenopodium olukondae.*

Reed beds Megagraminoid: *Phragmites australis* (d).

Flooded grasslands & herblands Low Shrubs: *Tetragonia schenckii* (d), *Litogryne gariepina.* Graminoids: *Cynodon dactylon* (d), *Setaria verticillata* (d), *Cenchrus cilliaris, Cyperus laevigatus, Eragrostis echinochloidea, Leucophrys mesocoma, Polypogon monspeliensis, Stipagrostis namaquensis.* Herbs: *Amaranthus praetermissus, Coronopus integrifolius, Frankenia pulverulenta, Gnaphalium confine, Pseadognaphalium luteo-album.*

4 Methods of Investigation

4.1 Visual Assessment

The site was investigated in order to identify visible impacts on the site with specific reference to impacts from surrounding activities. Both natural constraints placed on ecosystem structure and function as well as anthropogenic alterations to the system was assessed by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site-specific visual assessments included the following:

- instream and riparian habitat diversity;
- stream continuity;
- erosion potential;
- depth flow and substrate characteristics;
- signs of physical disturbance of the area;
- other life forms reliant on aquatic ecosystems;
- signs of impact related to water quality;
- Consideration of suitability for stream crossing purposes.

4.2 Biota Specific Water Quality

On-site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity, dissolved oxygen concentration and temperature. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems (DWAF 1996 vol. 7).

4.3 Instream Habitat Integrity

It is important to assess the habitat of the site, in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration. The general habitat integrity of the site should be discussed based on the application of the Intermediate Habitat Integrity Assessment for (Kemper; 1999). The Intermediate Habitat Integrity Assessment (IHIA) protocol, as described by Kemper (1999), should be used for site specific assessments. This is a simplified procedure, which is based on the Habitat Integrity approach developed by Kleynhans (1996). The IHIA is conducted as a first level exercise, where a comprehensive exercise is not practical. The Habitat Integrity of each site should be scored according to 12 different criteria which represent the most important (and easily quantifiable) anthropogenically induced possible impacts on the system. The instream and riparian zones should be analyzed separately, and the final assessment should be made separately for each, in accordance with Kleynhans' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone are, however, primarily interpreted in terms of the potential impact on the instream component. The assessment of the severity of impact of modifications is based on six descriptive categories with ratings. Analysis of the data should be carried out by weighting each of the criteria according to Kemper (1999). By calculating the mean of the instream and riparian Habitat Integrity scores, an overall Habitat Integrity score can be obtained for each site. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitats of the site. The method classifies Habitat Integrity into one of six classes, ranging from unmodified/natural (Class A), to critically modified (Class F).

Table 4: Classification of Present State Classes in terms of Habitat Integrity [Based on Kemper 1999]

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications. A small change in natural habitats and biota may have taken place but the basic ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Extensively modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.	<20

4.4 Habitat Suitability

The Invertebrate Habitat Assessment System (IHAS) was applied according to the protocol of McMillan (1998) to the Orange River in general with one assessment site being selected to be representative of the entire system. This index was used to determine specific habitat suitability for aquatic macro-invertebrates as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. Scores for the IHAS index were interpreted according to the guidelines of McMillan (1998) as follows:

- <65% inadequate for supporting a diverse aquatic macro-invertebrate community
- 65%-75% adequate for supporting a diverse aquatic macro-invertebrate community
- >75% highly suited for supporting a diverse aquatic macro-invertebrate community

4.5 Aquatic Macro-Invertebrates

Aquatic macro-invertebrate communities of the selected sites were investigated according to the method, which is specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter.

The assessment was undertaken according to the protocol as defined by Dickens & Graham (2001). All work was undertaken by an accredited SASS5 practitioner.

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et.al*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5 score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score in conjunction with a low habitat score can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score together with a high habitat score would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

The perceived reference state for the local streams was determined as a SASS5 score of 118 and an ASPT of 6.0 based on general conditions of streams in the Nama Karoo ecoregion and based on local habitat and flow conditions. Interpretation of the results in relation to the reference scores was made according to the classification of SASS5 scores presented in the SASS5 methodology published Dickens & Graham (2001) as well as Dallas 2007.

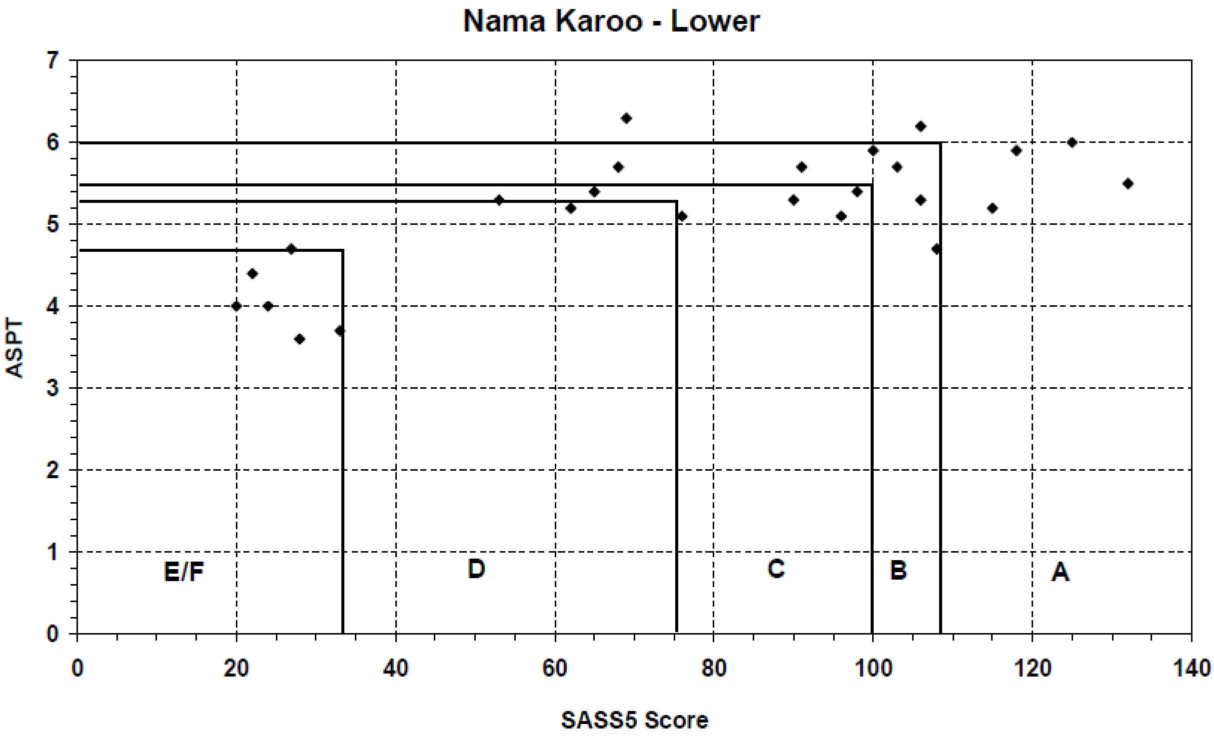

Figure 4: SASS5 Classification using biological bands calculated form percentiles for the Nama Karoo ecoregion, Dallas, 2007

Table 5: Definition of Present State Classes in terms of SASS scores as presented in Dickens & Graham (2001)

Class	Description	SASS Score%	ASPT Score %
A	Unimpaired. High diversity of taxa with numerous sensitive taxa.	90-100 80-89	Variable >90
B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.	80-89 70-79 70-89	<75 >90 76-90
C	Moderately impaired. Moderate diversity of taxa.	60-79 50-59 50-79	<60 >75 60-75
D	Largely impaired. Mostly tolerant taxa present.	50 – 59 40-49	<60 Variable
E	Severely impaired. Only tolerant taxa present.	20-39	Variable
F	Critically impaired. Very few tolerant taxa present.	0-19	Variable

4.6 Fish community Integrity

Whereas macro-invertebrate communities are good indicators of localized conditions in a river over the short-term, fish being relatively long-lived and mobile;

- are good indicators of long-term influences;
- are good indicators of general habitat conditions;
- integrate effects of lower trophic levels and
- are consumed by humans (Uys et al., 1996).

The Fish Assemblage Integrity Index (FAII) was applied according to the protocol of Kleynhans (1999). Fish species identified were compared to those expected to be present at the site, which were compiled from a literature survey including Skelton 2007. Fish samples were collected by means of a fixed generator driven electro-fishing device.

Table 6: Definition of Present State Classes in terms of FAII scores according to the protocol of Kleynhans (1999)

CLASS	DESCRIPTION	RELATIVE FAII SCORE (% OF EXPECTED)
A	Unmodified, or approximates natural conditions closely.	90-100
B	Largely natural, with few modifications.	80-89
C	Moderately modified. A lower than expected species richness and the presence of most intolerant species.	60-79
D	Largely modified. A clearly lower than expected species richness and absence of intolerant and moderately tolerant species	40-59
E	Seriously modified. A strikingly lower than expected species richness and a general absence of intolerant and moderately intolerant species	20-39
F	Critically modified. An extremely lowered species richness and an absence of intolerant and moderately intolerant species	<20

SPECIES NAME	COMMON NAME	INTOLERANCE RATING	COMMENTS
Austroglanis sclateri	Rock catfish	2.7	Rare, endemic to the Orange-Vaal system
Barbus paludinosus	Straightfin barb	1.8	Widespread
Barbus anoplus	Chubbyhead barb	2.6	Widespread
Labeobarbus aeneus	Smallmouth yellowfish	2.5	Widespread in the Orange-Vaal system
Labeobarbus kimberleyensis	Largemouth yellowfish	2.5	Widespread in the Orange-Vaal system but is becoming scarce
Labeo capensis	Orange river mud fish	3.2	Widespread in the Orange-Vaal system
Labeo umbratus	Moggel	2.3	Widespread in the Orange-Vaal system
Pseudocrenilabrus philander	Southern mouthbrooder	1.3	Widely distributed in southern Africa
Tilapia Sparrmanii	Banded tilapia	1.3	Widely distributed in southern Africa
Clarias gariepinus	Sharptooth catfish	1.2	Most widely distributed fish in Africa.
Cyprinus carpio	Carp	1.4	Widespread alien species
Micropterus salmoides	Largemouth bass	2.2	Widespread alien species
Gambussia affinis	Mosquito fish	2	Widespread

Tolerant: 1-2 moderately tolerant :> 2-3 Moderately Intolerant: >3-4 Intolerant: >4

For the purposes of applying the FAII, species which were considered unlikely to occur at the site due to habitat and cover conditions, flow conditions and due to historic impacts, were excluded from the reference list of fish species for the site.

4.7 Riparian Vegetation assessment

A desktop study was undertaken for the study area to determine historic distributions and vegetation type and structure of the riparian area in the vicinity of the proposed crossings. This gave an indication as to what would be expected to occur on each site and, therefore, offer possible explanations for any anomalies that could potentially occur.

The riparian vegetation assessment was conducted according to the procedure described by Kemper, 2001. The selected sites should be chosen to be relevant to the proposed development and to show any impacts that the licensed activity may be having downstream. The site assessment was conducted over a distance of 100m on both banks, in order to assess species composition and community structures and include an assessment with respect to the degree of exotic vegetation encroachment, dominance by recruitment and by biomass.

Table 7: Definition of present state classes in terms or RVI-scores, according to the protocol of Kemper (2000).

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications. A small change in natural habitats and biota may have taken place but the basic ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Extensively modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.	<20

4.8 Crossing assessment

The table below presents the characteristics of an ecologically "ideal crossing over a water course or River. Each crossing alternative was assessed with these characteristic's in mind.

Table 8: Characteristics of an ecologically "ideal" river crossing site,

Condition	Reason
Rocky or bedrock substrate	A rocky or bedrock substrate is more likely to withstand impacts and lead to fewer changes in bed characteristics compared to a substrate that may be easily compacted, such as gravel, sand or mud.
Steep river gradient	In stream habitats are likely to recover more rapidly from the impacts where the river gradient is steep and current speeds fast compared to a section of river where there is little or no flow, and where sediments may remain for long periods. A steep river gradient is likely to flush away finer sediments, and sort larger particles.
Stable banks	Stable banks reduce the potential for erosion.
Disturbed banks and riparian zone	The relative impacts of a crossing are likely to be less if the banks and riparian zone are already disturbed. Choosing an area that is already disturbed also improves the potential for rehabilitation.
Width of riparian zone	The wider the riparian and wet zone at the crossing site the more substantial the impact will be on stream continuity, riparian zone continuity and seepage patterns and the more rehabilitation work will be required.
Limited habitat diversity	The impacts of a crossing are likely to be less if the riparian and instream habitat diversity both at, and downstream of, the crossing site is limited.
Flow	The impacts of a crossing on stream flows are likely to increase with the size of the river or stream being crossed, as a large stream is more likely to come down in spate than a small stream. The downstream topography and stream gradient is also likely to affect the extent to which a crossing disrupts stream flows which is potentially greater on larger river sand channels.
Downstream ecological sensitivity should be minimal	A crossing is likely to lead to disturbance downstream, particularly sedimentation. Ecologically important or sensitive areas, such as gravel bed nursery areas, should therefore rather be situated upstream of the crossing, or as far downstream as possible.

4.9 Impact Assessment

In order for the EAP to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.

The first stage of risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that are possessed by an organisation.
- An **environmental aspect** is an 'element of an organizations activities, products and services which can interact with the environment'[1]. The interaction of an aspect with the environment may result in an impact.
- **Environmental risks/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or well being, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems.
- **Resources** include components of the biophysical environment.
- **Frequency of activity** refers to how often the proposed activity will take place.
- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor.

[1] The definition has been aligned with that used in the ISO 14001 Standard.

- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- **Spatial extent** refers to the geographical scale of the impact.
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the table below. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix and are used to determine whether mitigation is necessary[2].

The assessment of significance is undertaken twice. Initial, significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

Table 9: Criteria for assessing significance of impacts

LIKELIHOOD DESCRIPTORS

Probability of impact	**RATING**
Highly unlikely	1
Possible	2
Likely	3

[2] Some risks/impacts that have low significance will however still require mitigation

Highly likely	4
Definite	5
Sensitivity of receiving environment	**RATING**
Ecology not sensitive/important	1
Ecology with limited sensitivity/importance	2
Ecology moderately sensitive/ /important	3
Ecology highly sensitive /important	4
Ecology critically sensitive /important	5

CONSEQUENCE DESCRIPTORS

Severity of impact	**RATING**
Insignificant / ecosystem structure and function unchanged	1
Small / ecosystem structure and function largely unchanged	2
Significant / ecosystem structure and function moderately altered	3
Great / harmful/ ecosystem structure and function Largely altered	4
Disastrous / ecosystem structure and function seriously to critically altered	5
Spatial scope of impact	**RATING**
Activity specific/ < 5 ha impacted / Linear features affected < 100m	1
Development specific/ within the site boundary / < 100ha impacted / Linear features affected < 1000m	2
Local area/ within 1 km of the site boundary / < 2000ha impacted / Linear features affected < 3000m	3
Regional within 5 km of the site boundary / < 5000ha impacted / Linear features affected < 10 000m	4
Entire habitat unit / Entire system/ > 5000ha impacted / Linear features affected > 10 000m	5
Duration of impact	**RATING**
One day to one month	1
One month to one year	2
One year to five years	3
Life of operation or less than 20 years	4
Permanent	5

Table 10: Significance rating matrix

LIKELIHOOD (Frequency of activity + Frequency of impact)	CONSEQUENCE (Severity + Spatial Scope + Duration)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 11: Positive/Negative Mitigation Ratings

Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
Very high	126-150	Improve current management	Maintain current management

High	101-125	Improve current management	Maintain current management
Medium-high	76-100	Improve current management	Maintain current management
Medium-low	51-75	Maintain current management	Improve current management
Low	26-50	Maintain current management	Improve current management
Very low	1-25	Maintain current management	Improve current management

The following points were considered when undertaking the assessment:

- Risks and impacts were analysed in the context of the *project's area of influence* encompassing:
  - Primary project site and related facilities that the client and its contractors develops or controls;
  - Areas potentially impacted by cumulative impacts for further planned development of the project, any existing project or condition and other project-related developments; and
  - Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.
- Risks/Impacts were assessed for all stages of the project cycle including:
  - Construction;
  - Operation; and
  - Rehabilitation.
- If applicable, transboundary or global effects were assessed;
- Individuals or groups who may be differentially or disproportionately affected by the project because of their *disadvantaged* or *vulnerable* status were assessed.
- Particular attention was paid to describing any residual impacts that will occur after rehabilitation.

