KOTULO TSATSI ENERGY (PTY) LTD

FRESHWATER REPORT

For the construction of a water provision pipeline from the Orange River at Keimoes to the Uitkyk Farm near Kenhardt, Northern Cape

A requirement in terms of the
National Environmental Management Act (107 of 1998)
and the
National Water Act (36 of 1998)

November 2022
Version 3.0 March 2024

EnviroAfrica

WATSAN Africa

Executive Summary

Kutulo Tsatsi Energy (Pty) Ltd is planning a water provisioning pipeline from Keimoes on the Orange River to the Farm Uitkyk. This farm is located along the Sishen-Saldanha railway line to the west of a point on the R27 trunk road halfway between Kenhardt and Brandvlei in the Bushmanland of the Northern Cape. Water will be abstracted from the Orange River at Keimoes and pumped to the plant via a 190km long pipeline. Along the way several water reservoirs and a water purification plant will be constructed. The proposed pipeline's main purpose it to provide water to a proposed green hydrogen production plant. Water out of the pipeline will be supplied to the town of Kenhardt. Eventually, as a separate project, the proposed pipeline will connect to a pipeline for water provisioning to Brandvlei.

Concentrated solar-thermal power (CSP) installations will form the core of the energy-provision for the manufacture of hydrogen out of water. In fact, the CSP/ hydrogen combination may and likely will radically and globally move energy generation away from fossil fuels, along with contemporary solar and wind generation, which will augment CSP energy generation on the envisaged plant.

Hydrogen can be used widely in several applications apart from green energy. It is planned, among other, to manufacture green ammonia on a large scale, which in turn can be used for the manufacture of agricultural fertiliser.

For all of this, the pipeline and associated infrastructure, the CSP, solar and wind installations for the generation of electricity, the hydrogen and ammonia plant authorisation must be obtained from the relevant authorities such as the national Department of Water and Sanitation and the Department of the Fisheries, Forestry and the Environment as well as from their provincial offices. This Freshwater Report is one of the requirements for the proposed pipeline's official authorisation.

This project hinges on the authorisation of water abstraction from the Orange River at Keimoes. The pipeline will be constructed for most of the way along the R27 trunk road where it will cross numerous drainage line. Although mostly dry, these drainage lines are legitimate water resources in terms of the National Water Act. All of this will have to be properly authorised and licensed, as well as the evaporation ponds at the production site.

The consortium of national and international entities has already spent a great deal of funding towards the planning and authorisation. Several consulting companies have been appointed. This process has been ongoing for more than 10 years.

This initiative will predictably have a vast impact on the regional economy. The export of green hydrogen and its derivatives will earn the country valuable foreign currency. Green hydrogen is a global trend included in national energy strategies. Our authorities are cordially pressed upon to treat this application with the weight and urgency it deserves.

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Abbreviations

Critical Biodiversity Area	CBA
Department of Fisheries, Forestry and the Environment	DFFE
Department of Water and Sanitation	DWA
Ecological Importance	EI
Ecological Importance and Sensitivity Class	EISC
Ecological Sensitivity	ES
Ecological Support Area	ESA
Environmental Impact Assessment	EIA
Electronic Water Use License Application (on-line)	eWULAAS
Government Notice	GN
Metres Above Sea Level	masl
National Environmental Management Act (107 of 1998)	NEMA
National Freshwater Environment Priority Area	NFEPA
National Water Act (36 of 1998)	NWA
Northern Cape Department of Environment & Nature Conservation	DENC
Present Ecological State	PES
Section of an Act of Parliament	S
South Africa National Biodiversity Institute	SANBI
Water Use License Application	WULA

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1 Introduction

The following paragraphs were taken from an information document that was compiled by Dr A. Botha in June 2022 of Kotulo Tsatsi Energy (Pty) Ltd:

"The Kutulo Tsatsi Energy International Consortium envisages to develop a USD 7 to10 billion green hydrogen based green ammonia production plant on a 55000ha (plus a further up to 30000ha under option) site in the Northern Cape province of South Africa with water abstraction from the Orange River…..

"The total investment value in time may exceed USD 10billion, with up to 6000 jobs to be created. Social, economic- and enterprise development, job creation and socio-economic upliftment, especially for local communities, are prominent goals of the consortium.

The project will be base load powered by a 3-to-6-gigawatt hybridisation of renewable energy based on solar photovoltaic, concentrated solar-thermal power (CSP) and wind power. The production plants, at 6-gigawatt baseload power capacity, utilised for the electrolysis of water, will be able to produce up to a million metric tons of electrolytic green hydrogen per annum and up to 6 million metric tons of green ammonia per annum. Up to five million tons of nitrogen will be produced per annum for use in the production of green ammonia".

This is a major project of an unprecedented scale. It has been in the planning stage for the past 10 years (https://sr.energy/kotulo-tsatsi/).

"The project will have a significant Black Economic Empowerment (BEE) shareholding, and a percentage of total project revenues will be set aside for enterprise and socioeconomic development which will be invested for the benefit of local communities each year".

The envisaged pipeline has the potential to supply water to the towns of Kenhardt and Brandvlei as well. Plans along with the constitutional arrangements have already been developed to make this a possibility.

On social media it is evident that green hydrogen is still deemed with scepticism, as most novelties are. This is clearly based on ignorance, as the informed understand technology is to provide the world's current and growing energy demand. There are literally hundreds of postings on the internet to explain the importance of green hydrogen and green ammonia in the developed world. Tendencies in South Africa are likewise highlighted. Green hydrogen is not a novelty any longer and leading economies in the world are currently scrambling to share in the trend. South Africa is not lagging.

It stands to reason that the green hydrogen project, along with its various components, would be a major and welcome injection of capital and opportunities in a left-behind region that is almost devoid of opportunities and economic progress.

The consortium already has spent a great amount of money, energy and time towards the various components of the larger, overarching project's official approval. This application is for one such component, the water provision pipeline from the Orange River at Keimoes to the envisaged production plant that is to be located on the farm Uitkyk in the Bushmanland between the towns of Kenhardt and Brandvlei.

This application solely deals with the water provision pipeline from the abstraction point at Keomoed to the Farm Uitkyk. Other project components have been dealt with separate applications. A great deal of capital has already been spent on EIA's and official approvals, the detail of which is available from the consortium.

This Freshwater Report must provide information to the EIA and its various process and reports. Several prescribed evaluations and content are focussed on the EIA and its legal requirements.

Mr Bernard de Witt of Enviro Africa in Somerset West was appointed to conduct the EIA.

The EIA includes a public participation process. This process has been undertaken, with the legally prescribed notices put up in public places (Figure 1). Notices for the expansion of the project were posted during March 2024 and are shown in the Appendix.

Much of the Freshwater Report is focussed on the WULA and the DWS approval.

The WULA must be accompanied by a Freshwater Report as well as a completed Risk Matrix as published on the DWS webpage and in terms of GN509 of 2017. The completed Risk Matrix must be signed by a registered SACNASP scientist.

Dr Dirk van Driel of WATSAN Africa of Knysna was appointed to produce this report.

The Fresh Water Report must contain adequate information to allow for informed decision-making. The decision to approve the proposed development rests with DWS officials, in terms of S21 of the NWA. The Fresh Water Report must contain specified information according to a set profile, which has been developed over several years over many such reports.

The Freshwater Report must contain information for budgeting purposes. This first round budget is for the construction and trenching of the proposed pipeline. It was established that the pipeline will have to be buried deeper and that special attention is to be given in places along the path of the pipeline. These places are highlighted and quantified in the report.

A site visit was conducted, along with a team of specialist scientists, on 18 to 20 October 2022.

It was decided to expand the project. At first, the bulk potable water pipeline along the R27 trunk road was to be constructed from Keimoes southwards to the Soafkolk turnoff approximately halfway between Kenhardt and Brandvlei. The pipeline from the Soafkolk turnoff on the R27 must be extended further inland to a new site on the Farm Uitkyk close to the Sishen - Saldaha railway line. Site visits were conducted on 11 to

13 March 2024. These new developments led to the drafting of Version 3.0 of the Freshwater Report.

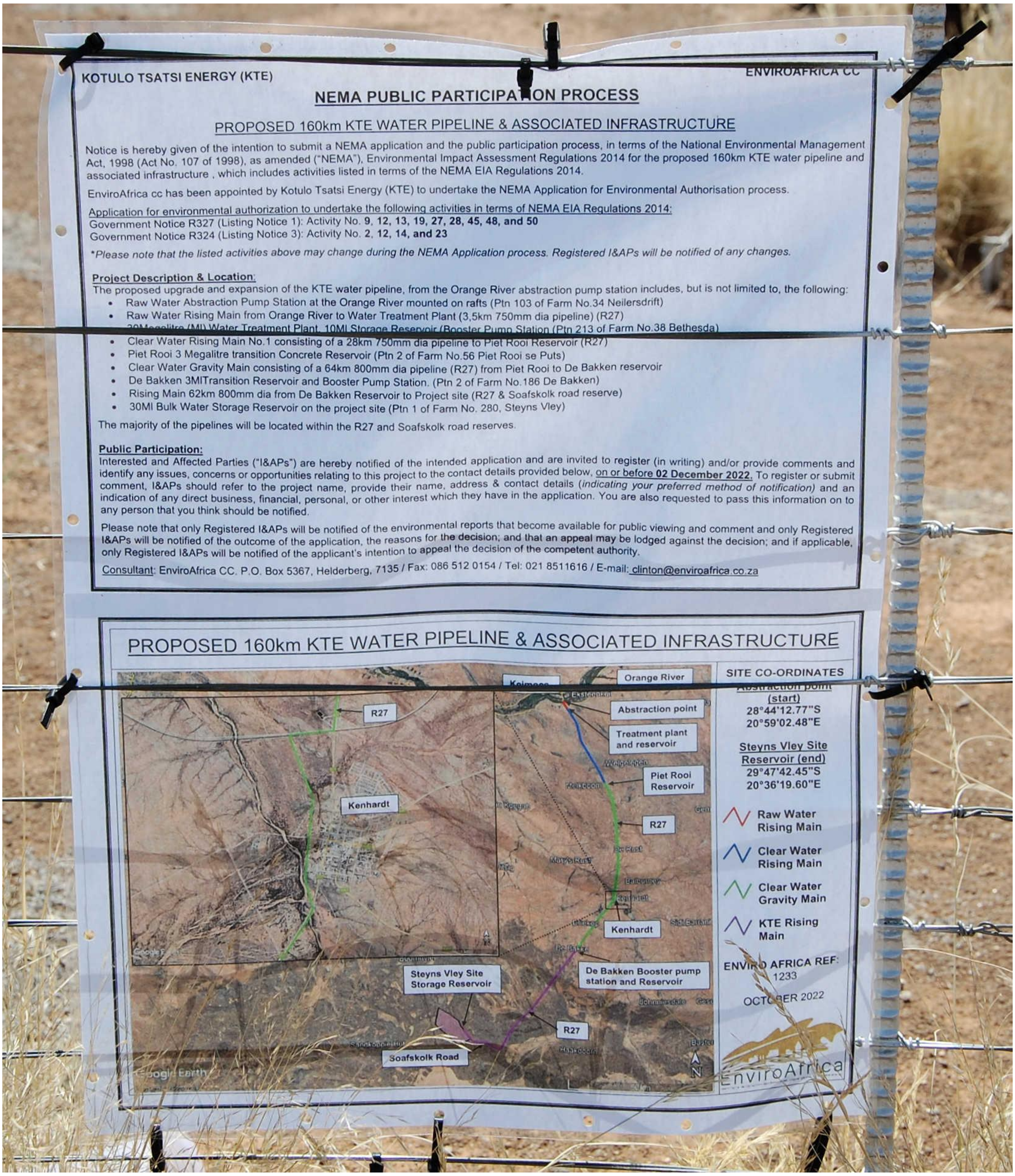


Figure 1 Public Participation

2 Legal Framework

The proposed development “triggers” sections of the National Water Act. These are the following:

S21 (c) *Impeding or diverting the flow of a water course.*

The proposed rock quarry is adjacent to natural drainage lines that are identified in the NWA and its regulations as legitimate water resources. The drainage lines could possibly be altered, should the development go ahead.

S21 (i) *Altering the bed, bank, course of characteristics of a water course.*

The proposed pipeline may alter the characteristics of the drainage lines.

Government Notice 267 of 24 March 2017

Government Notice 1180 of 2002. *Risk Matrix.*

The Risk Matrix as published on the DWS official webpage must be completed and submitted along with the Water Use Licence Application (WULA). The outcome of this risk assessment determines if a letter of consent, a General Authorization or a License is required.

Government Notice 509 of 26 August 2016

An extensive set of regulations that apply to any development in a water course is listed in this government notice in terms of Section 24 of the NWA. No development take place within the 1:100 year-flood line without the consent of the DWS. If the 1:100-year flood line flood line is not known, no development may take place within a 100m from a water course without the consent of the DWS. Likewise, no development may take place within 500m of a wetland without the consent of the DWS.

National Environmental Management Act (107of 1998)

NEMA and regulations promulgated in terms of NEMA determines that no development without the consent and permission of the DEA and its regional agencies, in this case the DENC of the Northern Cape Provincial Government, may take place within 32m of a water course. The mostly dry drainage lines are perceived to be legitimate water courses.

3 Locality

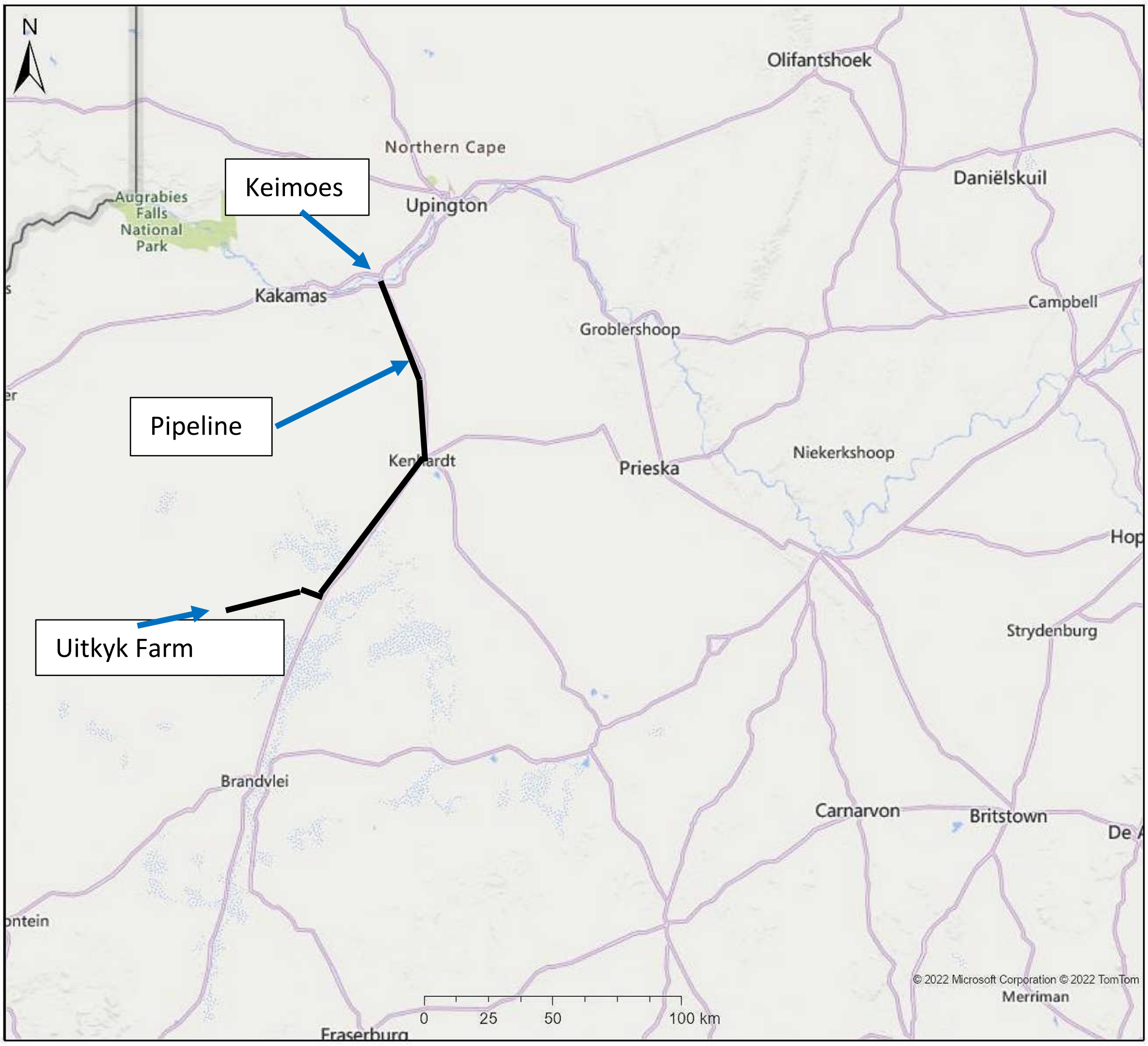


Figure 2 Locality

The proposed water provision pipeline will stretch from the Orange River south of the town of Keimoes to the Uitkyk Farm approximately halfway between Kenhardt and Brandvlei in the Northern Cape (Figure 2). The envisaged pipeline will cover approximately 190km, as measured with Google Earth's "path" function.

4 Brandvlei Climate

Brandvlei (Figure 1) is the closest locality to Uitkyk Farm for which an average annual rainfall is available on the internet. The scope and available budget for the average application of this nature does not allow to purchase accurate weather data but for the purpose of this application, the numbers given here are adequate.

Brandvlei normally receives about 54mm of rain per year, with most rainfall occurring mainly during autumn. The chart below (lower left, Figure 3) shows the average rainfall values for Brandvlei per month. It receives the lowest rainfall (0mm) in August and the highest (17mm) in March. The monthly distribution of average daily maximum temperatures (centre chart below) shows that the average midday temperatures for Brandvlei range from 17.1°C in July to 32°C in January. The region is the coldest during July when the mercury drops to 2°C on average during the night.

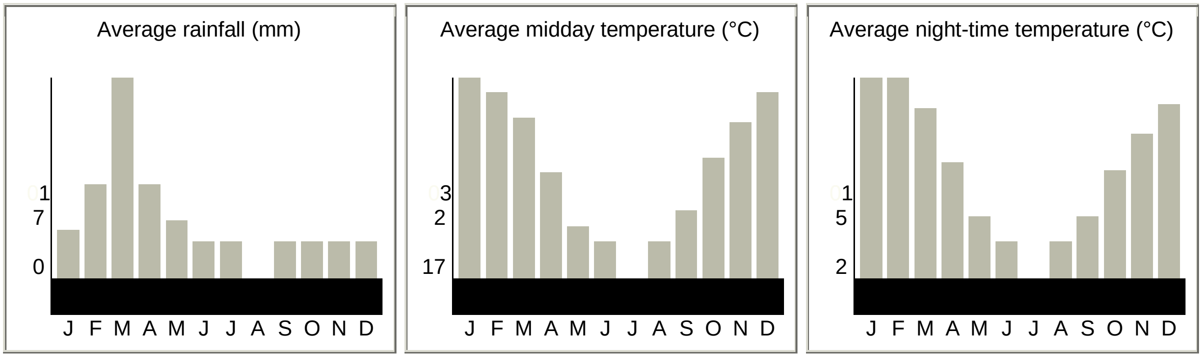


Figure 3 Brandvlei Climate

The evaporation rate amounts to 2800mm per year. This is tantamount to desert conditions.

Communities in the region are dependent on the occasional flooding of the Sak / Hartbees River system, which occasionally comes down in flood, once in a couple of years. Floods are mostly the result of violent and sudden electric thunderstorms.

The far south, the Sak River catchment touches on the winter rainfall region of the Western Cape.

Keimoes to the north receives 151mm of rain per year, which is slightly more, but still close to desert conditions.

