Basic Assessment and Water Use Licence for a proposed 15km Water Pipeline on the Farm Sanddraai 391 –Surface Water and Riparian Assessment Study

Acwa Power

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Basic Assessment and Water Use Licence for a proposed 15km Water Pipeline on the Farm Sanddraai 391 –Surface Water and Riparian Assessment Study

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Approval: Bronwen Griffiths (PrSciNat – Environmental Science – 400169/11)

Signature

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Glossary of Terms

Aeolian	Wind-borne – i.e. referring to wind-borne and deposited materials, and erosion caused by wind
Alluvial Fan	An alluvial deposit that is typically fan-shaped that is formed by a stream or watercourse where its velocity is abruptly decreased, as at the mouth of a ravine or at the foot of a slope
Alluvial Material / Deposits	Sedimentary deposits resulting from the action of rivers, including those deposited within river channels, floodplains, etc.
Baseflow	The component of river flow that is sustained from groundwater sources rather than from surface water runoff
Calcrete	A type of rock cemented together by calcareous material, formed in soils in semi-arid conditions
Cumulative impact	The impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.
Environmental Impact Assessment (EIA)	In relation to an application to which scoping must be applied, means the process of collecting, organising, analysing, interpreting and communicating information that is relevant to the consideration of that application as defined in NEMA.
Ephemeral	A river or watercourse that only flows at the surface periodically, especially those drainage systems that are only fed by overland flow (runoff).
Episodic	Relating to rivers and watercourses typically located within arid or semi-arid environments that only carry flow in response to isolated rainfall events
Fluvial	Pertaining to rivers and river flow and associated erosive activity
Herbaceous	A plant having little or no woody tissue and persisting usually for a single growing season
Hydric Soils	(= Hydromorphic soils) Soils formed under conditions of saturation, flooding or ponding for sufficient periods of time for the development of anaerobic conditions and thus favouring the growth of hydrophytic vegetation.
Hydrology	The science encompassing the behaviour of water as it occurs in the atmosphere, on the surface of the ground, and underground.
Hydroperiod	The term hydroperiod describes the different variations in water input and output that form a wetland, characterising its ecology – i.e. the water balance of the wetland
Interfluve	A watershed.
Phreatophyte	A plant with a deep root system that draws its water supply from near the water table.
Reach	A portion of a river
Riparian Area	the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas
Semi-desert	The transition zone between true desert and more mesic (moist) climatic areas, generally receiving annual rainfall in a range between 250 - 500mm/year. In terms of the Köppen climate classification, semi-desert climatic zones are intermediate between the desert climates and humid climates in ecological characteristics and agricultural potential.
Stream Order	A morphometric classification of a drainage system according to a hierarchy or orders of the channel segments. Within a drainage network the un-branched channel segments

which terminate at the stream head are termed as “first order streams”

Understorey The part of the forest / woodland which grows at the lowest height level below the canopy

Wrack (Flood Wrack) Material (primarily vegetative) that is transported along watercourses and rivers during floods, and which is typically deposited behind structures or large vegetation by the flood waters, especially at levels higher than the typical flow levels.

Specialist Declaration

I, **Paul da Cruz**, declare that I –

- act as a specialist consultant in the field of Surface Water assessment
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010;
- have and will not have any vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2010; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.

PAUL DA CRUZ

1 INTRODUCTION

Acwa Power has appointed **Royal HaskoningDHV** to undertake a **basic assessment study and water use licence application for a proposed 15km water pipeline**. The water pipeline received an Environmental Authorisation (EA) in March 2013 and its main use is to supply water to a solar power plant in the Groblershoop area of the Northern Cape. The need for a surface water study to be undertaken as part of the environmental studies (EIA substantive amendment and water use licence) was identified as the realigned portion of the pipeline crosses a number of surface water features that were not previously assessed as part of the original Basic Assessment Study.

The project is located in the Northern Cape, a highly arid part of South Africa. In this context drainage systems and their associated riparian zones are highly sensitive and environmentally important. Although not typically characterised by active flow of water, or the presence of hydric (wetland) soils, riparian zones of drainage features in this area are a critical component of the surface water drainage environment in the area, as they are distinct from the surrounding Karoo veld in terms of their species composition and physical structure. In the context of a semi-arid environment, these riparian environments are extremely sensitive as they are typically characterised by high levels of biodiversity and are critical for the sustaining of ecological processes as well as human livelihoods through the provision of water for drinking and other human uses. As such surface water resources and wetlands are specifically protected under the National Water Act, 1998 (Act No. 36 of 1998) and generally under the National Environmental Management Act, 1998 (Act No. 107 of 1998). In the context of the development of an underground water pipeline, the physical disturbance of these drainage systems and their riparian zones constitutes an important surface water-related impact. This report thus focuses on the potential impact of the proposed pipeline on the affected surface water features in the study area, and highlights how the potential impacts can be mitigated.

1.1 Aims of the Study (Project Terms of Reference)

The aims of the study are to:

- Assess the affected surface water features along the alignment alternatives in the field, to determine their characteristics using the VEGRAI Ecostatus tool.
- Delineate all riparian zones that are likely to be adversely affected by the proposed water pipeline.
- Determine the nature and degree of risk posed to surface water features by the proposed pipeline.
- Suggest suitable mitigation measures to ameliorate identified impacts.
- Comparatively Assess Alternatives and recommend preferred alternatives from a surface water perspective.

1.2 Assumptions and Limitations

This report has not assessed the potential impact of abstraction on the Orange River, as it is understood that this is being assessed under the auspices of a separate study.

This report only covers the realigned sections of the pipeline, and not the remainder of the original pipeline route, as this was previously assessed and an EA received in March 2013.

No design details of the infiltration gallery or proposed footprint at the Shalom abstraction point have been provided for assessment. It has thus not been possible to accurately assess the impact of this type of abstraction on the Orange River riparian zone.

1.3 Definition of Surface Water Features, Wetlands and Hydric Soils

1.3.1 Surface Water Features

In order to set out a framework in which to assess surface water features, it is useful to set out what this report defines as surface water resources. In this context the National Water Act is used as a guideline. The Act includes a number of features under the definition of water resources, i.e. watercourses, surface waters, estuaries and aquifers. The latter two do not apply as estuaries are marine features and this report does not consider groundwater, thus surface waters and water courses are applicable in this context. The Act defines a watercourse as (inter alia):

- a river or spring;
- a natural channel in which water flows regularly or intermittently;
- a wetland, lake or dam into which, or from which, water flows

The definition of a water course as used in the Act is taken to describe surface water features in this report. It is important to note that the Act makes it clear that **reference to a watercourse includes, where relevant, its bed and banks**. This is important in this report, as the riparian habitat associated with most linear drainage features in the study area have been included as an important part of surface water features and are thus given consideration in this report.

It is equally important to note that the Act does not discriminate on the basis of perenniality, and any natural channel, however ephemeral, is included within the ambit of water resources. This definition is applied in this report.

It should be noted that no wetlands were encountered in the study area due to the arid nature of the climate.

1.3.2 Riparian Habitat and Riparian Zones

The National Water Act defines riparian habitat as:

"the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas"

As detailed in the DWAF 2005 guidelines for the delineation of wetlands and riparian areas, riparian areas typically perform important ecological and hydrological functions, some of which are the same as those performed by wetlands (DWAF, 2005).

Riparian areas include plant communities adjacent to and affected by surface and underground water features such as rivers, streams, lakes, or watercourses. It is important to note that these areas may be a few metres wide along smaller systems or more than a kilometre in floodplains. Both perennial and non-perennial streams support riparian vegetation (DWAF, 2005).

Because riparian areas represent the interface between aquatic and upland ecosystems, the vegetation in the riparian area may have characteristics of both aquatic and upland habitats. Many of the plants in the riparian area require large volumes of water (moisture) and are adapted to shallow water table conditions. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high. This is certainly the case in riparian zones in the Karoo, as they typically contain trees and shrubs of a height, density and species diversity that is not present in the surrounding Karoo veld.

Riparian areas are important as they perform the following functions (DWAF, 2005):

- Storing water and thus assisting to reduce floods
- Stabilising stream banks
- Improving water quality by trapping sediment and nutrients;
- Maintaining natural water temperature for aquatic species;
- Providing shelter and food for birds and other animals;
- Providing corridors for movement and migration of different species;
- Acting as a buffer between aquatic ecosystems and adjacent land uses;
- Can be used as recreational sites; and
- Providing material for building, muti, crafts and curios.

These ecosystems may be considered 'critical transition zones' as they process substantial fluxes of materials from closely connected, adjacent ecosystems (Ewel *et al*, 2001).

As discussed below riparian habitat is important from a legislative perspective – in terms of the National Water Act. Section 3.3 of this document should also be referred to for a synopsis of the VEGRAI (Riparian Area Characterisation and Assessment) Template.

1.4 Legislative Context

The following section briefly examines the legislation that is relevant to the scope of the wetland assessment. The stipulations / contents of the legislation and policy that is relevant to the study are explored.

1.4.1 The National Water Act

It is important to note that water resources, including wetlands are protected under the National Water Act 36 of 1998 (NWA). Wetlands are defined as water resources under the Act. 'Protection' of a water resource, as defined in the Act entails:

- Maintenance of the quality of the quality of the water resource to the extent that the water use may be used in a sustainable way;
- Prevention of degradation of the water resource
- The rehabilitation of the water resource

In the context of the current study and the identification of pressures and threats acting on wetlands, the definition of pollution and pollution prevention contained within the Act is relevant. 'Pollution', as described by the Act is the direct or indirect alteration of the physical, chemical or biological properties of a water resource, so as to make it (inter alia)-

- Less fit for any beneficial purpose for which it may reasonably be expected to be used; or
- Harmful or potentially harmful to the welfare or human beings, to any aquatic or non-aquatic organisms, or to the resource quality.

The inclusion of physical properties of a water resource within the definition of pollution entails that any physical alterations to a water body, for example the excavation of a wetland or changes to the morphology of a water body can be considered to be pollution. Activities which cause alteration of the biological properties of a watercourse, i.e. the fauna and flora contained within that watercourse are also considered pollution.

In terms of section 19 of the Act owners / managers / people occupying land on which any activity or process undertaken which causes, or is likely to cause pollution of a water resource must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring. These measures may include measures to (inter alia):

- Cease, modify, or control any act or process causing the pollution
- Comply with any prescribed waste standard or management practice
- Contain or prevent the movement of pollutants
- Remedy the effects of the pollution; and
- Remedy the effects of any disturbance to the bed and banks of a watercourse

One of the key principles on which the National Water Act, as promulgated to replace the Water Act of 1956, was formulated was that that surface- and groundwater systems are indivisible from each other (le Maitre et al, 1999). This is important in the context of this report, as the drainage systems and their associated vegetation communities are understood to be sustained by the presence of not only surface water, but shallow groundwater which is very closely linked to surface water.

1.4.1.1 The National Water Act and Riparian Areas

Riparian habitat is afforded protection under the National Water Act in a number of ways. Firstly reference in the National Water Act to a watercourse includes its banks, on which riparian habitat is encountered. Riparian areas are thus afforded the same degree of protection as the rivers and channels alongside which they occur.

Riparian habitat is also important in the context of resource quality objectives that are a critical part of the Act. In terms of section 13(1) of the Act resource quality objectives must be determined for every significant water resource, and are central part of data type specifications relating to national monitoring systems and national information systems as determined in section 137(2) and section 139(2) of the Act respectively. Under Section 27 of the Act resource quality objectives must be taken into account in the issuing of any licence or general authorisation, and form a critical part of the duties of catchment management agencies. The purpose of resource quality objectives in the Act is to establish clear goals relating to the quality of the water resources. Resource quality is important in the context of riparian habitat as resource quality as defined in the Act means the quality of all aspects of a water resource and **includes the character and condition of the riparian habitat**. In terms of Section 26(4) of the Act, the need the conservation and protection of riparian habitat must be taken into account in the determination and promulgation of regulations under the Act.

The above stipulations of the Act have implications for the proposed development; as identified further on in this report the proposed development may be associated with certain direct or indirect impacts on wetlands in the area, some of which may affect the physical characteristics of the wetlands. These impacts are likely to be needed to be licensed under the Act. The National Water Act also stipulates requirements for permitting which would need to be followed.

1.5 Bioregional Conservation Planning Context – National Freshwater Ecosystem Database

The National Freshwater Ecosystem Priority Areas (NFEPA) Database has been analysed in order to determine whether any of the potentially-affected surface water resources on the development have been classified as being nationally or regionally important.

It should be noted that none of the episodic watercourses located away from the Orange River have been designated as being surface water features of national or regional importance. The Orange River however has been designated as both a NFEPA River and Wetland. In terms of its NFEPA wetland classification (relevant to parts of its riparian zone as assessed in this report) it is a floodplain wetland. The reach of the river adjacent to the site has been assigned an ecological category of "C" – being moderately modified (refer to section 3.2 below for the EcoStatus classes). The reach is not one of the final wetland Freshwater Ecosystem Priority Areas (FEPAs) selected (reviewed at NFEPA National Stakeholder Review Workshop, July 2010), nonetheless the impacts of any development on this river should be considered of regional importance, and should be avoided or adequately mitigated.

2 PROJECT DESCRIPTION

2.1 Project Technical Description

The project's aim is to construct a water supply system to supply filtered water from the Orange River to the Bokpoort Solar Power Plant utilising the following components based on the topography of the pipeline route.

2.1.1 Abstraction Options

There are two options for the abstraction of water from the Orange River:

- a raft structure without a floating boom (technically preferred) that would be placed within the channel of the Orange River
- infiltration galleries (not technically preferred)

It should be noted that the location of the proposed abstraction is at the Shalom abstraction point (refer to Figure 2 below), and not at the previously assessed abstraction point close to the Sishen-Saldanha Railway Bridge.

2.1.1.1 Raft System

Under the raft system two river pumps mounted on a raft structure will extract water from the Orange River. Two pumps would be stationed on a stainless steel floating device (raft) which will be anchored to concrete blocks. These anchor blocks will be on both sides of the quick coupling pipes on the side of the embankment fill and will be used to connect the raft when the water level rises. The pumps will not operate simultaneously, but will be altered automatically. In the case of one pump failing, the other pump will serve as the backup. Stabilising of the river embankment at the raw water extraction point must be done by means of Gabions, Reno mattresses or stone pitching. Each pump is designed to deliver water at a flow rate of 210m³/hr from the extraction point. This is 10% more volume than required. Providing a higher flow in the raw water rising main than the clear water rising main will ensure that the storage reservoir is always full and that the pumps are not required to pump 24hr/day.