4.9.1 Mitigation measure development

The following points present the key concepts considered in the development of mitigation measures for the proposed development.

- *Mitigation* and *performance improvement measures* and actions that address the risks and impacts[3] are identified and described in as much detail as possible.
- Measures and actions to address negative impacts will favour avoidance and prevention over minimization, mitigation or compensation.

[3] Mitigation measures should address both positive and negative impacts

- Desired outcomes are defined, and have been developed in such a way as to be *measurable events with performance indicators, targets and acceptable criteria* that can be tracked over *defined periods*, with estimates of the *resources* (including human resource and training requirements) *and responsibilities for implementation*.

5 Results

5.1 General Ecology of the Orange River

5.1.1 Physico-Chemical Water Quality

The table below records the biota specific water quality of the assessment site.

Table 12: Biota specific water quality data along the main drainage feature.

SITE	COND mS/m	D.O. mg/l	pH	TEMP ^{o}C
U/S	34.2	8.78	8.41	21.4
D/S	39.8	8.12	8.34	21.7

- General water quality can be considered fair although some variation from the expected natural condition is deemed likely;
- The impact on water quality is deemed likely to come from both industrial and urban activities as far upstream as Mpumalanga and Gauteng as well as impacts form agricultural runoff into the Vaal River, a major tributary of the Orange River and the Orange River itself;
- Dissolved salts present in the system are slightly elevated from the natural conditions but is not expected to impact on the aquatic community by too significantly in terms of osmotic stress.
- Between the upstream and downstream site, conductivity increases by 16.4% which exceeds the DWAF Target Water Quality Range (DWAF TWQR). This suggests that between the sites there is an input of salts, most likely from erosion and agricultural runoff entering the system.
- The pH is slightly alkaline but can be regarded as suitable for supporting a diverse and sensitive aquatic community. The difference in pH between the sites are negligible and falls within the DWAF TWQR for aquatic communities.
- The dissolved oxygen concentration is relatively good and can be regarded as suitable for supporting a diverse and sensitive aquatic community.
- Dissolved oxygen concentrations decrease downstream by 7.5%, this still falls within the DWAF TWQR limit. The dissolved oxygen concentrations can be regarded as suitable for supporting a diverse and sensitive aquatic community.

- Temperature can be regarded as normal for the time of year and time of assessment. The variation between the upstream and downstream sites can largely be ascribed to natural diurnal variation.

The Orange River can be best described as a strongly flowing river with high flow volumes. Significant variation in flow between the high and low flow seasons is also characteristic of the system. The river structure alternates between pools and glides with slow laminar flow and fast flowing turbulent rapids. Overall there is a wide diversity of instream habitats in the system which allows for a diversity of instream taxa to be supported including mammals such as otters (*Aonyx capensis*) reptiles (*Viranus niloticus*) as well as fish, aquatic macro-invertebrates and riparian vegetation. Some habitat for aquatic vegetation and frogs is also present although the species diversity of these groups is limited.

The riverine habitat on the Orange River has seen some disturbance as a result of agricultural development. In this regard specific mention is made of agricultural activities within the floodplain and the associated construction of levees along the active river channels.

- From the results of the application of the IHIA to the crossing alternative sites, it is evident that there are several large impacts on the habitat of the area.
- Instream impacts at the site included significant impacts in places from flow and bed modifications. Smaller impacts from water quality and channel modification were also noted.
- The largest riparian zone impacts included flow bank erosion, alien vegetation encroachment and vegetation removal. Smaller impacts from flow modification and channel modification on riparian vegetation structures were observed.

The table below is a summary of the results obtained from the application of the IHAS Index to the assessment site in the study area used as a representative site for the Orange River in the vicinity of the proposed project. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in interpretation of the SASS5 results.

Table 13: A summary of the results obtained from the application of the IHAS index to the assessment site.

SITE	**CO3**
IHAS score	70%

SITE	CO3
IHAS Adjustment score (illustrative purposes only)	+13
McMillan, 1998 IHAS description	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community.
Stones habitat characteristics	Good habitat was present at this site providing habitat for suitably adapted macro-invertebrate families.
Vegetation habitat characteristics	Marginal vegetation was present both in and out of current and had a fair amount of leafy material present to provide habitat and cover for suitably adapted macro-invertebrate families.
Other habitat characteristics	There was an abundance of gravel and sand deposits present in the area providing good habitat for suitably adapted macro-invertebrate families.
IHAS general stream characteristics	The river at this point is wide and on average deep although, there is good diversity in depth and flow at the site. The surrounding vegetation consists mainly of reeds and grasses and the dominant activity in the area is agriculture. Some discoloration of the water in the system has occurred.

- Habitat diversity and structure was considered adequate for supporting a diverse aquatic macro-invertebrate community and as such a fairly diverse and sensitive aquatic macro-invertebrate community can be expected provided that water quality impacts do not severely affect the system.

5.1.3 Aquatic Macro-invertebrates

The results of the aquatic macro-invertebrate assessment according to the SASS5 index are summarised in the tables below for a site assessed which was determined to be representative of the system in the vicinity of the proposed crossing alternatives. Table 14 indicates the results obtained at the site per biotope sampled. Table 15 summarises the findings of the SASS assessment based on the analyses of the data for the site, as well as interpretation of the data for the site.

Table 14: Biotope specific summary of the results obtained from the application of the SASS5 index to the CO3 site.

PARAMETER	SITE	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 Score	CO3	12	34	60	77
Taxa		1	5	9	12
ASPT		12.0	6.8	6.7	6.4

Table 15: A summary of the results obtained from the application of the SASS5 and IHAS indices to the site.

Type of Result	CO3
Biotopes sampled	Stones in current, marginal vegetation out of current, mud, sand and gravel.
Sensitive taxa present	*Atyidae; Heptageniidae; Leptophlebiidae;Tricorythidae*
Sensitive taxa absent	*Aeshnidae Chlorolestidae; Perlidae; Psephenidae; Athericidae; Naucoridae; Chlorocyphidae; Hydracarina; Gomphidae*
Adjusted SASS5 score	+13
SASS5 % of reference score	65.3%
ASPT % of reference score	106.7%
Dickens and Graham, 2001 SASS5 classification	Class C: Moderately impaired. Moderate diversity of taxa.
Dallas 2007 classification	Class A

- The SASS data indicates that the aquatic macro-invertebrate community at the site has suffered some loss in integrity when compared to the reference score for pristine Nama Karoo Ecoregion stream.
- It must however be considered that the aquatic assessment site was not necessarily optimum for the assessment of the aquatic macro-invertebrate community due to the abundance of bedrock on the river bed and because of very strong flows in the river making access to all sampling areas difficult.
- At present, the site can be considered as Class C (Moderately impaired) according to the Dickens & Graham (2001) classification system, and as a Class A (Unimpaired) according the Dallas (2007) classification system.
- In this situation the Dallas (2007) classification is likely to be more accurate since it considers the aquatic macro-invertebrate community sensitivity more strongly.
- If a balanced approach is considered between the two classification systems the system can be defined as a Class B system indicating largely natural conditions with few modifications.
- Further impacts on the system could potentially lead to further degradation of the system and, therefore, lead to a deviation from the PES of the system and reduced ecological functioning.

- Careful design and construction will be required to limit the impact on the system from developments in the area. Maintenance will also need to be well managed in the operational phase of the development to prevent impacts on the system from impounding, erosion and altered bed and bank conditions.

5.1.4 Fish Community Integrity

The fish community of the site was sampled for a period of one half hour. The table below serves as a summary of the results obtained for the site.

Table 16: A summary of the results obtained from the application of the FAII index to the site

SITE	CO3
Habitat and cover	Extensive habitat for fish is available at the site. There is a diversity of depth and flow classes, providing excellent diversity of habitat for fish. The most abundant cover type is rocky substrate. Limited amounts of overhanging bankside vegetation are present and some undercut root wads and reeds are present.
Species present and number of individuals obtained	*Labeobarbus aeneus* 8 150mm - 350mm *Labeobarbus capensis* 5 180mm – 250mm *Clarias gariepinus* 1 370 mm
Health and condition	No impairment of fish health observed.
Expected FAII score	135
Observed FAII score	34.5
Relative FAII score	25.6%
FAII classification (Kleynhans, 1999)	"Class E". Seriously modified. A strikingly lower than expected species richness and a general absence of intolerant and moderately intolerant species

- The FAII data indicates that the fish community at the site has suffered a serious loss in integrity when compared to the reference score for pristine Nama Karoo Ecoregion stream.
- Extensive habitat for fish is available at the site.
- There is a diversity of depth and flow classes, providing excellent diversity of habitat for fish.
- The lower than expected fish score can be ascribed to limitations in sampling due to the strong currents at the assessment site and the inability to access areas in the river for sampling. It is deemed highly likely that numerous additional species would have been captured if safe access to sampling areas was possible.
- Based on the above consideration, limited loss of diversity and sensitivity of the fish community is deemed likely at the current time despite the low yield (diversity and abundance) of the fish community observed

- The most abundant cover type is rocky substrate and water column depth. Limited amounts of overhanging bankside vegetation are present and some undercut root wads and reeds are present.

5.1.5 Riparian vegetation Integrity

The riverine and bankside vegetation of the Orange river can be considered to be dynamic with the sandy stream banks being constantly shifted during periods of high flow. The unstable nature of the system leads to the proliferation of pioneering vegetation on the stream banks and also leads to constantly changing instream habitat. Alien vegetation encroachment in the area was noticeable with some areas being worse affected than others. Some loss of riparian vegetation due to impacts from agriculture, with special mention of the clearing of areas for agriculture and the construction of levees along the active stream channels was evident.

5.1.5 Summary of General System Characteristics

Based on the consideration of the above factors the Orange River can be considered to be a tolerant system that is adapted to constantly changing substrate and bankside conditions as well as constant variation in flow. The system is also tolerant to changes in water quality with special mention of temperatures, dissolved salt and turbidity levels as water constituents change through the system.

The aquatic communities of the system are however still intact with more sensitive aquatic macro-invertebrate and fish populations still present and as such as much as the system is considered to be tolerant it must also be considered to be sensitive to impacts that occur on the system.

It is therefore deemed essential that any proposed activities which could affect the system be comprehensively assessed to define and understand the impacts and in order to ensure that suitable and sufficient mitigation measures are put in place to protect the system throughout the life of the project and associated infrastructure.

5.2 Crossing Alternatives

5.2.1 Crossing Alternative 1

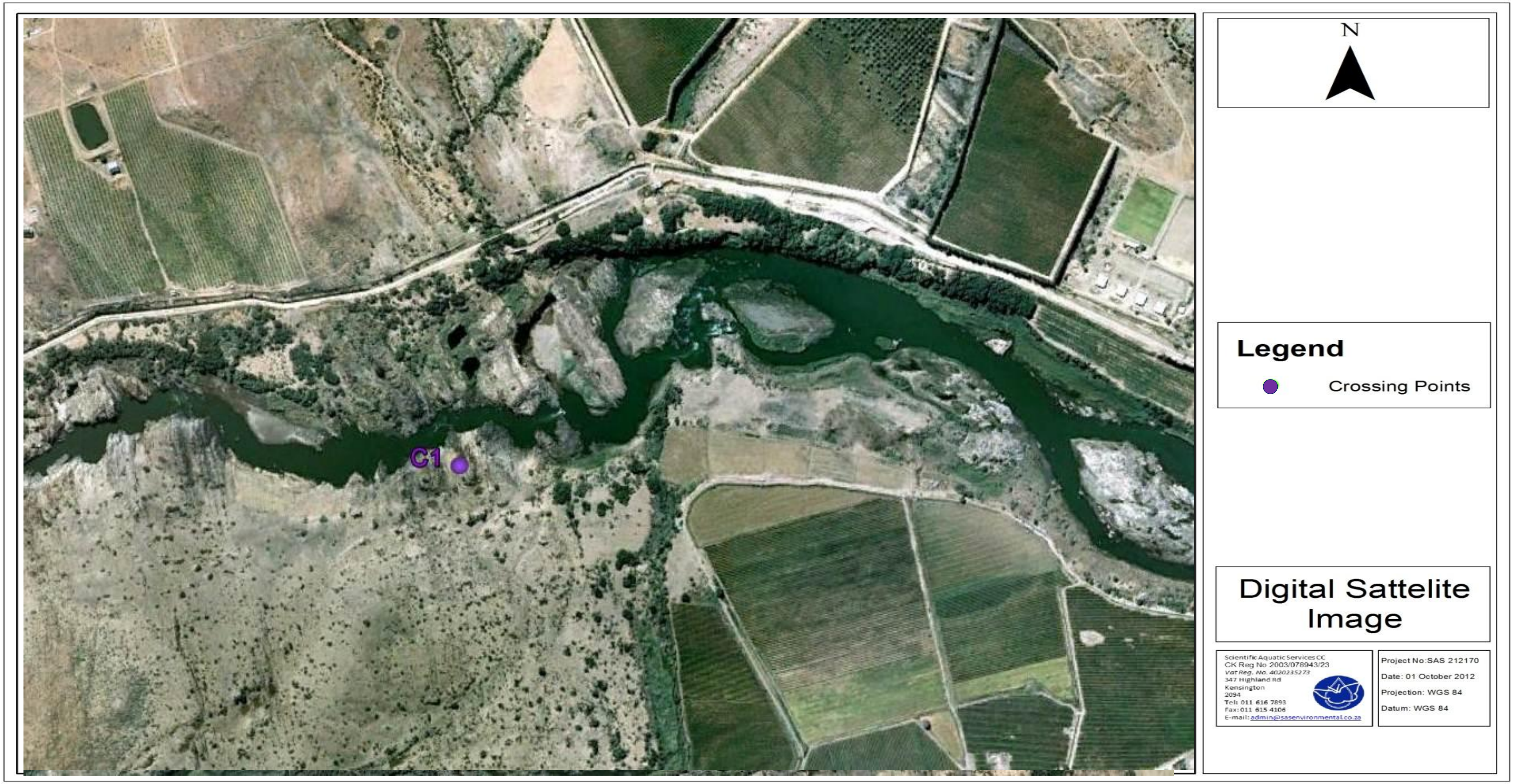

Figure 5: Aerial photograph depicting the crossing Alternative C1

5.2.1.1 Visual Assessment of Instream Conditions

A photographic record of the site was made in order to provide a visual record of the condition of the assessment site as observed during the field assessment. The photographs taken are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken on the site.

Figure 6: Upstream view of the C1 site, indicating extremely fast flowing white water and rocky substrate upstream of the crossing.

Figure 7: Downstream view of the C1 site showing the rocky rapids downstream of the crossing and the limited bankside vegetation in some places.