5 Conservation Status

5.1 Vegetation

According to Mucina & Rutherford (2006), the following vegetation types occur along the path of the proposed pipeline:

Lower Gariep Alluvial Vegetation

Bushmanland Arid Grassland

Lower Gariep Broken Veld

The Lower Gariep Alluvial Vegetation is "Endangered" because of the large-scale agricultural development on the Lower Orange River (Appendix 31.1, p113).

The pipeline starts in the Orange River south of Keimoes next to the R27 road bridge. The bank here is transformed into a solid layer of rock and concrete to withstand large floods. The pipeline is not about to add to the existing impact.

The other two vegetation types are of "Least Concern" (Appendix 31.1, p113) and are not endangered in any way. The landscape has not been subject to transformation or major impacts and the proposed pipeline will not change any of this, as it will be in existing road reserves.

5.2 DFFE Screening Tool

Table 1 DFFE Screening Tool Results

Theme	Sensitivity
Animal species Aquatic biodiversity Plant species Terrestrial biodiversity	High Very High Medium Very High

Animal species theme

The following birds of prey are responsible for the High sensitivity rating for the animal species theme:

Falco biarmicus	Lanner falcon
Polemeatus bellicosus	Martial eagle
Neotis ludwigii	Ludwig's bustard

These birds have a wide distribution area in South Africa and even in Africa. The lanner falcon is a cosmopolitan species. The proposed pipeline is not about to have any impact on the conservation status of these birds. Ludwig's bustard is prone to collide with power lines. The pipeline *per se* will not be provided with any power lines or high structures of the kind that pose a threat to any species of bird.

Aquatic Biodiversity

The aquatic biodiversity sensitivity is rated as "Very High" because the Orange River, the Hartbees River and some of the drainage lines are regarded as NFEPA's. This report aims to illustrate that the proposed underground pipeline is not about to change this rating, provided that the mitigating measures are adhered to.

Plant Species Theme

The plants and botanical communities will be dealt with in a separate botanical report compiled by an experienced and qualified botanist. The proposed pipeline will be constructed on existing road verge and will not impact on any natural plant communities along its path.

Terrestrial Biodiversity

The path of the proposed pipeline is rated as "Very High" for the Terrestrial Biodiversity Theme because it is identified as a CBA, an ESA, important according to the Protected Area Expansion Strategy and the rivers and some of the drainage lines are regarded as NFEPA's.

This report aims to illustrate that the proposed underground pipeline does not pose a threat of a change to any of these ratings, provided that the mitigating measures are adhered to, as the evaluations in the following paragraphs will illustrate.

6 The Project

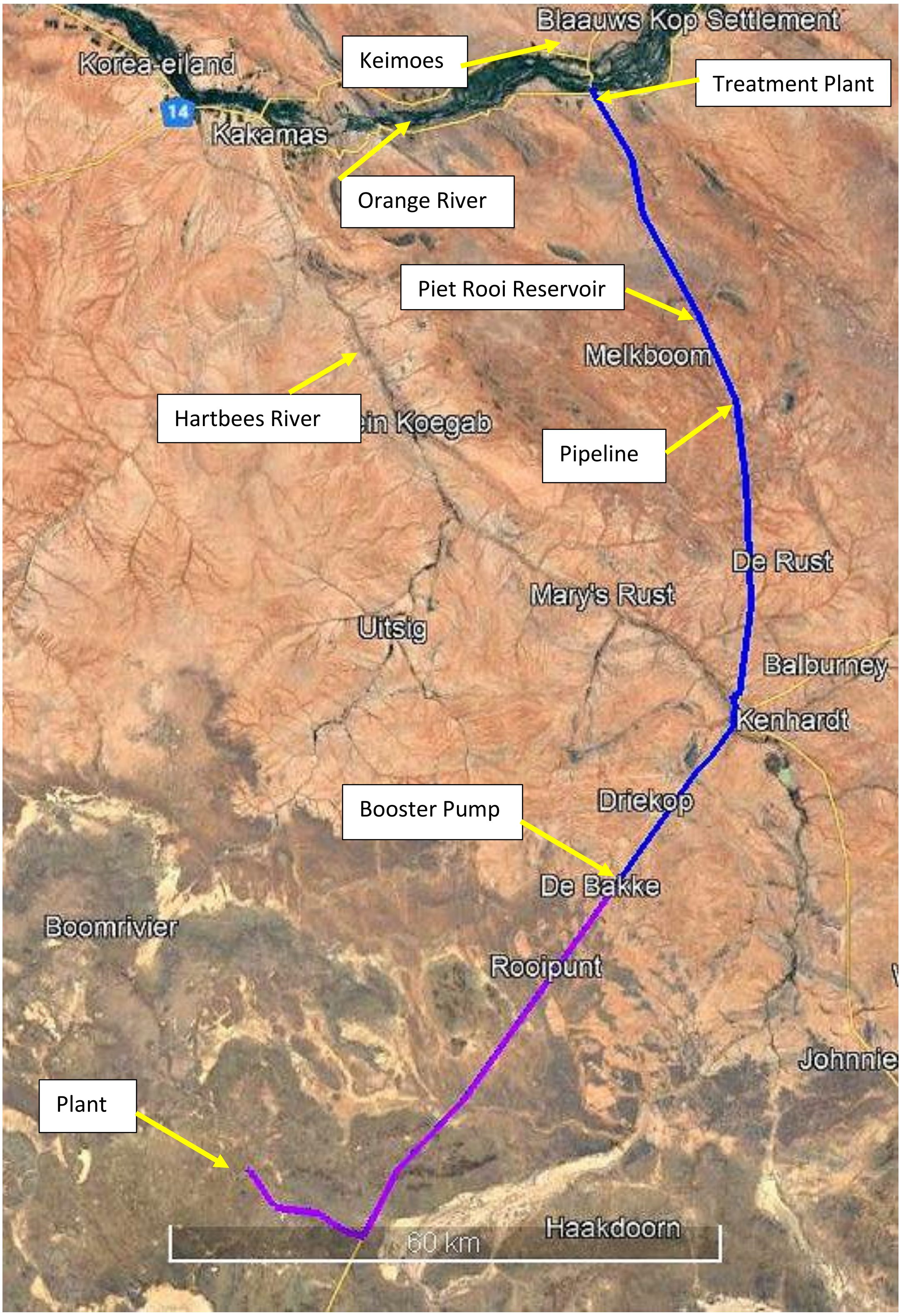


Figure 4 Project

A new pipeline is contemplated from the Orange River at Keimoes to a site between Kenhardt and Brandvlei in the Northern Cape, where the envisaged Green Nitrogen Plant is to be constructed (Figure 4) next to the Sishen – Saldanha railway line. A water storage facility will be constructed in this section of the pipeline.

This pipeline is to follow an existing pipeline along the R27 trunk road.

Water will be abstracted from the Orange River to the south of Keimoes. The river here is braided, with the southern stream known as Orange River 3, from where the water will be abstracted.

The current thought is that the pipeline will be 750 to 800mm in diameter and it will be manufactured of ductile iron. It will be trenched underground and will be in the R27 road reserve alongside an existing pipeline.

The existing water treatment works (Figure 15, p30) south of Keimoes will either be upgraded or replaced. This is on ground away from any river or drainage line and will not be discussed any further.

An existing reservoir at Piet se Berg (Figure 5) will be upgraded with more capacity and will not be discussed any further as it is away from any drainage lines.

Likewise, a new booster pump station will be constructed at De Bakke (Figure 4) and as this infrastructure is away from any drainage line, it does not warrant any more discussion.

Figure 5 Piet Rooi Reservoir

7 The Hartbees River, Sak River and the Pans

Several projects have been completed in the area and the next paragraphs were taken out of previous reports (Van Driel, 2021).

The Hartbees River rises as the Vis River on the highlands to the south of Sutherland more than 450km to the south (Figure 6).

The catchment area of this river system is large and covers a sizable chunk of the Bushmanland and the western Karoo.

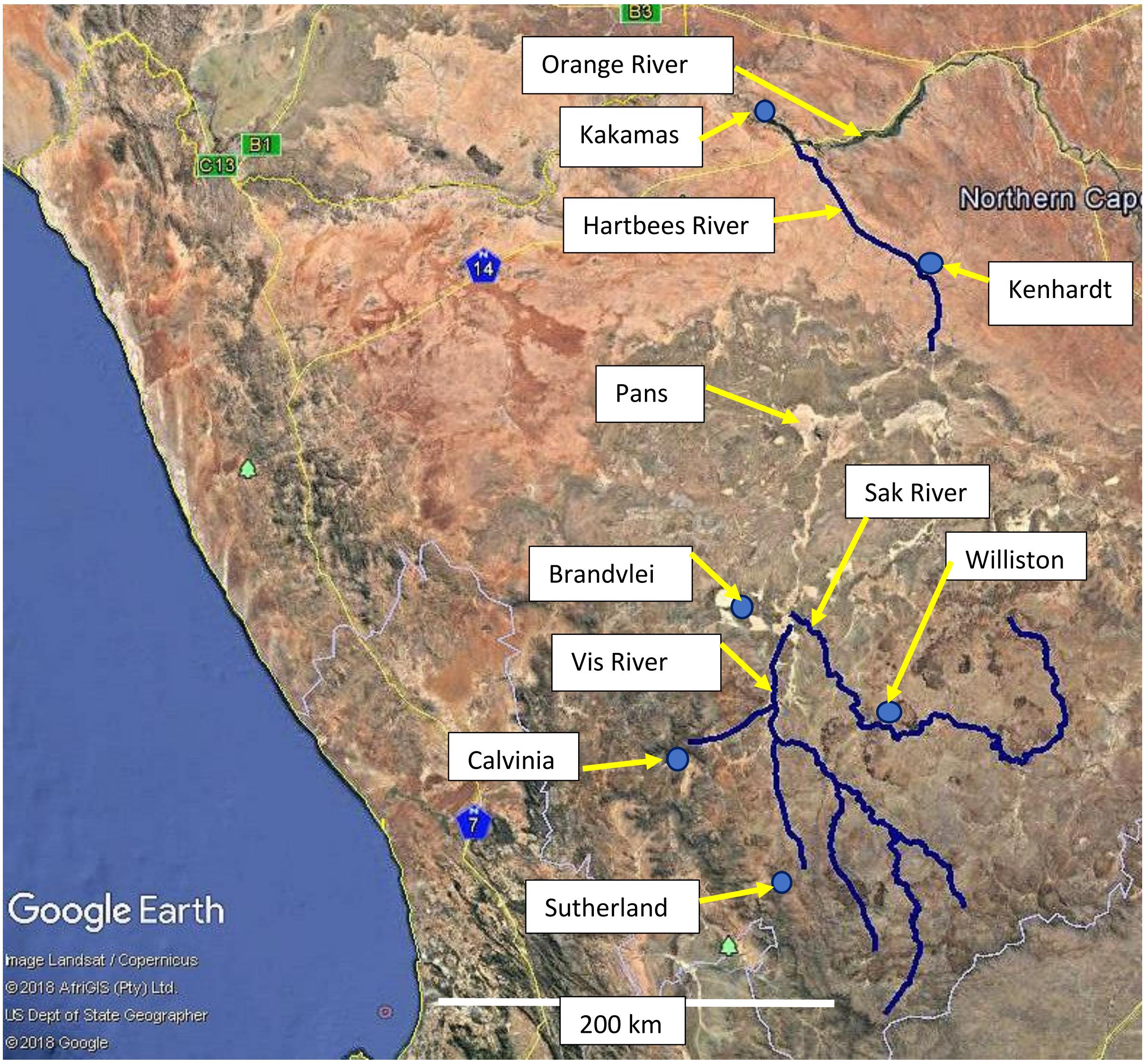


Figure 6 Sak / Hartbees River system

A series of pans separate the Vis River from the Hartbees River. Verneukpan is perhaps the one that is better known because the historical land speed record was set there. The Hartbees River only flows when these pans overflow. This happened in 1999 and in 2010. During a site visit in 2021, the pans along the R27 trunk road were under water. It is expected that these overflows will occur less often in future as water abstraction from the Sak River for agriculture increases.

It is however important to note that the Vis River do not contribute towards the Mean Annual Runoff (MAR) of the Orange River. This is an arid region and its contribution is negligible. The flow of the Orange River is mainly because of the contribution of the Lesotho Highlands.

The banks of the Hartbees River have been impacted since historical times, with agriculture leaving its mark. Currently there are several active agricultural concerns. In addition, there are several sand mines, some in the bed of the river, which are reportedly legally licenced entities.

8 Drainage Lines

The landscape around much of the Lower Orange River and the Sak River is dominated by a dense succession of drainage lines. They spread along the river with many smaller tributaries to cover the entire area. The iron oxides in the sands renders a red hue that is visible from space on the Google Earth images. These reds are concentrated in the drainage lines, making them even more visible (Figure 7).

The drainage lines are mostly dry, with water only during rains and perhaps shortly thereafter. During the odd thunderstorm, drainage lines can come down in flood. These floods maintain the drainage line’s morphological integrity, as sediments are moved and these water ways are scoured out.

Because rainfall events are far apart, the drainage lines must have been form over millennia, even since geological times.

These drainage lines are driven by the very scant rainfall events, sudden and sometimes severe thunderstorms, spread out over millennia. Rainfall is interspersed by prolonged droughts. This gives rise to a sparse and drought resistant vegetation. The shallow ground water that migrates along these drainage lines provides just enough moist for higher vegetation to take root and to hold on under these very harsh climatic conditions. Drainage lines are ecologically important, as it provides denser and higher vegetation in an otherwise barren landscape, contributing to habitat variation, biodiversity and migration routes.

The upper sub-catchments of these drainage lines are mostly near-pristine, with only grazing. The lower parts are heavily impacted by agriculture and sand winning. This stark contrast is evident all over the region.

Around the Orange River, the Hartbees River and even the Sak River, large-scale agriculture has changed the drainage lines into drainage channels among the vineyards and orchards. The upper reaches away from the rivers are less impacted, even near-pristine, as intense agriculture is not possible, apart from those areas where water is piped over long distances from the Orange River.

Much of the discussion in this report is about these drainage lines.

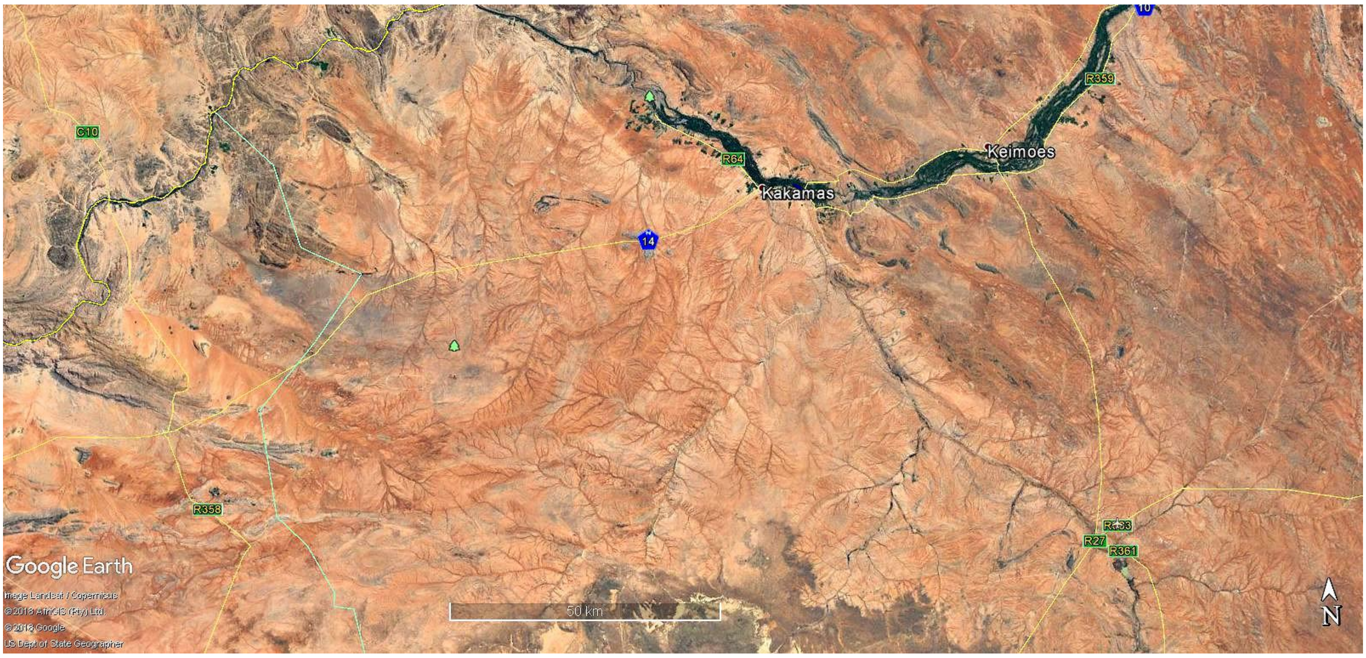


Figure 7 Drainage Lines

9 Sheet Wash Plains

Smaller drainage lines all over the landscape are marked by lines of driedoring (*Rhigozum trichotonum*) rather than red iron oxide depositions. These woody and thorny bushes find more soil moisture along the drainage lines than elsewhere, hence the denser stand. These small lines are visible on Google Earth images. This landform can be described as drainage line wash fields.

These drainage lines connect to one another in a continuous fan, interconnected, with no visual demarcation between drainage lines. This is visible on Google Earth Images, as well as on the ground. During rainfall events, storm water spreads out, migrates sideways, left and right, the flow slows down, deposits its sediment load to create sandy or gravely sheet wash plains. Sediment transportation and deposition are clearly visible.

Where larger drainage lines fuse in this manner lower down sub-catchments, much larger sheet wash plains are evident.

10 Sub-Catchments

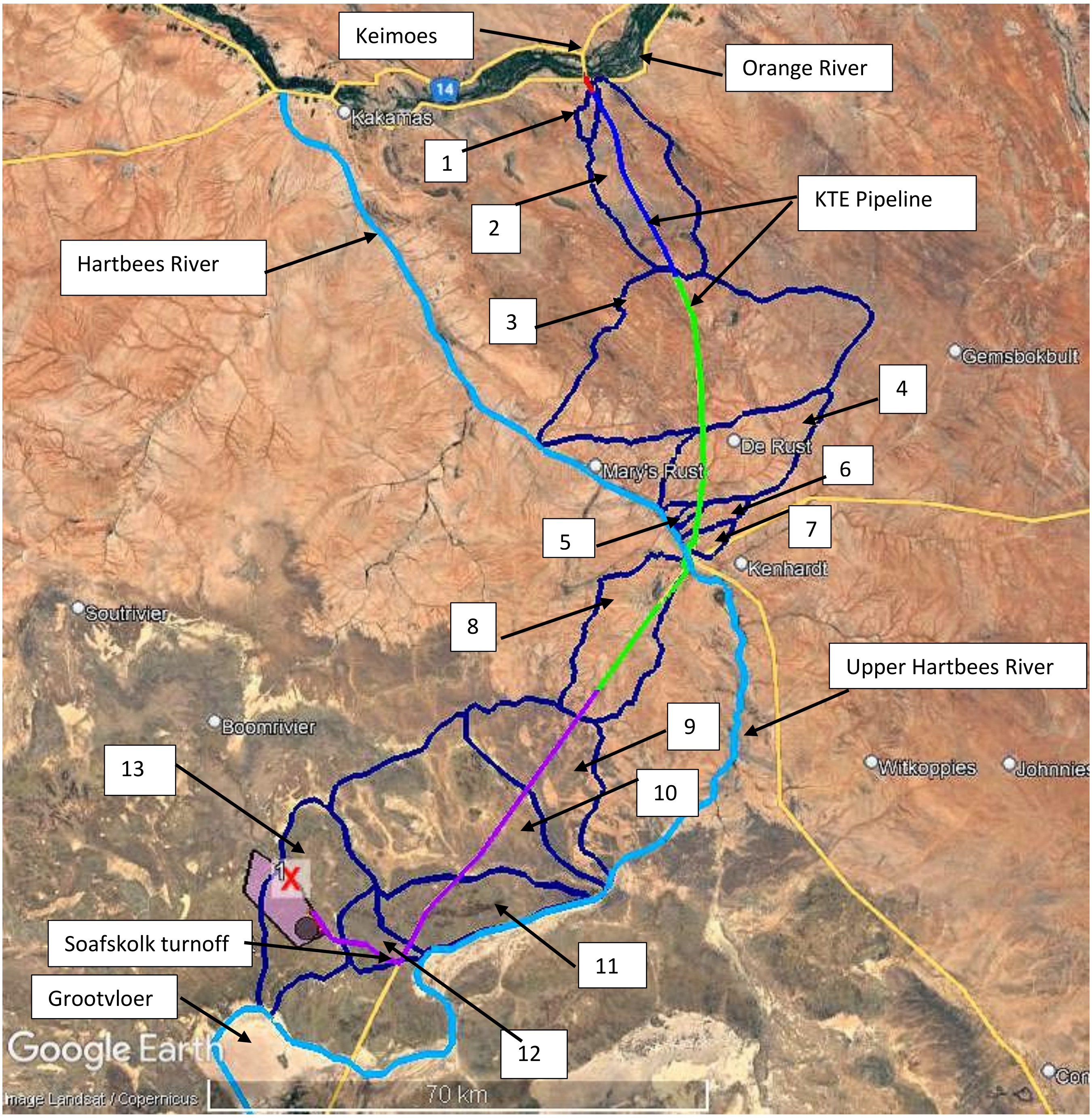


Figure 8 Sub-Catchments

Table 2 Sub-Catchment surface areas

No.	Surface area Ha	Circumference km	Length km	Width km	Slope
1	1598	20.7	8.4	2.9	1.24
2	25590	75.0	30.9	11.1	0.74
3	70460	124.0	49.8	23.0	0.55
4	20782	66.7	28.7	10.8	0.68
5	628	12.6	5.9	1.5	1.13
6	2552	25.1	11.1	3.2	0.86
7	2125	20.1	7.7	3.8	1.01
8	21991	70.0	26.9	11.5	0.55
9	25865	81.6	31.0	12.3	0.36
10	49018	107.6	31.8	26.8	0.35
11	18736	69.5	9.9	29.0	0.62
12	6695	37.7	12.0	6.6	0.52
13	27420	78.0	29.2	16.0	0.16

The proposed pipeline and its associated infrastructure transverses 13 sub-catchments (Figure 8). The sub-catchments vary greatly is size, from 1589 ha to more than 70 000ha and from as little as 12km long to over 100km long Table 2).