2.1.1.2 Infiltration Gallery

Infiltration galleries are abstraction systems based on the intake capacity of screens fed gravitationally from a saturated horizon that is located within the sediment of a river bed. The infiltration galleries comprise a concrete trough sunk in to the bedrock below the saturated horizon. The trough design will be in accordance with the screen layout required to achieve the desired length (i.e. volume). Accordingly multiple lengths can be joined via a manifold. The trough is filled with filter pack (rounded and semi rounded gravel) sorted to obtain the required permeability. The screens and all other ancillary parts are secured by anchoring them into the trough or bedrock. The construction is then covered to the initial level with the natural sediment. Pumping can be carried out by using a submersible pump. When natural conditions are suitable the gallery can be fed into a vertical well drilled on the highest terrace. This is always the preferred solution as it provides easy access to the submersible pump and the pumping unit is accessible and away from the flooded zone (is protected from flooding). The construction of this type of water supply system requires the mobilisation of heavy earth moving equipment which can work in unstable conditions (unconsolidated sediments). High volume earth moving is required sometimes to depths of 6m or more below the natural surface. In order to provide safe working conditions high volume dewatering pumps and lateral support must be part of the design.

2.1.2 Pipeline Technical Details

Once abstracted, the water will be pumped through a 250mm diameter uPVC pipeline over a distance of approximately 340m to a pump station. Upon entering the pump station, the water will be treated with a sand filtration system and then pumped into a sectional steel reservoir. The sand filters will backwash on a time and pressure differential principle and the backwash water will be flushed into a nearby pond. The clear water will then be pumped along the pipeline into 2 x 47 500m^3 storage ponds at the power plant using the clear water pumps in the pump station. The system will be automated as much as possible without utilising a telemetry system.

For the pipeline alignment away from the abstraction area, the required work area is a 10m corridor. The drawing below (Figure 1) indicates the typical profile of the pipeline.

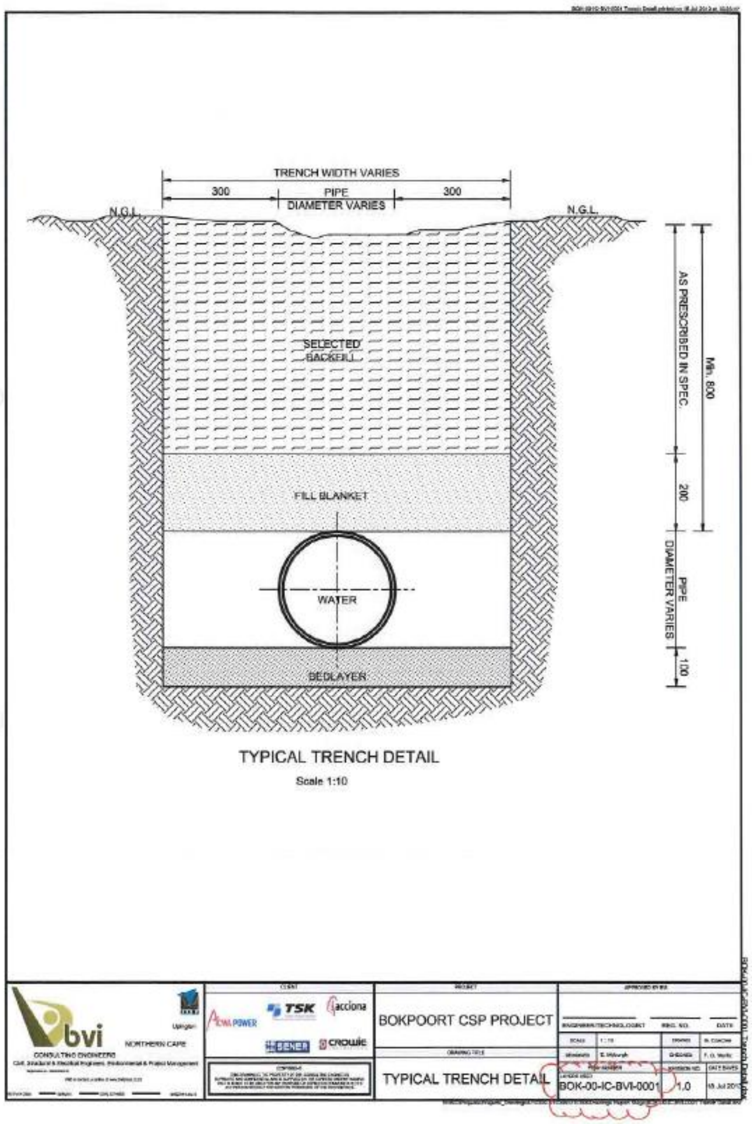

Figure 1 – Profile of the proposed pipeline trench

Once the pipeline has been laid, no vegetation with deep root systems will be allowed to occur over the pipeline.

2.1.3 Pipeline Alignment Alternatives

From the solar power plant, the pipeline is aligned roughly parallel to the Sishen-Saldanha Railway to a point east of the district road running parallel to, and east of the Orange River. From this point there are two alternatives (**refer to Figures 2&3 below**); under Alignment 1 the Pipeline continues in a westward alignment, crossing the district road and continuing to run roughly parallel to the railway and the Sanddraai Farmstead access road towards the river. At a point just to the south of Sanddraai Farmstead, Alignment 1 turns southwards under the railway to run along a local farm access track that runs parallel to the riparian zone of the Orange River towards the Glendana Farmstead. Alignment 1 intersects Alignment 2 close to the Shalom abstraction point and runs to the abstraction point on the river.

Alignment 2 originates along the original pipeline route to the east of the district road, running in a south-western direction immediately parallel to the farm (cadastral) boundary dividing the properties Sanddraai 391 and Bokpoort 390 and crossing both the Sishen-Saldanha Railway and the District Road. The alignment continues in a south-western direction along the cadastral boundary, turning westwards close to the Glendana Farmstead and intersecting Alignment 1 to the Shalom abstraction point.

2.2 Site Location and Description

The Study Site is located within the central part of the Northern Cape Province, being located to the north-west of the town of Groblershoop and to the south-east of Upington in the !Kheis Local Municipality. The area traversed by the pipeline route is rural in nature, with intensive cultivation occurring in a narrow strip alongside the Orange River. The remainder of the route comprises of rangeland that consists of sparse natural semi-desert vegetation, apart from the servitudes of the district road and railway line. The terrain along the route is flat along the Orange River corridor, becoming gently undulating away from the river. The pipeline route crosses a number of interfluves and valleys in rugged terrain, with the presence of dunes comprising of sand of aeolian origin along certain parts of the route. The Study area is indicated in Figures 2&3 below.

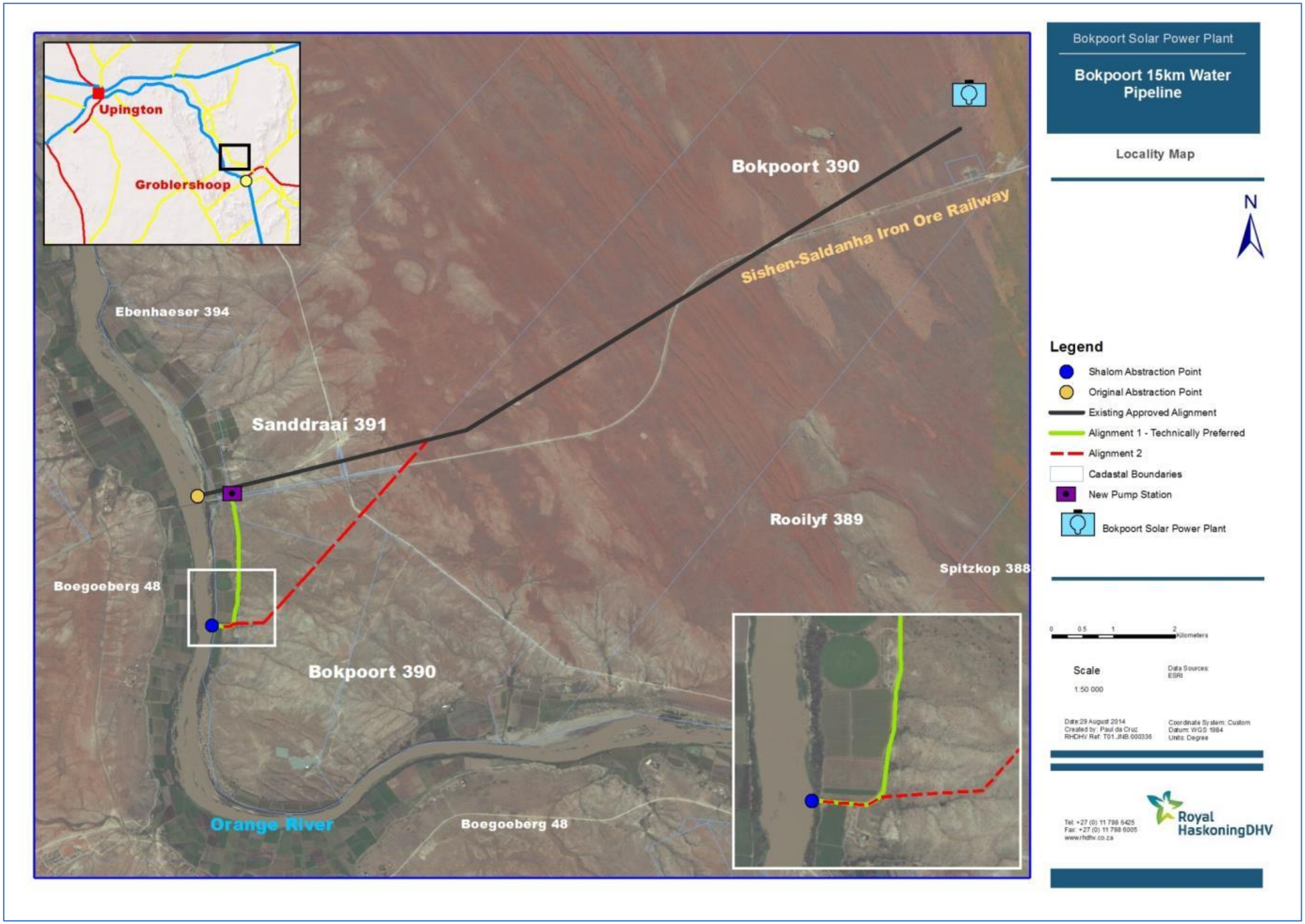

Figure 2 – Study Area

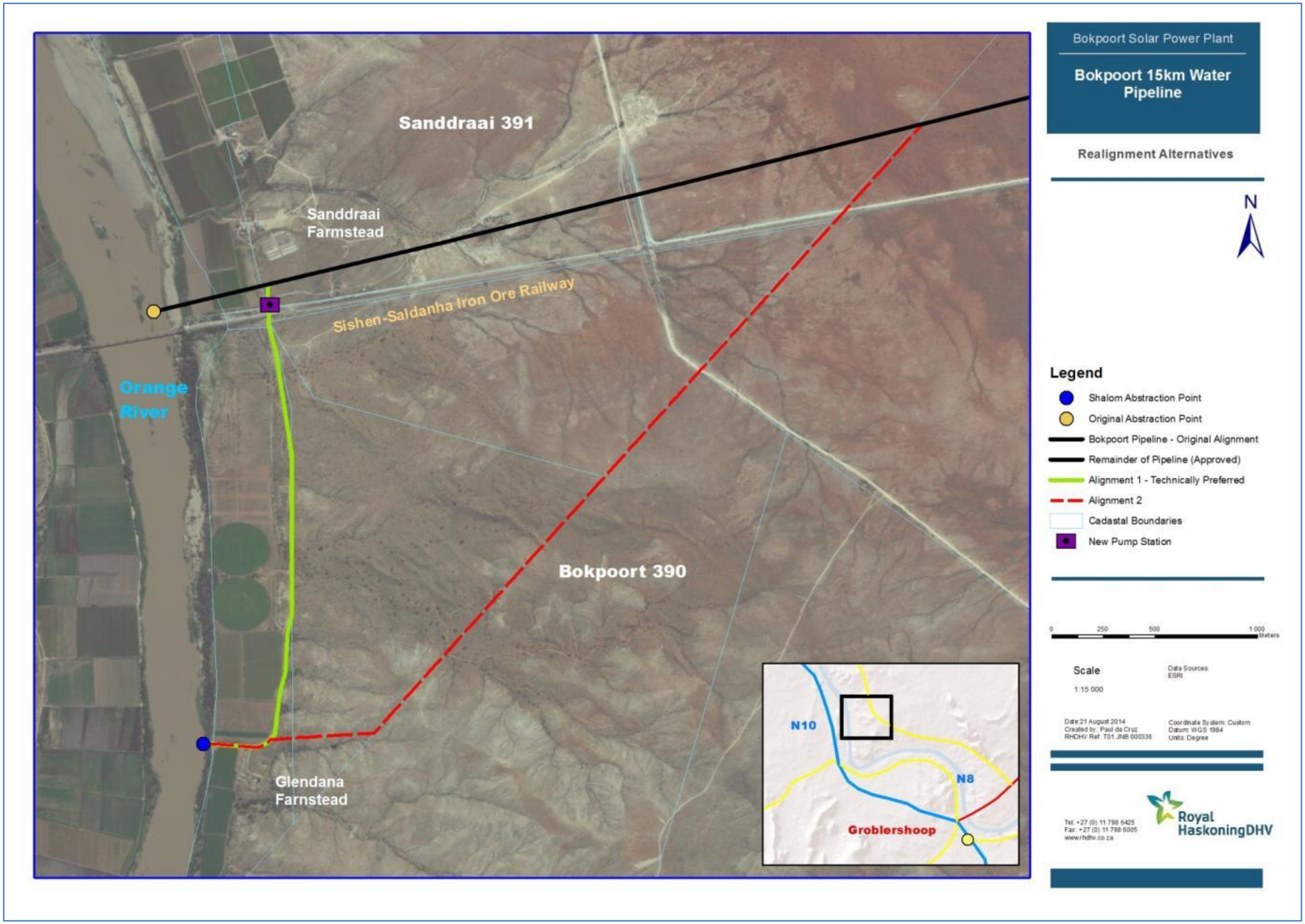

Figure 3 – Realigned Pipeline Alternatives

3 METHODOLOGY FOR ASSESSMENT

3.1 Field Assessment and Riparian Zone Delineation

A walk down of the realigned pipeline alternative route (Alignments 1 & 2) was undertaken in order to identify all surface water (drainage) features along it. Each watercourse crossed was assessed in the field, and a VEGRAI assessment was undertaken for the larger watercourses, as described below. Use was made of a GPS to identify important points (e.g. apparent boundaries of zones within the riparian corridors). These GPS points were converted into a GIS shapefile to allow these points to be mapped and to facilitate the delineation of the riparian boundaries.