Table 17: Description of the location of the Assessment site in the study area

SITE	C1
Braiding of the system	At this point the system mostly consists of one channel, which becomes constricted at points leading to very fast flow in some areas
Riparian zone characteristics	The riparian zone is wide. Some impact from alien vegetation encroachment has occurred. The existing weir causes upstream inundation which alters the vegetation characteristics in this area.
Algal presence	No algal proliferation was evident at the current time.
Visual indication of an impact on aquatic fauna	Water is turbid but not beyond the naturally expected conditions for the area.
Depth characteristics	The stream consists of deep pools, fast flowing rapids and fast glides.
Flow condition	The river at this point is generally fast flowing with extremely fast flowing narrow rapids, fast riffles and glides and slower deeper pool areas and eddies.
Water clarity	Water is discolored but can be considered natural.
Water odor	None
Erosion potential	Under high flow conditions the system will erode rapidly due to the fast flow of the water and the unstable sandy nature of the riparian zone. This can however be regarded as natural for the system in the area.

5.2.1.2 Habitat Assessment

Instream Habitat Integrity

Weights	14	13	13	13	14	10	9	8	6		
REACH	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
C11	4	3	0	0	6	0	0	3	0	91.4	A Unmodified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

Riparian Zone Habitat Integrity

Weights	13	12	14	12	13	11	12	13		
REACH	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
C11	14	18	14	2	3	6	3	0	52.8	D Largely modified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

REACH	*INSTREAM HABITAT*	*RIPARIAN ZONE*	*IHIA SCORE*	*CLASS*
C1	91.4	52.8	*72.1*	C Moderately modified

Figure 8: Integrated Habitat Integrity Assessment

- From the results of the application of the IHIA to the assessment site, it is evident that there are several large impacts on the habitat of the area with specific mention of riparian zone impacts while instream impacts were more limited.
- Instream impacts at the site included moderate impacts from water quality, and water abstraction. Smaller impacts from exotic fauna and flow modification were also noted. Overall, the site achieved a 91.4 % score for in stream integrity. Indicating unmodified (Class A) conditions.
- The largest riparian zone impacts included vegetation removal, alien vegetation encroachment and bank erosion. Smaller impacts from channel modification were observed. The site achieved a 52.8% score for riparian integrity representing largely modified (Class D) conditions.
- The site obtained an overall IHIA rating of 72.1% score for riparian integrity representing moderately modified (Class C) conditions. The site, therefore, falls below the DEMC for the quaternary catchment from a habitat integrity

perspective. Measures to prevent further impacts on the system are therefore required and care should be taken to prevent impacts from any future developments.

5.2.1.3 Riparian vegetation analyses

On this portion of the Orange, the river itself is anabranching with isolated small islands in the main channel. The active river channel is approximately 40 meters wide and the potential riparian zone width is approximately 75 meters on the left hand bank, 40 meters on the right hand bank and 25 meters on the islands. The substrate is dominated by bedrock and gravel and sand. Various bare areas were noted, although this is a feature of the river and a result of its natural flow level fluctuations and sediment deposition.

A list of the floral species observed during the assessment is presented in the following table but is briefly described below. The woody layer of the riparian vegetation was dominated by *Ziziphus mucronata, Searsia lancea* and *Tamarix usneoides*. These species are all indicative of the *Lower Gariep Alluvial Vegetation,* and as such the riparian zone vegetation can be considered natural. The instream vegetation was dominated by *Phragmites australis*. The grass component consists mainly of *Cynodon dactylon* and *Stipagrostis namaquensis.* Alien species included *Nicotiana glauca, Datura stramonium* and *Solanum sisymbrifolium.* Moving downstream, this pattern remains fairly constant, the only readily observable change is the density of vegetation and cover percentage. When comparing the species list (especially trees and grasses) to the vegetation list for *Lower Gariep Alluvial Vegetation,* it becomes clear that the species composition of the riparian zone is still largely intact, even though some impacts are evident due to agricultural practices adjacent to the river. The following table presents a list of vegetation encountered on site.

Table 18: Dominant riparian vegetation species noted during the riparian vegetation assessment at C1. Exotic species are marked by an asterisk.

Trees/shrubs	Forbs	Grasses/sedges
Acacia karroo	*Asclepias fruticosa*	*Cyperus marginatus*
*Nicotiana glauca**	*Bidens pilosa**	*Cynodon dactylon*
Searsia lancea	*Datura stramonium**	*Juncus effusus*
Tamarix usneoides	*Solanum sisymbrifolium**	*Stipagrostis namaquensis*
Ziziphus mucronata	*Veronica anagallis-aquatica**	*Panicum maximum*
*Salix babylonica**		*Phragmites australis*
		Setaria verticellata

The RVI for this site was 14.7 (out of a possible 20), a value which falls within the boundary of a class C (moderately modified) system. The reason for this site receiving this value is mainly due to the relatively intact representative *Lower Gariep Alluvial* vegetation, the presence of larger woody species and moderately high levels of habitat provision. Although some bare areas are present, it is most likely a natural feature of this highly dynamic system which experiences natural high flow level fluctuation and sediment deposition. The results for the RVI are presented in Appendix 1.

5.2.1.4 Crossing suitability analyses

The table below presents the advantages and disadvantages of the proposed crossing point

Table 19: suitability analyses of the C1 crossing alternative

C1	Advantages	Disadvantages
	The river channel is not branched at this point	The riparian zone substrate is unstable and prone to erosion and as such careful planning of foundations will be required and measures will be required to control erosion
	The river is narrow at this point and will most likely be easily spanned with towers outside of the riparian zone of the river and therefore no impact on the instream habitat is deemed likely	Alien vegetation is a problem in the area and measures to control erosion will need to be ensured
	The riparian zone vegetation at this point is a narrow strip along the river banks and impact thereon can be avoided	

5.2.1.5 Conclusion

The narrow river channel with limited anabranching and lowered RVI score means that the proposed crossing will have less impact on the receiving riparian environment than most of the other crossing points. Due to the narrow width of the river in this area the risk to the instream habitat and aquatic community is regarded as being limited provided that suitable mitigation is implemented. Based on these characteristic, this crossing point is highly recommended as the best alternative to cross the Orange River.

5.2.2 Crossing Alternative 2

Figure 9: Aerial photograph depicting the crossing point alternative C2

5.2.2.1 Visual Assessment of Instream Conditions

A photographic record of the site was made in order to provide a visual record of the condition of the assessment site as observed during the field assessment. The photographs taken are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken on the site.

Figure 10: Upstream view of the C2 site, indicating moderately deep system with slow flowing water.

Figure 11: Downstream view of the C2 site showing the abundant marginal vegetation at the site.

Table 20: Description of the location of the Assessment site in the study area

SITE	C2
Braiding of the system	At this point the system consists of an anabranching channel with a large island splitting two main channels although some smaller channels are also evident. This increases the extent of the riparian areas on the subject property.
Riparian zone characteristics	The riparian zone is narrow due to the encroachment of agricultural activities on the stream bank. This is particularly evident on the northern bank of the River. The riparian vegetation on the island banks is however extensive. Some impact from alien vegetation encroachment has occurred. Visually, the riparian vegetation looks to be in excellent condition.
Algal presence	No algal proliferation was evident at the current time.
Visual indication of an impact on aquatic fauna	Water is turbid but not beyond the naturally expected conditions for the area.
Depth characteristics	The river is dominated by deep relatively fast flowing glides at this point.
Flow condition	The river at this point is generally fast flowing with limited diversity of flow in the area.
Water clarity	Water is discolored but can be considered natural.
Water odor	None
Erosion potential	Under high flow conditions the system will be susceptible to erosion although bankside vegetation cover is good the risk of erosion under high flow conditions can be considered to be a natural characteristic of the system.

5.2.2.2Habitat Assessment

Instream Habitat Integrity

Weights	14	13	13	13	14	10	9	8	6		
REACH	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
C2	4	2	0	0	6	0	0	3	0	91.9	A Unmodified

None	Small	Moderate	Large	Serious	Critical

Riparian Zone Habitat Integrity

Weights	13	12	14	12	13	11	12	13		
REACH	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
CO2	17	14	14	2	3	13	3	0	46.1	D Largely modified

None	Small	Moderate	Large	Serious	Critical

REACH	INSTREAM HABITAT	RIPARIAN ZONE	IHIA SCORE	CLASS
C2	91.9	46.1	69	C Moderately modified

Figure 12: Integrated Habitat Integrity Assessment

- From the results of the application of the IHIA to the assessment site, it is evident that there are several large impacts on the habitat of the area with special mention of impacts on the riparian zone while instream habitat impacts are limited.
- Instream impacts at the site included some impacts from water abstraction, and water quality modification. Smaller impacts from exotic fauna and flow modification were also noted. Overall, the site achieved a 91.9 % score for in stream integrity. Indicating an unmodified (Class A) conditions.
- The largest riparian zone impacts included flow bank erosion, alien vegetation encroachment, vegetation removal as well as channel modification. Channel modification is largely as a result of the construction of levees to prevent impacts on adjacent vineyards and orchards. Smaller impacts from flow modification and water quality modification were observed. The site achieved a 46.1% score for riparian integrity representing largely modified (Class D) conditions.

- The site obtained an overall IHIA rating of 69% score for riparian integrity representing moderately modified (Class C) conditions. The site, therefore, falls below the DEMC for the quaternary catchment from a habitat integrity perspective. Measures to prevent further impacts on the system are therefore required and care should be taken to prevent impacts from any future developments.

5.2.2.3 Riparian vegetation analyses

On this portion of the Orange, the river is anabranching with various islands in the main channel. The active river channel is approximately 45 meters wide and the potential riparian zone is approximately 60 meters on the left hand bank, 70 meters on the right hand bank and 100 meters on the islands. The substrate is dominated by bedrock, gravel and sand. The riverbanks were vegetated and dominated by woody species and reeds.

A list of the floral species observed during the assessment is presented in the following table but is briefly described below. The woody layer of the riparian vegetation was dominated by *Ziziphus mucronata, Searsia lancea* and *Tamarix usneoides,* although much denser than at C1. These species are all indicative of the *Lower Gariep Alluvial Vegetation,* and as such the vegetation can be considered natural. The instream and bankside vegetation was dominated by *Phragmites australis*. As at C1, the grass component consists mainly of *Cynodon dactylon* and *Stipagrostis namaquensis.* Alien species included *Nicotiana glauca, Datura stramonium* and *Solanum sisymbrifolium.* This vegetation structure remains constant for a considerable distance up- and downstream, with vegetation density and abundance changing slightly. When comparing the species list (especially trees and grasses) to the vegetation list for *Lower Gariep Alluvial Vegetation,* it becomes clear that the species composition of the riparian zone is still largely intact, even though some impacts are evident due to agricultural practices such as vineyards adjacent to the river. The following table presents a list of vegetation encountered on site.

Table 21: Dominant riparian vegetation species noted during the riparian vegetation assessment at C2. Exotic species are marked by an asterisk.

Trees/shrubs	Forbs	Grasses/sedges
Acacia karroo	*Asclepias fruticosa*	*Cyperus marginatus*
*Nicotiana glauca**	*Bidens pilosa**	*Cynodon dactylon*
Searsia lancea	*Datura stramonium**	*Juncus effusus*
Tamarix usneoides	*Solanum sisymbrifolium**	*Stipagrostis namaquensis*
Ziziphus mucronata	*Veronica anagallis-aquatica**	*Panicum maximum*
*Salix babylonica**		*Phragmites australis*
		Setaria verticellata

The RVI for this site was 17.3 (out of a possible 20), a value which leads to the area being classified as a class B (largely natural) river segment. The reason for this site receiving this value is mainly due to the moderate to high abundances and diversity of indigenous species and representative *Lower Gariep Alluvial* vegetation. The dense reed beds provide habitat for a potentially diverse faunal community and also provide valuable flood attenuation and water filtration services. The results for the RVI are presented in Appendix 1.

5.2.2.4 Crossing suitability analyses

The table below presents the advantages and disadvantages of the proposed crossing point:

Table 22: suitability analyses of the C2 crossing alternative

C2	Advantages	Disadvantages
	The river channel branched at this point but support towers can be constructed on the river banks and the main island which will limit the impact on the instream ecology	The river channel branched at this point and support towers will have to be constructed on the river banks and the main island which will lead to an impact on the riparian vegetation of the system with special mention of the island vegetation
	The riparian vegetation zone on the main river banks is narrow and the impact of the support towers on the riparian vegetation and habitats can be avoided	Alien vegetation is a problem in the area and measures to control erosion will need to be ensured
	The instream habitat sensitivity at this point is limited in diversity and sensitivity and severe impacts on instream habitat is regarded as being limited.	Riparian vegetation at this point is in good condition and impacts could lead to an alteration of the characteristics of the riparian zone vegetation

5.2.2.5 Conclusion

The anabranching river channel and relatively high RVI score means that this proposed crossing alternative will have a significantly higher impact on the receiving riparian zone environment than most of the other crossing points. Due to the ability to place support towers on the river banks and islands as well as the limited diversity and sensitivity of the instream habitat the risk to the instream habitat and aquatic community is regarded as being limited, provided that suitable mitigation is implemented. Based on these characteristics, this crossing point is not recommended as a suitable alternative to cross the Orange River unless measures to minimise the impacts on the riparian vegetation can be implemented and that riparian vegetation can be rehabilitated.

5.2.3 Crossing Alternative 3

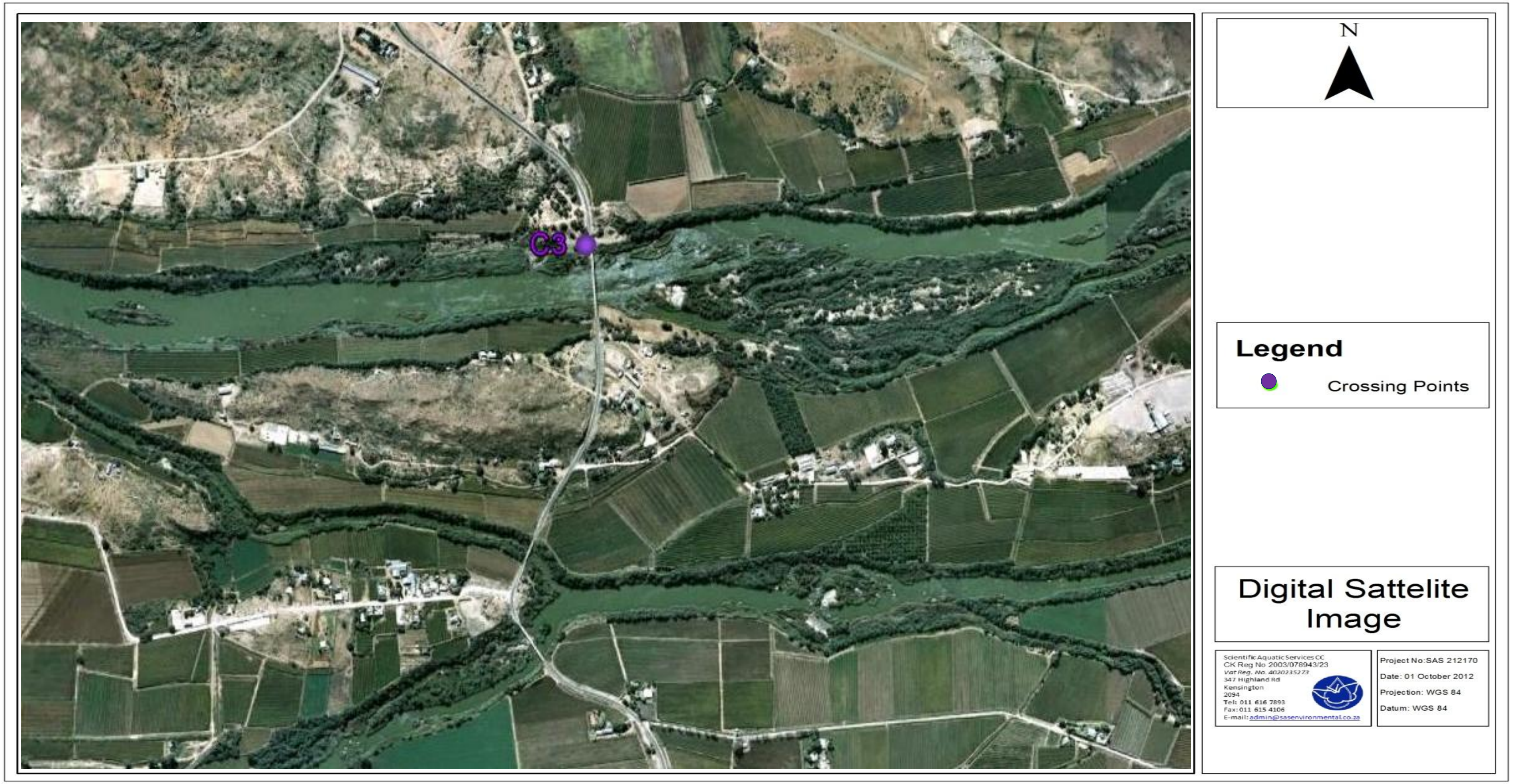

Figure 13: Aerial photograph depicting the crossing Alternative C3

5.2.3.1 Visual Assessment of Instream Conditions

A photographic record of the site was made in order to provide a visual record of the condition of the assessment site as observed during the field assessment. The photographs taken are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken on the site.