The sub-catchments can be demarcated by using Google Earth's polygon function (Figure 8). The highest points around a drainage line can be connected to draft the watershed boundaries. In the event of the mostly flat Bushmanland country, with little high topographical points, the red-stained drainage lines, even the finest tributaries, indicate these boundaries. It becomes more difficult in sheet wash plains, as well as in some of the upper catchments, where the literally hundreds of finer tributaries are intertwined, interconnected, but it still leaves adequate clarity for a reasonable estimation.

Sub-Catchments No.1 and No.2 discharge into the Orange River. Sub-Catchments No.3 to No.8 discharge into the Hartbees River. The Upper Hartbees River south of Kenhardt receives water from Sub-Catchments No.9 to No.12. Sub-Catchment No.13 drains into Grootvloer, an instream pan of the Sak River (Figure 8).

The average slope (Table 2) was calculated from the highest points in the upper catchments. The sparce rocky ridges standing out above the otherwise flat topography were not used to calculate the average slope, as this would distort the general impression of the flat landscape.

The landscape changes from the turnoff at Soafskolk southward towards Brandvlei. Larger drainage lines give way to a multitude of small drainage line wash plains. The boundaries of sub-catchments were difficult to determine.

The landscape here is dotted by a profusion of smaller diffuse pans. These are arranged in places along preferred stormwater flow paths.

The pipeline will pass through the Grootvloer Pan, a prominent feature on the Boesmanland landscape.

11 Methodology

There were numerous drainage lines along the paths of the envisaged pipeline, too many to find the coordinates for each of these crossings.

To get to grips with the volume of the work that had to completed within the available time and budget of this application, as is the case with most if not all applications, the drainage lines, depending on their size, were divided into 5 classes (Table 3)

Classes 1, 2 and 3 were only counted. Class 4 and 5 were marked, the coordinates were noted, using a hand-held GPS. These drainage lines were photographed, upstream and downstream of the road, as well as the culvert or bridge.

A complete record of these photographs is available. This photographic record is substantial and cannot be all included in this Freshwater Report, but is available upon request, should the contractor require more information.

The classification for some of the drainage lines posed difficulty because erosion downstream of a culvert can be substantial, with dongas, vertical sides and wide beds, while upstream there can be scarcely a sign of any drainage line. It was surmised that the smooth foundation of a box culvert or a large pipe culvert can cause the flow of storm water to be accelerated. Where it gushes out from underneath the road, it possesses adequate velocity and as a result an enhanced erosion potential to scour out a substantial drainage line. Upstream of the culvert, the drainage line can be a Class 1 of 2, while downstream it can be a Class 4 or 5. In this event, an average score for the class was arrived at.

This has consequences for the lying of the pipeline. It seems to be much more cost effective to excavate the trench and bury the pipeline upstream of the culverts and the roads. Downstream of the culverts, adjacent to the roads, there are many more Class 4 and 5 drainage lines that require much more earth works and other civil infrastructure.

This methodology was applied on 18, 19 and 20 October 2022 and again on 11 and 12 March 2024.

Table 3 Drainage Line Classes

Class	Characteristics	Actions
Class 1	There is no discernible or visible drainage line. There is only a culvert.	No action is required.
Class 2	There is a drainage line. The drainage line is faint.	No action is required.
Class 3	There is a discernible drainage line. The drainage line is distinct.	No action is required, apart from that the backfill must be 900mm deep.
Class 4	There is an obvious, discernible drainage line, with clear signs of sediment transportation.	Pipeline protection measures and erosion control measures must be implemented. The pipeline must be covered with 900 to 1200mm of backfill.
Class 5	Drainage lines resemble a river, more often than not incised, often with a wide riverbed.	Pipelines protection measures must be implemented, such as gabions, reno matrasses and anchors.

12 Field Observations

Table 4 gives the numbers of each class that was observed and counted during the site visits.

Table 4 Number of drainage line crossings

Route	Class 1	Class 2	Class 3	Class 4	Class 5
Orange River 3 to Brandvlei and Uitkyk Farm	401	51	41	18	11
Grand Total	522				

12.1 Class 1 and 2 drainage lines and culverts

Class 1 and class 2 drainage lines occur in clusters or are evenly stretched over a section of the road.

The clusters mark upper sub-catchments where the drainage lines are divided into many small tributaries that spread out over the landscape like the fingers of a hand. Each of these small tributaries are provided with a pipe culvert underneath the road.

Where the pipe culverts are evenly spread, often on set distances apart, these were obviously constructed for the drainage of the road in the event of downpours of rain with stormwater. These culverts were provided with embankments on the downhill side, on both sides of the road.

On top of each culvert, on both sides of the road, are walls, just above ground level, visible from the road, to stabilize the road verge. These are of cast concrete (Figure 9).

Culverts are marked with a reflective signpost next to the road, of the type that is often encountered along trunk roads.

During the site visit in October 2022, maintenance was going on, with teams of workers manually shoveling sediments, debris and weeds out of the entrance to the culverts. As a result, the entrances were clearly visible from a passing vehicle.

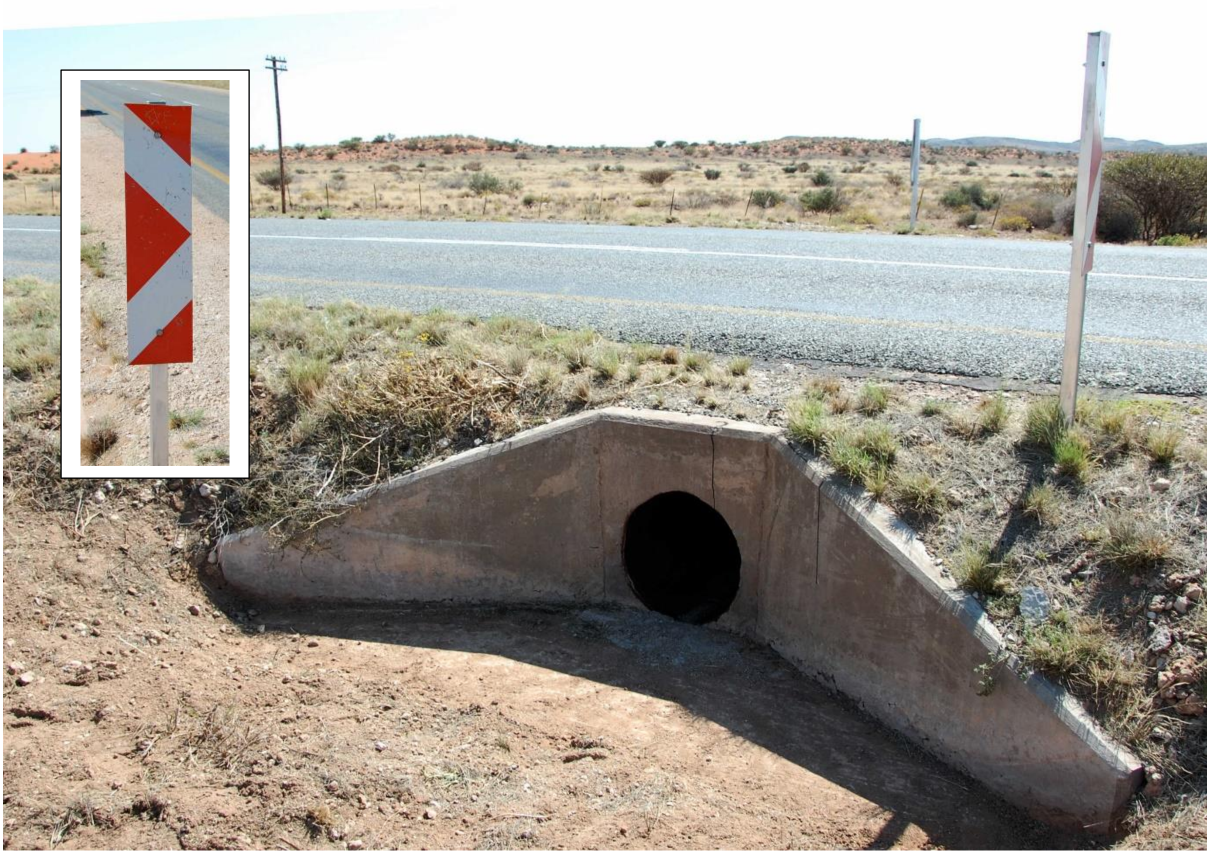


Figure 9 Class 1 drainage line with pipe culvert.

12.2 Abstraction Point to the Irrigation Canal

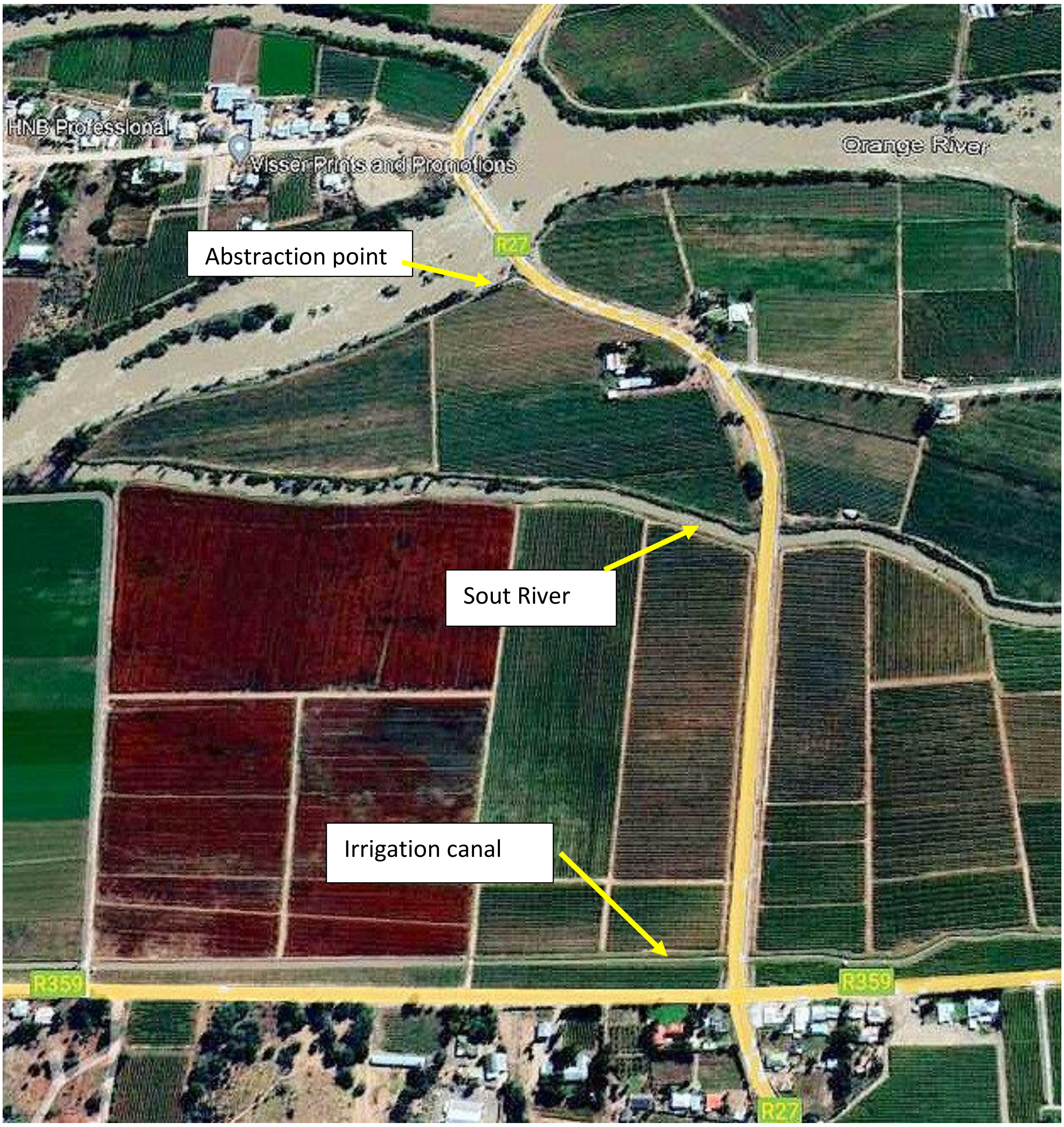


Figure 10 Start of the pipeline

The abstraction point on the Orange River 2 will on a large raft (Figure 10) that is currently operational with two pumps in the river. The new abstraction point's design details are still under discussion, with a possibility, depending on negotiations, that the current infrastructure will keep the new pump and associated equipment afloat.

Figure 11 Raft and pumps

Figure 12 Sout River

Figure 13 Irrigation canal

From here the pipeline is directed towards the south along the R27 and through the vineyards where it will cross the Sout River (Figure 12). This branch of the braided Orange River now is merely a deep trench that acts as a conduit for irrigation return flow. The pipeline will be constructed over the Sout River, on pedestals on the banks and will have no mentionable impact, as long as building rubble and loose dirt is kept out of the river during the construction phase.

The pipeline stretches further south through the vineyards and then over an irrigation canal (Figure 13).

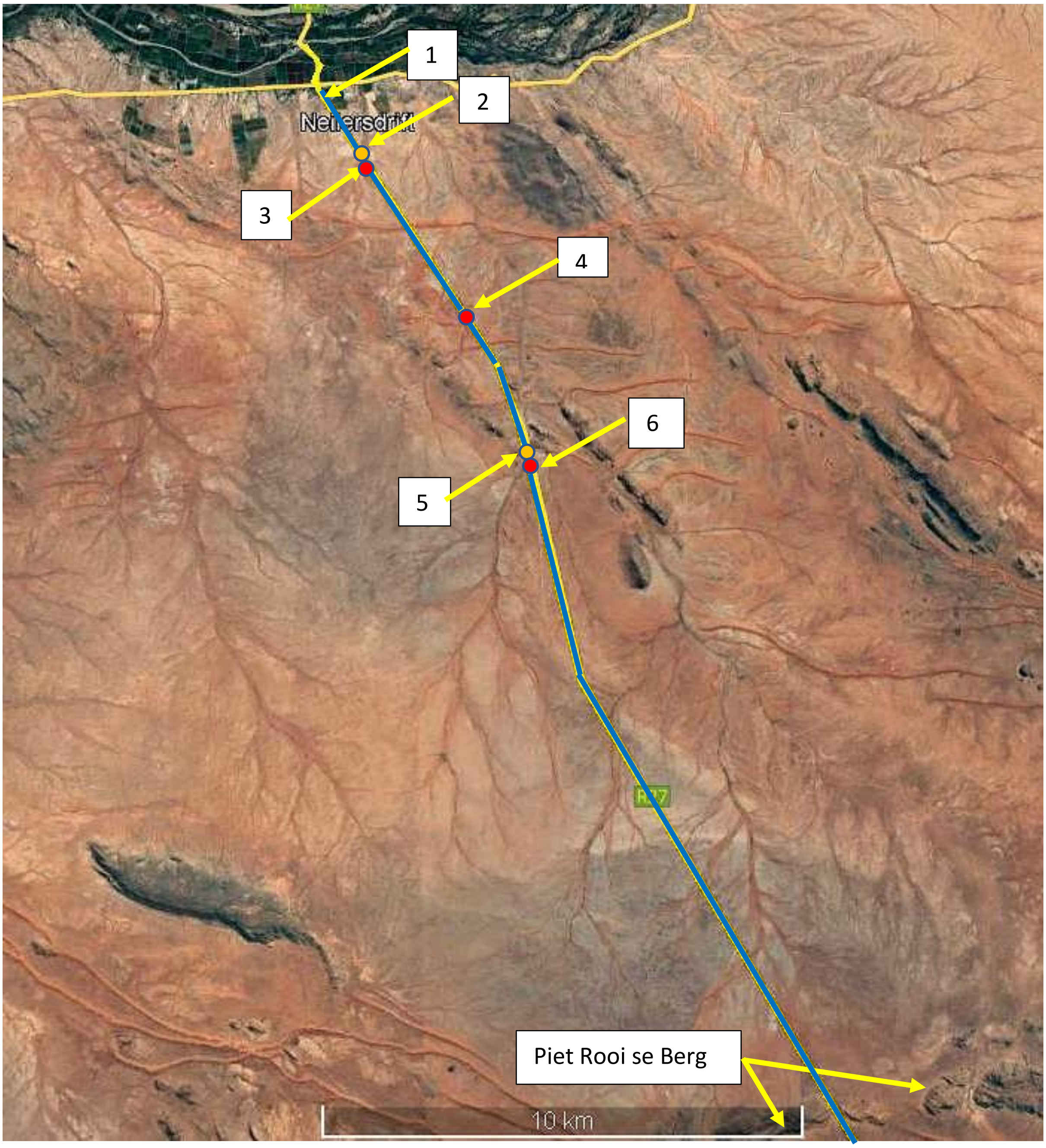


Figure 14 Pipeline from Orange River 3 to Piet Rooi se Berg

12.3 Orange River 3 to Piet Rooi se Berg (Figure 14)

The first Class 4 drainage line has a box culvert close to the municipal water works along the R27 Point No. 2 in Figure 15 and in Table 1. The drainage line at the crossing is shallow and sandy. The side of the road is enforced with a gabion. A precast concrete turret rises out of the existing underground pipeline and it was leaking water at the time of the site visit that collected in a puddle at the side of the road (Figure 15).

Crossing at Point No.3 is just 500m further along the R27 towards the south and is similar, except that the drainage line is more emphasised, wide and sandy (Figure 16).

The crossing at Point No.4 is similar, a box culvert on a sandy drainage line. There are some more box culverts along this stretch of road, but on Class 2 and 3 drainage lines that do not call for extra or special measures.