3.2 Riparian Area characterisation and assessment template

The VEGRAI (Riparian Vegetation Response Assessment Index) assessment methodology (Kleynhans *et al*, 2007) was utilised as the primary tool to assess the riparian zones of the larger watercourses along Alignment 2. With the exception of the Orange River, all surface water features potentially affected by the proposed pipeline are ephemeral watercourses. The most important feature of these watercourses is their riparian corridor, and as such the VEGRAI tool was used to assess these features.

This section briefly introduces riparian zones in terms of the hydromorphological and vegetation classification as per the VEGRAI (Riparian Vegetation Response Assessment Index) assessment methodology (Kleynhans *et al*, 2007), which has been used to classify riparian zones in this report.

In terms of the VEGRAI structure, riparian areas are divided into three (3) vegetation zones:

- Marginal Zone
- Lower Zone
- Upper Zone

This vegetation zone classification has been based upon:

- Periodicity of hydrological influence
- Marked changes in lateral elevation or moisture gradients
- Changes in geomorphic structure
- Changes in plant species distribution or community composition along lateral gradients

In spite of these zones being vegetative, they are also distinguished based on a combination of other factors including geomorphic structure and elevation along with vegetation. Elevation within the riparian zone is used as a surrogate for hydrological activation, which is taken to be moistening or inundation of the substrate by water in the channel. The figure below (from Kleynhans *et al*, 2007) indicates a typical riparian zone:

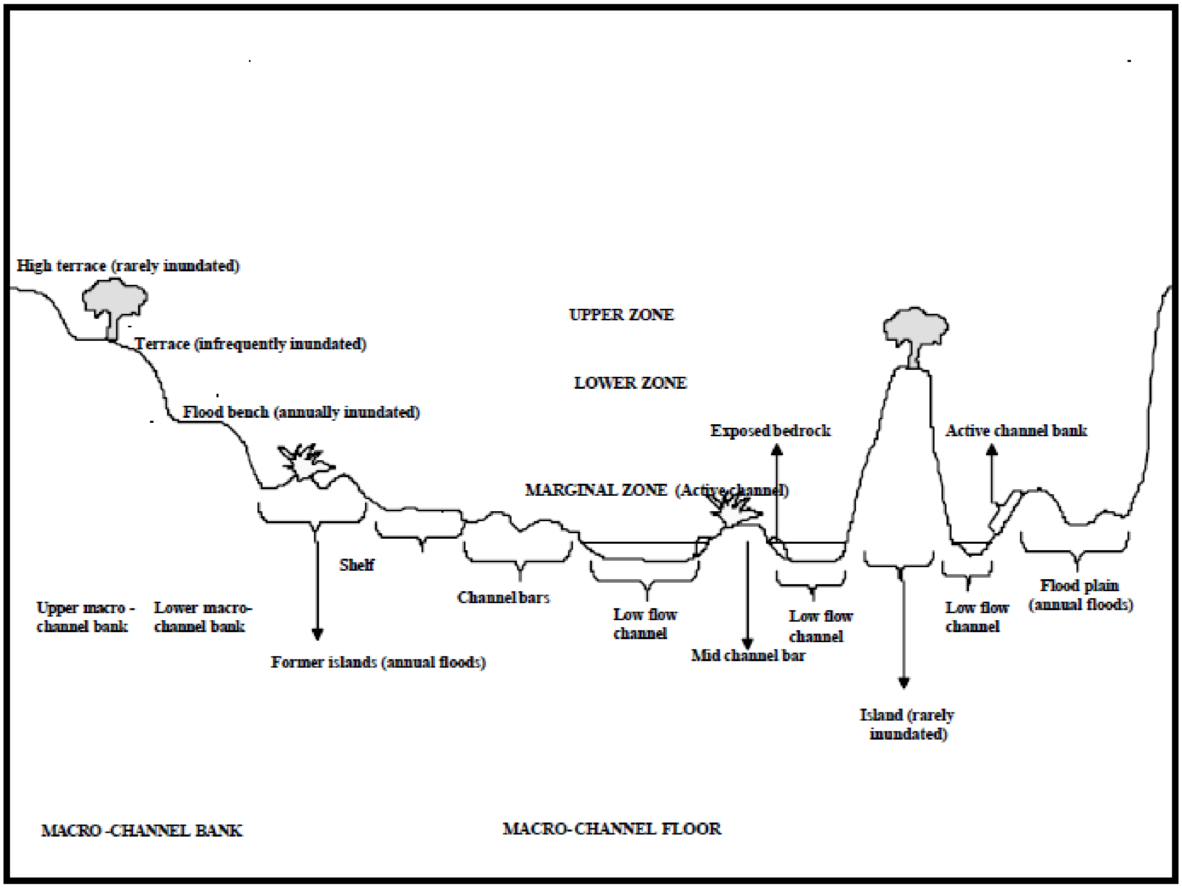

Figure 4 – Schematic diagram indicating the three zones within a riparian area relative to geomorphic diversity (Kleynhans et al, 2007)

3.2.1 Marginal Zone

The marginal zone incorporates the area from the water level at low flow (where present – if flow is not present areas that would be subject to baseflows would be included) to those features that are more or less permanently inundated. Vegetatively the marginal zone is typically characterised by the presence of hydrophytes that are vigorous in terms of abundance due to the near-permanent availability of moisture.

3.2.2 Lower Zone

The lower zone is the area of seasonal inundation (hydrological activation in this context is yearly inundation during high flows, or every 2-3 years), extending from the edge of the marginal zone to the point at which there is a marked increase in lateral elevation. This change in elevation may or may not be characterised by an associated change in species distribution patterns.

3.2.3 Upper Zone

The upper zone is characterised by hydrological activation on an ephemeral basis (less than every 3 years) and extends from the end of the lower zone to the end of the riparian corridor. The upper zone is usually characterised by steeper slopes and the presence of both riparian and terrestrial species, the latter typically having an enlarged structure as compared to the areas outside of the riparian area.

VEGRAI uses a number of metrics (measurement or ratings) for different riparian characteristics to define and rate riparian state:

- Abundance (how much indigenous vegetation there is under present condition)
- Cover (a measure of the extent to which the ground is covered by vegetation, and is measured as canopy cover)
- Recruitment (the arrival and establishment of new individuals into riparian populations / communities)
- Population structure (the relative abundance of life stages within respective populations of selected indicator species)
- Species composition (the arrangement of species in the riparian community that comprise the riparian assemblage in the study area)

All of these characteristics of riparian areas can be measured in terms of the level of divergence from what would be considered a reference state. Reference conditions for riparian zones are usually natural, i.e. conditions prior to significant human interaction with riparian structure and function. It is important that reference state be defined in terms of an understanding of the nature of impacts on a riparian corridor.

The VEGRAI methodology has defined six (6) different types of riparian vegetation to guide assessments of reference state:

- Tree-dominated state,
- Shrub-dominated state,
- Grass-dominated state,
- Herbaceous-dominated state,
- Reed-dominated state,
- Open-dominated state (substrate such as sand/rock).

There are degrees of flux between these different states that may be influenced by impacts on the riparian zone – e.g. the removal of woody vegetation from the riparian zone.

The key impacts that act on riparian zones include:

- **Vegetation Removal** – resulting in increases in water temperature, effecting aquatic primary production, and adversely affecting the ability of riparian areas to retain water
- **Exotic Invasion** – resulting in displacement of indigenous species and subsequently to a change in ecosystem properties, bank instability due to the exclusion of natural riparian vegetation due to vigorous growth, decrease of organic input, or a reduction in riparian habitat diversity

- **Water quantity change** (change in volume and seasonality of flows) – resulting in increased stream widths or down cutting of the streambed that can lead to the loss of riparian vegetation
- **Water quality change** – resulting in impacts on indigenous riparian plants and possible excessive growth of exotic riparian vegetation in the case of eutrophication.

Riparian zones can be divided up into a number of generic ecological categories based on their state of degradation (ecoStatus), as indicated in the figure below. The BVEGRAI EcoStatus Tool ascribes riparian reaches assessed into one of the following EcoStatus classes.

ECOLOGICAL CATEGORY	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 ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. 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	Seriously 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 the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

Figure 5 – EcoStatus Classes (Ecological categories)

3.3 Identification of Surface Water and Riparian Zone Impacts and Mitigation Measures

All potential impacts that could be caused by the proposed pipeline and that would affect surface water features along the realigned route have been identified. Impacts specifically relating to the placing of servitudes through riparian areas have been investigated.

Mitigation measures to either ensure that the identified impact does not materialise, or to ameliorate / limit the impact to acceptable levels have been stipulated.

4 SUMMARY OF STUDY AREA SURFACE WATER DRAINAGE AND CHARACTERISTICS

Rivers and wetlands are very important features of the natural landscape both in a hydrological and an ecological context. The freshwater ecosystems that occur within rivers and wetlands, as well as the associated riparian habitats, are very important in the context of biodiversity, as unique plant and animal communities occur within them. This is particularly important in the context of the semi-arid Great Karoo and Kalahari, where the availability of moisture in the vicinity of watercourses has led to the development of vegetation communities distinct from the surrounding veld types.

The study area is located in a semi-arid climatic zone, being located on the boundary between the Great Karoo and the Kalahari semi-desert and receives a mean annual rainfall figure of approximately 215mm (Source: SA Rainfall Atlas Database). There is a relatively strong seasonality in the rainfall figures, indicating that the area falls within the summer rainfall areas within the subcontinent; most of the rainfall occurs in the late summer / autumn between the months of January and April. The scarcity of rainfall and nature of precipitation also entails that rainfall events are episodic in nature, i.e. single rainfall events will contribute a relatively significant portion of rainfall.

In a macro drainage context, the study site is located adjacent to the Orange River, and thus occurs in the Lower Orange Water Management Area. The study site is located in the D73D quaternary catchment, a large quaternary catchment that encompasses a long reach of the Orange River from Kheis to the east of Groblershoop at the upstream end, to Lambrechtsdrift to the south-east of Upington at its downstream end, as well as a number of non-perennial tributaries of the Orange River along this reach of the river.

The primary surface water feature on the site is the Orange River, which runs in a north-south orientation on the study site. The proposed new abstraction point (Shalom) is located on the eastern bank of the Orange River, to the south of the Sanddraai Farmstead and the Sishen-Saldanha Iron Ore Railway Bridge, under which the previous abstraction point was located. To the east of the Orange River, the terrain rises up gently away from the riparian zone, with the landscape being gently undulating.

Away from the Orange River, the presence of surface water drainage in the area is dependent on slope and substrate. The eastern bank of the Orange River in the vicinity of the study area is characterised by the presence of rocky terrain that rises from the alluvial terrace within the Orange River valley bottom. The underlying geology in this area between the Orange River valley bottom (which is underlain by alluvium of recent geological age) and the district road consists of Quart-muscouite schist, quartzite, quart-amphibole schist and greenstone of the Brulpan Group of the Groblershoop Formation the with areas of relatively more resistant quartzite forming the low ridges (interfluves) in this area. Although this terrain is not very steeply sloping, there is a relatively high density of surface water drainage, with the presence of a number of first and second order drainage lines. However as one moves further away from the river, the terrain and substrate changes to being dominated by a highly sandy substrate, with the presence of low dunes (of Aeolian origin), or being defined by flat calcrete-dominated plains. This part of the study area (traversed by the portion of Alignment 2 to the north-east of the railway) is underlain by siliciclastic rocks of the Kalahari Group, with notable surface outcropping of calcrete. Parts of this area have been covered by wind-blown Kalahari sands, forming parallel-running dunes. This different geological substrate appears to be responsible for the flatter topography, in which a number of less incised drainage lines, or ‘washes’ exist. Where the highly porous sandy substrate occurs, surface water drainage is very poorly defined or even absent over large parts of this landscape type.

The two pipeline alternatives traverse the more sloping, rocky terrain located just behind the Orange River valley bottom. A number of ephemeral watercourses rise in this terrain, draining the valley bottoms between the low ridges in this area. Alignment 2 crosses a number of watercourses as it runs out of the Orange River riparian corridor and into the more undulating, rocky terrain away from the river. Alignment 1 runs parallel to the outer edge of the valley bottom (at the interface between the valley bottom and start of the footslopes) and thus similarly crosses a number of such watercourses that drain from the sloping area to the east of the Orange River valley bottom. Alignment 1 runs close to the outer edge of the Orange River riparian zone, and is thus likely to occur close to the interface between the alluvial sediments of the Orange River corridor and the schists as described in the above paragraph. The farm access track along which the pipeline alternative is proposed to be routed runs in the flat area at the valley bottom.

Figure 6 – Undulating topography in the vicinity of the valley bottom drained by the Crossing 2 watercourse

Alignment 2 crosses nine (9)[1] river crossings, as indicated on the map below, and Alignment 1 crosses (eight) 8[1] river crossings. Each crossing has been assigned a number.

Most of the watercourses crossed by Alignment 2 are very narrow first order watercourses in rocky terrain, but a lower order, larger watercourse with defined channel(s) and a well-defined riparian zone (Alt2_2) is crossed in the southern part of the alignment. More of the watercourses crossed by Alignment 1 are lower order streams with a well-defined riparian zone and channel due to its part of its alignment being located closer to the Orange River

[1] Both Alternative 1 and 2 cross the same watercourse, but each crossing has been labelled separately for this report.

valley bottom, however a number of poorly-defined drainage lines that drain a very small surface area are also crossed.