Figure 14: Upstream view of the C3 site, indicating some construction activities at the site.

Figure 15: Downstream view of the C3 site showing the rocky rapids downstream of the crossing.

Table 23: Description of the location of the Assessment site in the study area

SITE	**C2**
Braiding of the system	At this point the system mostly consists of a single channel to the west of the existing road crossing, while to the east the system is anabranching.
Riparian zone characteristics	The riparian zone is wide. Some impact from alien vegetation encroachment has occurred with special mention of the Kikuyu lawn at the hotel to the east of the existing road crossing.
Algal presence	No algal proliferation was evident at the current time.
Visual indication of an impact on aquatic fauna	Water is turbid but not beyond the naturally expected conditions for the area.
Depth characteristics	The stream consists of deep pools, fast flowing shallower rapids and fast glides of moderate depth.
Flow condition	The river at this point has a diversity of flow present but flow is generally fast. There are fast flowing rapids, fast riffles and glides and slower deeper pool areas and backwaters to the east of the existing bridge crossing.
Water clarity	Water is discolored but can be considered natural.
Water odor	None
Erosion potential	Under high flow conditions the system has the potential to erode due to the fast flow of the water and incised banks of the river. This can however be regarded as natural for the system in the area. Some protection will be afforded by fairly good bankside vegetation cover

5.2.3.2 Habitat Assessment

Instream Habitat Integrity

Weights	14	13	13	13	14	10	9	8	6		
REACH	**Water abstraction**	**Flow modification**	**Bed modification**	**Channel modification**	**Water quality**	**Inundation**	**Exotic macrophytes**	**Exotic fauna**	**Solid waste disposal**	**Total Score (%)**	**Classification**
C3	4	12	7	6	6	0	0	5	0	75	C Moderately modified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

Riparian Zone Habitat Integrity

Weights	13	12	14	12	13	11	12	13		
REACH	**Vegetation removal**	**Alien encroachment**	**Bank erosion**	**Water abstraction**	**Flow modification**	**Channel modification**	**Water quality**	**Inundation**	**Total Score (%)**	**Classification**
C3	19	17	12	2	9	9	3	0	43.1	D Largely modified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

REACH	*INSTREAM HABITAT*	*RIPARIAN ZONE*	*IHIA SCORE*	*CLASS*
CO3	75	43.1	*59.1*	D Largely modified

Figure 16: Integrated Habitat Integrity Assessment

- From the results of the application of the IHIA to the assessment site, it is evident that there are several large impacts on the habitat of the area with impacts more prevalent in the riparian zone than the instream habitat.
- Instream impacts at the site included large impacts from flow and bed modifications. Smaller impacts from water quality and channel modification were also noted. Overall, the site achieved a 75 % score for in stream integrity. Indicating moderately modified (Class C) conditions.
- The largest riparian zone impacts included flow modification bank erosion, alien vegetation encroachment and indigenous vegetation removal. Smaller impacts from flow modification and channel modification were observed. The site achieved a 43.1% score for riparian zone integrity representing largely modified (Class D) conditions.
- The site obtained an overall IHIA rating of 59.1% score for riparian integrity representing largely modified (Class D) conditions. The site, therefore, falls

below the DEMC for the quaternary catchment from a habitat integrity perspective. Measures to prevent further impacts on the system are therefore required and care should be taken to prevent impacts from any future developments. If the crossing was however to take place at this point the impact on the riverine habitat would be reduced, due to the reduced level of integrity and sensitivity of the riverine habitat.

5.2.3.3 Riparian vegetation analyses

The Orange River at this point is anabranching with islands scattered throughout the main channel to the east of the river crossing but consists largely of a single channel to the west for the bridge. The active river channel is approximately 80 meters wide and the potential riparian zone is approximately 40 meters on the left hand bank, 50 meters on the right hand bank and 30 meters on the islands to the east of the existing bridge crossing. The substrate is dominated by bedrock, cobbles, gravel and sand. The riverbanks were vegetated and dominated by woody species and reeds, although they were transformed in some areas by landscaping activities and bridge developments.

The woody layer of the riparian vegetation was dominated by *Ziziphus mucronata, Searsia lancea* and *Tamarix usneoides,* in various densities. Although some areas have been transformed by landscaping and bridge development, the overall vegetation composition is indicative of the *Lower Gariep Alluvial Vegetation*. The instream vegetation was dominated by *Phragmites australis*. The grass component consists mainly of *Cynodon dactylon* and *Stipagrostis namaquensis,* although the landscaped section contains the exotic *Pennisetum clandestinum.* Alien species included *Eucalyptus camaldulensis, Nicotiana glauca, Pennisetum clandestinum, Datura stramonium* and *Solanum sisymbrifolium.* This vegetation structure remains constant for a considerable distance up- and downstream, with vegetation density and abundance changing slightly. When comparing the species list (especially trees and grasses) to the vegetation list for *Lower Gariep Alluvial Vegetation,* it becomes clear that the species composition of the riparian zone is still largely intact, even though some impacts are evident due to landscaping activities and infrastructure construction. The following table presents a list of vegetation encountered on site.

Table 24: Dominant riparian vegetation species noted during the riparian vegetation assessment at C3. Exotic species are marked by an asterisk.

Trees/shrubs	Forbs	Grasses/sedges
Acacia karroo	*Asclepias fruticosa*	*Cyperus marginatus*
*Nicotiana glauca**	*Bidens pilosa**	*Cynodon dactylon*
Searsia lancea	*Datura stramonium**	*Juncus effusus*
Tamarix usneoides	*Solanum sisymbrifolium**	*Stipagrostis namaquensis*
Ziziphus mucronata	*Veronica anagallis-aquatica**	*Panicum maximum*
*Salix babylonica**		*Phragmites australis*
*Eucalyptus camaldulensis**		*Setaria verticellata*
		*Pennisetum clandestinum**

The RVI for this site was 13 (out of a possible 20), a value which falls within the boundary of a class C (moderately modified) system. The reason for this site receiving this value is mainly due to the disturbances associated with the landscaping activities and infrastructure upgrades. However the larger riparian zone is still representative of *Lower Gariep Alluvial* vegetation. The results for the RVI are presented in Appendix 1.

5.2.3.4 Crossing suitability analyses

The table below presents the advantages and disadvantages of the proposed crossing point

Table 25: suitability analyses of the C3 crossing alternative

C2	Advantages	Disadvantages
	The river channel to the west of the existing bridge crossing is a single channel which can be spanned with support towers outside of the riparian zone on each bank.	The river channel branched at this point and support towers will have to be constructed on the river banks and the main island which will lead to an impact on the riparian vegetation of the system with special mention of the island vegetation.
	The river channel branched at this point but support towers can be constructed on the river banks and the main island which will limit the impact on the instream ecology.	Alien vegetation is a problem in the area and measures to control erosion will need to be ensured.
	The riparian vegetation zone on the main river banks is narrow and the impact of the support towers on the riparian vegetation and habitats can be	Riparian vegetation at this point is in good condition and impacts could lead to an alteration of the characteristics of the riparian zone vegetation

C2	Advantages	Disadvantages
	avoided	
	The instream habitat sensitivity at this point is limited in diversity and sensitivity and severe impacts on instream habitat is regarded as being limited.	

5.2.3.5 Conclusion

The anabranching river channel and relatively high RVI score means that this proposed crossing alternative will have a significantly higher impact on the receiving riparian zone environment than the other crossing points if construction is undertaken to the east of the existing road bridge. If however the crossing is made to the west of the existing bridge crossing the impact on the Orange River ecology can be largely avoided. If construction takes place to the east of the bridge a tower will most likely need to be placed on the island which will impact on the riparian vegetation of the system. The riparian vegetation of the islands is in good condition and the tower will have a significant impact on the island riparian vegetation. The instream habitat in this areas is of increased sensitivity in relation to the other sites further downstream as well as in relation to crossing alternative 5 due to increased diversity and sensitivity of the instream habitat and the risk to the instream habitat and aquatic community is regarded as being relatively significant at this point. If this crossing point is selected measures will be required to prevent impacts on the instream habitats and associated communities. Based on these findings, this crossing point is not recommended as a suitable alternative to cross the Orange River unless it occurs to the west of the existing road crossing. A crossing to the east of the existing road crossing is not deemed suitable unless extensive measures to minimise the impacts on the riparian vegetation and instream habitat can be implemented and that riparian vegetation can be rehabilitated.

5.2.4 Crossing Alternative 4

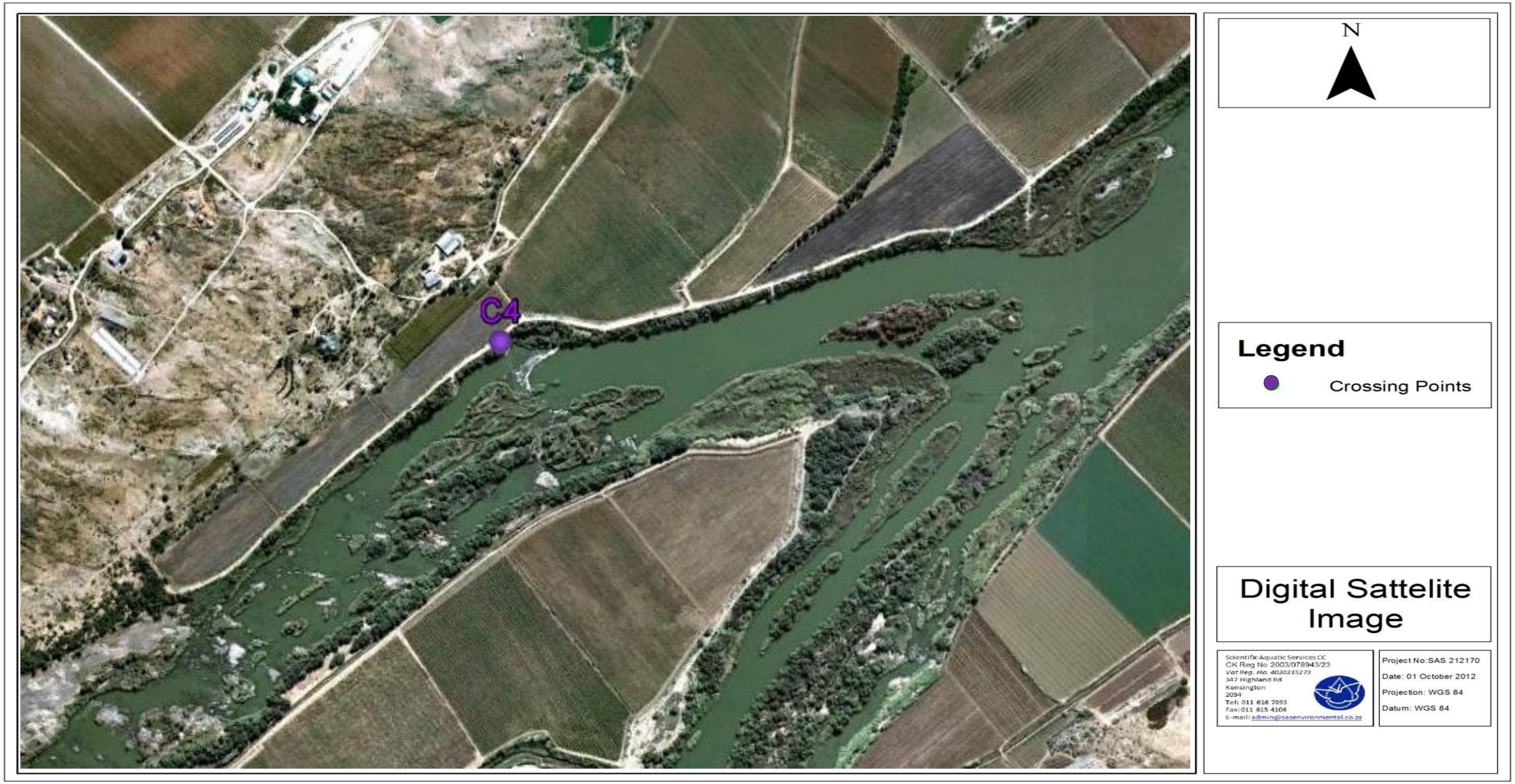

Figure 17: Aerial photograph depicting the crossing Alternative 4

4.2.4.1 Visual Assessment of Instream Conditions

A photographic record of the site was made in order to provide a visual record of the condition of the assessment site as observed during the field assessment. The photographs taken are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken on the site.

Figure 18: Upstream view of the C4 site, indicating the impact from inundation caused by a small weir.

Figure 19: Downstream view of the C4 site showing the laminar flows in the system at this point.

Table 26: Description of the location of the Assessment site in the study area

SITE	C4
Braiding of the system	At this point the system is braided with two main channels. The main island is large and is under cultivation. The two main river channels are further anabranched with small islands with natural riparian vegetation cover.
Riparian zone characteristics	The riparian zone is narrow on the main stream banks and the large island due to the effects of clearing for agriculture and the construction of levees to protect the adjacent vineyards and orchards. Some impact from alien vegetation encroachment has occurred. The existing weir causes upstream inundation which alters the vegetation characteristics in this area.
Algal presence	No algal proliferation was evident at the current time.
Visual indication of an impact on aquatic fauna	Water is turbid but not beyond the naturally expected conditions for the area.
Depth characteristics	The stream consists of deep pools, fast flowing rapids and fast glides.
Flow condition	The river at this point is generally fast flowing with fast flowing narrow rapids, fast flowing glides.
Water clarity	Water is discolored but can be considered natural.
Water odor	None
Erosion potential	Under high flow conditions the system will erode rapidly due to the fast flow of the water and the unstable sandy nature of the riparian zone. This can however be regarded as natural for the system in the area. The area does have good bankside cover which will protect the banks to some degree.