Point No. 5 and No.6 are 400m apart on the same drainage line. This is a large drainage line at the dolerite hills. Two sets of culverts are at Point No.5, the one is a pair of pipe culverts and the next a pair of box culverts (Figure 17). The two sets are adjacent to one another. At Point No.6 is a proper bridge (Figure 18) with adequate space for a large flood. The drainage line bed is sandy and wide.

From here onwards to the crest of Piet Rooi se Berg along the R27 southbound are 45 more culverts, mostly pipe culverts.

Figure 15 Crossing at Point No.2 at municipal water works.

Figure 16 Crossing at Point No.3

Figure 17 Crossing at Point No.5

Figure 18 Bridge at Point No.6

12.4 Piet Rooi se Berg to Kenhardt

The next section of the R27 of importance stretches from Piet Rooi se Berg to Kenhardt (Figure 19). This is the most challenging section, as there are larger drainage lines that call for an additional civil engineering effort when the pipeline is trenched.

There are 111 pipe culverts on this stretch of road, 8 of which are Class 2 and the rest Class 1. There is only one Class 3 with a 2-box and 3-box culvert close together over the same drainage line.

There are 3 Class 4 drainage lines and 2 Class 5 drainage lines.

The crossing at Point No.7 has a two-box culvert as well as a 3-box culvert (Figure 20). These culverts are provided with gabions. At trench dug into the calcrete substrate follows the road next to the verge. This is a substantial trench that will need some redesign and restoration following the trenching of the new pipeline (Figure 21).

Point No.8 has a large drainage line spanned by a proper bridge as well as a single box culvert close by. The drainage line shows signs of erosion and sediment transport, which will have to be addressed following the trenching of the new pipeline. The drainage line bed is sandy, with gravel and rocks (Figure 22).

Point No.9 has a wide drainage line with several culverts. There are 3 single box culverts, each provided with a stack of upright gabions and reno mattresses. Another box culvert further on with a sandy drainage line floor shows signs of erosion (Figure 23).

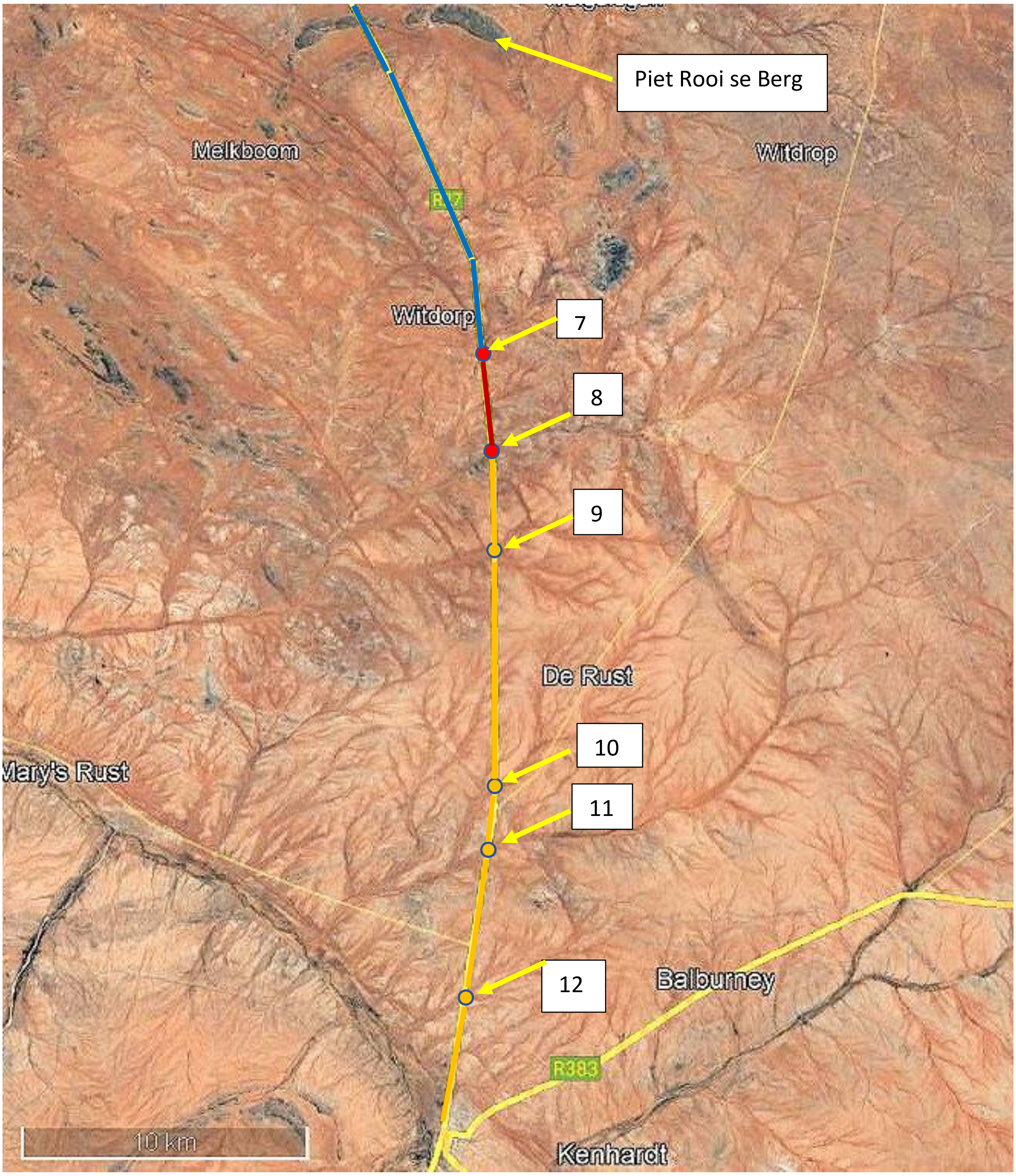


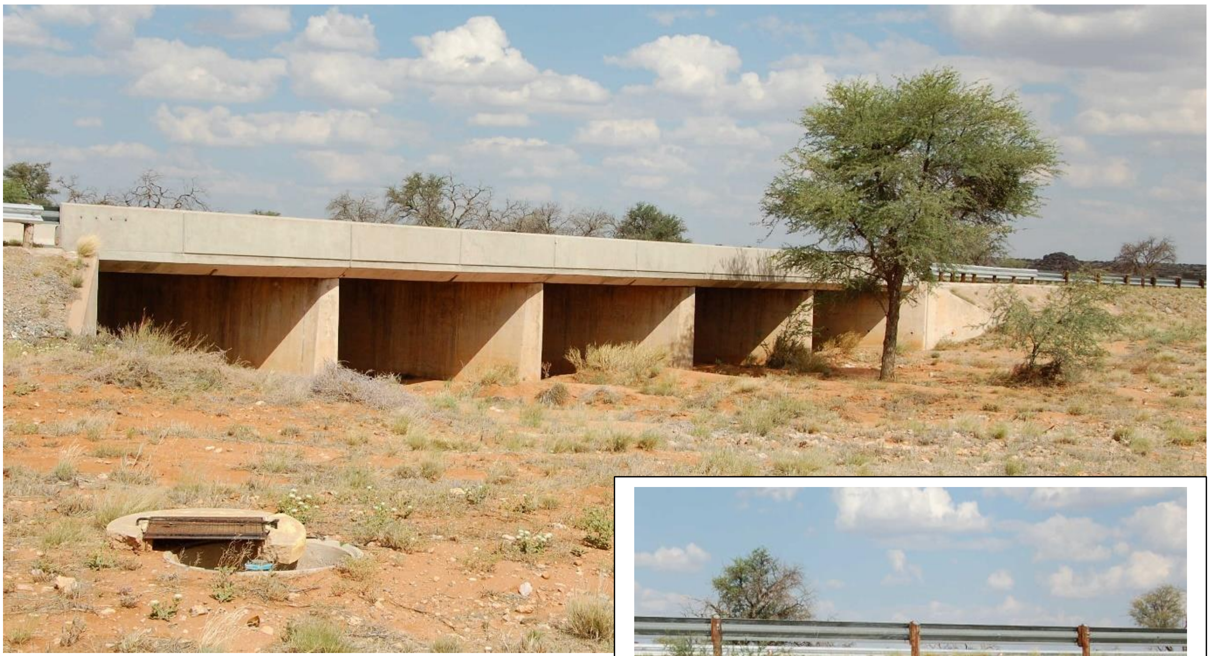
Figure 19 Piet Rooi se Berg to Kenhardt

Point No.10 has a similar cluster of culverts (Figure 24). The drainage line is wide and sandy. This is a Class 4 drainage line.

Point No.11 is marked by a wide drainage line (Figure 25) and the bottom is deep sand. It has two culverts, one with two boxes and the other with only one. These culverts are large, with space for a flood.

Figure 20 Point No.7 drainage line crossing

Figure 21 Continued Point No.7 drainage line crossing



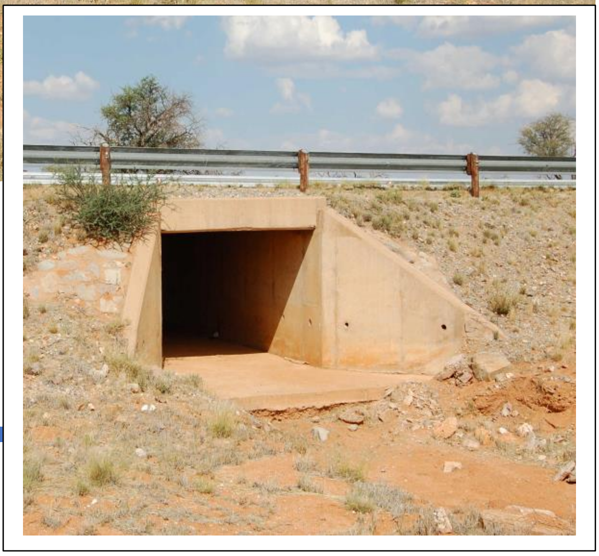


Figure 22 Bridge and box culvert at Point No.8 crossing

Figure 23 Point No.9 Box culverts

Figure 24 Cluster of culverts at Point No. 10

Figure 25 Culverts at Point No. 11

Figure 26 Culverts at Point No.12.

The culverts at Point No.12 (Figure 26) sizeable, with two boxes in the one and three in the next.

12.5 Through Kenhardt

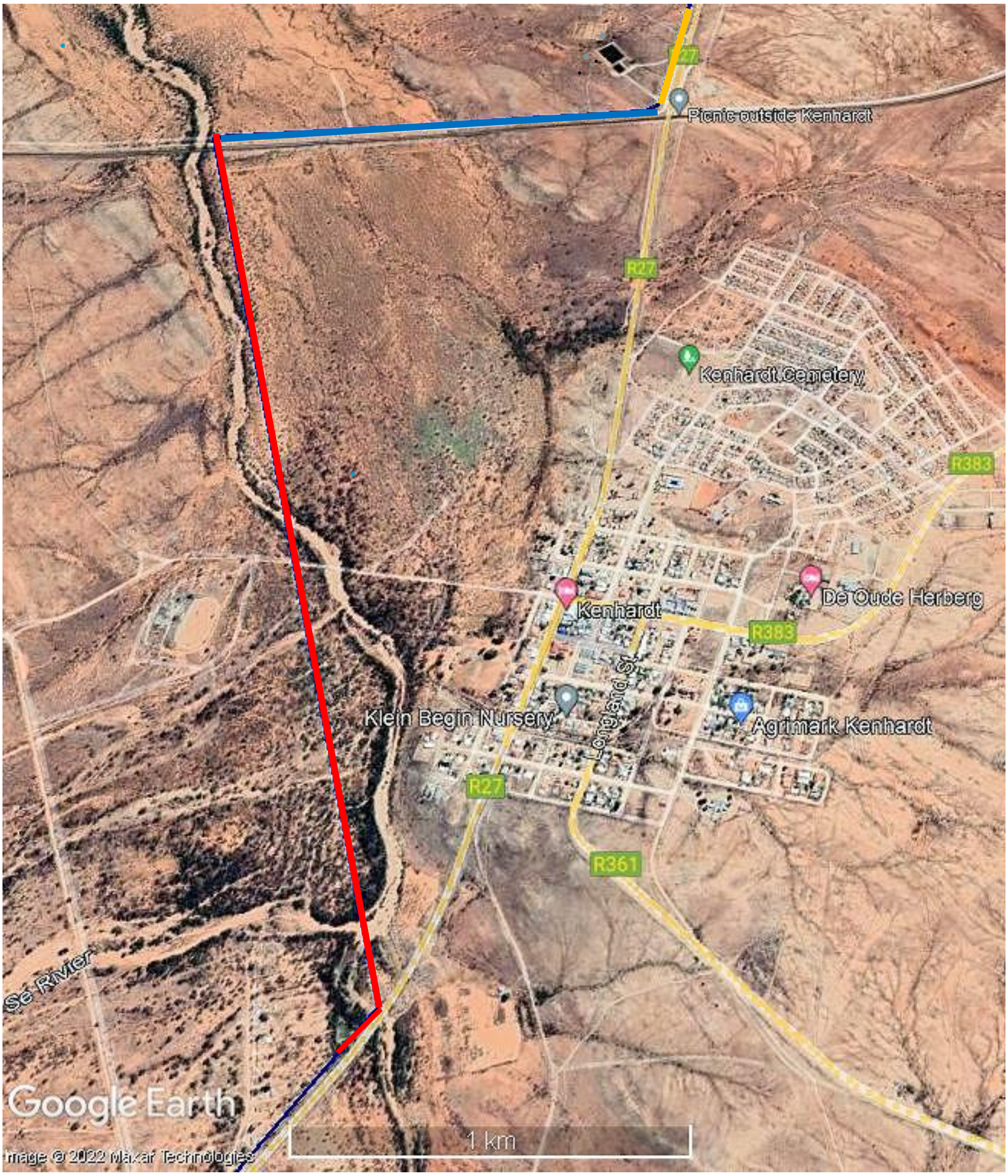


Figure 27 Route through Kenhardt

The proposed pipeline will swing to the west from the R27 (Figure 27) to follow the Sishen-Saldanha railway line to the railway bridge across the Hartbees River (Figure 28). The pipeline will swing towards the south underneath the railway bridge to cut across the riverbed on the west of Kenhardt to the R27 road bridge (Figure 29) south of the town. From there, the pipeline will follow the R27 on the western verge further south in the direction of Brandvlei.

The section from the R27 to the railway bridge to the north of Kenhardt is marked in blue, Class 1, at there is a sheetwash plain without distinct drainage lines. From the railway bridge to the R27 road bridge south of Kenhardt, the route is marked in red, Class 5, as the pipeline must be buried deep under the riverbed. Likewise, where it passes under the Hartbees River adjacent and to the west of the R27 road bridge, the section is marked in red.

Figure 28 Railway bridge

The Hartbees Riverbed is wide and sandy, but heavily overgrown with *Prosopis* trees (Figure 29). These trees are declared weeds and are aggressive invaders in this part of the country.

The invasive trees (Figure 31) are perpetually fertilized by the partly or even untreated sewage (Figure 30) out of Kenhardt that flows out of the dysfunctional wastewater treatment works, passes under the R27 through a culvert north of town and then down into the river.

At the R27 road bridge south of the town, the river is dry, as it is most of the time, with no trace of any sewage effluent. All of it dissipates in the river to the west of the town.

Figure 29 R27 Road bridge south of Kenhardt

Figure 30 Sewage effluent

Figure 31 Composite image of the Hartbees River west of Kenhardt

12.6 Kenhardt to the ridge

This is the first stretch of the Kenhardt to the Uitkyk Farm pipeline (Figure 32)

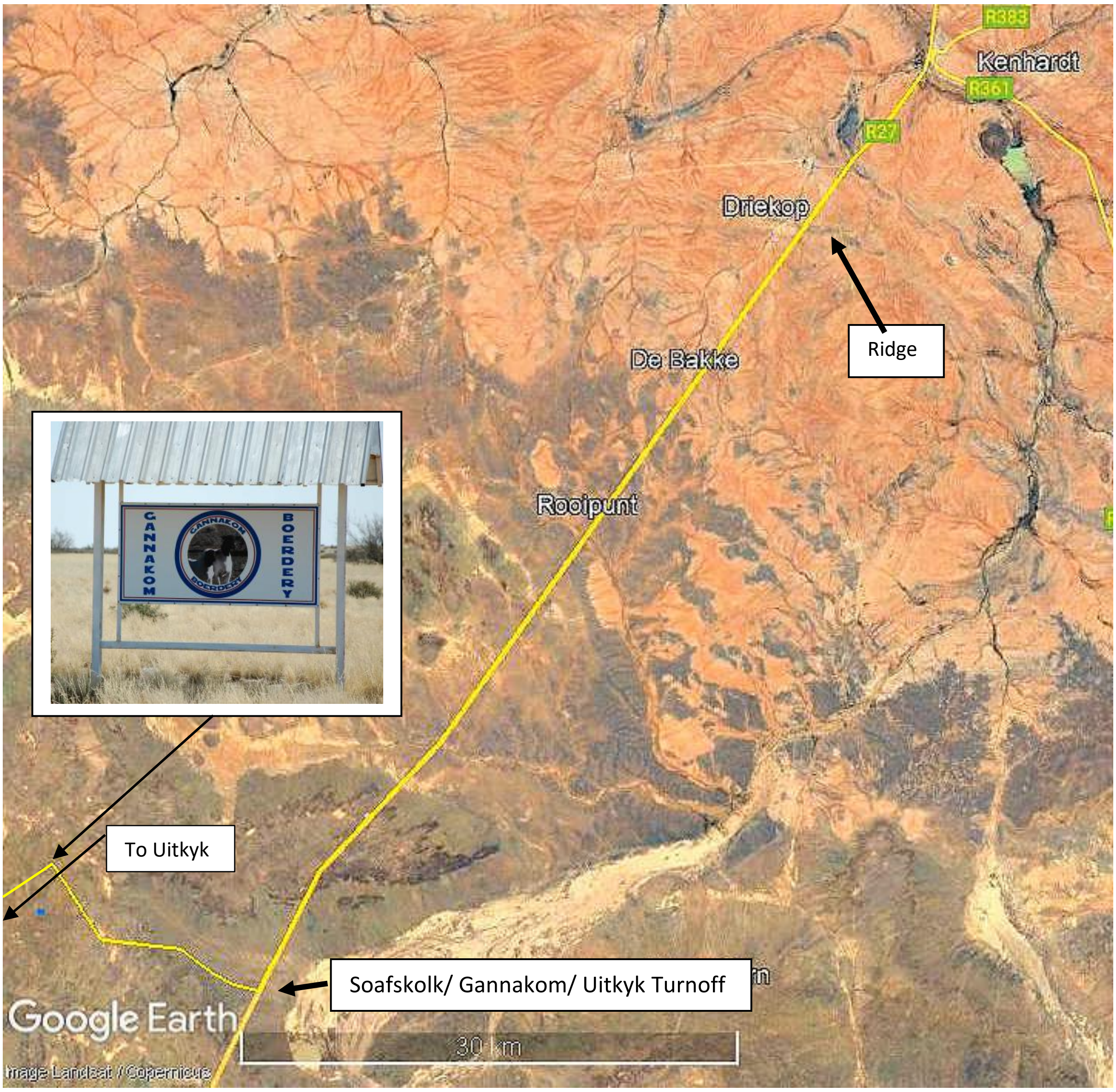


Figure 32 Kenhardt to Uitkyk Farm

Driekop se Rivier (Sub-Catchment No.8, Figure 19) is one of the larger drainage lines along the proposed pipeline. It stretches from Kenhardt to the south along the western side of the R27 trunk road (Figure 33). The smaller and finer tributaries at the edge of the sub-catchment cross the R27, as well as some of the bigger ones.

The topography is typified with wide, shallow valleys with low ridges across the R27. The drainage lines typically occur in clusters, with the largest ones in the bottoms of the valleys, surrounded by a several smaller ones. This is apart from the many pipe culverts underneath the R27 for stormwater drainage purposes.