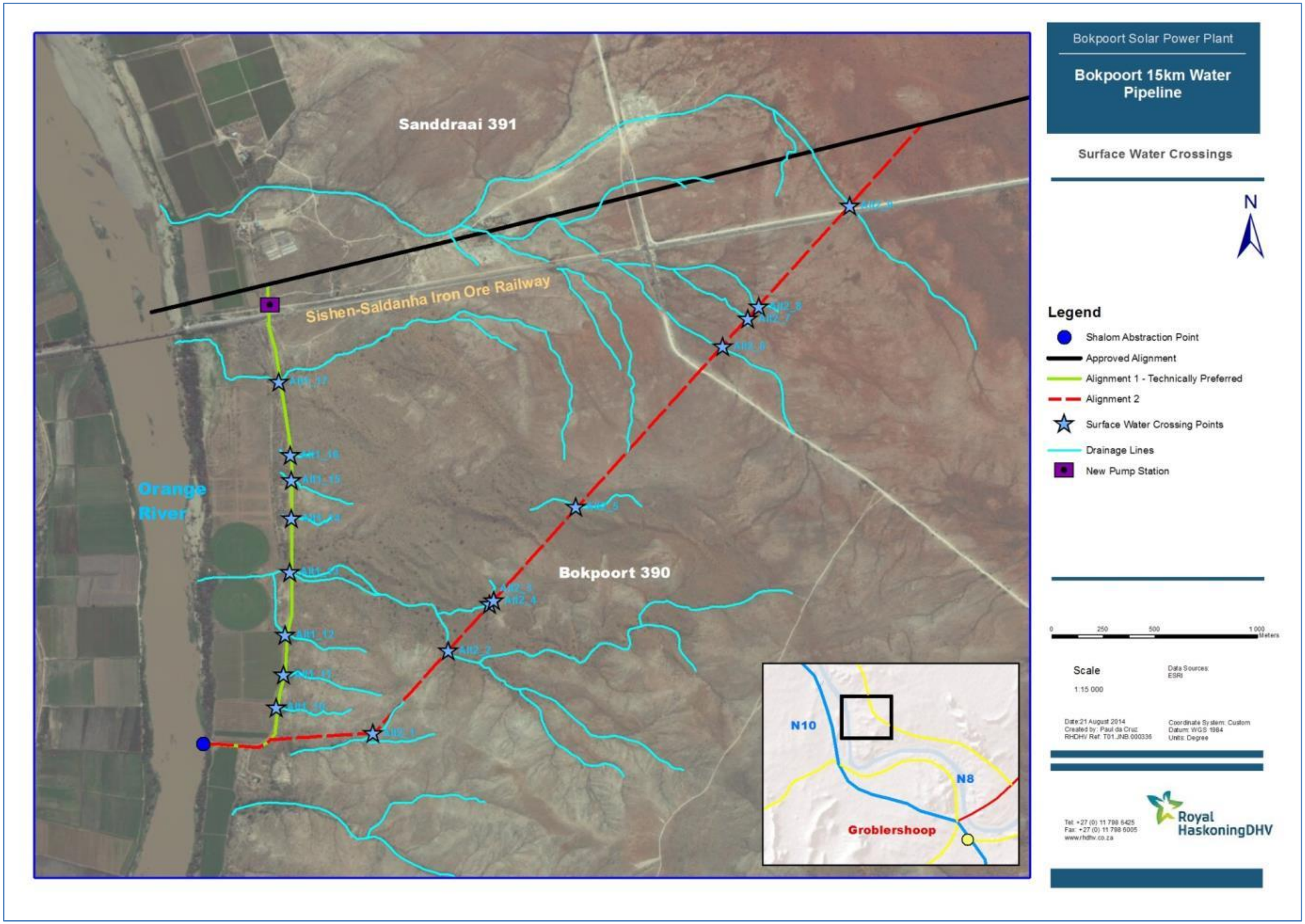

Figure 7 – Surface water drainage on the study site and location of surface water crossings along the two alternative alignments

5 PHYSICAL CHARACTERISTICS OF SURFACE WATER FEATURES IN THE STUDY AREA

This section describes the physical features of surface water features in the study area. Although the Orange River is affected through abstraction, the hydrological characteristics of this river are not explored in detail in this report as this is being assessed as part of a different study. Nonetheless the riparian characteristics of this river are assessed as the new abstraction point will be located with the Orange River riparian corridor. This section includes aspects of riparian zones as assessed through the VEGRAI tool.

5.1 Hydrology and Morphology of Ephemeral Watercourses in the study area

All watercourses on the study site with the exception of the Orange River are ephemeral / episodic. Flow regimes of rivers within the wider Succulent Karoo (a biome to the south-west of the study site, but with a similarly arid climate) are highly erratic with prominent temporal and spatial variability in flows even in the larger rivers (Le Maitre, *et al*, 2009). The nature of the soils in the catchments of watercourses and riparian areas, especially with respect to clay soils, entail that soil or mineral crusting (dispersed clay particles can form a 'cap' that significantly blocks infiltration into the soil – Esler *et al*, 2010) tends to be prevalent in overgrazed, bare areas. This has the result that when rainfall events occur there is a high degree of surface water runoff into the drainage systems, due to the reduced infiltration capacity in the soil. As a result the riverine habitats are naturally unstable and are subject to unpredictable flooding events, with consequent high levels of disturbance and soil movement (Palmer and Hoffamn, 1997). This is likely to be the case in the study area, as described above, as much of the study area is underlain by a rocky substrate and structured soils, on which a soil cap may have developed.

No evidence of active surface water flow was noted along any of the watercourses assessed in the field away from the Orange River, and all are likely to be strictly episodic, flowing only in response to rainfall events of sufficient duration and intensity. Evidence of periodic flow along these watercourses is provided primarily by the presence of wrack that is deposited on the upstream side of obstacles in the path of the watercourse, in particular the fence lines along which most of both pipeline alternative route run. In this context wrack is the (primarily vegetative) material washed down river courses during flood / spate flow events, and which is trapped behind branches and other obstacles, remaining in situ after the flood has passed. The evidence of wrack beyond the active channel indicates that these areas were inundated by flood waters and gives a good indication of the extent of higher / spate flows along the rivers in the study area. Although the presence of wrack does not provide an indication of the frequency of flooding, it does give an indication that a spate flow did occur along the water course, and the position of the wrack horizontally away from the channel, and vertically above the channel bed indicates the extent of the flooding and the volume of water that passed along the system, and is a reliable indicator of the extent of maximum hydrological activation and as such is a good indicator of the lateral extent of the riparian zone. Evidence of flow in the watercourses of the study area was also provided by the presence of water that had collected behind a dam wall across a watercourse in the southern part of the Alignment 2 alignment.

Figure 8 - Flood wrack trapped behind the fence line along which the realigned pipeline section runs at Crossing Alt2_6

Rainfall events of sufficient intensity are associated with significant runoff, and results in flows along the river systems for short periods of time. Once overland flow from the catchment area drops off, flows typically respond by decreasing and ceasing. Surface water is typically transpired into alluvial sediments, or is lost to evaporation. This hydrological regime of no surface baseflow punctuated by short-lined flow events in response to rainfall is typical of ephemeral watercourses, as found across the study area.

There is likely to be an interrelationship between groundwater and surface water in the watercourses of this semi-arid area. Although no extensive alluvial deposits were observed along all of the watercourses in the study area (only the larger watercourses were noted to be characterised by a wider, sandy bed comprising of deposited alluvial sediment), there is likely to be some form of hydrological connection between the watercourses and groundwater. Alluvium within rivers is hydrologically recharged by rain, surface water runoff, spring flow, flood recharge from rivers or by groundwater from the surrounding geology (IWR, 2011). In arid and semi-arid regions transmission losses of surface flow into alluvium can be substantial (IWR, 2011), and alluvial aquifers can hold relatively large volumes of water compared with rock-based aquifers where the water is confined to fractures and faults (le Maitre *et al*, 2009). Although not likely to exist on a large scale there is likely to be an element of such groundwater presence along watercourses located in valley bottoms, as evidenced by the presence of large trees which would depend on the presence of an underground water source. The presence of large trees (especially *Vachellia* (*Acacia) erioloba* and *Ziziphus mucronata*) along the larger watercourses cannot be attributed to surface flooding alone. This vegetation is likely to derive the majority of their required moisture inputs from alluvial groundwater. In the context of the delineation of riparian zones (as required by the regulatory requirements of the National Water Act) the hydrological connection between alluvial groundwater and surface flows along watercourses entails that the peripheries or areas beyond the primary channel(s) in which these larger shrubs and trees occur should be included as part of the riparian zone of the watercourse.

In a hydromorphological context most of the watercourses assessed in the field contained a main (active) channel, a feature of most fluvial systems. The high stream order of certain of the watercourses crossed by the pipeline alternatives is indicated by the relatively lack of incision and lateral extent of most of the channels of the watercourses crossed. The largest watercourse crossed (Crossing Alt2_2 and Crossing Alt1_13 at its downstream end) was characterised by a relatively un-incised central channel at the upstream crossing (Alt2_2), and narrow and shallow primary channel and a series of shallow side channels at the downstream crossing point (Alt1_13). Fluvial channels were not noted to be subject to significant degrees of channel bank erosion, and were well-vegetated. All channels were characterised by a sandy, alluvial substrate, with little vegetative cover. This alluvial substrate is likely to shorten the period of flow within the system following a rainfall event, as it would enhance the ability of overland flow entering and flowing down the system to permeate into the substrate. In the larger watercourses, especially upstream the access road along Alignment 1, the entire riparian corridor was noted to consist of alluvially-transported material (sand), with a number of interlinked / braided flow paths present within the wider 'bed' of the river. Evidence of the presence of deposition of pebbles and cobbles was noted in the main channel at crossing Alt1_13. Along Alignment 1 certain of the smaller watercourses drained through sandy substrate (low dunes) between the valley bottom and the rocky ground to the east, while the more southerly crossings located closer to the Shalom abstraction point drained through rocky terrain.

Figure 9 – Main channel of the watercourse at Crossing Alt2_2, looking upstream to the crossing point

Figure 10 – Narrow channel upstream of Crossing Alt1_15 in low duneveld, with the presence of rocky terrain upstream (in the background)

Some of the watercourses crossed by Alignment 2 – i.e. the north-most watercourses located along the pipeline route (between the district road and the railway) were very indistinctly defined in a hydromorphological context and displayed no evident of a channel. Rather these drainage systems are characterised by very diffuse overland flow during flow events, and as such could be termed as ‘washes’ rather than as classical watercourses. These watercourses were characterised by a clayey substrate which showed signs of previous wetting and drying at the surface.

Figure 11 – Vegetation and clayey soils within a 'wash' at Crossing Alt2_7

Along the two larger watercourses (crossings Alt2_2 & Alt1_13, and crossing Alt1_17) secondary lateral channels (note: all channels form part of the same watercourse crossing) were noted at the crossing point, The presence of these smaller lateral channel is indicative of the larger catchments of these two watercourses that has a potential to generate flows of greater volumes than some of the smaller watercourses with smaller catchments. The area between the primary channel and these smaller lateral channels was characterised by slightly higher-lying ground consisting of alluvially-deposited material, which would be termed as a bar or terrace in a hydromorphological context. These watercourses display the widest, most prominent riparian zones of all the watercourses crossed, as discussed further below.

Underlying substrate appears to have a bearing on the morphological form of the channels assessed, with channels in areas of rocky substrate being narrower and slightly more incised (e.g. crossing Alt2_1 and Alt1_12) than those where a sandy substrate (within the part of the study site where dunes and aeolian sand exists) – e.g. Crossing Alt2_2 or Alt1_15&16. Crossings Alt2_3 and Alt2_4 occur at the interface between such rocky substrate and aeolian substrate, with the watercourse's eastern bank and immediate catchment being characterised by rocky substrate covered with *Senegalia* (*Acacia) mellifera* shrubs, and the opposite (western) bank and catchment being akin to an uncovered dune face.

Figure 12 – Poorly defined drainage line (Alt2_5) looking downstream

In the context of the VEGRAI template, the delineation and zonation of the riparian zones of the watercourses can be undertaken based on the hydromorphological template that is evident for most of the watercourses crossed. Due to their episodic nature, the more simplistic zonation of the riparian corridor into two zones – the marginal zone and non-marginal zone is most appropriate. In all cases the marginal zone is not characterised by frequent hydrological activation, due to the ephemeral nature of the drainage systems, and thus a case could be made that the marginal zone in terms of definition based on hydrological activation would not exist in the study area. Nonetheless most of these systems display morphological indicators and vegetative indicators typical of the marginal zone. Thus the marginal zone is most suitably defined as being confined to the (narrow) channel, with the immediate channel banks or channel bar / terrace and secondary lateral channel (where present) comprising the non-marginal zone. Along the smaller systems, the non-marginal zone would be likely to be very narrow, due to the narrow extent of hydrological activation beyond the channel.

5.2 Vegetative Composition and Lateral Zonation of Ephemeral Watercourses

Riparian zones support distinctive vegetation that differs in structure and function from adjacent aquatic and terrestrial ecosystems. Riparian zones form the interface between aquatic and terrestrial ecosystems and, except in broad floodplains, are relatively narrow, linear features across the landscape (Holmes *et al*, 2005), as is the case in the study area. A number of processes shape riparian areas; especially disturbances associated with aquatic systems, such as flooding, debris flows and sedimentation processes (Tang & Montgomery, 1995). Riparian plants are typically adapted to fluctuations in the water-table, as river levels alternate between low base flows and floods (Holmes *et al*, 2005). However most of the rivers in the study area are episodic, with relatively scarce rainfall events causing short-lived periods of flow, as described above, and thus this vegetation along riparian zones in the study area does not need to be tolerant of frequent saturation. Rather shallow (alluvial) aquifers appear to be the main driver of riparian vegetation in the drainage systems within the study area, as explored above.

In the context of the Karoo (the wider area into which the study site falls), mean annual precipitation (MAP) is a key determinant of soil moisture availability which, in turn, together with soil fertility, has a controlling influence on the production of digestible biomass (Le Maitre *et al,* 2009).There are only a certain number of days in a year when soil moisture does not limit plant growth, thus the growing seasons are short (Le Maitre *et al,* 2009).The increased availability of sub-surface moisture in riparian areas of drainage systems in the Karoo accounts for the much denser and larger structure of plants as compared to surrounding upland areas. This is true of the study site as vegetation associated with the watercourses on the site differs in composition and structure from the surrounding upland shrubveld vegetation, although the presence of sandy substrate is an important driver of vegetation occurrence. This change in the vegetation composition and structure is an indication of the presence of the accumulation of both surface and groundwater (le Maitre et al, 2009).