5.2.4.2 Habitat Assessment

Instream Habitat Integrity

Weights	14	13	13	13	14	10	9	8	6		
REACH	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
C4	4	7	4	8	6	0	0	3	0	83.1	B Largely modified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

Riparian Zone Habitat Integrity

Weights	13	12	14	12	13	11	12	13		
REACH	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
C4	17	14	11	2	3	13	3	0	47.8	D Largely modified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

5

REACH	*INSTREAM HABITAT*	*RIPARIAN ZONE*	*IHIA SCORE*	*CLASS*
C4	83.1	47.8	*65.4*	C Moderately modified

Figure 20: Integrated Habitat Integrity Assessment

- From the results of the application of the IHIA to the assessment site, it is evident that there are several large impacts on the habitat of the area. Impacts on the riparian zone are particularly significant in relation to those in the instream area.
- Instream impacts at the site included large impacts from flow and channel modifications. Smaller impacts from water quality modification were also noted. Overall, the site achieved an 83.1% score for in stream integrity. Indicating largely natural (Class B) conditions.
- The largest riparian zone impacts included flow bank erosion, vegetation removal, channel modification and alien vegetation encroachment. Smaller impacts from flow modification, and water quality modification were observed. The site achieved a 47.8% score for riparian integrity representing largely modified (Class D) conditions.

- The site obtained an overall IHIA rating of 65.4% score for riparian integrity representing moderately modified (Class C) conditions. The site, therefore, falls below the DEMC for the quaternary catchment from a habitat integrity perspective. Careful planning will be required in order to prevent impacts on this stream segment which would lead to local deterioration of the system.

5.2.4.3 Riparian vegetation analyses

At this assessment point, the Orange River is anabranching, with islands located in the main channel. The active river channel is approximately 45 meters wide and the potential riparian zone is approximately 60 meters on the left hand bank, 60 meters on the right hand bank and 60 meters on the islands except for the main island where the extent of the riparian zone is limited due to the agricultural activities on the island. The substrate is dominated by bedrock, cobbles, gravel and sand. The riverbanks were vegetated and dominated by indigenous woody species and reeds, with low levels of disturbance encountered, most notably a weir which has caused low levels of bank erosion.

The woody layer of the riparian vegetation was dominated by *Ziziphus mucronata, Olea europaea* subsp. *africana, Searsia lancea* and *Tamarix usneoides,* and is mostly extremely dense. As a result of the low levels of disturbance, the overall vegetation composition is indicative of the *Lower Gariep Alluvial Vegetation*. The instream vegetation was dominated by *Phragmites australis*. The grass component consists mainly of *Cynodon dactylon* and *Stipagrostis namaquensis* in areas where the woody layer is not very dominant. Alien species included *Nicotiana glauca, Datura stramonium* and *Solanum sisymbrifolium.* The pattern of vegetation structure remains constant for a considerable distance up- and downstream, with vegetation density and abundance changing slightly. When comparing the species list (especially trees and grasses) to the vegetation list for *Lower Gariep Alluvial Vegetation,* it becomes clear that the species composition of the riparian zone is still largely natural. The following table presents a list of vegetation encountered on site.

Table 27: Dominant riparian vegetation species noted during the riparian vegetation assessment at C4. Exotic species are marked by an asterisk.

Trees/shrubs	Forbs	Grasses/sedges
Acacia karroo	*Asclepias fruticosa*	*Cyperus marginatus*
*Nicotiana glauca**	*Bidens pilosa**	*Cynodon dactylon*
Searsia lancea	*Datura stramonium**	*Juncus effusus*
Tamarix usneoides	*Solanum sisymbrifolium**	*Stipagrostis namaquensis*
Ziziphus mucronata	*Veronica anagallis-aquatica**	*Panicum maximum*
*Salix babylonica**		*Phragmites australis*
Oleae europaea subsp. *africana*		*Setaria verticellata*

The RVI for this site was similar to the C2 site and also calculated as 17.3 (out of a possible 20), which falls within the boundary of a class B (largely natural) system. The reason for this site receiving this value is mainly due to the moderate to high abundances and diversity of indigenous species and representative *Lower Gariep Alluvial* vegetation. The dense reed beds provide habitat for a potentially diverse faunal community and also provide valuable flood attenuation and water filtration services. Although the weir has been constructed, it has only had a low impact on riparian vegetation. The results for the RVI are presented in Appendix 1.

4.2.4.4 Crossing suitability analyses

The table below presents the advantages and disadvantages of the proposed crossing point

Table 28: suitability analyses of the C4 crossing alternative

C4	Advantages	Disadvantages
	The river channel branched at this point but support towers can be constructed on the river banks and the main island which will limit the impact on the instream ecology	The river channel branched at this point and support towers will have to be constructed on the river banks and the main island which has the potential to an impact on the riparian vegetation of the system.
	The riparian vegetation zone on the main river banks is narrow and the impact of the support towers on the riparian vegetation and habitats can be avoided	Alien vegetation is a problem in the area and measures to control erosion will need to be ensured
	The instream habitat sensitivity at this point is limited in diversity and sensitivity and severe impacts on instream habitat is regarded as being limited.	Riparian vegetation at this point is in reasonable condition and impacts could lead to an alteration of the characteristics of the riparian zone vegetation

5.2.4.5 Conclusion

The anabranching river channel and relatively high RVI score means that this proposed crossing alternative will have a significantly higher impact on the receiving riparian zone environment than most of the other crossing points. Due to the ability to place support towers on the river banks and islands as well as the limited diversity and sensitivity of the instream habitat the risk to the instream habitat and aquatic community is regarded as being limited, provided that suitable mitigation is implemented. Based on these characteristics, this crossing point is not recommended as a suitable alternative to cross the Orange River unless measures to minimise the impacts on the riparian vegetation can be implemented and that riparian vegetation can be rehabilitated.

5.2.5 Crossing Alternative 5

Figure 21: Aerial photograph depicting the crossing Alternative 5

5.2.5.1 Visual Assessment of Instream Conditions

A photographic record of the site was made in order to provide a visual record of the condition of the assessment site as observed during the field assessment. The photographs taken are presented below together with a table summarising the observations for the various criteria made during the visual assessment undertaken on the site.

Figure 22: Upstream view of the C5 site, indicating rocky rapids and abundant bankside vegetation cover.

Figure 23: Downstream view of the C5 site showing the slow flowing river and bankside cover.

Table 29: Description of the location of the Assessment site in the study area

SITE	C4
Braiding of the system	At this point the system is braided with two main channels. The main island is large and is under cultivation. The two main river channels are largely unbranched with small islands with natural riparian vegetation cover.
Riparian zone characteristics	The riparian zone is narrow on the main stream banks and the large island due to the effects of clearing for agriculture and the construction of levees to protect the adjacent vineyards and orchards. Some impact from alien vegetation encroachment has occurred. The existing weir causes upstream inundation which alters the vegetation characteristics in this area.
Algal presence	No algal proliferation was evident at the current time.
Visual indication of an impact on aquatic fauna	Water is turbid but not beyond the naturally expected conditions for the area.
Depth characteristics	The stream consists of deep pools, fast flowing rapids and fast glides.
Flow condition	The river at this point is generally fast flowing with fast flowing narrow rapids, fast flowing glides.
Water clarity	Water is discolored but can be considered natural.
Water odor	None
Erosion potential	Under high flow conditions the system will erode rapidly due to the fast flow of the water and the unstable sandy nature of the riparian zone. This can however be regarded as natural for the system in the area. The area does have good bankside cover which will protect the banks to some degree.

5.2.5.2 Habitat Assessment

Instream Habitat Integrity

Weights	14	13	13	13	14	10	9	8	6		
REACH	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
CO5	4	2	3	0	8	0	0	3	0	89.1	B Largely natural

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

Riparian Zone Habitat Integrity

Weights	13	12	14	12	13	11	12	13		
REACH	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
CO5	8	9	12	2	3	16	3	0	65.6	C Moderately modified

None	*Small*	*Moderate*	*Large*	*Serious*	*Critical*

REACH	*INSTREAM HABITAT*	*RIPARIAN ZONE*	*IHIA SCORE*	*CLASS*
CO5	89.1	65.6	*77.3*	C Moderately modified

Figure 24: Integrated Habitat Integrity Assessment

- From the results of the application of the IHIA to the assessment site, it is evident that there are two large impacts on the habitat of the area with impacts on the riparian zone being more significant than those on the instream habitat.
- Instream impacts at the site included some impacts from water abstraction and water quality modification. Smaller impacts from exotic fauna and bed modification were also noted. Overall, the site achieved a 89.1% score for in stream integrity. Indicating largely natural (Class B) conditions.
- The largest riparian zone impacts included flow bank erosion and channel modification. Smaller impacts from indigenous vegetation removal, and exotic vegetation encroachment. The site achieved a 65.6% score for riparian integrity representing moderately modified (Class C) conditions.
- The site obtained an overall IHIA rating of 77.3% score for riparian integrity representing moderately modified (Class C) conditions. The site, therefore, falls below the DEMC for the quaternary catchment from a habitat integrity

perspective. Prevention of further impacts in this area are required in order to improve the habitat conditions of the area. Due to the impacts in the area, however the impact of any proposed development in the area is of lower significance than in areas where the habitat is less impacted.

5.2.5.3 Riparian vegetation analyses

As with all the other assessment points, the Orange River at this point is anabranching however the system is comprised of two main channels at this point, with very few small islands scattered throughout the main channel. The active river channel is approximately 50 meters wide and the potential riparian zone is approximately 30 meters on the left hand bank and 30 meters on the right hand bank. The main island in the river has been transformed completely by vineyards and other forms of crop cultivation and thus has a very narrow functional riparian zone. The substrate consists of a mixture of bedrock, soil, cobbles, gravel and sand. The river banks have been severely transformed by earthworks and the construction of levees for flood management purposes. This has caused vegetation transformation, erosion, incision and alien floral invasion.

The woody layer of the riparian vegetation was dominated by *Ziziphus mucronata, Searsia lancea* and *Tamarix usneoides.* Invasion by the alien tree species *Eucalyptus camaldulensis* was moderate to high. Although some vegetation representative of *Lower Gariep Alluvial Vegetation* was present, it was significantly more transformed than the other proposed crossing sites. The instream vegetation, as with the other proposed crossing sites, was dominated by *Phragmites australis*. The grass component consists mainly of *Cynodon dactylon* and *Stipagrostis namaquensis,* and it was notable that *Cynodon dactylon* was more prevalent than at the other proposed crossing sites due to this species being a known invader in disturbed areas. Alien species included *Eucalyptus camaldulensis, Nicotiana glauca, Datura stramonium* and *Solanum sisymbrifolium.* The vegetation structure changes when moving upstream and downstream due to lower levels of vegetation transformation. The following table presents a list of vegetation encountered on site.

Table 30: Dominant riparian vegetation species noted during the riparian vegetation assessment at C5. Exotic species are marked by an asterisk.

Trees/shrubs	Forbs	Grasses/sedges
Acacia karroo	*Asclepias fruticosa*	*Cyperus marginatus*
*Nicotiana glauca**	*Bidens pilosa**	*Cynodon dactylon*
Searsia lancea	*Datura stramonium**	*Juncus effusus*
Tamarix usneoides	*Solanum sisymbrifolium**	*Stipagrostis namaquensis*
Ziziphus mucronata	*Veronica anagallis-aquatica**	*Panicum maximum*
*Salix babylonica**		*Phragmites australis*
*Eucalyptus camaldulensis**		*Setaria verticellata*

The RVI for this site was 10.33 (out of a possible 20), a value which falls within the boundary of a class D (largely modified) system. The reason for this site receiving this value is mainly due to the disturbances associated with the earthmoving and levee construction activities. The crop cultivation activities have also largely transformed the island riparian vegetation. The results for the RVI are presented in Appendix 1.

5.2.5.4 Crossing suitability analyses

The table below presents the advantages and disadvantages of the proposed crossing point

Table 31: suitability analyses of the C5 crossing alternative

C4	Advantages	Disadvantages
	The river channel branched at this point but support towers can be constructed on the river banks and the main island which will limit the impact on the instream ecology	The river channel branched at this point and support towers will have to be constructed on the river banks and the main island which has the potential to an impact on the riparian vegetation of the system.
	The riparian vegetation zone on the main river banks is narrow and the impact of the support towers on the riparian vegetation and habitats can be avoided	Alien vegetation is a problem in the area and measures to control erosion will need to be ensured
	The instream habitat sensitivity at this point is limited in diversity and sensitivity and severe impacts on instream habitat is regarded as being limited.	Riparian vegetation at this point is in reasonable condition and impacts could lead to an alteration of the characteristics of the riparian zone vegetation

5.2.5.5 Conclusion

The anabranching river channel and relatively low RVI score means that this proposed crossing alternative is the second most suitable crossing point and will have a significantly lower impact on the receiving riparian zone environment than all of the other crossing points except for site C1. Due to the ability to place support towers on the river banks and island as well as the limited diversity and sensitivity of the instream habitat the risk to the instream habitat and aquatic community is regarded as being limited, provided that suitable mitigation is implemented. Based on these characteristics, this crossing point is recommended as a suitable alternative to cross the Orange River provided that measures to minimise the impacts on the riparian vegetation can be implemented and that riparian vegetation can be rehabilitated.

6. IMPACT ASSESSMENT

6.1 Impact identification and assessment

The tables below serve to summarise the significance of potential impacts on the aquatic integrity of the proposed rehabilitation sites. A summary of all potential construction, operational, rehabilitation and cumulative impacts is provided in Section 6.1. The sections below present the impact assessment according to the method described in Section 4.7 of the Materials and Methods. In addition, it also indicates the required mitigatory measures needed to minimise the impact and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures assuming that they are fully implemented.

IMPACT 1: IMPACTS ON INSTREAM FLOW

Pre-Construction	Construction	Operational
Placement of power line towers in the active channels of the river may cause local changes to instream flow patterns but not instream flow.	Vehicles accessing area through riparian area and area of natural bankside vegetation leading to altered streamflow patterns	Placement of power line towers in the active channels of the river may cause local changes to instream flow patterns but not instream flow
	Placement of power line towers in the active channels of the river may cause local changes to instream flow patterns but not instream flow	
	Incorrect rehabilitation and reshaping of the stream bed and banks	

Impacts on instream flow were seen to be characteristic of the aquatic resources in this area. Numerous dams, weirs and bridges occur along the systems in the area as a result of increasing farming and mining activities.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	3	2	4	1	5	7	35 (Low)
Managed	1	3	1	1	1	4	3	12 (Very Low)

Prior to mitigation there is a possibility of this impact occurring through the placement of support towers within the active river channel or in the riparian zone. Within the context the system with moderate level of ecological sensitivity the severity of the impact can be considered limited with ecosystem structure and function being unchanged. Without mitigation the duration of impact will be for the life of the infrastructure. Prior to mitigation the impact can be considered to be a low level impact. The impact will have a very limited extent of impact. With mitigation the probability, severity and duration of the impact can be significantly reduced leading to an overall very low level impact.

Recommended mitigation measures:

- No support structures should be constructed within the riparian areas or within the active stream channel. If at all possible all support structures should be developed above the 1: 50 year flood line and above the 1:10 year flood line as a minimum;
- During construction all building materials should be kept out of the riparian areas as well as the active stream channels;
- All waste and remaining building materials should be removed from site on completion of the project;
- No vehicles should be allowed to indiscriminately drive through the riparian areas or within the active stream channels. Movement on all midstream islands where indigenous vegetation occurs must be prohibited or limited as far as possible;
- If it is inevitable that support towers are to be developed within the active channels measures to ensure that the structures will cause limited turbulence must be ensured;
- The bed profile should be re-instated in such a way as to prevent incision and erosion in all areas that may be disturbed.