When driving south from Kenhardt past the turn-off to Pofadder, 6.7km from the bridge over the Hartbees River, the first valley and its cluster of drainage lines start. This valley is, from the Pofadder turnoff to the next ridge, is 4.4km wide with the largest tributary of the tributary crossing at 2.3km from the turnoff (Figure 33).

The bottom of the valley at the largest tributary crossing is at an elevation of 867masl and the ridge is at 887masl over 1.4km.

The valley bottom is granite and not the more common shale and dolerite.

This section of pipeline's map (Figure 32) resolution is too low to illustrate the locality of the crossings and another map was drafted with a higher resolution (Figure 33).

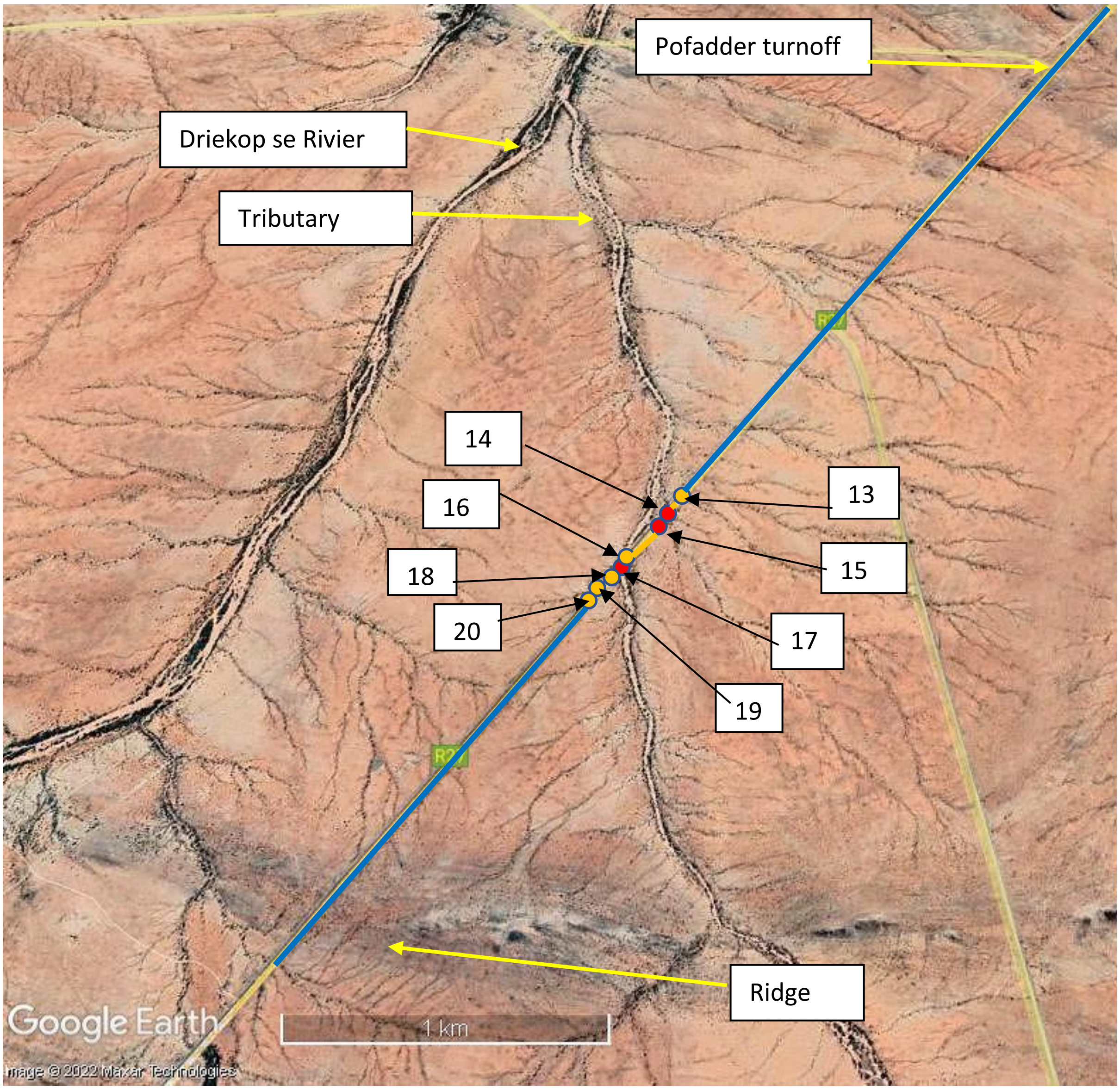


Figure 33 Driekop se Rivier tributary

It is important to note that there are 34 drainage lines crossings before the first Class 4 crossing (No. 13 on Figure 33) is encountered. Five of them are Class 3; two are Class 2 and the rest is Class 1. From the end of the cluster (Point 20, Figure 33), there are another 5 drainage line crossings to the ridge, two of them in Class 2 and the rest in Class 3. This is a really “busy” valley, with 47 crossings in 4.4km. The valley floor is of granite, that is about to significantly add to the effort and cost for trenching the pipeline.

The following is a photographic record of some of the drainage line crossings.

The culverts and the drainage lines at Point No.14 and 15 are similar (Figure 34 and 35). The drainage line is sandy underlain by granite.

The drainage line at Point No.17 is a 2-box bridge (Figure 36). It has a sturdy row of gabions on the one side. This is of the larger drainage lines with a wide bed of sand and loose stones. If there is solid granite down below, it was not seen during the site visit and was covered by sand.

The bridge is flanked by pipe culverts. The one to the south is a concrete one into a gabion (Point 16). The one on the north is corrugated metal pipe (Point 18).

Figure 34 Point No.14 crossing

Figure 35 Point No.15 crossing

Figure 36 Point No.17 crossing

Figure 37 Point 19

Figure 38 Pipe culvert at Point 20

To the north is flanked by another one-box culvert (Point 19, Figure 37) like the ones at Point 14 and 15. The embankment and floor next to the culvert is paved with stone and cement.

Further on is another corrugated iron pipe culvert (Class 4, Figure 38, Point 20).

12.7 From the Ridge to the Soafskolk Turnoff.

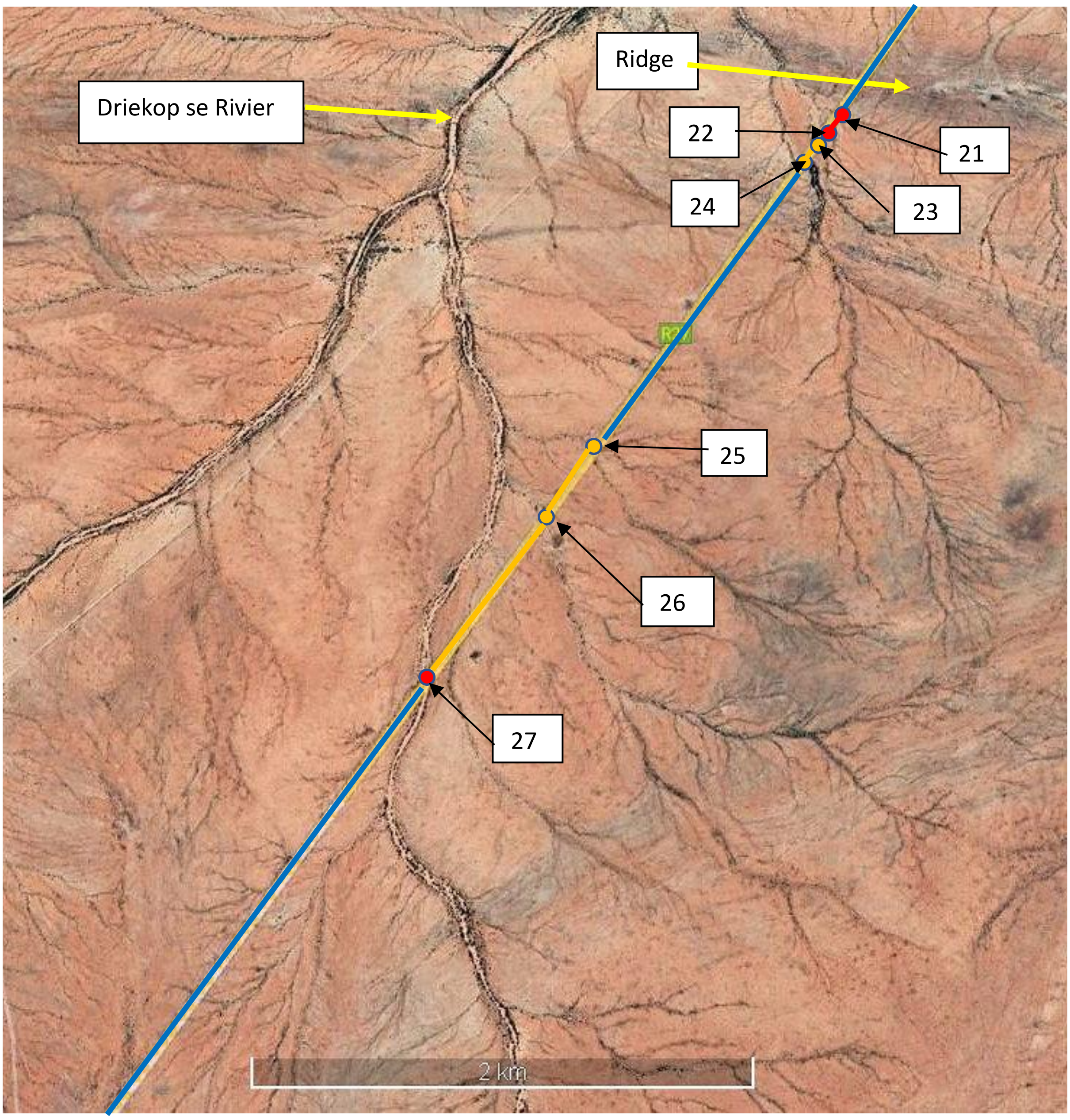


Figure 39 South of the Ridge

A smaller tributary of Driekop se Rivier breaks through the ridge just west of the R27. It gives rise to a cluster of drainage lines on the R27 (Figure 39, No. 21 to 24). No. 21 has a box culvert and No. 22 has a pipe culvert. No. 23 has a double box culvert with a paved exit floor (Figure 40). There is a paved gulley of rock and cement next to the road that has broken up on places. This gulley must be rebuilt after the new pipeline has been trenched. Point No. 24 has a single box culvert that resembles similar ones along the R27. These drainage lines are underlain with granite that is covered with a layer of fluvial sand.

Then follows a huge Class 5 drainage line (Point No.27 on Figure 41), which is from the second large tributary of Driekop se Rivier. It has five large box culverts.

Figure 40 Culvert at Point No. 23

From here follows an incline up to the next low ridge. There are another three Class 1 drainage lines up to the ridge.

South of this low ridge are two more Class 2 and two more Class 3 drainage lines that leads up the next two Class 4 drainage lines (Point No. 25 and No. 26), each with the usual single box culvert. Between these two drainage lines are another three lesser ones.

Figure 41 Class 5 at Point No. 27

There are another 17 lesser drainage lines up the incline to the next ridge just more than 2km away to the south.

At an area known as De Bakke, 6.85km south of Point No.27, at a signpost marking 120km away from Brandvlei, is another Class 4 drainage line. It resembles similar single box culverts along the R27.

Figure 42 Past De Bakke

Figure 43 From De Bakke past Rooipunt

Point No. 28 on Figure 42 consists of a cluster of 5 culverts. The first one is only a Class 1 drainage line and is located at the 118.4km mark, as indicated on a signpost next to the road. The second one has 4 arches in the constructed culvert (Figure 44). The next culvert is a two-arch box culvert. The fourth one is 50m on and has two arches. The drainage line here was eroded the deepest and was classified as a Class 4. The fifth culvert in the cluster has three low arches (Figure 44).

Figure 44 Class 4 at Point No. 28.

Figure 45 Point No. 29

The next drainage line of interest, Point No. 29, is just to the south of Rooipunt (Figure 45). There are two constructed culverts alongside one another, one with 2 arches and the other with three (Figure 1). Upstream is vegetated but with no visible drainage line. Downstream is marked by an eroded Class 4 drainage line. The drainage lines alongside the culverts, downstream. Are protected by reno mattresses. Which must be restored if the pipeline passes on that side of the road.

Point No.30 (Figure 43) is on a big drainage line that according to the adopted classification is of little interest because it demands to only a Class 1 drainage line, where no extra measures are required for the digging in of the proposed pipeline. The drainage line is vegetated with no sign of sediment transport. Because it is such a big drainage line, a WULA may be required, despite its classification.

Likewise, Point No.31 (Figure 46) is marked by another very big drainage line where sediment transport is not apparent and therefore was designated Class 1. Because it is such a big drainage line, a WULA may be asked for, despite its classification. There are several large conduits under the R27 to let through occasional stormwater. The riparian zone is well-vegetated with trees. Downstream, pastures for agriculture were established in the drainage line bed, but since this is an arid area, it is questionable if these pastures still produce any notable harvest.

Figure 46 Point No. 31.

To the south along the R27 from here is a dolerite ridge with smaller drainage lines. The rocks combined with the drainage lines represent some challenges for the construction of the pipeline. Further south, down the decline, on the west road shoulder, are 8 concrete stormwater management structures (Figure 47), which must be restored if the pipeline follows the west side of the road.

Figure 47 Concrete structure

The last drainage line 1.4km to the north of the Soafskolk (Gannakolk Farm) turnoff only amounts to a Class 1, even though its culvert has 4 low arches. This completes the investigation into this part of the proposed pipeline.

12.8 R27 Drainage line summary

Table 5 gives a summary of the drainage lines, their classification and their location.

Table 5 Drainage line Summary

No.	Coordinates	🔵 🟡 🔴
1	28°44’40.17”S 20°59’14.04”E	🔵
2	28°45’30.20”S 20°59’47.47”E	🟡
3	28°45’51.46”S 21°00’51.46”E	🔴
4	28°47’32.11”S 21°01’11.55”E	🔴
5	28°49’07.44”S 21°01’58.98”E	🟡
6	28°49’08.85”S 21°01’57.30”E	🔴
7	29°04’55.65”S 21°09’14.20”E	🔴
8	29°06’59.07”S 21°09.32.04’E	🔴
9	29°09’26.10”S 21°09.43.89’E	🟡
10	29°14’14.06”S 21°09’58.98”E	🟡
11	29°15’27.52”S 21°09’52.97”E	🟡
12	29°18’19.77”S 21°09’26.80”E	🟡
13	29°25’12.24”S 21°05’13.95”E	🟡
14	29°25’22.35”S 21°05’32.93”E	🔴
15	29°25’26.83”S 21°05’28.69”E	🔴
16	29°26’03.56”S 21°04’58.49”E	🟡
17	29°26’03.56”S 21°04’58.49”E	🔴
18	29°26’03.56”S 21°04’58.49”E	🟡
19	29°26’06.22”S 21°04’55.62”E	🟡
20	29°26’08.60”S 21°04’53.70”E	🟡
21	29°26’49.06”S 21°04’22.03”E	🔴
22	29°26’51.06”S 21°04’20.53”E	🔴
23	29°26’54.15”S 21°04’18.06”E	🟡
24	29°26’57.24”S 21°04’15.75”E	🟡
25	29°27’42.70”S 21°03’38.99”E	🟡
26	29°27’55.60”S 21°03’29.07”E	🟡
27	29°28’16.24”S 21°03’11.50”E	🔴
28	29°31’17.18”S 21°00’46.32”E	🟡
29	29°36’46.94”S 20°56’21.97”E	🟡
		🔵

12.9 From the turnoff to the production facility

The pipeline will be placed into the road reserves of existing officially proclaimed dirt roads among the farms to the west of the R27 trunk road. There may be a small section that will have to cross private land, but this is yet to be finally decided. The very western part will follow the railway line, from where it will swing to the production facility to the west (Figure 48). The total length will be 60km.

There are 11 drainage lines crossing the dirt road to the farm from the water storage facility over 11.4km. These are class 2 and 3 crossings. The area here is a finely reticulated wash field interspersed by sheet wash plains. These plains have signs of sediment transport, with eroded parts leaning to the beginnings of drainage lines and other parts with signs of deposition. These are mostly sandy, with some parts with coarse gravel.

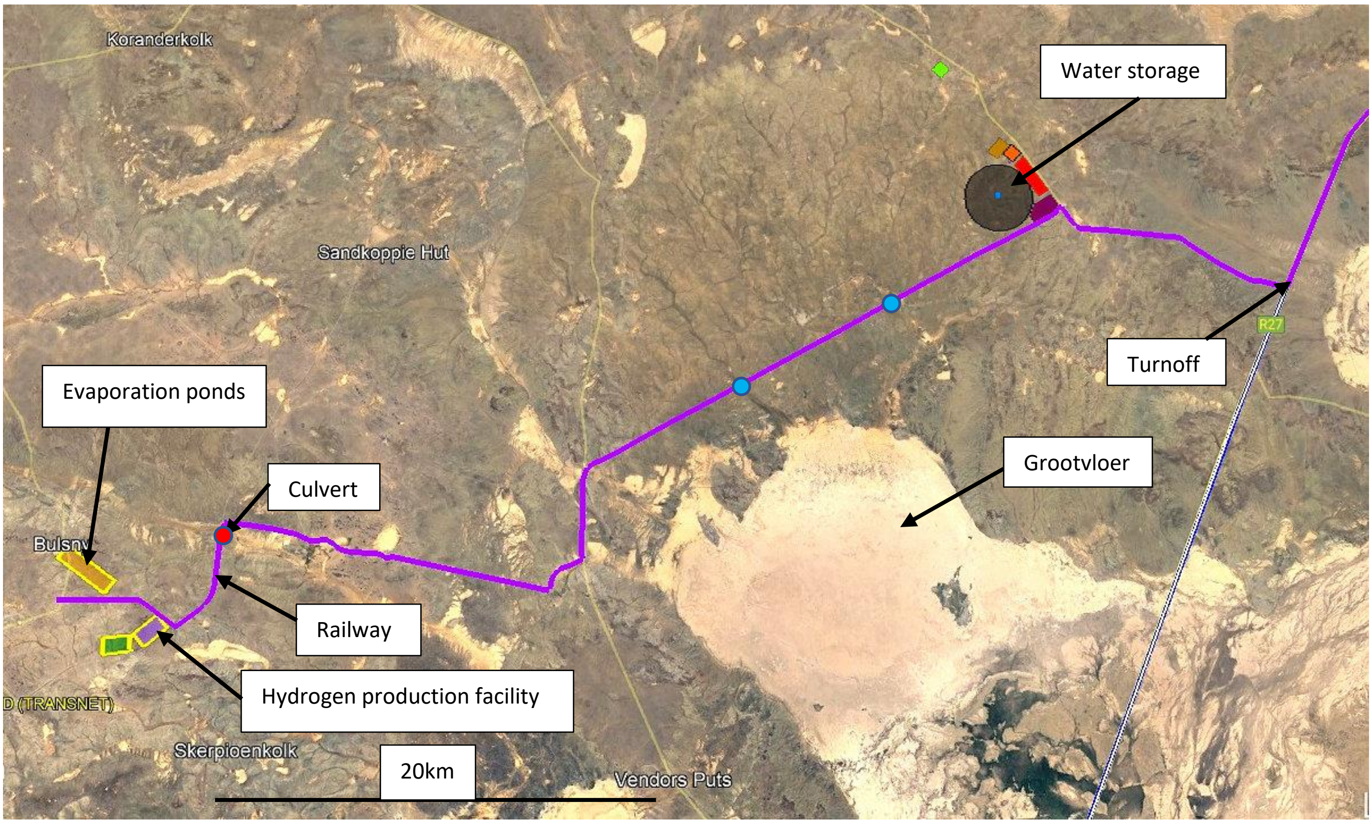


Figure 48 Pipeline route from the turnoff to the production facility

From the water storage facility, the pipeline angles sharply to the southwest through a coarsely reticulated wash field for another 25.2km. The proposed pipeline will cross two class 2 drainage lines marked by blue dots (Figure 48). These are densely overgrown with *Prosopis* trees.