The hydrology of the rivers and smaller drainage systems influences the vegetation through flooding, droughts and water-table fluctuations. Rivers are typically dynamic environments and flood events can change the channel structure and remove vegetation - riparian vegetation is shaped by disturbances associated with aquatic systems, such as flooding, debris flows and sedimentation processes (Holmes *et al*, 2005). Conversely fluvial processes can result in sediment deposition that provides new habitat for plant colonisation within the riparian zone. In the context of the study site, the nature of watercourses crossed, i.e. being mostly first order streams ensures that fluvial processes are not sufficiently well-developed to exert such an important effect on vegetation. Rather the presence of underground moisture appears to be more important in determining the structure and lateral composition of vegetation within riparian zones - the distribution of riparian vegetation types is primarily determined by gradients of available moisture and oxygen (Holmes *et al*, 2005). This is very important in the study area context - due to the ephemeral / episodic nature of most of the fluvial systems in the study area, riparian vegetation that occurs along these systems depends to a significant extent on groundwater availability to sustain the riparian vegetation communities. The relationship between riparian vegetation and groundwater is frequently complex; plants may source water stored in river banks or in alluvial aquifers. Moisture found within the substrate of drainage systems may emanate from periodic flooding that recharges into the aquifer or may be groundwater that discharges into the streams (le Maitre et al, 1999). The former is likely to be the case in the study area as discussed above.

Plants which are riparian specialists (referred to as obligate phreatophytes) are species adapted to fluctuating water tables; as such their roots typically remain in, or in contact with, the saturated soil layers (le Maitre et al, 1999). Although such species are typically vulnerable to long-term drawdown of groundwater levels due to over-abstraction (le Maitre *et al*, 1999), riparian plants are naturally adapted to fluctuations in the water-table, as river levels alternate between low base flows and floods (Holmes et al, 2005). A study by Milton (1990) demonstrated that rivers and associated riparian zones and washes had the highest plant species richness and structural diversity in the Karoo (in spite of occupying a minor percentage of the area), as compared to the surrounding plains and 'heuweltjies' (hillock) communities.

Figure 13 – *Ziziphus mucronata* tree in the non-marginal part of the riparian zone of Crossing Alt2_2

A number of lateral zones typically occur across the cross-sectional profile of a riparian zone, with the ability of plants to withstand flooding being an important determinant. This template is not typically expressed in the rivers of the wider Karoo and in the study area, as frequent flooding is not a significant factor, and access to underground water is more important. The most distinctive vegetative feature of all watercourses along the length of the pipeline alternatives is the presence of *Senegalia* (*Acacia) mellifera* shrubs. These typically lined the channel, forming a 10-15m wide strip of shrubs on either side of the channel, or occurring in small bush clumps. Along the two larger watercourses, in particular the largest watercourses, a few other shrub and even tree species were present on the margins of, and slightly away from the channel, including *Senegalia (Acacia) mellifera*, *Boscia albitrunca, Vachellia (Acacia) erioloba, and Ziziphus mucronata*. Smaller shrubs of the species *Lycium cinereum, Lycium oxycarpum* and *Nymania capensis* were encountered in the substratum close to the channel. *Senegalia (Acacia) mellifera* shrubs are found in non-riparian habitats on the site, especially in rocky terrain. However they do not occur as densely in this terrain as along watercourses, which reflects the relative supply of moisture along watercourses.

Channels and flow paths were typically noted to be un-vegetated, but lined with a relatively dense layer of grasses, of which *Stipagrostis namaquensis* was the most common, along with *Cenchrus ciliaris, Stipagrostis obtusa,* and *Stipagrostis ciliata.* The latter two species are not exclusively encountered along watercourses, but do occur in parts of the site where sandy soils of sufficient depth occur. In the largest watercourse at Crossing 2, where an intervening terrace is located between the primary channel and a lateral secondary channel, the sandy substrate on the terrace is densely vegetated by *Stipagrostis namaquensis.* A number of other shrub and succulent species found away from watercourses were also present in the non-marginal zone of the channel.

The VEGRAI tool requires that vegetation composition be assessed and differentiated between the marginal zone and non-marginal zones. The table below lists the vegetation species and type of plant (woody or non-woody) for the two most prominent watercourses in the area and their associated riparian zones.

Figure 14 – View into the riparian zone of Crossing Alt2_2 from its boundary, with dense stands of *Stipagrostis namaquensis* in the foreground and shrubs closer to the channel

Figure 15 – Boundary of the riparian zone of Crossing Alt2_6, showing the transition between the *Senegalia mellifera* shrub-dominated riparian zone and adjacent Karoo dwarf scrubland upland

Watercourse at Crossing Alt2_2				Watercourse at Crossing Alt2_6			
Marginal		**Non-Marginal**		**Marginal**		**Non-Marginal**	
Woody	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**
	Stipagrostis ciliata	*Senegalia mellifera*	*Stipagrostis ciliata*	*Senegalia mellifera*	*Cenchrus ciliaris*	*Senegalia mellifera*	*Cenchrus ciliaris*
	Stipagrostis namaquensis	*Vachellia erioloba*	*Cenchrus ciliaris*		*Stipagrostis ciliata*	*Lycium cinereum*	*Eriocephalus spinescens*
	Stipagrostis obtusa	*Ziziphus mucronata*	*Eragrostis lehmanniana*				*Pentzia incana*
		Boscia albitrunca	*Sacrostemma viminale*				*Rhigozum trichotomum*
		Nymania capensis					*Stipagrostis obtusa*
		Lycium cinereum					*Peliostomum leucorrhizum*
		Lycium oxycarpum					*Stipagrostis ciliata*
							Schmidtia pappophoroides
							Lycium cinereum
							Salsola tuberculata
							Fingerhuthia africana

Watercourse *upstream of* Crossing Alt1_13				Watercourse *upstream of* Crossing Alt1_17			
Marginal		**Non-Marginal**		**Marginal**		**Non-Marginal**	
Woody	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**
Ziziphus mucronata	*Eragrostis lehmanniana*	*Senegalia mellifera*	*Stipagrostis namaquensis*	*Vachellia erioloba*	*Stipagrostis namaquensis*	*Senegalia mellifera*	*Stipagrostis namaquensis*
	Osteospermum spp.	*Vachellia erioloba*	*Eragrostis lehmanniana*	*Lycium cinereum*	*Stipagrostis obtusa*	*Vachellia erioloba*	*Sacrostemma viminale*
		Lycium cinereum	*Osteospermum spp.*		*Osteospermum spp.*	*Ziziphus mucronata*	*Osteospermum spp.*
						Boscia albitrunca	
						Lycium oxycarpum	
						Lycium cinereum	

No alien invasive vegetation was noted along any of the watercourses assessed along Alignment 2, and only limited alien invasive vegetation was noted along Alignment 1 (with the presence of some *Prosopis spp.* trees in the road reserve along Alignment 1). This is an important factor in terms of the determination of the state of these watercourses, as the prevalence of alien vegetation within riparian vegetation can exert a significant impact on groundwater availability within riparian zones; groundwater is likely to be affected by deep-rooted alien invasive trees such as gums (*Eucalyptus spp.*), *Prosopis* and poplar (*Populus spp*.) (Milton, 2010).

5.3 State of Alteration of Ephemeral Watercourses

A basic distinction emerged between the state of the watercourses along Alignment 1 as opposed to those along Alignment 2. As discussed below, this is a significant factor in the comparative assessment of the two alternatives. The state of the watercourse reaches along Alignment 1 is substantially poorer than the state of the watercourses along Alignment 2. This is due to the significant, and often complete physical transformation of the watercourses along Alignment 1 as they enter the Orange River valley bottom, as detailed below. Alignment 2 runs along a cadastral boundary in an uninhabited part of the study area in which stock grazing occurs. Thus apart from certain potential impacts on these watercourses and their respective catchments due to livestock grazing pressure, the watercourses along Alignment 2 were noted to be subject to no pressures, and were concomitantly assessed to be in a state close to a reference state.

Alignment 1 runs along the edge of the zone of cultivation along the Orange River (along which a farm access track is aligned). The corridor adjacent to the river is subject to intense irrigated cultivation. In the study area a narrow band of riparian vegetation has typically been retained in the sloping area between the channel of the Orange River and a flat alluvial terrace lying behind. The flat terrace area extends from the current boundary of the riparian zone back from the river for a distance of approximately 200-280m. This terrace area has been completely transformed from a natural state with the establishment of orchards as well as a number of cultivated fields, some of which are irrigated centre pivots. It is also possible that this area has historically been levelled to facilitate the cultivation of crops and pastures and other irrigated areas.

This physical and vegetative modification of this alluvial terrace has exerted a severe impact on the numerous watercourses that naturally would have drained towards the Orange River from the higher-lying area to the east of the river. Under natural (pre-development) conditions these watercourses would have drained into the flatter valley bottom, either continuing to drain into the Orange River through its riparian zone, or could have formed an alluvial fan-like feature, naturally dissipating and draining (recharging) into the silty alluvial sediment on this terrace. However, with the exception of the most northerly watercourse (Alt1_17) all of the eight watercourses have been physically stopped from draining into the cultivated fields to the west of the access road. A berm of 2-3m in height consisting of soil and rocky material has historically been constructed along the outer boundary of the cultivated fields. Thus any water draining down the watercourses after draining over the farm access road will be impounded behind this berm, not reaching the fields behind. With the exception of the watercourse at Alt1_17, any evidence of any natural channels on the alluvial terrace now occupied by fields has been removed. In the case of the larger watercourse crossed at Alt1_13 (and at Alt2_2), the greater volume of flows down draining from this larger catchment necessitated further measures to manage the flows; two further retaining walls made of sand have been constructed along the width of the watercourse's riparian zone just upstream of the farm access road. These walls would likely help to impound flows temporarily in this area, before allowing them to drain through an opening on the northern side, across the access road and into the intervening area behind the rocky berm to prevent any water from flooding the fields behind. In the case of the northern-most watercourse (Alt1_17), a channel has been constructed downstream of the road, with an opening through the rocky berm. The modified channel drains through a vacant area cleared of vegetation and through a field, before entering the Orange River riparian zone.

Figure 16 – Berm / impounding wall (left) constructed across the width of the watercourse at Crossing Alt1_13, with area behind in which water is trapped

In all cases the watercourses have been significantly physically modified at the point at which they drain through fence separating the cultivated fields from the grazing camp. Along seven of the watercourses the hydrological regime of these watercourses has been completely modified, in that little or no surface water flow reaches the valley bottom. Complete physical (morphological) modification of the certain reaches of these drainage systems has occurred in that channels or natural depositional features have been completely removed. Lastly, the vegetative state of the affected reaches has been extensively modified, with the almost complete removal of naturally-occurring riparian vegetation (especially non-woody vegetation) that has left these reaches devoid of vegetation except for a few remnant trees and pioneer species which have colonised the area.

It is important to note that the pipeline along Alignment 1 crosses each of these eight watercourses across the reaches which have been modified. The pipeline runs immediately parallel to the farm access road on its upstream (eastern) side, thus crossing the watercourses at the point at which they become physically modified. Along the southern part of the alignment, the pipeline is routed along the current rocky berm, and thus any evidence of a surface water feature has been removed. However the watercourses will continue to drain into this area, and although in practical terms crossings Alt1_10-12 are no longer surface water crossings, the design of the pipeline will have to consider the need to manage these periodic flows down the system.

This degree of physical modification of these watercourses along Alignment 1 is an important factor, when the much improved hydromorphological and ecological state of the watercourses along Alignment 2 is considered.

Figure 17 – Photographs indicating the degree of physical modification of the watercourse downstream of crossing Alt1_17 as it drains through the berm (left) and through the alluvial terrace (right)

5.4 The Orange River Riparian Zone

The Orange River riparian zone is assessed in this report as the new proposed abstraction location is located on the banks of the Orange River, within the riparian corridor of the river. It should be noted that there is an existing abstraction point where two existing pumps abstract water for the farming activities on the Sanddraai Farm. A concrete ramp has been constructed into the riparian zone to allow access to the water for the pumps, and as such the riparian corridor at the location of the new abstraction point is already impacted, as discussed in the impact assessment section below. As described above two technical options for abstracting water from the Orange River have been presented, and the infiltration gallery in particular could impact on the river's riparian zone, hence the characteristics of the Orange River riparian corridor have been assessed.

The Orange River is a very large perennial River, being one of the largest rivers on the southern African subcontinent, draining a very large catchment that encompasses much of the eastern and western interior of South Africa. In spite of the highly arid nature of the climate in the study area, the perennial nature of the river ensures that a distinct and prominent riparian corridor naturally occurs along the River. The distinct nature of the riparian corridor of the Orange River is indicated in its classification as a distinct vegetation class – the Lower Gariep Alluvial Vegetation. This vegetation class is described as a complex of riparian thickets and reedbeds with flooded grasslands and herblands along sandbanks and terraces (Mucina and Rutherford, 2006). As discussed further below, it is important to note that this vegetation type is classified as an ***endangered terrestrial ecosystem*** under the National Environmental Management: Biodiversity Act (Act 10 of 2004).

Morphologically, the riparian corridor of the river is heavily fluvially influenced by flooding along the riverine corridor that results in the deposition of alluvial silt in the bed and banks of the river. At the current Shalom abstraction point, the cross-sectional profile of the river is characterised as a steep bank that slopes up from the water level to the top of the macro channel bank with no intervening terraces. Behind the macro channel bank an irrigation canal to transport the abstracted water has been constructed (running parallel to the river to the north and the south) and behind this the terrain slopes down to a lower-lying flatter area (wide terrace) that has been extensively transformed by agricultural cultivation as described in section 5.3 above. The access to the river at the abstraction point has cut into the macro channel bank to allow a less steep access to the water level, however the macro-channel bank remains on either side of the concreted access.

Figure 18 – Indigenous riparian vegetation adjacent to the existing Shalom abstraction point

The morphological template of the riparian zone is not homogenous, and varies according to factors such as bedrock outcropping and the curvature of the river, with the inner and outer banks differing in terms of degree of deposition versus erosion. Downstream of the abstraction point on the same (eastern) side of the river the riparian corridor is much wider and has a different cross-sectional profile. Bedrock outcrops downstream of the abstraction point, and this has allowed the creation of mudbanks at the margins of the channel and sandy, flood terraces adjacent to the margins that are partly un-vegetated and partly covered in *Phragmites australis* reedbeds. It should be noted that a secondary lateral channel is densely vegetated by *Phragmites* and *Typha capensis* reed species (these species, in particular *T. capensis* which is an obligate hydrophyte (i.e. always grows in saturated conditions) are indicative of a high degree of hydrological activation associated with likely seasonal inundation of this part of the channel). Moving away from the channel the substrate is silty and un-vegetated, and slopes up gently to a higher flood terrace where the first trees and shrubs are located. The higher bank further away from the channel is slightly steeper and is covered in dense thickets with the presence of large *Vachellia (Acacia) karroo* and *Ziziphus mucronata* trees. The thickets extend up the slope on silty alluvial substrate all the way up to the top of the macro-channel bank, behind which the heavily-transformed cultivated area is located.