IMPACT 2: IMPACTS DUE TO SEDIMENTATION AND INCREASED TURBIDITY

Pre-Construction	Construction	Operational
Inadequate design of access roads as well as tower footprints.	Disturbance of soils resulting in erosion	Erosion caused by altered flow around the tower base.
Inadequate planning of rehabilitation	Removal of riparian vegetation	Obstacles in the riparian zone obstructing flow and causing a build-up of sediment.
	Obstacles in the riparian zone obstructing flow and causing a build-up of sediment.	
	Inadequate rehabilitation of the riparian zone	

Impacts due to sedimentation can be significant and have the potential to affect the biodiversity and functioning of the system although the Orange River can be considered to be resilient to sedimentation in the vicinity of the study area. Specific issues can be impacts on taxa requiring a rocky substrate clear of sediment and taxa requiring fast flowing water with limited amounts of suspended solids. With disturbance of the soils associated with the project, there is a risk of sedimentation of the aquatic resources occurring. This impact is defined below

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	2	2	4	1	4	7	28 (Low)
Managed	1	2	1	1	1	3	3	9 (Very Low)

Prior to mitigation there is a possibility of this impact occurring through the placement of support towers within the active river channel or in the riparian banks. In addition there is a risk that construction access roads could lead to disturbances of vegetation and soils which in turn could lead to sedimentation. Within the context the system with moderate level of ecological sensitivity the severity of the impact can be considered limited with ecosystem structure and function being unchanged. Without mitigation the duration of impact will be for the life of the infrastructure. Prior to mitigation the impact can be considered to be a low level impact. The impact will have a very limited extent of impact. With mitigation the probability, severity and duration of the impact can be significantly reduced leading to an overall very low level impact.

Recommended mitigation measures:

- As far as possible no activities, with special mention of access roads, should occur within the riparian zones of stream channels as well as the stream channels themselves;
- The duration in which soils are exposed during construction activities should remain as short as possible;
- Concurrent rehabilitation is to take place as far as possible and footprint areas should be minimised as far as possible;
- All areas affected by construction should be rehabilitated upon completion of the construction phase of the development;
- River banks must be appropriately re-profiled and re-vegetated with indigenous grasses and trees such as (*Searsia lancea, Searsia pyroides, Acacia karroo, Olea europaea* subsp. *africana* and *Cynodon dactylon* and *Panicum maximum*) as required. Steep banks should be stabilised with hessian sheets.
- Adequate stormwater management must be incorporated into the design of the proposed upgrade in order to prevent erosion and the associated sedimentation of the riparian and instream areas, as these systems have aquatic communities which rely on stream substrates clear of sediment and on, fast flowing water over rocky substrates.
    - During the construction and operational phases of the proposed upgrade, erosion berms should be installed to prevent gully formation and siltation of the riparian resources. The following points should serve to guide the placement of erosion berms:
    - Where the track has slope of less than 2%, berms every 50m should be installed.
    - Where the track slopes between 2% and 10%, berms every 25m should be installed.
    - Where the track slopes between 10%-15%, berms every 20m should be installed.
    - Where the track has slope greater than 15%, berms every 10m should be installed.

IMPACT 3: IMPACTS ON INSTREAM HABITAT AND REFUGIA FOR AQUATIC SPECIES

Pre-Construction	Construction	Operational
Planning of towers within channels which regularly become inundated.	Direct impact on instream habitats	Ongoing use of access roads during the operational phase of the power line
Planning of construction temporary access roads through channels in the river	Sedimentation may lead to a loss of deeper refuge pools and erosion impacts may lead to loss of overhanging vegetation.	Erosion caused by stormwater runoff causing siltation in a downstream direction.
	Erosion may cause the formation of large dongas leading to flow impediments and loss of wetland habitat.	
	Inadequate rehabilitation of access roads and footprint areas	

Impacts on instream habitat has the potential to be significant and has the potential to affect the biodiversity and functioning of the system through the loss of instream habitat and refuge areas for aquatic biota. Disturbances caused by activities within the riparian zone, vegetation clearing and soil disturbance are the key activities which could lead to this impact.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	3	2	4	1	5	7	35 (Low)
Managed	1	3	1	1	1	4	3	12 (Very Low)

Prior to mitigation there is a possibility of this impact occurring through the placement of support towers within the active river channel or in the riparian banks. In addition there is a risk that construction access roads could lead to disturbances of vegetation and soils which in turn could lead to sedimentation. During the operational phase ongoing use of access roads for maintenance may lead to impacts on instream habitat and refugia for aquatic biota. Within the context the system with moderate level of ecological sensitivity the severity of the impact can be considered limited with ecosystem structure and function being unchanged. Without mitigation the duration of impact will be for the life of the infrastructure. Prior to mitigation the impact can be considered to be a low level impact. The impact will have a very limited extent of impact. With mitigation the probability, severity and duration of the impact can be significantly reduced leading to an overall very low level impact.

Recommended mitigation measures:

- The time in which soils are exposed during construction activities should remain as short as possible.
- As small an area should be disturbed as possible.
- No unnecessary support structures should be constructed within the riparian zones or active stream channels.
- During construction all construction materials should be kept out of the riparian or wetland zones.
- All waste and remaining building materials should be removed from site on completion of the project.
- No vehicles should be allowed to indiscriminately drive through the riparian or wetland zones.
- In any areas where disturbance of river channels or bankside vegetation occurs, bank and bed profile should be re-instated in such a way as reinstate predevelopment habitat conditions
- Adequate erosion control and siltation control measures should be put in place.
- Adequate stormwater management must be incorporated into the design of any construction access roads in order to prevent erosion and the associated sedimentation of the riparian and instream areas, as these systems have aquatic communities which rely on stream substrates clear of sediment and on, fast flowing water over rocky substrates.
  - During the construction and operational phases of the proposed upgrade, erosion berms should be installed to prevent gully formation and siltation of the riparian resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed.
  - Where the track slopes between 2% and 10%, berms every 25m should be installed.
  - Where the track slopes between 10%-15%, berms every 20m should be installed.
  - Where the track has slope greater than 15%, berms every 10m should be installed.

IMPACT 4: IMPACTS ON INSTREAM MIGRATORY CORRIDORS

Pre-Construction	Construction	Operational
Inadequate design of support towers and their placement within areas which are regularly inundated.	Stream bed modifications due to construction of temporary construction access roads	Stream bed modifications due to ongoing use of temporary construction access roads.

Both aquatic species such as fish, with special mention of the *Labeobarbus* species and *Labeo capensis* as well as species with an affinity for riverine systems such as certain avifaunal species, which may migrate along linear riverine features may be significantly affected by impacts on the aquatic resources within the area. The area has a moderate importance for the migration of aquatic species and unless, some impact on the migratory routes of fish and other species may occur as a result of activities associated with the proposed colliery development although the risk of these impacts are deemed unlikely.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	3	1	5	3	5	9	45 (Low)
Managed	1	3	1	2	1	4	4	16 (Very Low)

In the absence of suitable management and mitigation measures, impacts affecting instream migratory corridors are deemed to be low and will be largely limited to the construction phase of the project. Should adequate mitigatory measures be implemented to ensure the preservation of instream migratory corridors, impacts are deemed to be insignificant.

Recommended mitigation measures:

- No dumping or fires should occur within the riparian areas.
- Disturbance of the riparian areas should be avoided as far as possible.
- No support structures should be constructed within the riparian areas or river channels.

IMPACT 5: IMPACTS ON TAXA SENSITIVE TO CHANGES IN WATER QUALITY

Pre-Construction	Construction	Operational
Inappropriate positioning of support towers.	Direct impact on instream habitat due to access road construction and placement of support towers	Ongoing use of access roads for maintenance activities
Poor design and positioning of construction access roads.	Vegetation clearing and soil disturbance.	
	Pollution such as litter and any spills (both chemical and organic) may occur during the construction phase.	

Impacts on instream water quality can be significant and has the potential to affect the biodiversity and functioning of the system. Specific risks occur to taxa, which have an increased sensitivity to water quality changes, with special mention of increased dissolved salt loads as well as changes to the sediment load in the system. Disturbances caused by direct disturbance of instream habitats, vegetation clearing and soil disturbance are the key activities which could lead to this impact.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	3	2	4	1	5	7	35 (Low)
Managed	1	3	1	1	1	4	3	12 (Very Low)

Prior to mitigation there is a possibility of this impact occurring through the placement of support towers within the active river channel or in the riparian banks. In addition there is a risk that construction access roads could lead to disturbances of vegetation and soils which in turn could lead to sedimentation. During the operational phase ongoing use of access roads for maintenance may lead to impacts on instream habitat which in turn may have a local impact on more sensitive aquatic taxa. Within the context the system with moderate level of ecological sensitivity the severity of the impact can be considered limited with ecosystem structure and function being unchanged. Without mitigation the duration of impact will be for the life of the infrastructure. Prior to mitigation the impact can be considered to be a low level impact. The impact will have a very limited extent of impact. With mitigation the probability, severity and duration of the impact can be significantly reduced leading to an overall very low level impact.

Recommended mitigation measures:

- The time in which soils are exposed during construction activities should remain as short as possible.
- As small an area should be disturbed as possible. .
- No unnecessary support structures should be constructed within the riparian zones or active stream channels.
- During construction all construction materials should be kept out of the riparian or wetland zones.
- All waste and remaining building materials should be removed from site on completion of the project.
- No dumping should take place in or near the construction site.
- All spills should be immediately cleaned up and treated accordingly.
- No fires should be permitted on site.
- Appropriate sanitary facilities must be provided for the duration of the proposed development and all waste removed to an appropriate waste facility.

IMPACT 6: IMPACTS DUE TO INUNDATION

Pre-Construction	Construction	Operational
Inappropriate positioning of support towers.	Ponding upstream of the proposed upgrade due to loss of stream flow.	Ongoing use of access roads for maintenance activities
Poor design and positioning of construction access roads.	Alteration of bed and bank profiles.	
	Alteration of instream habitat conditions	
	Alteration of soil wetness profiles due to changes in topography	

The proposed power line construction, with special mention of the use of construction access roads, has the potential to alter bed and bank profiles which in turn can lead to inundation of the riverine systems in the vicinity of the proposed upgrade. Inundation can affect instream habitat conditions which in turn can affect aquatic biota. Inundation can also affect bankside and riparian vegetation which can die back due to altered soil wetness profiles.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	2	1	2	1	4	4	16 (Very low)
Managed	1	2	1	1	1	3	3	9 (Very Low)

Prior to mitigation there is a possibility of this impact occurring through the placement of support towers within the active river channel or in the riparian banks. In addition there is a risk that construction access roads could lead to disturbances of vegetation and soils which in turn could lead to sedimentation. During the operational phase ongoing use of access roads for maintenance may lead to impacts on instream habitat and refugia for aquatic biota. Within the context the system with moderate level of ecological sensitivity the severity of the impact can be considered limited with ecosystem structure and function being unchanged. Without mitigation the duration of impact will be for a few months during construction. Prior to mitigation the impact can be considered to be a low level impact. The impact will have a very limited extent of impact. With mitigation the probability, severity and duration of the impact can be significantly reduced leading to insignificant levels of significance.

Recommended mitigation measures:

- No unnecessary activities or structures should be allowed within the riparian zones and active river channels;
- Any areas disturbed during construction should ensure that natural drainage patterns are re-instated as far as possible;
- The natural drainage patterns must be encouraged as far as possible.

IMPACT 7: IMPACTS DUE TO CANALISATION AND EROSION

Pre-Construction	Construction	Operational
Planning of towers within channels which regularly become inundated.	Direct impact on instream habitats	Ongoing use of access roads during the operational phase of the power line
Planning of construction temporary access roads through channels in the river	Erosion may cause the formation of large dongas leading canalisation and erosion of the system.	
	Inadequate rehabilitation of access roads and footprint areas	

Impacts on instream habitat has the potential to be significant and has the potential to affect the biodiversity and functioning of the system through the loss of instream habitat and refuge areas for aquatic biota. Disturbances caused by activities within the riparian zone, vegetation clearing and soil disturbance are the key activities which could lead to this impact.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	2	3	2	5	2	5	9	45 (Low)
Managed	1	3	1	1	1	4	3	12 (Very Low)

Prior to mitigation there is a possibility of this impact occurring through the placement of support towers within the active river channel or in the riparian banks. In addition there is a risk that construction access roads could lead to disturbances of vegetation and soils which in turn could lead to sedimentation. During the operational phase ongoing use of access roads for maintenance may lead to impacts on instream habitat and refugia for aquatic biota. Within the context the system with moderate level of ecological sensitivity the severity of the impact can be considered limited with ecosystem structure and function being unchanged. Without mitigation the duration of impact could potentially occur beyond the life of the infrastructure. Prior to mitigation the impact can be considered to be a low level impact. The impact will have a limited extent of impact. With mitigation the probability, severity, extent and duration of the impact can be significantly reduced leading to an overall very low level impact.

Recommended mitigation measures:

- The time in which soils are exposed during construction activities should remain as short as possible.
- As small an area should be disturbed as possible. .
- No unnecessary support structures should be constructed within the riparian zones or active stream channels.
- During construction all construction materials should be kept out of the riparian or wetland zones.
- All waste and remaining building materials should be removed from site on completion of the project.
- No vehicles should be allowed to indiscriminately drive through the riparian or wetland zones.
- In any areas where disturbance of river channels or bankside vegetation occurs, bank and bed profile should be re-instated in such a way as reinstate predevelopment conditions;
- Adequate erosion control and siltation control measures should be put in place;
- Adequate stormwater management must be incorporated into the design of any construction access roads in order to prevent erosion and the associated sedimentation of the riparian and instream areas, as these systems have aquatic communities which rely on stream substrates clear of sediment and on, fast flowing water over rocky substrates;
    - During the construction and operational phases of the proposed upgrade, erosion berms should be installed to prevent gully formation

and siltation of the riparian resources. The following points should serve to guide the placement of erosion berms:

- Where the track has slope of less than 2%, berms every 50m should be installed.
- Where the track slopes between 2% and 10%, berms every 25m should be installed.
- Where the track slopes between 10%-15%, berms every 20m should be installed.
- Where the track has slope greater than 15%, berms every 10m should be installed.

IMPACT 8: ALIEN VEGETATION ENCROACHMENT

Pre-Construction	Construction	Operational
Inadequate design of proposed river crossings and placement of infrastructure	Removal of indigenous vegetation	Encroachment of terrestrial vegetation
Failure to develop an alien vegetation control strategy.	Colonisation of disturbed river banks by invasive and opportunistic species	Loss of indigenous vegetation
	Failure to effectively implement the alien vegetation control strategy	Failure to monitor efficiency of alien control strategy

Construction and introduction of foreign material such as soils may lead to the introduction of alien invader species, impacting on the floral characteristics of the river banks; while construction related activities could lead to vegetation disturbance that may result in the proliferation of alien and invasive species. Pioneer alien species that are adapted to growth in bare soil areas, may proliferate on exposed soils.

Unmanaged alien plant invasions have the capacity to change the structure and dynamics of vegetation communities and out-compete indigenous species, thus lowering species diversity and natural riparian habitat structures'.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	5	3	4	5	3	8	12	96 (Medium-high)
Managed	2	3	2	3	1	5	6	30 (Low)

Alien or invader floral infestation is likely to occur if unmitigated, and may occur after the project is completed and possibly affect the regional environment, resulting in a medium high significance. If mitigation measures are effectively implemented, the probability, severity, duration and scale of the impact can be reduced to result in a low significance.