The pipeline bends towards the south for 4.2km, it forms a short elbow and then heads off to the northwest, altogether over 17.5km, at the end of which it hits the Sishen –

Saldanha railway line. It skirts and even passes through small pans, mostly mixed grass pans and scrub pans. The pipeline will not have adverse effects on these pans and no extra engineering is required, other than digging in and backfilling the trench to the normal depth as required for most of the pipeline.

The pipeline must cross the railway to reach the commercial part of the development to the west. The crossing will either be through the existing culvert (Figure 49) or through a directionally drilled passage through the fill underneath the railway, depending on the authority's approval. Both options will be through or near a Class 4 drainage line that passes underneath the railway through the set of large culverts (Figure 49).

Figure 49 Railway culverts

This railway culvert is located at the following coordinates:

29°56'46.36"S and 20°13'30.53"E

There are several large culverts as well as smaller pipe culverts along the railway line to the south but none of these show drainage lines with sediment movement or erosion. No extra action is required along any on these railway culverts.

12.10 The R27 Pan

Figure 50 Pan along the R27

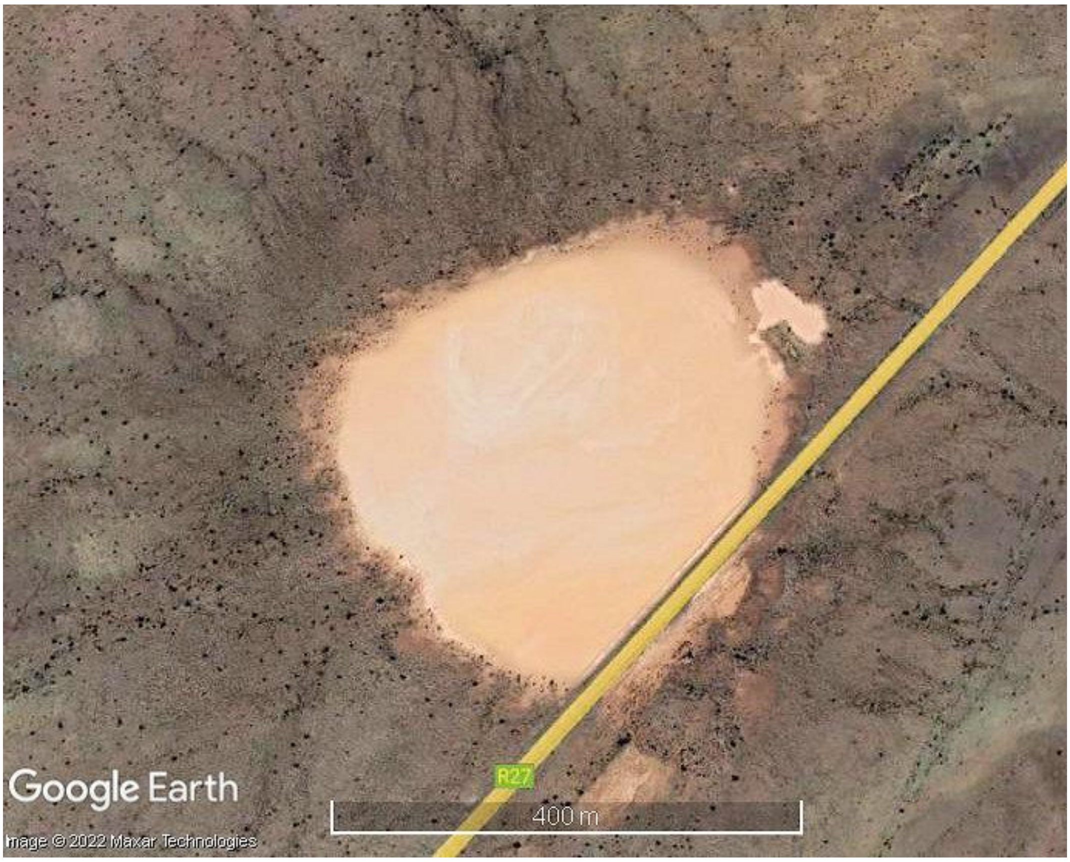


Figure 51 R27 bare pan Google Earth Image

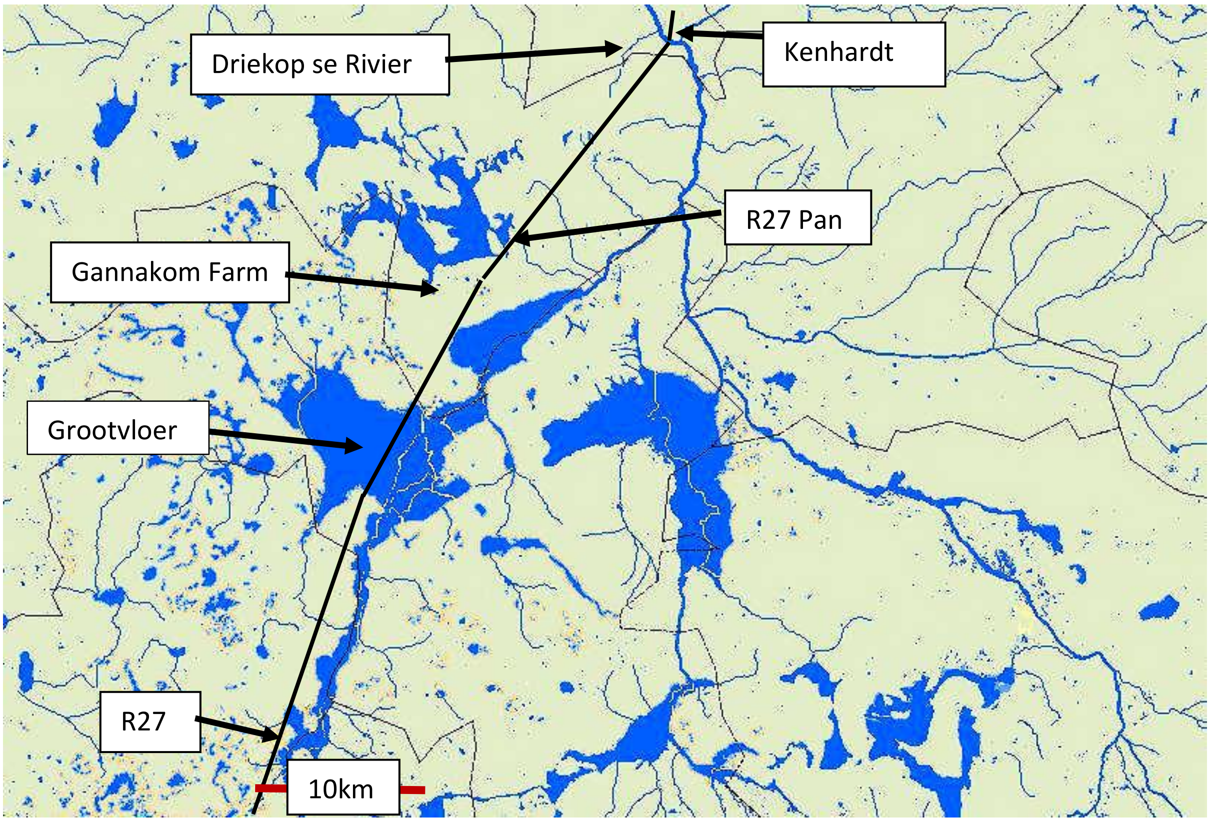


Figure 52 NFEPA (SANBI BGIS)

The one pan that stands out along the path of the new pipeline is right next to the R27 south of Kenhardt, close to the turnoff to Soafskolk / Uitkyk Farm (Figure 50). It is a bare pan, only 12.8 hectares. It is located at the coordinates:

29°45'52.08"S and 20°48'14.05"E.

This pan has no discernible riparian vegetation. The surrounding vegetation on the banks resemble that of the Bushmanland plains, with no wetland indicator species.

It is on the western side of the R27 (Figure 51). A small portion passes underneath the R27 to the other side of the road. The new pipeline will pass through the side of the pan on the verge of the road.

This pan is part of a much larger system of pans (Figure 52). All these pans are classified as NFEPA's (SANBI BGIS webpage).

Figure 62 is insightful in more than one way. The flow across the R27 just south of Kenhardt is from east to west into the Driekop se Rivier. The flow is from west to east towards the Upper Hartbees River. This has implications for the trenching of the new pipeline, as it usually is less costly to trench on the upstream side of culverts, as has been explained before. Most of the new pipeline towards the turnoff is on the "right" side of the R27.

13 Current Limnological Knowledge

The question is often asked if South African pans in arid landscapes qualify as valid wetlands, considering that it is devoid of any water or moist most of the time, that the submerged period is brief and that aquatic life forms bear little resemblance to that of regular freshwater habitats. In many ways science still must find a spot as to where to position these pans and the like in the array of aquatic habitats that occur on the planet.

National Research Foundation (NRF) is an agency of the South African national government Department of Science and Technology. It was advertised on-line

(http://www.saeon.ac.za/2016%20Postdoc%20Ad%20SAEON%20-%20Landscape%20Ecology%20of%20Pans.pdf)

for a post-doctoral position. This was to study the ecology of ephemeral pans of the Northern Cape.

"The SAEON Arid Lands node offers opportunities for detecting changes in ephemeral pans across the Northern Cape Province. Though usually dry and only briefly wet from time to time, these pans are possibly the most sensitive ecosystems in this area, potentially supporting many species of conservation significance, and probably acting as key ecosystem structures for numerous species. Despite this, the pans of the Karoo (Bushmanland) and southern Kalahari (Hakskeenpan Complex; Ghaap Plateau; Kimberley) have received little attention in terms of research. By comparison, the geomorphology and biodiversity of ephemeral pans in less arid regions of South Africa are better studied and serve as good comparison. This postdoc project sets out to characterize pans, including the use of maps and remote sensing, and gather historic data on wetting. Samples of pans will be selected for more detailed data collection, which will then feed into a model incorporating abiotic (geomorphological, climatic, hydrological) and biotic (biodiversity, life histories, metapopulation dynamics, food-webs and community ecology) features and processes in their landscape context. This will include both aquatic and alternating dormant phases, as well as the interrelationship between pans to adjacent terrestrial ecosystems. The model should incorporate drivers and indicators of environmental changes of pans and make management recommendations for pans in their landscapes context in view of potential anthropogenic developments and in relation to global change."

The closing date was 30 June 2016.

From this advertisement it was evident that there was very little known about the ecology of these pans. This very much complicates the drafting of a Freshwater Report, for which a whole lot of knowledge is required.

Nevertheless, it can be deducted from the advertisement that the pans are mostly dry. When it rains the pans suddenly floods, which only happens occasionally.

When flooded, so is surmised, an entire ecology springs to life. Micro-algae (primary producers) reproduce rapidly in the nutrient-laden water to form a source of food for the microbial grazers (secondary producers) and a complicated chain of microbial predators, with macro-invertebrates at the top of the food chain. These may be dense clouds of swimming fairy shrimps (Crustacea, Anacostraca).

The pans dry up as suddenly as it flooded. As the last of the moist evaporates, the planktonic organisms perish, but leaving behind a wealth of spores and eggs. These sink into the red soil, in among the cracks that typically develop in these drying pans, to sub-terraneously withstand the scorching temperatures of the harsh Bushmanland sun and the sub-zero temperatures of winter nights for months and even years on end.

These are very special organisms with highly adapted life cycles. They successfully survive in their dormant state under extreme conditions on the floor of the pans, ready to explode into life at the next flood event.

If one reads through the advertisement, it is evident that birds are important. These birds feed on the macro-invertebrates and include flamingos and Palearctic waders.

Much of the above is mere speculation, based on research in ephemeral pans in other parts of the world. On the other hand, much of the above description of this ecological marvel is probably quite true must be confirmed by meticulous scientific research. This process has already started, with several scientific accounts that have been published out of the SAEON initiative (Meyer-Milne *et al*, 2019, 2020 & 2021).

The Northern Cape pans are indeed a legitimate water resources that answer to the definition of the National Water Act, even though the only acknowledged user of the resource is nature. Because of the dormant but very much alive biota in the bone-dry soil, it is indeed a water resource, even though there is no water during the dry part of the cycle.

13.1 Salt Pans Concise Knowledge Overview

How credible will an impact assessment and a risk assessment be based on the current limited knowledge of South African pans? A better picture emerges as relevant research that has been done for comparable habitats. This will have to be very much limited to fit the scope and nature of this WULA Technical Report elsewhere, away from the Bushmanland pans, in South Africa but mostly outside of the country's boundaries.

13.2 Geomorphology

Thomas & Shaw (2012) described the geomorphology of numerous South African pans on a continuum from permanently flooded to mostly dry. These pans are termed terminal basins as they all lack an outflow.

These wetlands in arid regions are known as *playas* or salt pans.

The ground water table is mostly deep down, surface water is from a small catchment area, the bottom sediments are mostly alkaline clay with surface efflorescence.

This efflorescence happens when salts are brought up through the soil with capillary action to form a crystalline crust of the surface.

A depression associated with a series of longitudinal and parallel dunes are often associated with pans in arid areas. These dunes may not be active anymore, which means that they are not being moved about by strong desert winds as during geological times.

13.3 Sua Pan

The comprehensive work of McCulloch (2008) and his co-workers on Sua Pan in Botswana sets the standard for the scope and depth of the biological research that is needed for the facilitation of informed decision-making. It links the fluctuations of aquatic invertebrates in this saline pan to the change in salinity as the pan floods and subsequently dries out, as these pans do in arid regions.

It can be expected that the aquatic fauna in the Bushmanland pans follows a similar pattern.

This base-line information is required to assess environmental impacts on the Bushmanland pans because of future development.

There are only 16 taxa of aquatic invertebrates present in Sua Pan. This relatively small number illustrates that ephemeral saline pans are harsh environments in which only organisms adapted to these circumstances can survive.

The scientific paper on Sua Pan contains a most comprehensive literature list that could be regarded as an inventory of significant research that has been done on African saline pans up to 2008.

13.4 Etosha Pan

Etosha in northern Namibia forms part of a system known as the Cuvelai Pans with its catchment area on the Angolan highlands on an altitude of 1450m and more than 400 km to the north.

Rainfall on the highlands exceed 1000mm per year, which feeds a system of pans and rivulets known as *oshanas* or *omarumbas* in an area that is acknowledged as an ecoregion on its own.

This gives rise to an annual fish migration, which is harvested by the local population. The bulk of the biomass of these pans is replenished by migration from higher ground, while the Bushmanland pan's replenishment can be expected to be derived from only the dormant life forms in the sediments below.

The saline Etosha spans an incredibly large surface area of 7000km^2.

As it is located at the very end of the Cuvelai, it is covered with water only once in 7 years.

The bottom is mainly of lime as opposed to tillite and shale of the Bushmanland pans. It could therefore be expected that the water quality constituents and properties is quite different of that of the Bushmenland pans, with differently adapted aquatic organisms.

No less than 40 crustacean species have been identified from the Cuvelai (Lucy Scott, http://www.feow.org/ecoregions/details/etosha). Fairy shrimp is one of them.

Etosha Pan is one of two regular breeding sites in southern Africa for lesser and greater flamingos, *Phoenicopterus minor* and *P. ruber*.

Community structures are yet to be investigated.

The riparian vegetation at Etosha includes the sedge *Cyperus marginatus*, several species of the grass *Sporobolus* and several other genera of plants

Salt pans in the western Free State were studied by Janecke *et al* (2003), but information about the riparian vegetation and specifically indicator species were not given.

Perhaps some of the cyanobacteria and some other cosmopolitan aquatic microbes may be the same in both pans. It has been reported that Etosha is covered with a layer of blue green algae when it floods.

13.5 Eastern Highveld Pans

There are a large number of ephemeral pans on the Mpumalanga Highveld, some of which are still near-pristine and not impacted by coal mining and large-scale farming such as dairies and maize.

The community structures of these pans have been studied by Ferreira *et al* (2012). It was indicated that community structures are complex with a large number of species and that each of these pans is to a variable degree different from one another. It can be postulated that the Bushmanland pans would prove to be unique as well, given its location in the arid Northern Cape and its isolation from other comparable habitats. This could emphasize its conservation value.

Ferreira *et al* (2012) indicated that human activities indeed have a deleterious effect on the macroinvertebrates of these pans. Moreover, the company JG Africa with funding from the CSIR found that brachiopods in the Highveld pans utilised an "escape in time" survival strategy according to which life cycles are rapidly completed and eggs produced before the onset of the forthcoming arid period. These eggs are the survival stages and occur as egg banks in the sediments. However, the hatching of the eggs is severely curtailed by acid mine drainage, which then as a result has a profound effect on the community structure during the next wet phase.

It can be surmised that if acid mine drainage from the coal mines has such a marked effect on the hatching of branchiopod eggs, a fuel spill or sewage spill would result in mortality of macroinvertebrate survival stages in Bushmanland as well. It should be very clear that acid mine drainage perpetually floods and covers an entire Highveld pan, while an unfortunate and accidental fuel or perhaps a sewage spill would be a once off event on a localised area of a very large pan. This nevertheless raises attention to the necessity to prevent spills and to clean them up, should they happen.

13.6 Australia

Australians have collected much more information on their ephemeral pans. As long ago as 1983 De Decker published an account on the vast body of basic research on Australia's saline pans.

(http://people.rses.anu.edu.au/dedeckker_p/pubs/120.pdf).

The driver that sets the food web going when flooded is phytoplankton. This is followed by microbial grazers and planktonic predatory organisms on various trophic levels.

From then research developed into population dynamics. They determined that the number of predatory invertebrate species increases as flood water recedes and that more trophic levels are introduced into the food web. The food web becomes more complicated as the hydroperiod nears its end. Community structure is determined by the frequency of flooding and the depth of the pan.

There is no reason to believe that the population dynamics of the Bushmanland pans is any different from that of the Australian situation.

13.7 Classification of Pans

Geldenhuys (1982) classified the Free Sate pans

Bare pans
Sedge pans
Scrub pans
Mixed grass pans
Closed *Diplachne* pans
Open *Diplachne* pans

Geldenhuys' classification is useful for this Freshwater Report.

Bare pans can regress into sedge pans, then into scrub pans and from there into grass pans. Eventually these pans become grasslands that can hardly be distinguished from the surrounding areas.

Pans can evolve in both directions, from grassland into a bare pan and back from a bare pan into grassland. This can be because of long-term natural tendencies or because of human impact.

It seems as if the bare pan along the R27 is stable and is not about to regress.

During the site visit in September 2022, larger pans further south were overgrown with low vegetation, following the good rains of the past two or three seasons. These pans very much resemble bare pans, but during the last site visit, regression was suggested towards scrub pans.

It is not known if this small pan has any unique organisms or special planktonic assemblages. Future research will, no doubt, illustrate these pan's contribution to biodiversity. Meanwhile, mitigating measures must be taken seriously.

14 Biomonitoring the Lower Orange River

The proposed pipeline and its associated infrastructure start at the Orange River and Keimoes and this Freshwater Report won't be complete without a thorough evaluation of the ecological status of the river, according to the prescribed methodologies.

14.1 Methodology

The biomonitoring was carried out according to the description of Dickens & Graham (2002).

Biomonitoring was carried out on the Lower Orange River during site visits for successive WULAs. So far 14 samples have been analyzed at 13 localities (Table 1). The site furthest east was at Hopetown and furthest west at Augrabies, with Upington in the middle. Thirteen of these localities are located upstream of the Augrabies Falls. One sample was analyzed at Styerkraal just east of the border post of Onseepkans downstream of the Augrabies Falls.

The river is mostly braided, with many smaller streams and with islands in the middle. The river sports many rapids and riffles, but also pool-like features where the river is broad and slower flowing.

The bottom is mainly muddy, with some large rocky outcrops in the middle of the river.

14.2 Impacts on the Lower Orange River

The river is heavily utilized for agriculture, with the banks entirely modified into cultured vineyards. A multitude of large electric water pumps have been placed in the river for abstracting large volumes of water for irrigation. Abstraction significantly lowers the flow in the river.