Figure 19 – Sandy alluvial terrace and thickets along the macro channel bank downstream of the abstraction point

The vegetation in the riparian zone adjacent to the abstraction point consists of dense thickets of trees and shrubs with a dense understorey. The primary tree and shrub species noted were *Vachellia (Acacia) karroo, Ziziphus mucronata, Rhus lancea, Diospyros ramulosa* and *Lycium cinereum* in the substratum. A dense stand of the reed *Phragmites australis* occurred along the water's edge and up the macro channel bank on the southern side of the abstraction point. It was apparent that the riparian vegetation at this location had been invaded by *Prosopis spp.*, with an estimated 10-20% coverage of the riparian corridor by alien vegetation, primarily of this species.

It was noted that the vegetation adjacent to the existing abstraction point (on the southern side) had recently been disturbed through the movement of a large vehicle, with damage to the *Phragmites* reedbeds. The infiltration gallery (if selected for development) will have a footprint in the riparian zone, being likely to physically alter a part of the riparian zone. The potential impact of the abstraction footprint on the riparian zone is discussed in section 7.2 below.

6 RESULTS OF (VEGRAI) RIPARIAN STATE ASSESSMENT

The VEGRAI model has been used to calculate an ecological category for the two most prominent ephemeral watercourses along both Alignment 1 and 2 respectively. Although the fluvial regime of the watercourses in the area does not correspond to a classical fluvial and corresponding riparian morphological template, as characterised by differing degrees of hydrological activation within the riparian zone, and the presence of certain parts of the river cross section which are more or less permanently inundated, the VEGRAI tool remains a useful way to determine the state of the riparian zones of certain of the watercourses in the study area.

Only the more prominent drainage lines have been assessed as the other drainage lines are too poorly structurally defined to be properly assessed using the tool (i.e. the small headward watercourses crossed), or are similar in nature to the watercourse assessed, thus enabling the assessed watercourse to be used as a proxy. Along Alignment 2 landuse-related impacts and hydrology were noted to differ very little between the nine drainage lines, and the ecological category assigned to the two watercourses assessed can be relatively confidently applied to the other watercourses along the alignment. Along Alignment 1, all watercourses are subject to the same degree of extreme modification in the area between the Orange River riparian zone and the rising ground away from the valley bottom, thus the ecological categorisation for the two larger watercourses can be applied to the smaller watercourses.

The following riparian zone characteristics (as relevant to the VEGRAI assessment) were noted as part of the assessment:

Alignment 1

- Agricultural cultivation is the prominent land use within the Orange River valley bottom that has historically, and continues to exert a severe impact on the riparian zones along their most downstream reaches. An ***extreme degree of modification*** of the riparian zones in area between the farm access road and the current edge of the Orange River riparian zone has occurred – a high degree of hydrological modification (complete impoundment in the case of the watercourse at Alt1_13) that prevents any water from flowing into the valley bottom, morphological modification (destruction of naturally-occurring channels or depositional features on the valley bottom), and almost complete removal of naturally occurring riparian vegetation.
- Upstream of the fence separating the cultivated area from the rangeland (veld camp) to the east, the two watercourses were in a much more natural state (similar to the state of the watercourses along Alignment 2). There were no signs of physical modification or alien invasive plants, and overgrazing is the only potential pressure acting on these riparian zones.
- In the un-impacted sections the marginal zone was limited to the central active channels and smaller flow paths of the respective watercourses, as these areas parts of the riparian corridor are most likely to be hydrologically activated when surface flow occurs along these systems. The other parts of the riparian zone would only be hydrologically activated in significant flood events, thus being delineated as the non-marginal zone (i.e. a combination of the upper and lower zones).
- The channels / flows paths were found to be largely devoid of vegetation, with no woody vegetation present
- Coverage of non-woody vegetation was lower (20-40%) in the watercourse at Crossing Alt1_17 than that of the watercourse at Crossing Alt1_13 (60-80%), whereas woody vegetation cover was roughly the same (<10%) for both watercourses, irrespective of the crossing point.
- Lastly, an assessment of the reference state needed to be made, in relation to the above factors. Overall, the findings of the field assessment were that the watercourses assessed were relatively close to a reference state ***upstream of the fence between the cultivated area and rangeland*** due to the following factors;

- The absence of any alien invasive vegetation was a very important factor in this context.
- The vegetation coverage within the non-marginal riparian zone was noted to be relatively high, especially non-woody vegetation,
- A reasonable diversity of non-woody and woody species was encountered in the context of the climate of the area being highly arid.
- There were no obvious signs of erosion, and the palatable grass species and herbaceous species appeared to not be heavily grazed, although grazing in these areas is potentially reducing species diversity.

Alignment 2

- Stock farming is the prominent land use that would potentially affect the riparian zones along the alignment. It is difficult to fully assess the degree of impact of stock farming on riparian zones without having a more comprehensive understanding of current levels of rainfall; however this landuse appeared to have a relatively low impact footprint in the context of altering the vegetative composition and morphological structural integrity of riparian zones.
- An almost complete absence of alien invasive vegetation was noted along the alignment (in terms of the ephemeral watercourses), which is a very important factor in the context of the abundance metric.
- The marginal zone was limited to the central active channel of the respective watercourses, as the channel is the part of the riparian corridor most likely to be hydrologically activated when surface flow occurs along these systems. The other parts of the riparian zone would only be hydrologically activated in significant flood events, thus being delineated as the non-marginal zone (i.e. a combination of the upper and lower zones).
- The channels were found to be largely devoid of vegetation, with no woody vegetation present
- Coverage of woody vegetation was lower (10-20%) in the watercourse at Crossing Alt2_2 than that of the watercourse at Crossing Alt2_6 (c50%), whereas non-woody vegetation cover was roughly the same (60-80%) for both watercourses, irrespective of the crossing point.
- Lastly, an assessment of the reference state needed to be made, in relation to the above factors. Overall, the findings of the field assessment were that the watercourses assessed were relatively close to a reference state due to the following factors;
  - The absence of any alien invasive vegetation was a very important factor in this context.
  - The vegetation coverage within the non-marginal riparian zone was noted to be relatively high, especially non-woody vegetation,
  - A reasonable diversity of non-woody and woody species was encountered in the context of the climate of the area being highly arid.
  - There were no obvious signs of erosion, and the palatable grass species and herbaceous speciesappeared to not be heavily grazed.

The tables below present the outcomes of the VEGRAI assessment in terms of the ecological category assigned to each of the watercourses assessed.

Table 1 – VEGRAI Ecological Category Scores for Alignment 1 Crossings*

Crossing Point	Level 3 VEGRAI % score	VEGRAI Ecological Category
Crossing Alt1_13	14.6	F
Crossing Alt1_17	21.7	E/F

* - Note - the above scores represent the scores for the reaches of the watercourses crossed by the proposed pipeline – i.e. the most downstream reach of the watercourses on the Orange River valley bottom and the start of the footslopes to the east of the farm access track. The state of the riparian zones of the watercourses just upstream of the valley bottom is much more natural, and would be similar to the 'B' ecological category as assessed for the Alignment 2 crossings.

Table 2 – VEGRAI Ecological Category Scores for Alignment 2 Crossings

Crossing Point	Level 3 VEGRAI % score	VEGRAI Ecological Category
Crossing Alt2_2	83.1	B
Crossing Alt2_6	84.4	B

It is noteworthy that both watercourses along Alignment 2 (and the reaches of the watercourses upstream of the Orange River valley bottom) fall into the Ecological Category B – i.e. largely natural with few modifications. That is a small change in natural habitats and biota may have taken place for these watercourses but the ecosystem functions remain largely unchanged. This assessment of the state of riparian zones in the most prominent riparian zones is important, as the potential impacts of constructing and operating the pipeline within these areas could potentially be significant if not properly mitigated (refer to section 7 below for an assessment of the potential degradation of the ecological category of watercourses in the area if potential impacts were not mitigated).

Conversely, the reaches of the watercourses crossed along Alignment 1 were assigned an extremely low Ecological Category (EC) score, reflecting the extreme degree of modification of these watercourses within the Orange River valley bottom. The reach of the watercourse at Crossing Alt1_13, has effectively ceased to exist as a surface water feature, with complete hydrological, morphological and vegetative modification of due to the impounding function of the berms and ploughing of the valley bottom. The EC category score of 'F' is indicative of a critically modified state. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota, as is the case in this reach of the watercourse. The slightly higher score for the watercourse at Crossing Alt1_17 represents the residual hydrological connection between the upstream reaches and the Orange River riparian zone, but the reach has still been assessed to be in a serious state of modification. It is important to note that the other six crossings along Alignment 1have experienced similar complete modification to the watercourse of at Alt1_13, and thus would fall into the lowest ecological category.

6.1 Delineation and Zonation of Riparian Zones in the Study Area

As noted above, riparian zones were delineated based not only on hydromorphological factors, such as channel structure and areas of surface water-related hydrological activation (as prescribed in the VEGRAI template) but also based on the presence of vegetation of differing composition and structure to the surrounding Karoo veld, and thus the presence of alluvial groundwater supply. The riparian zones in the study area are indicated in the maps below.

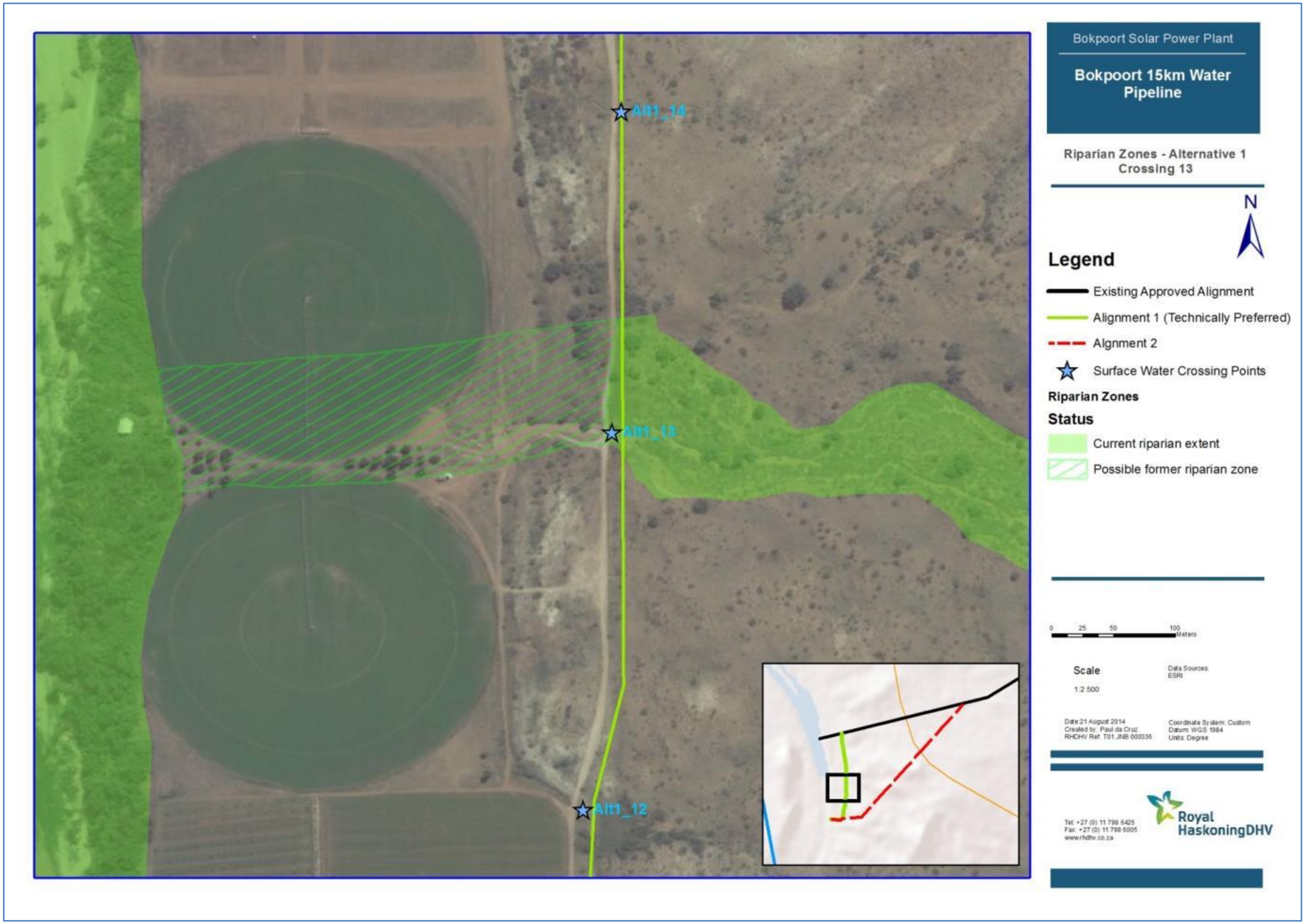

Figure 20 – Riparian zone of the Watercourse at Crossing Alt1_13

Figure 21 – Riparian zone of the Watercourse at Crossing Alt1_17

Figure 22 – Riparian Zone of the Watercourse at Crossing Alt2_2

Figure 23 – Riparian Zones of Crossings Alt2_6-8

Figure 24 – Riparian Zone of the Orange River

7 IMPACTS AND MITIGATION ASSOCIATED WITH THE PROPOSED PIPELINE

7.1 Ephemeral Watercourses

The primary impact associated with the proposed pipeline is the disturbance of watercourses and associated riparian zones through excavation of the pipeline. The pipeline will be buried, and thus a pipeline trench will need to be excavated across the affected watercourses. This will result in the disturbance and erosion of substrate within and immediately adjacent to the watercourses. A trench line and adjacent working right of way will need to be established, thus vegetation in the riparian zone within the footprint of the works will need to be cleared. The creation of a working right of way for machinery and the excavation of a trench would result in the felling and removal of all vegetation, in particular woody vegetation. This would leave the servitude devoid of vegetation after construction, which is important for a number of reasons.