Recommended mitigation measures:

- All tower footprint areas should remain as small as possible and should only encroach onto the river and banks if absolutely unavoidable.
- Proliferation and a further increase of alien and invasive species are expected within disturbed areas. These species should be eradicated and controlled to prevent their spread beyond the site boundary. Seed dispersal within the top layers of the soil within footprint areas, will have an impact on rehabilitation in the future and also needs to be controlled.
- Removal of the alien and weed species encountered on the property in order to comply with existing legislation (amendments to the regulations under the Conservation of Agricultural Resources Act, 1983 and Section 28 of the National Environmental Management Act, 1998). Removal of species should take place throughout the pre-construction, construction, operational, and rehabilitation/ maintenance phases.
- Species specific and area specific eradication recommendations:
  - Care should be taken within riparian areas with the choice of herbicide to ensure no additional impact due to the herbicide used.
  - Footprint areas should be kept as small as possible when removing large trees,
  - No vehicles should be allowed to drive through riparian areas during eradication of alien and weed species.

IMPACT 9: IMPACT ON RIPARIAN VEGETATION

Pre-Construction	Construction	Operational
Irresponsible design of river crossings and tower placements	Indiscriminate removal of indigenous riparian vegetation	Encroachment of terrestrial vegetation
Planning of construction access roads through riparian vegetation stands	Colonisation of disturbed river banks by invasive and opportunistic species	Loss of indigenous vegetation
	Erosion due to exposed soils and ineffective rehabilitation	Ineffective aftercare and maintenance

Indiscriminate clearing of riparian vegetation will have an impact on the riparian vegetation condition resulting in erosion, habitat degradation and landscape function reduction. Terrestrial vegetation encroachment is another highly significant problem in disturbed areas and this will need to be mitigated during the rehabilitation phase and during aftercare and maintenance.

Management	Probability of Impact	Sensitivity of receiving environment	Severity	Duration of impact	Spatial Scale	Likelihood	Consequence	Significance
Unmanaged	5	3	3	5	2	8	10	96 (Medium-high)
Managed	3	3	2	3	1	6	6	36 (Low)

Indiscriminate construction and vegetation clearing activities will have a definite impact on the receiving environment which may continue perpetually and have a local effect, resulting in a medium high impact significance. With mitigation, the probability, severity and spatial scale of the impact can be reduced, resulting in a low impact significance.

Recommended mitigation measures:

- All construction footprint areas should remain as small as possible and should not encroach onto sensitive riparian areas unless absolutely unavoidable.
- Proliferation of alien and invasive species is expected within disturbed areas. These species should be eradicated and controlled to prevent their spread beyond the proposed construction footprint areas. Alien plant seed dispersal within the top layers of the soil within footprint areas, that will have an impact on rehabilitation in the future, has to be controlled.
- All soils compacted as a result of construction activities falling outside the construction footprint areas should be ripped and profiled. Special attention should be paid to alien and invasive control within these areas. Alien and invasive vegetation control should take place throughout all phases of the power line development.
- Upon completion of the project, rehabilitation with indigenous species should be implemented in all affected riparian areas.

6.2 Impact assessment conclusion

Based on the above assessment it is evident that there are nine possible impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the proposed Orange River Power line crossing. The table below summarises the findings indicating the significance of the impacts before mitigation takes place as well as the significance of the impacts if appropriate management and mitigation takes place. From the table it is evident that prior to mitigation, most of the impacts are low to medium high level impacts, while if mitigation takes place the majority of the impacts can be reduced to very low level impacts.

Table 32: Summary of impact significance.

No	Impact	Prior to mitigation	Post mitigation
1	Impact on instream flow	Low	Very low
2	Impacts due to sedimentation	Low	Very low
3	Impacts on instream habitat and refugia for aquatic species	Low	Very low
4	Impacts on instream migratory corridors	Low	Very low
5	Impacts on taxa sensitive to changes in water quality	Low	Very low
6	Impacts due to inundation	Very low	Very low
7	Impacts due to canalisation and erosion	Low	Very low
8	Alien vegetation encroachment	Medium-high	Low
9	Impacts due to increased turbidity	Medium-high	Low

The points below serve to summarise the measures deemed necessary in order to ensure protection of the riparian and aquatic resources and to ensure environmental protection during the construction phase of the propose power line crossing.

- Flow continuity has already been affected due to channel and bed modifications in the form of instream-barriers and the existing Neusberg weir. It is considered essential that flow continuity not be further altered in the Orange River during the construction phase of the proposed development. This is necessary to ensure the ongoing viability of the aquatic communities downstream of the proposed power line crossing, which are dependent on the fair levels of flow in the system.
- The power line crossing design must ensure that the creation of turbulent flow in the system is minimised, in order to prevent downstream erosion. No support pillars should be constructed within the active channel.
- The duration of impacts on the stream should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised.
- During construction, erosion berms should be installed to prevent gully formation and siltation of the Orange River. This is necessary to ensure the ongoing viability of the aquatic communities downstream of the proposed crossing which are dependent on cobble substrates which are free of sediment deposition. There is already evidence of sedimentation at the site and further degradation of the river in this regard must be minimised and avoided.
- The following points should serve to guide the placement of erosion berms during the construction phase of the power line crossing:

    - Where the track has slope of less than 2%, berms every 50m should be installed.
    - Where the track slopes between 2% and 10%, berms every 25m should be installed.
    - Where the track slopes between 10%-15%, berms every 20m should be installed.
    - Where the track has slope greater than 15%, berms every 10m should be installed.
- All areas affected by construction should be rehabilitated upon completion of the construction phase of the power line crossing. Areas should be reseeded with indigenous grasses as required.
- During the construction phase, no vehicles should be allowed to indiscriminately drive through the riparian areas.
- No dumping of waste should take place within the riparian zone.
- No fires should be permitted near the bridge construction area.
- If any spills occur, they should be immediately cleaned up.
- The characteristics of the stream bed are likely to be altered locally. In particular, the rock and rubble created during the construction process is likely to have sharp edges, and not the smooth surfaces that are typically associated with river rocks and pebbles. All rock and rubble must be removed from the active stream channel once construction has been completed.
- All alien vegetation in the riparian zone should be removed upon completion of construction.
- Throughout the construction phase of the development, biomonitoring, using the same techniques as were used in this baseline report should be implemented in order to monitor the effects of the development on the aquatic systems present. Assessments should be undertaken on a quarterly basis. If the SASS and ASPT scores decrease by more than 15%, it should serve as an indication that the system is suffering harm and measures to minimise the impacts of the development on the system should be implemented.

The points below serve to summarise the measures deemed necessary in order to ensure protection of the riparian and aquatic resources and to ensure environmental protection during the operational phase of the proposed power line crossing.

- Any areas where bank failure is observed, due to the effects of the power line crossing, should be immediately repaired by reducing the gradient of the banks to a 1:3 slope.

- Bank vegetation cover should be monitored to ensure that sufficient vegetation is present to bind the bankside soils and prevent further bankside erosion.
- For a minimum period of three years after construction, active management of the crossing should take place to remove any recruited alien vegetation.

7 Conclusions & Recommendations

Based on the findings of this assessment several conclusions can be drawn on the Ecological Importance and Sensitivity and Present Ecological State of the system. Conclusions were drawn on the sensitivity of each proposed crossing alternative and the suitability of each crossing alternative for the construction of the crossing.

The study then identified nine potential impacts that the construction of the proposed power line crossing will have on the receiving aquatic environment. The report then highlighted the key mitigation measures deemed necessary in order to prevent and mitigate impacts on the receiving aquatic environment.

The Orange River is considered to be a tolerant system that is adapted to constantly changing substrate and bankside conditions as well as constant variation in flow. The system is also tolerant to changes in water quality with special mention of temperatures, dissolved salt and turbidity levels as water constituents change through the system.

The aquatic communities of the system are however intact with more sensitive aquatic macro-invertebrate and fish populations still present and as such as much as the system is considered to be tolerant, it must also be considered to be sensitive to impacts that occur on the system.

It is therefore deemed essential that any proposed activities which could affect the system be comprehensively assessed to define and understand the impacts and in order to ensure that suitable and sufficient mitigation measures are put in place to protect the system throughout the life of the project and associated infrastructure.

Based on the consideration of habitat integrity and the characteristics of the crossing points with special mention of riverine structure and stream braiding, riparian zone integrity and instream habitat, two suitable crossing point alternatives were identified and three sites were identified which were considered less suitable as crossing points as follows:

- Crossing alternative 1: highly suitable for proposed crossing
- Crossing alternative 2: not suitable as a crossing point
- Crossing alternative 3: moderately suitable as a crossing point however the crossing should take place to the west of the existing road bridge
- Crossing alternative 4: suitable as a crossing point provided that care is taken with tower placement to prevent impacts on riparian vegetation
- Crossing alternative 5: suitable as a crossing point provided that care is taken with tower placement to prevent impacts on riparian vegetation

Based on the impact assessment it is evident that there are nine possible impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the proposed Orange River Power line crossing. From the impact analyses it is evident that prior to mitigation, most of the impacts are low to medium high level impacts, while if mitigation takes place the majority of the impacts can be reduced to very low level impacts while the impacts on form alien vegetation encroachment and increased turbidity can be reduced to low levels.

The report highlights key management and mitigation measures in order to prevent and minimise impacts on the receiving aquatic environment.

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Appendix 1: IHAS score sheets September 2012

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: ORANGE RIVER
Site Name: C03 **Date**: 19/09/2012

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			**19**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				**10**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				**13**	
	HABITAT TOTAL (MAX 55):				**42**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					**28**
	TOTAL IHAS SCORE (%):				**70**	

Appendix 2: SASS5 score sheets September 2012

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 19/09/2012	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E:	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: CO3	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5		A	A	B
RIVER: Orange River	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2			A	A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1			1	1
WEATHER CONDITION: WARM CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 21.4 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.41	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 8.78 mg/l	Atyidae	8		A		A	Veliidae/M...veliidae*	5					Muscidae	1				
Cond: 34.2 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5			C	C
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1 sp	4					Hydropsychidae 1 sp	4			B	B	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	B	C	B	C	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13			A	A	Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9			A	A	**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9			A	A	Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		12	34	60	77
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		1	5	9	12
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		12.00	6.80	6.67	6.42
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		%			
	Coenagrionidae	4		A		A	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		1		1	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

Appendix 3: Fish assemblage Integrity Index Calculations

	EXPECTED DATA	Tolerance	Health rating	Expected score
	SPECIES	CO3	CO3	CO3
EXPECTED	*Austroglanis sclateri*	2.7		
	Barbus paludinosus	1.8		
	Barbus anoplus	2.6		
	Labeobarbus aeneus	2.5		
	Labeobarbus kimberleyensis	2.5		
	Labeo capensis	3.2		
	Labeo umbratus	2.3		
	Pseudocrenilabrus philander	1.3		
	Tilapia Sparrmanii	1.3		
	Clarias gariepinus	1.2		
	Cyprinus carpio	1.4		
	Micropterus salmoides	2.2		
	Gambussia affinis	2		
	SUM	27	5	135
	OBSERVED DATA	Tolerance	Health rating	Observed score
	SPECIES	CO3	CO3	CO3
OBSERVED	*Austroglanis sclateri*			
	Barbus paludinosus			
	Barbus anoplus			
	Labeobarbus aeneus	2.5		
	Labeobarbus kimberleyensis			
	Labeo capensis	3.2		
	Labeo umbratus			
	Pseudocrenilabrus philander			
	Tilapia Sparrmanii			
	Clarias gariepinus	1.2		
	Cyprinus carpio			
	Micropterus salmoides			
	Gambussia affinis			
	SUM	6.9	5	34.5
				25.6

Appendix 4: Riparian Vegeation Index Scoresheets

Appendix A1 – Riparian Vegetation Index Data and Calculations: C1

RIPARIAN VEGETATION INDEX (RVI)

A. Site details

River:	Orange River	Date:	18/09/2012
Site No:	1	Assessors:	E vd Westhuizen
Site Name:	C1		
Location (GPS):	S28°46'10.41" E20°42'15.57"	Elevation:	

B. Riparian vegetation index details

RVI score calculation

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where:

EVC = Extent of vegetation cover

SI = Structural intactness

PCIRS = Percentage cover of indigenous riparian species

RIRS = Recruitment of indigenous riparian species

Riparian Vegetation Index Details:

			RVI Score	14.7
EVC Score	8		PCIRS Score	1.8
SI Score	0.94		RIRS Score	5

C. RVI Score, assessment class and its description

RVI Score	Assessment Class	Description
19 to 20	A	Unmodified conditions, natural state
17 to 18	B	Largely natural with few modifications
13 to 16	C	Moderately modified
9 to 12	D	Largely modified
5 to 8	E	Extensive loss of the natural habitat
0 to 4	F	Critical level of modifications, almost a complete loss of natural habitat

D. Riparian ecosystem state variables

Channel type	Anabranching

Width of potential riparian zone	LHB = ca. 75m; RHB = ca. 40m Islands = ca. 25m
Substrate	50% bedrock, 40% rock and gravel, 10% sand
Disturbances	Erosion/ incision
	Alien encroachment
	Agriculture
Surrounding land use	Rural agricultural
Dominant cover	Approximately: grass 20%; trees/shrubs 50%; reeds 20%; forbs 10%
Indigenous species richness	Medium-High Diversity
Exotic species richness	Low diversity; low abundance

Evidence of riparian ecosystem functioning:	
Channel bank stability	Medium; most banks covered in grasses, trees or reeds.
Flood attenuation potential	Medium; the absence of dense reeds and extensive riparian banks lessen flood attenuation potential.
Filtering potential (water quality)	Medium; reeds and sedges present
Habitat provision	Available: Indigenous woody vegetation provide suitable habitat for diversity of faunal and floral species

RVI SCORE CALCULATIONS

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where: EVC = Extent of vegetation cover
SI = Structural intactness
PCIRS = Percentage cover of indigenous riparian species
RIRS = Recruitment of indigenous riparian species

The final score is out of 20 (comparable to the six Ecological Reserve Assessment Classes)

EVC

EVC: determined by calculating the mean score of the EVC1 and EVC2, by two alternative methods:

EVC1 - Combined vegetation cover score out of 10 for the LHB, RHB & islands (if present)

Percentage vegetation cover (all vegetation)

Percentage score	0%	1-5%	6-25%	26-50%	51-75%	76-100%	
EVC score	0	2	4	6	8	10	8

EVC2 - Total site disturbance score (out of 10) Natural vs disturbed

% score			Disturbed	Natural			
EVC score	0	2	4	6	8	10	8

EVC Score (out of 10) = [(EVC1 + EVC2)/2]		8

SI

SI is determined with reference to the following scoring table of vegetation distribution for *Present State* VS *Perceived Reference State*

Perceived reference state vs present state

	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

Trees	2
Shrubs	3
Reeds	3
Sedges	3
Grasses	3
Bare ground	3

SI Score (out of 1) = [((SI1 + SI2 + SI3 + SI4 + SI5 + SI6) /6) * 0.33]	0.94

PCIRS

Percentage cover of indigenous riparian species (PCIRS): Scoring system for the cover of exotic species, terrestrial species & reeds

Cover score	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

If no indigenous riparian spp are present at the site, the PCIRS (min) = 0

Exotic species	2
Terrestrial species	2
Reeds	3
PCIRS score (out of 5) = [(EVC/2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]	1.8

RIRS

Recruitment of indigenous riparian species (RIRS), the recruitment of positive significance and importance at a site is that of indigenous riparian species, particularly the dominant species present (by biomass)

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

RIRS VALUE	5

RIPARIAN VEGETATION INDEX SCORE	14.7	**CLASS**	C

Appendix A2 – Riparian Vegetation Index Data and Calculations: C2

RIPARIAN VEGETATION INDEX (RVI)

A. Site details

River:	Orange River	Date:	18/09/2012
Site No:	2	Assessors:	E vd Westhuizen
Site Name:	C2		
Location (GPS):	S28°45’31.62” E20°48’56.03”	Elevation:	