Berms for the purpose of flood protection have been constructed on the banks of the river for most of its length. These berms have been constructed by the Department of Water Affairs and now have been a feature of the landscape for many decades. The berms keep flood water out of adjacent agricultural land and has denaturalised the riparian zone.

The single most impact on the Orange River are the two very large dams, The Gariep Dam and the Vanderkloof Dam. The river flow has been modified to a much even regime, different from the varied flown with high peak flows and low drought flows.

The Lower Orange River is lined with a dense system of mostly dry drainage lines. These drainage lines only flow during and shortly after heavy rains. Their contribution to the flow of the Orange River is insignificant. Most of the flow comes from the Lesotho Highlands and some from the Vaal River. However, many of these drainage lines have been transformed into engineered agricultural return flow furrows that carries the excess of over irrigation back to the Orange River. Agricultural return flow adds much to the nutrient load of the Orange River because runoff contains fertilizer. Nitrogen is added in large quantities. Since phosphorus readily binds to the soil, not much phosphorus is added.

Return flow can contain a heavy silt load, thereby elevating turbidity in the river.

It is suspected that pesticides in agricultural return flow have a heavy impact on biomonitoring results, significantly reducing the SASS5 score.

The banks of the Orange River in the area are densely overgrown with Spaanse Riet (*Arundo donax*). This is classified as an aggressive and exotic invasive plant, which effectively prevents access to the river. The reeds result in a homogeneous aquatic habitat. This lack of variation supresses the SASS5 score, with only a limited number of aquatic macroinvertebrate species present in this habitat.

14.3 Lower Orange River Biomonitoring Results

The biomonitoring results have been captured in Table 6 and depicted in Figure 49.

The classes from A to F in Figure 49 has been assigned for mature rivers on flood plains such as the Lower Orange River.

Only 2 of the samples were classified a good and relatively unimpacted (Class A). Five were in Class B and C, which can be regarded as acceptable under the circumstances of an impacted river reach. These classes can possible be labelled as the ideal, a compromise between agriculture and aquatic ecological functioning.

Four samples were poor (Classes E and F), an undesirable situation.

The one sample downstream of the Augrabies Falls was extremely poor.

Table 6 Biomonitoring in the Lower Orange River

Locality	Coordinates	Date	SASS 5	No Taxa	ASPT
Augrabies Lair trust	28°38’41.53S 20°26’08.49E	5/09/17	18	4	4.5
Augrabies Lair Trust	28°38’41.53S 20°26’08.49E	5/10/17	43	9	4.8
Groblershoop	28°52’31.80S 21°59’13.49E	14/8/18	41	7	5.9
Kakamas Triple D	28°45’08.37S 20°35’06.16E	15/8/18	50	9	5.6
Hopetown Sewer	29°36’05.07S 24°06’05.00E	7/10/18	29	7	4.1
Hopetown Sewer	29°36’08.06S 24°21’06.16E	7/10/18	29	8	3.6
Keimoes Housing	28°42’37.12S 20°55’07.81E	8/02/19	51	7	7.3
Upington Erf 323	28°27’11.91S 21°16’14.02E	12/2/19	56	9	6.2
Upington Affinity	28°27’11.91S 21°16’14.02E	20/5/19	54	9	6
Styerkraal	28°27’25.28S 21°15’01.87E	21/5/19	15	6	2.5
Grootdrink Bridge	28°17’15.30S 21°03’50.87E	17/5/20	34	7	5.3
Turksvy Dam	28°27’09.21S 21°17’20.72E	17/5/21	69	13	5.3
Belurana Upington	28°27’49.79S 21°14’32.67E	15/12/21	51	11	4.6
Bakenrant	28°38’55.84S 20°26’07.96E	30/9/22	33	6	5.5
Keimoes	28°44’13.14S 20°59’01.76E	19/10/22	43	9	4.8

14.4 Limitations

The DWS maintains a formal and scheduled biomonitoring program throughout the country, including the Lower Orange River. This gives, no doubt, a much better indication of the state of the river than self-collected data. Because this data is not available to the consulting fraternity, self-collected data such as that of Table 6 must suffice.

15 Sampling the river at Keimoes

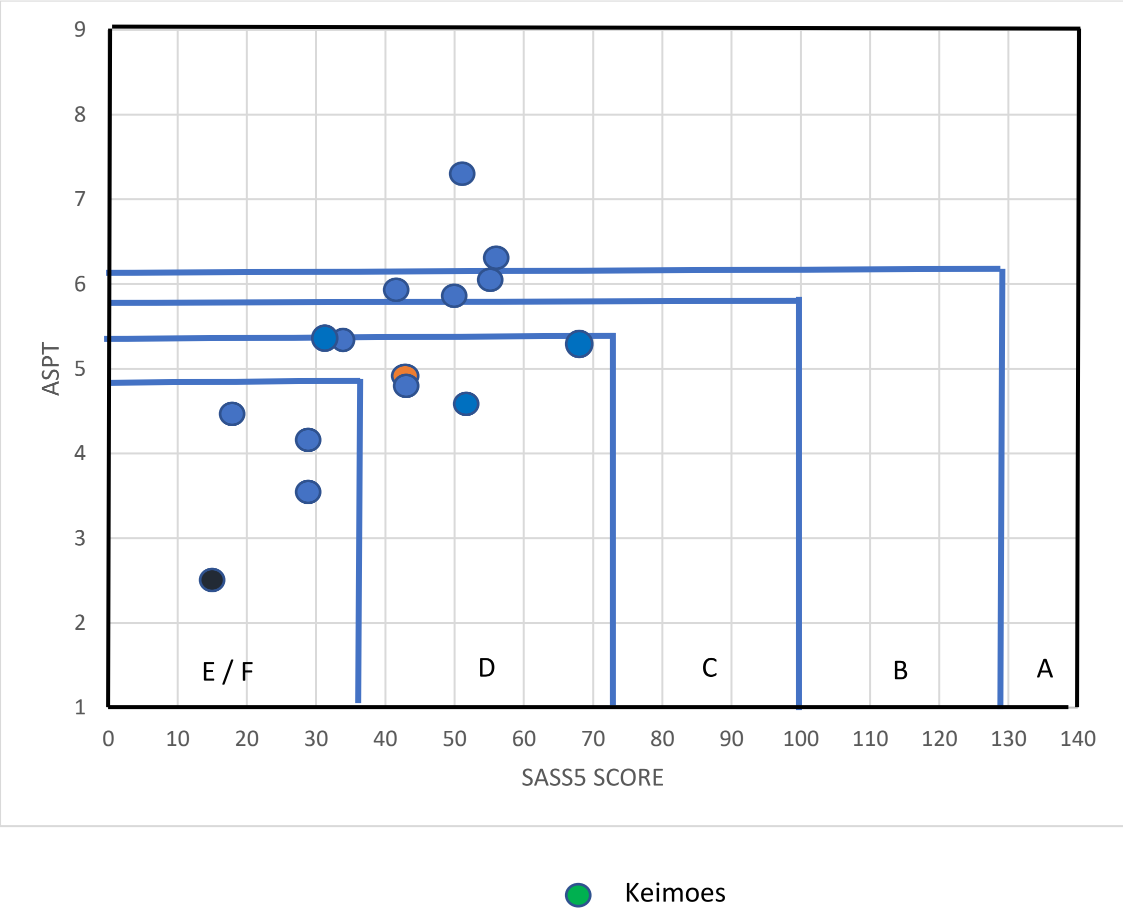
The sampling point was at the new abstraction point, or rather, at the addition of another abstraction point at the existing one. The sampling point was right at the anchored raft on which existing pumps at mounted in one of the arms of the braided Orange River branded as Orange River 3 (Figure 53). This is next to the R27 trunk road bridge to Groblershoop (Figure 54).

The river here was fast flowing with a velocity of more than 2ms^{-1} in the middle and somewhat slower against the banks. The banks are very steep and enforced with a layer of rocks and concrete. The rocks and the steel structure of the raft acted as bedrock and stones-in-current. The banks are lined with a thick stand of reeds, but reeds are kept short at the abstraction point. There was no emerging vegetation at the time of sampling. The bottom was muddy. The habitat was limited, with little variation.

The SASS5 score came to 43, with 9 taxa and an ASPT of 4.8 (Figure 55). This signifies a moderately impacted river, with most of the ecological functioning intact. It is classified as a "D". The ideal class is put at a "C", which calls for controls on the impacts on the river. This is within the range of scores for the Lower Orange River, somewhere in the lower middle range (Figure 55).

Figure 53 Orange River 3 at the sampling point

Figure 54 R27 Road Bridge



Integrity Class	Description
A	Pristine; not impacted
B	Very Good; slightly impacted
C	Good; measurably impacted with most ecological functioning intact
D	Fair; impacted with some loss of ecological functioning
E	Poor; loss of most ecological function
F	Very Poor; loss of all ecological function

Figure 55 Lower Orange River Biomonitoring results

16 Present Ecological State

The PES is a protocol that have been produced by Dr Neels Kleynhans (Table 7 and 8) in 1999 of the then DWAF to assess river reaches. This is one of the prescribed tests and the results must be presented in the Risk Matrix. Drainage lines are legitimate water resources, in terms of the NWA and those along the R27 crossing the proposed pipeline are accordingly assessed. The scores and entirely that of the assessor.

Table 7 Habitat Integrity according to Kleynhans, 1999

Category	Description	% of maximum score
A	Unmodified, natural	90 – 100
B	Largely natural with few modifications. A small change in natural habitats and biota, but the ecosystem function is unchanged.	80 – 89
C	Moderately modified. A loss and change of the natural habitat and biota, but the ecosystem function is predominantly unchanged.	60 – 79
D	Largely modified. A significant loss of natural habitat, biota and ecosystem function.	40 – 59
E	Extensive modified with loss of habitat, biota and ecosystem function	20 – 39
F	Critically modified with almost complete loss of habitat, biota and ecosystem function. In worse cases ecosystem function has been destroyed and changes are irreversible	0 - 19

16.1 Sub-Catchments

There are 13 sub-catchments along the path of the proposed pipeline.

Most of them are only impacted by grazing farm animals and existing roads and fences.

Sub-catchments along the Orange River are heavily impacted by large-scale agriculture, with irrigated vineyards lining the banks of the river. Further away from the river, where irrigation is no longer economically feasible because of the distance that water for irrigation must be pumped, sub-catchments are less impacted to near-pristine. Evaluation of these sub-catchments pose difficulties, because of the sharp contrast between the developed part and the near-pristine upper part.

Classification of agriculture or urban development impacted sub-catchments is dependent on the size of sub-catchments. These impacts are generally larger on small sub-catchments as the impacts cover a larger surface area if compared to those in a much larger sub-catchment, where the impact covers a comparatively smaller part. Again, this is valid only for sub-catchments with apparent large impacts.

The 13 sub-catchments can be grouped according to the nature of the impacts.

Group1

The impacts on Group1 are mainly grazing livestock, bridges, culverts, roads, farm roads, fences and some *Prosopis*.

Group 2

Sub-catchments of similar size, with notable developments in the lower part. This includes Sub-Catchment No.2 with vineyards and some urban development as well as Sub-Catchment No.7 with the town of Kenhardt in the lower part.

Group 3

Small sub-catchments with impacts in their lower part, such as Sub-Catchment No.1 with vineyards and No.6 with its wastewater and *Prosopis* trees.

16.2 Hartbees and Orange River

Other waterways that must be assesses include the Hartbees River (Table 1) and the Orange River (Table 2).

16.3 Sout River

The Sout River at Keimoes on the south bank of the Orange River was not assessed because it is an entirely blocked arm of the braided Orange River, because it contains virtually nothing but agricultural return flow, its ecology does not resemble that of the Orange River anymore and it has developed its own ecology, like that of an altered channel surrounded by large-scale agriculture. If assessed according to Kleynhans' method, looking at the deviation from the unimpacted state, the Sout River would score a "F" or even lower. This means it would not have any ecology, or at least nothing that can be restored. It does indeed have an ecology, that is probably higher than a "F", but much unlike the unimpacted state, a new ecology of a heavily impacted stream.

The question arises if the envisaged pipeline is going to change or lower the classification of these water ways.

Table 8.1 Present Ecological State of Group 1 drainage lines

(3, 4, 5, 8, 9,10,11, 12 and 13)

Instream	Score	Weight	Product	Maximum score
Water abstraction	24	14	336	350
Flow modification	20	13	260	325
Bed modification	20	13	260	325
Channel modification	19	13	247	325
Water quality	24	14	336	350
Inundation	21	10	210	250
Exotic macrophytes	24	9	216	225
Exotic fauna	15	8	120	200
Solid waste disposal	25	6	150	150
Total		100	2135	2500
% of total			85.4	
Class			B	

Riparian				
Water abstraction	24	13	312	325
Inundation	20	11	220	275
Flow modification	20	12	240	300
Water quality	24	13	312	325
Indigenous vegetation removal	24	13	312	325
Exotic vegetation encroachment	22	12	264	300
Bank erosion	21	14	294	350
Channel modification	19	12	228	300
Total			2182	2500
% of total			87.3	
Class			B	

Table 8.2 Present Ecological State of Group 2 drainage lines (2 and 7)

	Score	Weight	Product	Maximum score
Instream				
Water abstraction	24	14	336	350
Flow modification	16	13	208	325
Bed modification	18	13	234	325
Channel modification	15	13	195	325
Water quality	15	14	336	350
Inundation	16	10	210	250
Exotic macrophytes	16	9	144	225
Exotic fauna	15	8	120	200
Solid waste disposal	11	6	66	150
Total		100	1849	2500
% of total			74.0	
Class			C	
Riparian				
Water abstraction	24	13	312	325
Inundation	15	11	165	275
Flow modification	15	12	180	300
Water quality	15	13	195	325
Indigenous vegetation removal	16	13	208	325
Exotic vegetation encroachment	16	12	193	300
Bank erosion	19	14	266	350
Channel modification	15	12	228	300
Total			1747	2500
% of total			70.0	
Class			C	

Table 8.3 Present Ecological State of Group 3 drainage lines (1 and 6)

Instream	Score	Weight	Product	Maximum score
Water abstraction	24	14	336	350
Flow modification	10	13	130	325
Bed modification	11	13	260	325
Channel modification	12	13	143	325
Water quality	9	14	126	350
Inundation	14	10	140	250
Exotic macrophytes	16	9	216	225
Exotic fauna	15	8	120	200
Solid waste disposal	15	6	90	150
Total		100	1471	2500
% of total			58.8	
Class			D	

Riparian				
Water abstraction	24	13	312	325
Inundation	14	11	154	275
Flow modification	11	12	132	300
Water quality	9	13	117	325
Indigenous vegetation removal	11	13	143	325
Exotic vegetation encroachment	16	12	192	300
Bank erosion	19	14	266	350
Channel modification	12	12	144	300
Total			1460	2500
% of total			58.4	
Class			D	

Table 8.4 Present Ecological State of the Hartbees River

Instream	Score	Weight	Product	Maximum score
Water abstraction	15	14	210	350
Flow modification	18	13	234	325
Bed modification	20	13	234	325
Channel modification	20	13	260	325
Water quality	20	14	280	350
Inundation	18	10	180	250
Exotic macrophytes	22	9	198	225
Exotic fauna	24	8	192	200
Solid waste disposal	24	6	144	150
Total		100	1932	2500
% of total			77.2	
Class			C	
Riparian				
Water abstraction	15	13	325	325
Inundation	18	11	198	275
Flow modification	18	12	216	300
Water quality	20	13	260	325
Indigenous vegetation removal	22	13	286	325
Exotic vegetation encroachment	18	12	216	300
Bank erosion	20	14	280	350
Channel modification	20	12	240	300
Total			2021	2500
% of total			80.8	
Class			B	

It seems preposterous for one person to come up with a score for the Hartbees River, as this is in the domain of a team of specialists. However, such a grand undertaking is beyond the scope and budget of the usual WULA. Since this is required for approval, an assessment is submitted, together with its shortcomings.

Upstream the Sak and Hartbees River's water is heavily used for agriculture and irrigation. However, when the occasional flood happens, the volume of water that flows down the catchment is of such a magnitude that it overruns the abstraction capacity by far. The abstraction does indeed shorten the hydroperiod of the river system.

Table 8.5 Present Ecological State of the Lower Orange River

Instream	Score	Weight	Product	Maximum score
Water abstraction	15	14	210	350
Flow modification	15	13	195	325
Bed modification	20	13	260	325
Channel modification	22	13	286	325
Water quality	15	14	210	350
Inundation	12	10	120	250
Exotic macrophytes	18	9	162	225
Exotic fauna	15	8	120	200
Solid waste disposal	20	6	120	150
Total		100	1593	2500
% of total			63.7	
Class			C	
Riparian				
Water abstraction	15	13	195	325
Inundation	10	11	110	275
Flow modification	11	12	132	300
Water quality	15	13	195	325
Indigenous vegetation removal	5	13	65	325
Exotic vegetation encroachment	4	12	48	300
Bank erosion	20	14	280	350
Channel modification	10	12	120	300
Total			950	2500
% of total			38.0	
Class			E	

Again, an entire team of specialist scientists is needed to assess the Orange River, which is beyond the scope of the run-of-the-mill Freshwater Report. This report draws from previous reports. This does not necessarily validate the numbers. Nevertheless, this is what the procedure requires and this is what is presented.

16.4 R27 Pan PES

Table 9 Habitat integrity assessment criteria for palustrine wetlands (DWAF,1999)

Criteria and attributes	Relevance	R27 pan	Groot-vloer	Uitkyk pan
Hydrology				
Flow modification.	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	**4**	**2**	**5**
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	**5**	**5**	**5**
Water Quality				
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	**4**	**3**	**5**
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	**4**	**3**	**4**
Hydraulic/ Geomorphic				
Canalization	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage	**4**	**3**	**5**
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activity which reduces or changes wetland habitat directly or through changes in inundation patterns.	**3**	**3**	**5**
Biota				
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	**4**	**3**	**5**
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	**4**	**3**	**4**
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	**5**	**4**	**5**
Alien fauna	Presence of alien fauna affecting faunal community structure.	**4**	**2**	**5**
Over utilisation of biota	Overgrazing, Over-fishing, etc.	**5**	**4**	**5**

Table 10 Scoring guidelines for the habitat integrity assessment for palustrine wetlands (DWAF, 1999).

Guideline	**Score**
Natural, unmodified Largely natural Moderately modified. Largely modified. Seriously modified. Critically Modified	5 4 3 2 1 0
Confidence	
Very high confidence High confidence Moderate confidence Low confidence	4 3 2 1

Table 11 Category's assigned to the scores for wetland habitat assessment (Kleynhans, 1999; DWAF, 1999).

Category	Score	Description
A B C D E F	>4 >4 and ≤3 >2 and ≤3 2 >0 and ≤2 0	Unmodified or approximated natural condition. Largely natural with few modifications, but with some loss of natural habitats. Moderately modified, but with some loss of natural habitats. Largely modified with a large loss of natural habitat and ecosystem function Seriously modified with extensive loss of habitat and ecosystem function Critically modified with a near-complete loss of natural habitat

The pan was scored separately from the drainage lines according to the methodology of Kleynhans (1999). (Tables 9 to 11).

The R27 cuts through the bank of the pan and probably creates a stormwater runoff from the tarmac and the road reserve into the pan. Sheep are farmed on the land, but with a low stock density. No alien vegetation was noticed during the site visit. The pan was barren. Except for two or three small bushes, the pan was devoid of vegetation.

The average for all assessed parameters was 4.2. This can be stated with a very high level of confidence.

Table 12 PES Summary

Waterway	Instream	Riparian
Group1 drainage lines Group 2 drainage lines Group 3 drainage lines Hartbees River Lower Orange River	B C D C C	B C D B E
R27 Pan	A	

The proposed pipeline is not expected to change this classification. There already is a pipeline and another one along the same route is not about to make a difference, the pipeline will be in the already disturbed road reserve and the nature of the operation, the laying of the new pipeline, is as such that it is not going to create an undue disturbance, provided that the mitigation measures are adhered to.