The felling of all vegetation impacts negatively on the structural integrity of the riparian zone. The removal of (woody) vegetation from the servitude is one of the most important impacts on riparian zones that can occur, as it alters the vegetative composition of the servitude, and exposes the understorey that is dependent to a large degree on the shade created by the canopy to the sun. Clearing of woody vegetation also exposes the understorey that is dependent on the protection offered by the typically spiny / thorny woody vegetation to grazing pressure by livestock. Combined, these two factors can result in much of the understorey being lost. Erosion may result from the clearing of vegetation and die off of roots that bind the soil, thus potentially resulting in the inundation of downstream reaches with sediment causing the impairing of filtering functions associated with the riparian zone.

In addition the clearing of most riparian vegetation from servitudes leaves the soils exposed to erosion – both water-borne and wind-borne erosion. This is significant as much of the substrate within the riparian corridors of the larger watercourses in the area was noted to be silty in nature and thus powdery and highly unconsolidated, thus being particularly vulnerable to erosion by water and wind if the vegetation cover that binds the underlying soil is removed. Although the watercourses along the pipeline rarely flow, when flow does occur along these watercourses it is possible that flows of high volume and velocity, although brief in duration, would occur along the watercourses. Such flows would be associated with a relatively high degree of erosive force and this would be greatly exacerbated if vegetation in the servitude was removed, leaving the sandy substrate highly vulnerable to erosion. The occurrence of a flow event through such an un-vegetated area could initiate a ‘knick point’ which may lead to development of gulley (donga) erosion into the upstream part of the watercourse. For this reason securing the servitude through measures such a re-vegetation is an important mitigation measure as discussed below.

Importantly the clearing of vegetation introduces another potential impact– that of the invasion of the riparian zone by alien invasive vegetation. This introduces the edge effect which can have an important effect on biota within the riparian zone, and create a very convenient ‘entry point’ into the riparian zone and wider riverine corridor for alien invasive vegetation – such human-related disturbances further exacerbate the natural susceptibility of riparian ecosystems to invasion by alien plants, as the transformed habitat is highly suitable for colonisation by alien invasives, and is less suitable for the less aggressive indigenous riparian species (Holmes et al, 2005). Riparian zones are particularly vulnerable to invasion by alien plants due to their dynamic hydrology and opportunities for recruitment following floods (Holmes et al, 2005). Servitude clearing is similar in that the cleared area is similar in nature to an area of the riparian corridor where flooding has washed away much of the vegetation. Many alien invaders of riparian habitats in South Africa are tall trees with higher water consumption than the indigenous vegetation (Holmes et al, 2005), and this could affect the vegetation-groundwater balance.

Although the actual spatial area of the cleared servitude is likely to be relatively small in the context of the wider riparian corridor, this could create a convenient foothold for the invasion of wider areas of the riparian corridor, and initiate an impact over a much wider area than simply the cleared servitude.

The ephemeral nature of these watercourses and the relatively shallow depth of the pipeline trench is unlikely to result in the presence of any shallow water tables that would result in seepage in the trench, as it often is in the case of the construction of pipelines through water features. It is unlikely that seepage water will be encountered within the trench (the top of the pipe would be located at a minimum of 0.8m below the natural ground level, thus the trench would be likely to be approximately 1.5m in depth), as such shallow groundwater is unlikely to be present unless construction occurs immediately following a large flow event.

A number of factors will determine the intensity of the impact of the pipeline construction on each watercourse; the length of the works through each riparian zone affected, the width of the works area, and the physical (especially vegetative) characteristics of the affected riparian zone, and possibly most importantly the current state of modification of the watercourses along Alignment 1 and Alignment 2 respectively. The highly modified state of the watercourses along Alignment 1 (especially crossings Alt10, 11 & 12) would be likely to result in relatively less damage to the riparian zone, especially as the alignment of the pipeline in all cases along this alternative alignment is immediately adjacent to a road, or along a berm. The watercourses along Alignment 2 are much less impacted and modified and the impact would be much greater.

If Alignment 2 were to be developed, the larger watercourses would be likely to be subject to an impact of greater intensity than most of the ephemeral first order watercourses that are narrow in width and which have a less developed riparian zone. The crossings are characterised by a lesser density of woody vegetation, and a less distinct vegetation community compared to the adjacent upland areas. The larger watercourses (especially Crossing Alt2_2 and to a lesser degree Crossing Alt2_6) display riparian zones that are well-developed and distinct from the upland areas in terms of species composition and vegetation structure and density. The riparian corridor of the Crossing Alt2_2 watercourse is relatively wide, and a signficantly larger area of riparian corridor would be subject to physical impact.

The re-instatement of vegetation within the riparian corridor of the watercourse after the pipeline trench has been reinstated is a critical factor in the prevention of impacts during the operational phase on the affected surface water feature. If vegetation is not re-instated after trenching, soils would remain exposed. This is exacerbated by the likely operational practice of keeping the pipeline servitude free of large *deep-rooted* woody shrubs and trees that may damage the pipeline through their roots. This is likely to preclude the reestablishment of the larger trees and shrubs over the pipeline trench, including *Vachellia* (*Acacia) erioloba* and *Senegalia (Acacia) mellifera.* The inability to re-establish a woody vegetation layer could hinder efforts to re-establish an understorey of grass and other shrubs, although coverage of woody vegetation is not greater than 70%, and the non-woody species that occur in the riparian zones are tolerant of exposure to full sun. Reinstatement of non-woody vegetation within the footprint of the works area is a very important priority once the pipeline trench has been reinstated.

Lastly, the incorrect reinstatement of the channel bed and banks could have an impact on the integrity of the riparian zone, and could result in an important hydrological impact. If the channel and banks of the drainage features, as well as features such as flood terraces were not restored to a pre-construction state, this could lead to a permanent alteration of the hydromorphological state of the watercourse and associated vegetation composition. It is important that the cross-sectional channel structure be restored to a pre-construction state as far as possible. The construction of any impounding structures across the channel, such as raised roads or berms across the channel that would trap water behind them and deprive the downstream reach of flow in a flow event could exert an important impact on the downstream riparian corridor as deprivation of downstream stretches of water could lead to the alteration and loss of riparian vegetation that rely on periodic flow (and associated sub-surface water) inputs, and thus the degradation of these stretches of the riparian corridor.

7.1.1 *Results of Predictive Use of VEGRAI to assess the effect of the pipeline construction on Riparian Zones along Alignment 2*

The VEGRAI tool can be applied for predictive use that can assist with the assessing of potential impacts of a development on a riparian zone of the watercourses along Alignment 2 that were assessed using the VEGRAI tool. Using the VEGRAI spreadsheet model, it is possible to make some qualitative predictions as to how the riparian vegetation is likely to respond when changes in driver components, and specifically particular driver metrics, occur. Essentially these predictions are scenario assessments and will be of a conceptual nature, with low confidence of how close to reality they actually are (Kleynhans *et al*, 2007).

The tool has been used in this way to simulate the impact of the proposed pipeline on the two more prominent riparian zones that were assessed using the tool under a scenario in which no mitigation measures were applied (i.e. a worst case scenario), and the resulting change in the Ecological Category that could materialise. The VEGRAI assessment gave the watercourses at Crossings 2 and 6 an Ecological Category Score that falls within Class B – largely natural with few modifications.

The following parameters would change under the scenario in which the pipeline would be constructed through the riparian zones with no / little mitigation applied:

- A strip of vegetation would be cleared from pipeline servitude, resulting in a corresponding change in vegetation cover and species composition of both woody and non-woody vegetation. Cover may be further reduced by the development of erosion that removes topsoil from the servitude area and potentially from upstream sections.
- The 'opening-up' of the riparian zone could create highly suitable conditions for the invasion of this part of the riparian zone by alien invasive plants that would result in a change in abundance of indigenous vegetation.
- Water quality in downstream reaches may be adversely affected through the creation of silt through the development of erosion from the cleared servitude.

Applying the changes to these parameters, the model has predictively assessed that the Ecological Category for both riparian zones assessed would potentially drop from a B into a C Class – moderately modified. In this context, it is critical that the mitigation measures stipulated below in section 7.4 are applied.

7.2 Impacts on the Orange River Riparian Zone

As described above there is an existing abstraction point at Shalom, being used for abstraction to supply the local farming (cultivation) activities. As such the riparian zone has been physically modified, with a concreted access to the river having being cut through the macro-channel bank. Two technical options have been presented for the abstraction. The first, a floating raft would be likely to be installed at the existing abstraction point (although this has not been confirmed in the technical information presented). Under this scenario there would be some disturbance to the bed or banks of the river with the installation of the concrete blocks to which the raft is anchored. If these concrete blocks are placed at the existing abstraction point, this will represent a consolidation of an existing impact with no likely further increase in the footprint of the existing impacted area.

In the case of the infiltration gallery the footprint will be much larger, and it is likely that a previously un-impacted area of the riparian zone would be impacted. No design details of the infiltration gallery or proposed footprint at the Shalom abstraction point have been provided for assessment. However bearing in mind the profile of the riparian zone at the Shalom abstraction point as described in section 5.4 above – a narrow and steeply sloping macro channel bank lying between the edge of the channel and the transformed area of cultivation behind with no intervening alluvial terraces – it is uncertain whether an infiltration gallery would be able to be placed at the Shalom point due to topographical limitations. It is not known whether the infiltration gallery could be placed in the cultivated area immediately behind the riparian zone and irrigation canal. The photographs in the technical document (Golder, 2014) indicate that the infiltration gallery would ideally be placed within an area of alluvial sediment adjacent to the channel of the river. No such alluvial terrace exists at the Shalom abstraction point with the closest such area occurring 900m to the north (downstream) on the eastern side of the eastern bank. However the design drawings for the older abstraction point (adjacent to the railway bridge) as presented in the Golder Report (Golder, 2014) show that a relatively large area of indigenous thicket vegetation would fall within the footprint of two infiltration galleries, that would be likely to result in the destruction / transformation of this area of indigenous vegetation. Due to the similar profile of the riparian zone on the eastern bank of the river at the Shalom abstraction point, a similar area of transformative impact thus appears likely to need to be developed at the Shalom abstraction point, to the north or south of the existing abstraction point.

More information is required in order to accurately assess the actual impact of the infiltration gallery on the riparian zone. However it is likely that the infiltration gallery would have a physical footprint within the riparian zone, being likely to lead to the destruction of riparian vegetation due to the need to excavate the area to lay the underground infrastructure. The impact on riparian vegetation would be less if the infiltration gallery was placed within an area of open sand or *Phragmites* reedbeds. *Phragmites* is a pioneer species that will recolonise an area once disturbed if a suitable shallow groundwater hydrological regime persists, and thus the area of disturbance could be naturally rehabilitated once construction was complete. However it appears more likely that the infiltration gallery would be placed within an area of mature indigenous thicket vegetation (as occurs adjacent to the Shalom abstraction point); it is important to note that the impact on this vegetation would be of greater significance. It should be noted that the Lower Gariep Alluvial Vegetation Type (AZa 3) is listed as an *Endangered* Ecosystem, and any impact on the mature thickets within this vegetation would be highly significant in both a localised context as well as a cumulative context. In this context it is important that the technical design of the infiltration gallery (if selected for development) attempt to minimise destruction / loss of riparian habitat.

7.3 Other Potential Construction-related Impacts

The process of constructing the pipeline through watercourses could potentially impact these features in other ways through a series of construction-related impacts. The following impacts on surface water features can result from construction activities along the pipeline servitude:

- The uncontrolled interaction of construction workers with watercourses that could lead to the pollution of these watercourses, e.g. dumping of construction material into the drainage system, washing of equipment (in the case of the Orange River) etc.
- The lack of provision of adequate sanitary facilities and ablutions on the servitude may lead to direct or indirect faecal pollution of surface water resources.
- Leakage of hazardous materials, including chemicals and hydrocarbons such as fuel, and oil, which could potentially enter nearby surface water resources through stormwater flows, or directly into the sandy soils within watercourses. This may arise from their incorrect use or incorrect storage. This is not only associated with a risk of pollution of surface water, but with a risk of the pollution of shallow groundwater within the riparian zone due to the presence of typically highly permeable alluvial substratum.

- The incorrect mixing (batching) of cement could lead to siltation and contamination of watercourses, as described above.
- Inadequate stormwater management and soil stabilisation measures in cleared areas could lead to erosion that could cause the loss of riparian vegetation and which would lead to siltation of nearby watercourses.
- The creation of new access roads for construction traffic across watercourses may lead to the erosion of banks and disturbance of riparian vegetation that may trigger the further development of gulley (donga) erosion.
- Construction of accesses across watercourses may impede the natural flow of water. This would alter the hydrology of the watercourse. Uncontrolled access of vehicles through surface water features, in particular wetlands (where these occur) can cause a significant adverse impact on the hydrology and soil structure of these areas through rutting (which can act as flow conduits) and through the compaction of soils.

7.4 Mitigation Measures

7.4.1 Pipeline Construction

A number of mitigation measures can be specified to minimise impact on the ephemeral watercourses and their associated riparian zones. As an overarching principle, it is very important that these surface water features, although mostly devoid of flow must be recognised as sensitive features, with care being taken to avoid unnecessary impacts on them.

- The footprint of the works area through these watercourses must be kept a narrow as possible, and be restricted to a width that allows construction vehicles and equipment to access the trench line, with provision made on the opposite side of the trench for stockpiling of excavated substrate.
- If Alignment 1 is developed, the current footprint of the works (and impacted area) must not be extended upstream into the riparian area beyond a reasonable construction footprint. No new impounding structures must be constructed into the upstream (un-impacted) riparian corridors as a measure to manage surface water (storm event) flows down the system. Rather flows entering the alluvial terrace must be managed in the area between the fence and the local access road where the crossings are already impacted.
- The pipeline must be strung outside of the riparian area, and extra space for stringing the pipeline must not be created within the works area within the riparian zone of watercourses.
- Both the trench line and working right of way must be clearly demarcated prior to any construction occurring through the affected watercourse.
- No stockpiles or lay down areas must be established in the riparian zone of any watercourse along the pipeline.
- No storage areas for hazardous materials must be located within 100m of the outer edge of a riparian zone.
- Once vegetation has been removed from these areas, the adjacent riparian zone that does not fall within the footprint of the works must be demarcated as a no-go area that must not be physically affected by the proposed works.
- Construction should ideally occur during the drier winter months, when the possibility of rainfall and thus flow within these drainage systems is reduced.