B. Riparian vegetation index details

RVI score calculation

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where:

EVC = Extent of vegetation cover

SI = Structural intactness

PCIRS = Percentage cover of indigenous riparian species

RIRS = Recruitment of indigenous riparian species

Riparian Vegetation Index Details:

			RVI Score	17.3
EVC Score	9		PCIRS Score	3.3
SI Score	0.99		RIRS Score	5

C. RVI Score, assessment class and its description

RVI Score	Assessment Class	Description
19 to 20	A	Unmodified conditions, natural state
17 to 18	B	Largely natural with few modifications
13 to 16	C	Moderately modified
9 to 12	D	Largely modified
5 to 8	E	Extensive loss of the natural habitat
0 to 4	F	Critical level of modifications, almost a complete loss of natural habitat

D. Riparian ecosystem state variables

Channel type	Anabranching

Width of potential riparian zone	LHB = ca. 60m; RHB = ca. 70m Islands = ca. 100m
Substrate	30% bedrock, 30% rock and gravel, 40% sand
Disturbances	Erosion/ incision
	Alien encroachment
	Agriculture
Surrounding land use	Rural agricultural
Dominant cover	Approximately: grass 5%; trees/shrubs 45%; reeds 50%;
Indigenous species richness	Medium-High Diversity
Exotic species richness	Low diversity; low abundance

Evidence of riparian ecosystem functioning:	
Channel bank stability	Moderate to high; most banks covered in grasses, trees or reeds.
Flood attenuation potential	Moderately high to high; the presence of dense reeds and extensive riparian banks increase flood attenuation potential.
Filtering potential (water quality)	Medium to high; reeds and sedges present
Habitat provision	Available: Indigenous woody and reed vegetation provide suitable habitat for diversity of faunal and floral species

RVI SCORE CALCULATIONS

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where: EVC = Extent of vegetation cover
SI = Structural intactness
PCIRS = Percentage cover of indigenous riparian species
RIRS = Recruitment of indigenous riparian species

The final score is out of 20 (comparable to the six Ecological Reserve Assessment Classes)

EVC

EVC: determined by calculating the mean score of the EVC1 and EVC2, by two alternative methods:

EVC1 - Combined vegetation cover score out of 10 for the LHB, RHB & islands (if present)

Percentage vegetation cover (all vegetation)

Percentage score	0%	1-5%	6-25%	26-50%	51-75%	76-100%	
EVC score	0	2	4	6	8	10	10

EVC2 - Total site disturbance score (out of 10) Natural vs disturbed

% score			Disturbed	Natural			
EVC score	0	2	4	6	8	10	8

EVC Score (out of 10) = [(EVC1 +		9

EVC2)/2]		

SI

SI is determined with reference to the following scoring table of vegetation distribution for *Present State* VS *Perceived Reference State*

Perceived reference state vs present state

	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

Trees	3
Shrubs	3
Reeds	3
Sedges	3
Grasses	3
Bare ground	3

SI Score (out of 1) = [((SI1 + SI2 + SI3 + SI4 + SI5 + SI6) /6) * 0.33]	0.99

PCIRS

Percentage cover of indigenous riparian species (PCIRS): Scoring system for the cover of exotic species, terrestrial species & reeds

Cover score	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

If no indigenous riparian spp are present at the site, the PCIRS (min) = 0

Exotic species	1
Terrestrial species	1
Reeds	2
PCIRS score (out of 5) = [(EVC/2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]	3.3

RIRS

Recruitment of indigenous riparian species (RIRS), the recruitment of positive significance and importance at a site is that of indigenous riparian species, particularly the dominant species present (by biomass)

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

RIRS VALUE	5

RIPARIAN VEGETATION INDEX SCORE	17.3	**CLASS**	**B**

Appendix A3 – Riparian Vegetation Index Data and Calculations: C3

RIPARIAN VEGETATION INDEX (RVI)

A. Site details

River:	Orange River	Date:	18/09/2012
Site No:	3	Assessors:	E vd Westhuizen
Site Name:	C3		
Location (GPS):	S28°46'10.41" E20°59'20.67"	Elevation:	

B. Riparian vegetation index details

RVI score calculation

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where:

EVC = Extent of vegetation cover

SI = Structural intactness

PCIRS = Percentage cover of indigenous riparian species

RIRS = Recruitment of indigenous riparian species

Riparian Vegetation Index Details:

			RVI Score	13
EVC Score	8		PCIRS Score	1.2
SI Score	0.83		RIRS Score	4

C. RVI Score, assessment class and its description

RVI Score	Assessment Class	Description
19 to 20	A	Unmodified conditions, natural state
17 to 18	B	Largely natural with few modifications
13 to 16	C	Moderately modified
9 to 12	D	Largely modified
5 to 8	E	Extensive loss of the natural habitat
0 to 4	F	Critical level of modifications, almost a complete loss of natural habitat

D. Riparian ecosystem state variables

Channel type	Anabranching
Width of potential riparian zone	LHB = ca. 40m; RHB = ca. 50m Islands = ca. 30m

Substrate	50% bedrock, 40% rock and gravel, 10% sand
Disturbances	Landscaping activities
	Alien encroachment
	Vegetation clearing
	Infrastructure upgrades
Surrounding land use	Residential (Urban)
Dominant cover	Approximately: grass 25%; trees/shrubs 30%; reeds 40%; forbs 5%
Indigenous species richness	Medium-High Diversity
Exotic species richness	Low diversity; moderate abundance

Evidence of riparian ecosystem functioning:	
Channel bank stability	Moderate to high; most banks covered in grasses, trees or reeds.
Flood attenuation potential	Moderate to high; the presence of reeds and extensive riparian banks increase flood attenuation potential.
Filtering potential (water quality)	Medium; reeds and sedges present
Habitat provision	Available: Indigenous woody vegetation and reed beds provide suitable habitat for diversity of faunal and floral species.

RVI SCORE CALCULATIONS

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where: EVC = Extent of vegetation cover
SI = Structural intactness
PCIRS = Percentage cover of indigenous riparian species
RIRS = Recruitment of indigenous riparian species

The final score is out of 20 (comparable to the six Ecological Reserve Assessment Classes)

EVC

EVC: determined by calculating the mean score of the EVC1 and EVC2, by two alternative methods:

EVC1 - Combined vegetation cover score out of 10 for the LHB, RHB & islands (if present)

Percentage vegetation cover (all vegetation)

Percentage score	0%	1-5%	6-25%	26-50%	51-75%	76-100%	
EVC score	0	2	4	6	8	10	10

EVC2 - Total site disturbance score (out of 10) Natural vs disturbed

% score			Disturbed	Natural			
EVC score	0	2	4	6	8	10	6

EVC Score (out of 10) = [(EVC1 + EVC2)/2]		8

SI

SI is determined with reference to the following scoring table of vegetation distribution for *Present State* VS *Perceived Reference State*

Perceived reference state vs present state

	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

Trees	2
Shrubs	2
Reeds	3
Sedges	3
Grasses	2
Bare ground	3

SI Score (out of 1) = [((SI1 + SI2 + SI3 + SI4 + SI5 + SI6) /6) * 0.33]	0.83

PCIRS

Percentage cover of indigenous riparian species (PCIRS): Scoring system for the cover of exotic species, terrestrial species & reeds

Cover score	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

If no indigenous riparian spp are present at the site, the PCIRS (min) = 0

Exotic species	3
Terrestrial species	3
Reeds	2
PCIRS score (out of 5) = [(EVC/2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]	1.2

RIRS

Recruitment of indigenous riparian species (RIRS), the recruitment of positive significance and importance at a site is that of indigenous riparian species, particularly the dominant species present (by biomass)

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

RIRS VALUE 4

RIPARIAN VEGETATION INDEX SCORE	13	**CLASS**	**C**

Appendix A4 – Riparian Vegetation Index Data and Calculations: C4

RIPARIAN VEGETATION INDEX (RVI)

A. Site details

River:	Orange River	Date:	18/09/2012
Site No:	4	Assessors:	E vd Westhuizen
Site Name:	C4		
Location (GPS):	S28°45'31.62" E20°59'20.67"	Elevation:	

B. Riparian vegetation index details

RVI score calculation

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where:

EVC = Extent of vegetation cover

SI = Structural intactness

PCIRS = Percentage cover of indigenous riparian species

RIRS = Recruitment of indigenous riparian species

Riparian Vegetation Index Details:

			RVI Score	17.3
EVC Score	9		PCIRS Score	3.3
SI Score	0.99		RIRS Score	5

C. RVI Score, assessment class and its description

RVI Score	Assessment Class	Description
19 to 20	A	Unmodified conditions, natural state
17 to 18	B	Largely natural with few modifications
13 to 16	C	Moderately modified
9 to 12	D	Largely modified
5 to 8	E	Extensive loss of the natural habitat
0 to 4	F	Critical level of modifications, almost a complete loss of natural habitat

D. Riparian ecosystem state variables

Channel type	Anabranching

Width of potential riparian zone	LHB = ca. 60m; RHB = ca. 60m Islands = ca. 60m
Substrate	30% bedrock, 500% rock and gravel, 20% sand
Disturbances	Erosion/ incision
	Agriculture
Surrounding land use	Rural agricultural
Dominant cover	Approximately: grass 5%; trees/shrubs 45%; reeds 50%;
Indigenous species richness	Medium-High Diversity
Exotic species richness	Low diversity; low abundance

Evidence of riparian ecosystem functioning:	
Channel bank stability	Moderate to high; most banks covered in grasses, trees or reeds.
Flood attenuation potential	Moderately high to high; the presence of dense reeds and extensive riparian banks increase flood attenuation potential.
Filtering potential (water quality)	Medium to high; reeds and sedges present
Habitat provision	Available: Indigenous woody and reed vegetation provide suitable habitat for diversity of faunal and floral species

RVI SCORE CALCULATIONS

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where: EVC = Extent of vegetation cover
SI = Structural intactness
PCIRS = Percentage cover of indigenous riparian species
RIRS = Recruitment of indigenous riparian species

The final score is out of 20 (comparable to the six Ecological Reserve Assessment Classes)

EVC

EVC: determined by calculating the mean score of the EVC1 and EVC2, by two alternative methods:

EVC1 - Combined vegetation cover score out of 10 for the LHB, RHB & islands (if present)

Percentage vegetation cover (all vegetation)

Percentage score	0%	1-5%	6-25%	26-50%	51-75%	76-100%		
EVC score	0	2	4	6	8	10		10

EVC2 - Total site disturbance score (out of 10) Natural vs disturbed

% score			Disturbed	Natural				
EVC score	0	2	4	6	8	10		8

EVC Score (out of 10) = [(EVC1 + EVC2)/2]			9

SI

SI is determined with reference to the following scoring table of vegetation distribution for *Present State* VS *Perceived Reference State*

Perceived reference state vs present state

	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

Trees	3
Shrubs	3
Reeds	3
Sedges	3
Grasses	3
Bare ground	3

SI Score (out of 1) = [((SI1 + SI2 + SI3 + SI4 + SI5 + SI6) /6) * 0.33]	0.99

PCIRS

Percentage cover of indigenous riparian species (PCIRS): Scoring system for the cover of exotic species, terrestrial species & reeds

Cover score	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

If no indigenous riparian spp are present at the site, the PCIRS (min) = 0

Exotic species	1
Terrestrial species	1
Reeds	2
PCIRS score (out of 5) = [(EVC/2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]	3.3

RIRS

Recruitment of indigenous riparian species (RIRS), the recruitment of positive significance and importance at a site is that of indigenous riparian species, particularly the dominant species present (by biomass)

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

RIRS VALUE	5

RIPARIAN VEGETATION INDEX SCORE	17.3	**CLASS**	**B**

Appendix A5 – Riparian Vegetation Index Data and Calculations: C5

RIPARIAN VEGETATION INDEX (RVI)

A. Site details

River:	Orange River	Date:	18/09/2012
Site No:	5	Assessors:	E vd Westhuizen
Site Name:	C5		
Location (GPS):	S28°46'10.41" E20°11'12.32"	Elevation:	

B. Riparian vegetation index details

RVI score calculation

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where:

EVC = Extent of vegetation cover

SI = Structural intactness

PCIRS = Percentage cover of indigenous riparian species

RIRS = Recruitment of indigenous riparian species

Riparian Vegetation Index Details:

			RVI Score	10.33
EVC Score	7		PCIRS Score	0.5
SI Score	0.66		RIRS Score	3

C. RVI Score, assessment class and its description

RVI Score	Assessment Class	Description
19 to 20	A	Unmodified conditions, natural state
17 to 18	B	Largely natural with few modifications
13 to 16	C	Moderately modified
9 to 12	D	Largely modified
5 to 8	E	Extensive loss of the natural habitat
0 to 4	F	Critical level of modifications, almost a complete loss of natural habitat

D. Riparian ecosystem state variables

Channel type	Anabranching
Width of potential riparian zone	LHB = ca. 30m; RHB = ca. 30m

Substrate	30% bedrock, 40% rock and gravel, 30% sand
Disturbances	Earthmoving activities
	Alien encroachment
	Vegetation clearing
	Topographic alteration
Surrounding land use	Rural agricultural
Dominant cover	Approximately: grass 30%; trees/shrubs 325%; reeds 40%; forbs 5%
Indigenous species richness	Moderate Diversity
Exotic species richness	Low diversity; moderate to high abundance

Evidence of riparian ecosystem functioning:	
Channel bank stability	Moderate, evidence of stabilising activities observed. Very steep banks in some areas.
Flood attenuation potential	Moderate; vegetation clearing has decreased flood attenuation potential.
Filtering potential (water quality)	Medium; reeds present
Habitat provision	Available: Reed beds provide suitable habitat for diversity of faunal and floral species.

RVI SCORE CALCULATIONS

The RVI formula is:

RVI = [(EVC) + (SI x PCIRS) + (RIRS)]

Where: EVC = Extent of vegetation cover
SI = Structural intactness
PCIRS = Percentage cover of indigenous riparian species
RIRS = Recruitment of indigenous riparian species

The final score is out of 20 (comparable to the six Ecological Reserve Assessment Classes)

EVC

EVC: determined by calculating the mean score of the EVC1 and EVC2, by two alternative methods:

EVC1 - Combined vegetation cover score out of 10 for the LHB, RHB & islands (if present)

Percentage vegetation cover (all vegetation)

Percentage score	0%	1-5%	6-25%	26-50%	51-75%	76-100%	
EVC score	0	2	4	6	8	10	8

EVC2 - Total site disturbance score (out of 10) Natural vs disturbed

% score			Disturbed	Natural			
EVC score	0	2	4	6	8	10	6

EVC Score (out of 10) = [(EVC1 + EVC2)/2]		7

SI

SI is determined with reference to the following scoring table of vegetation distribution for *Present State* VS *Perceived Reference State*

Perceived reference state vs present state

	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

Trees	2
Shrubs	2
Reeds	2
Sedges	2
Grasses	2
Bare ground	2

SI Score (out of 1) = [((SI1 + SI2 + SI3 + SI4 + SI5 + SI6) /6) * 0.33]	0.66

PCIRS

Percentage cover of indigenous riparian species (PCIRS): Scoring system for the cover of exotic species, terrestrial species & reeds

Cover score	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

If no indigenous riparian spp are present at the site, the PCIRS (min) = 0

Exotic species	3
Terrestrial species	3
Reeds	3
PCIRS score (out of 5) = [(EVC/2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]	0.5

RIRS

Recruitment of indigenous riparian species (RIRS), the recruitment of positive significance and importance at a site is that of indigenous riparian species, particularly the dominant species present (by biomass)

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

RIRS VALUE	3

RIPARIAN VEGETATION INDEX SCORE	10.33	**CLASS**	**D**