- Once the pipe has been laid, the original substrate must be reinstated as far as possible (it is recognised that padding material may need to be laid adjacent to the pipeline to protect it). Any excess material that is not required for reinstatement must be removed from the riparian zone and placed elsewhere.
- The channel and banks must be restored to a pre-construction state as far as possible. It is very important that the channel be reinstated to a level that is similar to the upstream and downstream level, and no structures that could impound water behind them must be constructed across the channel.
- Any track / road constructed within the channel and adjacent riparian zone must be fully removed once construction has ended.

7.4.2 Servitude Rehabilitation and Re-vegetation

It is important that re-vegetation be undertaken to ensure that the works footprint does not remain devoid of vegetation and thus vulnerable to erosion by aeolian and water-borne processes. A number of mitigation measures are pertinent in this case:

- The topsoil within the works area must be retained once excavation for the pipeline has been completed and must be reinstated over the pipeline as this will contain a natural seed bank that will assist with natural re-vegetation.
- Once reinstatement of the pipeline has been completed and the rehabilitation of the servitude through riparian areas is underway, the riparian area must be reseeded with a grass species mix consisting of grasses found in the local area such as *Cenchrus ciliaris* and *Stipagrostis spp*.
- It is important that a shrub layer be re-established, with non-deep rooted species being re-established, as detailed below
- Bare areas, such as reinstated banks and terraces, and especially those areas vulnerable to erosion by water during flow events must be protected from erosion while re-vegetation is occurring. It is recommended that geotextile be used to cover such areas, staked into the ground to protect seedlings.
- Where possible (e.g. in the footprint of the construction right of way), the growth of shrubs and bushes, as well as grasses must be encouraged, as this will assist in the protection of the understorey. It is recommended that shrubs of species indigenous to the area with shallow root systems be sourced from local nurseries and established in such areas.
- Monitoring of re-vegetated areas must be undertaken, and follow up re-vegetated measures undertaken if necessary.
- It is critical that operational procedures for the rehabilitation and subsequent management of the servitude include measures to remediate any developing erosion and to remove and prevent proliferation of alien invasive vegetation. This should be undertaken at an interval of at least 6 months. Thus for a period after construction the servitude through riparian areas must be monitored for the development of erosion, as well as the growth of alien invasive plant species.
- If erosion is noted to be developing, immediate measures must be taken to remediate the erosion. It is very important that the integrity of the riparian zone post-construction be checked
- In the case of alien invasive vegetation, all such species must be fully removed and measures taken to prevent further proliferation. In this context it is also very important that parts of the servitude adjacent to the watercourses (outside of riparian zones) also be subject to similar measures as without this the servitudes outside of the riparian zones would become ‘springboards’ for proliferation into the riparian area.

7.4.3 Abstraction-related construction

- It is strongly recommended that the raft abstraction methodology be developed as this would have a much lesser footprint than the infiltration gallery type of abstraction.
- In the construction of the raft methodology, design must attempt to ensure that the construction and development footprint does not extend into any un-impacted adjacent areas of the riparian corridor, and that the footprint be limited to the existing abstraction footprint.

7.5 Comparative Assessment of Alignments

7.5.1 Alignment Alternatives

Two alignment alternatives have been presented for comparative assessment. The respective alternative alignments cross a similar number of crossings, thus the respective state of the crossings needs to be taken into account as the most important factor in comparatively assessing the two alternative routes.

Alignment 2 runs along a cadastral boundary but otherwise would run through a greenfield area with no current development impacts except for the presence of the district road and the railway. Developing this alternative would entail that a number of currently un-impacted watercourses would be affected, but would also likely result in the impacting / disturbance of the catchment areas of each watercourse, with the creation of construction (and possibly operational) accesses along the pipeline that could lead to indirect impacts on the watercourses such as increased siltation from erosion in the catchment during periods of rainfall.

Conversely, a large portion of Alignment 1 is proposed to run along an existing farm access track, as well as running on the edge of a highly transformed area of intense cultivation. The presence of this area of intense cultivation has significantly transformed the watercourses that drain into this area as explored in detail above, thus if the pipeline is aligned on the edge of this area, it will cross the watercourses at the point at which they are already transformed. All of the eight watercourses crossed are highly transformed in this way.

As a result the development of Alignment 1 would represent a consolidation of existing impacts on the watercourses in the area traversed by each alternative, rather than extending the development footprint into a currently un-impacted area. Alignment 1 is thus strongly preferred from a surface water perspective.

7.5.2 Abstraction Alternatives

Two alternative techniques for abstraction have been presented for assessment. Although no design or footprint of the infiltration galleries at the Shalom abstraction point have been provided for assessment, the design drawings for the older abstraction point (adjacent to the railway bridge) as presented in the Golder Report (Golder, 2014) show that a relatively large area of indigenous thicket vegetation would fall within the footprint of two infiltration galleries, that would be likely to result in the destruction / transformation of this area of indigenous vegetation. This seems likely to be similar to the scenario at the Shalom abstraction point. Impacting of riparian thickets in this way would be significant in the context of the thicket vegetation falling within an endangered ecosystem, and would represent a localised impact as well as a cumulative impact on this endangered ecosystem.

Conversely the raft technique would presumably be able to be installed at the existing Shalom abstraction point which has already disturbed the riparian zone of the river. This technique would result in no further, or limited damage to the existing riparian corridor.

As such the raft method of abstraction is strongly preferred, as it is associated with a much lower physical transformative footprint on the riparian zone of the Orange River and on the Lower Gariep Alluvial vegetation type.

7.6 Impact Rating Matrix

The Impact rating matrix for the project appears below.

Table 3 Impact Rating Matrix Consideration

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	• Irresponsible construction practices could lead to the pollution of watercourses and rivers (e.g. faecal contamination, or pollution of surface water through hydrocarbons) • Poor stormwater management could lead to the siltation (pollution) of surface waters • Temporary accesses across watercourses could cause hydrological and morphological impacts and degrade the resource quality • Excessive removal of / damage to vegetation would degrade the resource quality of the riparian zone	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Construction to be monitored by an ECO according to the stipulations of the EMPr • No batching or chemical / fuel storage areas to be located within any surface water feature or **within 100m of a surface water feature** • Clearing of vegetation to be limited to the construction footprint • No temporary construction accesses (other than the construction right of way) to be constructed through any surface water feature and no machinery to enter any wetland unless authorised under the EMPr by the ECO as part of a construction activity • Watercourse channels and other parts of the surface water feature must be restored to as close a pre-construction state as possible.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operations	• The pipeline servitude as it crosses riparian areas will be kept cleared of most woody trees and shrubs due to the limitations relating to deep root systems, thus constituting an impact on the affected part of the riparian corridor for the entire operational length of the pipeline. • Improper rehabilitation of the construction works area through riparian areas would leave such parts of the riparian zones vulnerable to erosion by water and wind. • In addition, the cleared servitude through the riparian corridor will pose a risk of encroachment of alien invasive vegetation into the riparian zone due to the servitude creating favourable	**Extent:** Local (-2) **Duration:** Long term (-3) **Intensity:** Moderate (-2) **Probability:** Highly Probable (-3) **Significance: Medium (-10)**	• All construction footprint areas through riparian areas must be fully rehabilitated with the re-establishment of a vegetative cover that matches pre-construction vegetative cover. • Any development of erosion must be carefully monitored and managed. • It is critical that all alien invasive vegetation management in the servitude be undertaken at regular intervals (at least every 6 months) for the operational life of the pipeline servitude. This must not just be undertaken for riparian areas but for servitudes in adjacent areas. As part of this management all alien invasive vegetation within the servitude must be removed.	**Extent:** Local (-2) **Duration:** Long term (-3) **Intensity: Low** (-1) **Probability: Possible** (-2) **Significance: Medium (-8)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	conditions for the establishment of alien pioneers. The risk will be even greater should operational management of the servitude not be properly undertaken.			
Decom-missioning	• The termination of servitude management through riparian corridors post-decommissioning could increase the risk of alien invasive plant encroachment into the servitude area, and thus into adjoining riparian habitat.	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-8)**	• Decommissioning to be monitored by an ECO according to the stipulations of the EMPr • No temporary accesses to be constructed through any surface water feature and no machinery to enter any wetland unless authorised under the EMPr by the ECO as part of a decommissioning activity • After decommissioning of the pipeline, management of alien invasive vegetation should continue for a period.	**N/A**
Cumulative	• Cumulative loss of riparian habitat due to clearing of riparian vegetation and due to the risk of increased proliferation of alien invasive plant species within the riparian corridor associated with the new servitude could occur. These cumulative effects exist in the context of the most important existing impacts on riparian zones which are clearing of riparian vegetation for cultivation and proliferation of alien invasive vegetation in riparian zones. • Impacts on individual surface water features across the site could result in a cumulative impact on respective catchments, although other land use-related practices are more likely to cause degradation of watercourses and their associated riparian zones. • Pollutants released into more than one surface water features through construction activities could result in downstream impacts, although this is thought to be unlikely.		• Refer to activity / phase specific mitigation measures above	**N/A**

8 PHOTOGRAPHIC RECORD OF CROSSINGS ALONG ALIGNMENT 1

8.1.1 Crossing Alt1_10

GPS Co-ordinate(s) of Crossing: -28.80379; 21.88774

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.2 Crossing Alt1_11

GPS Co-ordinate(s) of Crossing: -28.80254 21.88797

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.3 Crossing Alt1_12

GPS Co-ordinate(s) of Crossing: northern edge of riparian zone: -28.80058; 21.88815

Southern edge of riparian zone: -28.80077; 21.88816

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.4 Crossing Alt1_13

GPS Co-ordinate(s) of Crossing: northern edge of riparian zone: - 28.79692 21.88835

Southern edge of riparian zone: -28.79785 21.88833

Riparian zone Ecological Category (as assessed by VEGRAI) – Category F

8.1.5 Crossing Alt1_14

GPS Co-ordinate(s) of Crossing:: - 28.79545 21.88835

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.6 Crossing Alt1_15

GPS Co-ordinate(s) of Crossing:: - -28.79372 21.88835

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.7 Crossing Alt1_16

GPS Co-ordinate(s) of Crossing:: - - 28.79289 21.88834

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.8 Crossing Alt1_17

GPS Co-ordinate(s) of Crossing: northern edge of riparian zone: - -28.78917 21.88781

Southern edge of riparian zone: - -28.78952 21.88786

Riparian zone Ecological Category (as assessed by VEGRAI) – Category E/F

9 PHOTOGRAPHIC RECORD OF CROSSINGS ALONG ALIGNMENT 2

9.1.1 Crossing Alt2_1

GPS Co-ordinate(s) of Crossing: -28.8048; -28.8048

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.2 Crossing Alt2_2

GPS Co-ordinate(s) of Crossing: South-western edge of riparian zone: -28.80137, 21.89506

North-eastern edge of riparian zone: -28.80094, 21.89551

Riparian zone Ecological Category (as assessed by VEGRAI) – Ecological Category B

9.1.3 Crossing Alt2_3 &4

GPS Co-ordinate(s) of Crossing: -28.79912, 21.89713

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.4 Crossing Alt2_5

GPS Co-ordinate(s) of Crossing: -28.7949, 21.90078

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.5 Crossing Alt2_6

GPS Co-ordinate(s) of Crossing: south-western edge of riparian zone: -28.78798, 21.9071

North-eastern edge of riparian zone: -28.78789, 21.90721

Riparian zone Ecological Category (as assessed by VEGRAI) – Ecological Category B

9.1.6 Crossing Alt_7

GPS Co-ordinate(s) of Crossing: south-western edge of riparian zone: -28.78673, 21.90825

North-eastern edge of riparian zone: -28.78664, -28.78664

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.7 Crossing Alt2_8

GPS Co-ordinate(s) of Crossing: south-western edge of riparian zone: -28.786, 21.90891

North-eastern edge of riparian zone: -28.7863, 21.90868

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.8 Crossing Alt2_9

GPS Co-ordinate(s) of Crossing: -28.781895, 21.912732

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

10 CONCLUSIONS AND RECOMMENDATIONS

The two alternatives of the proposed realigned pipeline section cross a number of ephemeral watercourses that are characterised by a well-developed to poorly developed riparian zone, depending on their size. The larger drainage systems along both alignments have been assessed with the VEGRAI tool and the results have shown that the two larger drainage systems along Alignment 2 (and by proxy the other smaller watercourses crossed) display riparian corridors that are largely natural with few modifications (category B). In contrast physical modifications have resulted in all eight crossings of watercourses along Alignment 1 being highly impacted, with the two larger watercourses that were assessed by the VEGRAI tool having been assigned a serious or critically modified state (category E/F or F)

The proposed pipeline would traverse the narrow Orange River riparian corridor at the proposed Shalom abstraction point, however the riparian corridor is already disturbed at this location due to the presence of two existing abstractions for farming activities. Two technical alternatives for abstraction from the river have been presented for assessment (a floating raft and infiltration gallery). Utilising the raft option, it has been assumed that the pipeline and associated abstraction footprint will be able to be limited to this existing transformed area, thus not entailing the further damage to the adjacent riparian vegetation, whereas the infiltration gallery has assessed to be likely to result in the destruction of an area(s) of riparian vegetation. Due to these factors, the raft option for abstraction is strongly preferred.

The proposed pipeline could result in a number of potential impacts on the ephemeral watercourses crossed, especially if rehabilitation of the pipeline servitude and works area through the associated riparian corridors is not properly undertaken. This could lead to the exposure of the sandy substrate to wind and water erosion, and could result in the long term degradation of the riparian zones of the affected watercourses. A number of mitigation measures have been specified for the proposed pipeline. Should these be implemented, the likely impacts of the proposed pipeline on surface water features will be able to be mitigated to acceptable levels.

In the context of the comparative assessment of the two alignment alternatives, Alignment 1 is strongly preferred. Due to the alignment of Alignment 1 adjacent to the boundary of a heavily impacted area of cultivation and along an access track, the impacts associated with the pipeline would occur within an area of existing impacts, whereas Alignment 2 traverses a largely un-impacted area. The development of alignment 1 would represent the consolidation of impacts on these watercourses into an area in which they are already highly modified, and thus the development of this alternative is recommended from a surface water perspective.

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11.1 Web pages referred to in the text

South Africa Rainfall Atlas: http://134.76.173.220/rainfall/index.html