17 Ecological Importance

17.1 Orange River

The Ecological Importance (EI) is based on the presence of especially fish species that are endangered on a local, regional or national level (Table 13).

Table 13 Ecological Importance according to endangered organisms (Kleynhans,1999).

Category	Description
1	One species or taxon are endangered on a local scale
2	More than one species or taxon are rare or endangered on a local scale
3	More than one species or taxon are rare or endangered on a provincial or regional scale
4	One or more species or taxa are rare or endangered on a national scale (Red Data)

According to Skelton (1993) 12 species of indigenous fish occur in the Lower Orange River. Since 2011 another one was added, as well as 3 exotic species. These are the following:

Barbus trimaculatus
B paludinosus
B. hospus
Labeobarbus kimberleyensis (Near threatened)
L aenus
Labeo umbratus
L capensis
Austroglanis sclateri (Widespread elsewhere)
Clarias gariepinus
Pseudocrenilabrus philander (Threatened locally but abundant elsewhere)
Pseudobarbus quathlabae
Mesobola brevianalis (critically endangered)
Exotic and translocated fish:

Cyprinus carpio
Tilapia sparrmanii
Oreochromus mossambicus

Those in blue are endangered to a varying extent. Those indicated in red are exotic or translocated fish.

The only one that causes real concern in the largemouth yellow-fish *Labeobarbus kimberleyensis*. It is endemic to the Orange River system and hence is threatened not only on a local scale, but on a national scale as well. This puts the Lower Orange in category 4. This renders the Orange River as important.

According to the owners of the Kalahari River and Safari Co. along the northern bank of the Orange River on the Riemvasmaak Road, mature blue kurper *Oreochromus mossambicus* are regularly captured in increasing numbers. It now takes at least 4 man-days to capture a single yellow fish.

Yellow fish are generally infected with cestode bladder worms, while darters (*Anhinga rufa*) that predate on these fish are heavily infected with tape worms. It seems as if the translocated Tilapia are not affected by these parasites.

According to Mr Chris van der Post, a renown angling guide and the owner of the Gkhui Gkhui River Lodge near Hopetown, there are still many smallmouth-yellow fish around, but largemouth yellow-fish are scarce.

The Belurana property will not add or detract to the importance of the Orange River, as measured by the fish species assemblage, as it has little if any impact.

17.2 Drainage Lines

The Ecological Importance (EI) is based on the presence of especially fish species that are endangered on a local, regional or national level (Table 13).

There are no fish in the drainage lines, as there is no permanent water. According to this assessment, the drainage lines are not important.

No other endangered species, either plant or animal, were detected in or near the drainage line. A protected tree, camel thorn *Vachellia erioloba* is listed as "least concern" on the SANBI Red List. Another protected tree of the area, the shepherd's tree *Boscia albitrunca,* was noticed along some of the drainage lines.

The riparian zones and associated higher vegetation, the ecologically important corridors this brings about and the migration routes in an otherwise featureless and homogeneous landscape render drainage lines ecologically important.

17.3 Hartbees River

There is no fish in the mostly dry Hartbees River.

17.4 Pans

When the pans flood with the occasional rain, a fascinating ecology springs to life, as has been described previously. It is not known if any species are endemic to the pans or if there are new species or if the planktonic community is unique. Until this has been researched and published, the pans are regarded as potentially ecologically important.

18 Ecological Sensitivity

Ecological Sensitivity (ES) is often described as the ability of aquatic habitat to assimilate impacts. It is not sensitive if it remains the same despite of the onslaught of impacts. Put differently, sensitive habitat changes substantially, even under the pressure of slight impacts.

The Ecological Sensitivity also refers to the potential of aquatic habitat to bounce back to an ecological condition closer to the situation prior to human impact. If it recovers, it is not regarded as sensitive.

The drainage lines are ecologically sensitive because it would take many decades for the riparian vegetation to regrow once it has been removed during the excavation of the trench for the pipeline. Most of the envisaged pipeline is in the road reserve where vegetation is controlled.

The pans are extremely sensitive as well. If the bottom of a pan is disturbed, there is no telling if the succession of organisms is going to happen anymore. Research is lacking to predict the consequences, but according to general ecological principles, it seems obvious that once destroyed, the system won't be able to resurrect itself.

The Lower Orange River has absorbed numerous and deep-cutting human impacts. Yet it still functions as an aquatic ecosystem. In the highly improbable event of ceased human impact, the river here would probably bounce back to its previous glory. In this respect the river cannot be categorised as sensitive. It is dreaded among conservation minded people that the Lower Orange River might have some more capacity to absorb further impact.

Likewise, the lower Hartbees River is ecologically sensitive because of the same reasons. If the riparian vegetation were to be removed, it would take many years to recover. However, the riparian vegetation below Kenhardt where the envisage pipeline is going to be trenched is almost exclusively *Prosopis*, highly invasive and comparatively fast-growing. If these were to be removed, it would not represent an ecological disaster. In fact, given two or three seasons, the disturbed land would be fully covered with a fresh stand of *Prosopis*.

19 EISC

Table 14 EISC

Determinant	Group 1 Drainage Lines	Group 2 Drainage lines	Group 3 Drainage lines
Rare and endangered species	1	0	0
Populations of unique species	1	0	0
Species / Taxon richness	2	1	1
Diversity of habitat	2	1	1
Migration Route/ Breeding and feeding site for wetland species	3	1	1
Sensitivity to water quality changes	1	1	1
Flood storage, energy dissipation, particulate / element removal	2	1	1
Protection status	1	1	0
Ecological integrity	4	3	1
Average	1.9	1.0	0.7
Score	Low	Low	Low

Determinant	R27 Pan	Hartbees River	Orange River
Rare and endangered species	2	2	4
Populations of unique species	2	2	3
Species / Taxon richness	2	2	3
Diversity of habitat	1	2	2
Migration Route/ Breeding and feeding site for wetland species	0	4	4
Sensitivity to water quality changes	2	1	3
Flood storage, energy dissipation, particulate / element removal	0	3	4
Protection status	1	1	3
Ecological integrity	3	3	3
Average	1.4	2.2	3.2
Score	Low	Moderate	High

Score guideline:
Very High 4, High 3, Moderate 2, Low 1, None 0
Confidence Rating
Very High 4, High 3, Moderate 2, Low 1

The DWS demand that the drainage line and the wetlands be placed in a category according to the EISC methodology. The EISC is one of the essential items that is required for the Risk Matrix.

20 Numerical Significance

Decision-makers often press on a numerical score for Significance**.** The score takes into consideration both the environmental value of the site and the degree of impact.

Table 31.4, p121, Appendix provides a system for allocation values for each of the parameters Conservation Value, Extent, Duration, Severity and Likelihood about possible impacts These values are then entered into the equation on p122 to derive at a value for Significance. The value for Significance can subsequently be evaluated according to Table 31.4.2.

Table 31.4.2 provides a yardstick for decision-making to allow or disallow a development with its concomitant impact on the environment.

The scores that were given are entirely those of the specialist (Table 15), based on his or her knowledge and experience. These scores form a bases for debate and consensus, should contemporaries and decision-makers wish to add to the process.

The scores apply under the assumption that mitigation measures will be in place.

Table 15 Significance Score

Parameter	Drainage lines	Hartbees River	Orange River	R227 Pan
Conservation value	1	3	4	1
Likelihood	5	5	1	5
Duration	1	1	5	5
Extent	1	2	1	1
Severity	1	1	1	1
Significance	8	27	32	12
	Insignificant	Low	Low	Insignificant

The significance rating for the drainage lines came out as "Insignificant", mainly because the conservation value is regarded as low. The trenching of the pipeline through the drainage lines, the subsequent infilling and rehabilitation rating was insignificant because this is a once-of construction with a short duration on a short drainage line reach (rather a point than a reach).

The incremental impact of a bigger pump on existing infrastructure in the Orange River is small and the rating was perceived to be "Low".   However, the cumulative impacts of large-scale agriculture in the Lower Orange River are the most prominent features of the landscape.

21 Possible Impacts and Mitigating Measures

Mitigating measures have been discussed all along in this report but the purpose of the EIA report, it is necessary that these measures be put together under a single heading.

21.1 Drainage lines

Disturbed vegetation in these arid areas takes decades to restore itself, if not a millennium. The proposed pipeline follows an existing trenched pipeline in the R27 road reserve and as such will not have an additional impact on the Bushmanland vegetation. From the R27 to Uitkyk Farm, even though it is a dirt road a farm access road, the road has a wide reserve. No natural, undisturbed vegetation would be in jeopardy because of the construction of the pipeline.

Stormwater flow can potentially be impacted. Any change in the surface of drainage lines next to the R27 where the pipeline has been trenched can cause deposition or erosion.

The envisaged pipelines are to follow the roads, according to planning, in the road reserves.

There are numerous crossings of the pipes over or through the drainage lines. Where these crossings occur, the water supply pipeline must:

- Not wash open during the occasional storm event, when drainage lines may come down in flood.
- Allow the free flow of storm water as it was before the installation of the pipeline. Storm water must not dam up behind the pipeline. The installed pipeline and its associated infrastructure must not deviate the flow of storm water in any way.
- The pipeline, its construction and operation, must not be conducive to more sediment transportation along with occasional moving flood water.

These are the main aims of the environmental program during the life cycle of the envisaged pipeline.

Protection measures include the following:

- The pipeline must be entrenched deeper, with more backfill cover. It is assumed that 700mm is adequate for most of the distance, but where it crosses more prominent drainage lines, it can vary between 900mm and 1200mm, depending on the size of the drainage line.
- Where large drainage lines or rivers are crossed, the pipeline must be protected with gabions, reno matrasses or even concrete structures. It should be buried deep enough so that the chance of washing open is minimized, at 1200mm or more. The riverbanks may need stabilization as well.

The best time to construct the pipelines will be during the dry season, when the likelihood of flash floods are at its lowest.

Clusters

There are 3 clusters with one or two Class 5 drainage lines, flanked by several Class 1 up to Class 3 drainage lines, spread out over several hundred meters. It is best that these clusters are viewed as a single unit instead of only one Class 5 drainage line. In practical terms, this means that the pipeline must be trenched deeper, with 1 to 1.5m backfill over it, to ensure that it does not become exposed because of a flood. This trench must stretch over the entire width of the cluster where it passes underneath the R27, covering all the drainage lines, big and small. This policy makes provision for erosion and deposition, when drainage lines migrate over the landscape, as they do, during major flood events.

Sandy Drainage Line Beds

Several drainage lines have smooth sandy beds with little signs of erosion, but with strong signs of deposition. It is important not to disturb the flow resistance in the floors of these drainage lines. After the pipeline has been trenched and backfilled, the ground surface must be smooth and without any obstacles that can give rise to either erosion or more deposition in the event of a flood. Careful landscaping is necessary to finish off the project in these drainage lines. This is important for the larger Class 4 drainage lines that are spanned by proper bridges and many of the Class 3 drainage lines with single or double box culverts and even some with only pipe culverts.

Granite

The substrate to the south of Kenhardt is granite, covered with a thin layer of sand. Trenching will require heavy earthmoving machinery or even blasting. The pipe, after placed in the trench, will be backfilled with sand, according to the usual practice. The trench will be further filled with gravel or broken rock, probably retrieved from the trench. Enough space must be left to backfill the top layer with the same fluvial sand that was first removed from the surface when the trench was started. Again, the surface must resemble the original smoothness and the same flow resistance of the original channel.

It is not expected to encounter much dolerite in the drainage lines, as this formation usually forms the base for the ridges. This rock is hard and would probably require blasting and even more care during the backfill and rehabilitation phase.

Eroded drainage lines

The culvert’s floors underneath the R27 are flat, smooth concrete with little flow resistance, with the result that stormwater flowing through the culverts may experience a significant increase in flow velocity, coming out at the downstream end of the culvert much vaster, with an increased erosion potential. Many of the drainage lines are hardly visible or are small upstream of culverts, but apparently increase in size downstream because of erosion. A drainage line may be Class1 or 2 upstream of the R27 but may appear as a Class 3 or 4 downstream.

It is therefore advisable to trench the pipeline upstream of the R27. This may not possible, as the new pipeline is to follow the path of the existing one, which is either on the downstream or the upstream side of the R27.

It is suggested that already eroded areas adjacent and downstream of the R27 road culverts are paved with concrete to effectively stop any further erosion after the pipeline has been laid. This may, unfortunately, exacerbate the problem, as erosion would be transferred further downstream adjacent the newly paved exit.

If it is necessary to even further pave culvert exits, it may be done so with rock and cement, with a special effort to create a rough surface with much flow resistance to slow stormwater down. At the far end, on the verge of the pavement, bigger rocks can be placed and cemented in to finally break up the current (Figure 56).

Figure 56 Stormwater calming infrastructure.

Observations on the ground suggest that people drive their vehicles over drainage lines in the road reserves, for whatever purpose. The rock and concrete paving must therefore be of such a nature that the usual pickup truck can still drive over it.

Gabions and other structures

Several drainage lines have gabions, reno mattresses and rock-and-cement paving that must be broken up for trenching the pipeline. Having completed the laying of the pipeline, these structures must be restored to match or improve their previous functionality.

There are a great many berms at the pipe culverts that must be restored. These were not counted, but according to estimation, there must be at least 150 such culverts, with berms on both sides of the road. The restoration of the numerous berms represents a significant cost.

To the south of Kenhardt, on the southern slope of a dolerite ridge, are 8 walls in the road reserve for the purpose of flood control (Figure 57). These will have to be demolished for the pipeline to be trenched and afterwards be fully restored.

21.2 Hartbees River

The pipeline will be trenched in the bed of the Hartbees River at Kenhardt. The backfill on top of the pipeline must be more than anywhere else along the route, probably 1.5m and deeper. The Hartbees River does not come down often in flood, but when it does it can be brutal. Under these conditions, the pipeline must be burrowed deep enough to escape any damage.

Figure 57 Flood control walls

21.3 Orange River

The new pumps will be placed onto the existing raft or the existing raft can be replaced with a new one. Either way, the raft must be anchored with cables onto the riverbank, sturdy enough to withstand a major flood. No new impacts are foreseen. During the construction phase, building rubble and debris must not end up in the river.

21.4 Pans

Dickens *et al* (2003) lists several possible impacts on wetlands. This outline serves as a template for the discussion of the mitigating measures.

Flow modification.

The R27 and the road reserve already constitutes a preferential flow path into the R27 pan. The compacted backfill can add to this. No more water other than the natural runoff must be allowed to enter the pans.

Permanent inundation

Stormwater must not be allowed to dam anywhere on the compacted backfill on the pipeline to subtract from the natural flow down the decline into the pans. The inundation regime must not be affected.

Water quality modification

The soil will be loosened during the digging and filling in of the trench, with a possibility of the sediments washing into the pan along with storm water. This must be prevented, as it will greatly upset the natural properties of the pans. It is best to instal the pipeline during the dry season, especially in the along the section at the R27 pan.

Sediment load modification

Soil will be disturbed during the construction phase and it is possible that storm water can wash sand and mud into the pans. This must be prevented at all costs.

Canalization

Proper backfilling and compaction will assure that a canal will not be created along the R27 at the pans.

Topographic alteration

The envisaged pipeline is not about to alter the topography of the landscape in any way.

Terrestrial encroachment

The installation of the pipeline will not be the cause of vegetation encroaching onto the pan. Scheduled road maintenance, of which there was adequate evidence during the site visit, will further prevent encroachment of vegetation onto the pan in the road reserve.

Indigenous vegetation removal

No indigenous vegetation of special note was noted on the road reserve at the pans where the pipeline is to be installed.

Invasive vegetation encroachment

There was no invasive vegetation in and around the R27 and Uitkyk pans at the time of the site visit. It is not foreseen that the installation of the pipeline will alter in any way the vegetation regime. However, disturbance pf the soil may well add to the *Prosopis* infestation in the Grootvloer. It would take a serious effort to combat further encroachment.

Alien fauna

The farm is used for grazing sheep that occur in low numbers on the wide expanse of the Bushmanland. Sheep do not have a material impact on the pans.

Over-utilization

The farm is currently utilized as sheep grazing but does not seem to be overly grazed. The vegetation was in a good condition during the site visit.

Isolation / Migration

The affected pans are part of a much larger system of pans (Figure 1). Recent research indicated that wind is important to distribute planktonic spores and eggs and to ecologically connect the various parts of the system. The proposed pipeline will obviously not alter any of this.

Ground water table

The trenched pipeline must not create a preferential flow path for the any of the pan's water, when it floods, to enter the ground water. It is not known if the pans are underlain by impermeable material, as much of the landscape in the area. The precautions that must be taken include the storage of the topsoil as it is removed for the trench, layer by layer and subsequently replaced and compacted on top of the backfilled pipeline. Once the pipeline is underground, the permeability must resemble that of the conditions prior to the pipeline, or as close as technically possible.

Waste

Portable toilets will be serviced by a reputable company and wastewater will be discharged in the municipal wastewater treatment works. Litter will be collected in household wheelie bins and it will be disposed of on the municipal waste disposal site.

22 Impact Assessment

Some of the authorities prescribe an impact assessment according to a premeditated methodology. It follows the stages of the project life cycle, planning, construction, operation and decommissioning and rehabilitation. In this event, the assessment is focussed on the aquatic environment. Only the construction and operation phase are discussed. The prevention of dirt and sand because moving into the drainage lines and the pan and the trench's filling in and the levelling and landscaping after the pipe has been laid is of particular importance.

Table 16 Impact Assessment

Description of impact Construction Phase

Trenching of the new pipeline, washing of soil down the drainage line during storm events
Trenching of the new pipeline through the Hartbees River, washing sediments down the Hartbees River when it rains
Trenching of the new pipeline along the banks of the pan, washing of sediments into the pan

Mitigation measures

Do not disturb any land outside of designated trenching area in the reserve of existing roads
Construct outside of rainy season
Ensure that the new pipeline is trenched deep enough as appropriate for various water ways.
Carefully replace backfill in layers and compact to resemble permeability prior to construction
Level and landscape wherever the pipeline is trenched
Remove divots and bumps as not to encourage deposition or erosion
Take measures to ensure that the pipeline is not denuded in drainage lines and the river.

Type Nature	Spatial Extent	Severity	Duration	Significance	Probability	Confidence	Reversibility	Irreplaceability
Without mitigation								
Direct	Regional	High	Temporary	High	Definite	Certain	Reversible	Replaceable
With mitigation measures								
Negative	Regional	Low	Temporary	Low	Definite	Certain	Reversible	Replaceable

Description of impact Rehabilitation following construction								
Destruction of stormwater infrastructure in the road reserve such as walls, berms, gabions and reno mattresses								
Mitigation measures								
Repair the stormwater infrastructure in the road reserve to effectively prevent erosion and excessive runoff.								
Type Nature	Spatial Extent	Severity	Duration	Significance	Probability	Confidence	Reversibility	Irreplaceability
Without mitigation								
Direct	Regional	High	Temporary	High	Definite	Certain	Reversible	Replaceable
With mitigation measures								
Negative	Regional	Low	Temporary	Low	Definite	Certain	Reversible	Replaceable

Description of impact Operational phase								
Operation of new pipeline								
Mitigation measures								
Budget for the maintenance of the pipeline and the road reserve Inspect according to schedule and repair if leaking, prevent denuding of pipeline, cover when denuded. Maintain and repair stormwater infrastructure if required								
Type Nature	Spatial Extent	Severity	Duration	Significance	Probability	Confidence	Reversibility	Irreplaceability
Without mitigation								
Direct	Regional	Medium	Permanent	Medium	Probable	Certain	Reversible	Replaceable
With mitigation measures								
Negative	Regional	Low	Permanent	Low	Unlikely	Certain	Reversible	Replaceable

The main benefit of this exercise is that it allows for the evaluation of mitigation measures. The mitigating measures, as evaluated in this assessment, have the potential of being successful.

The methodology is set out in the Appendix.

23 Risk Matrix

The assessment was carried out according to the interactive Excel table that is available on the DWS webpage. Table 17 is a replica of the Excel spreadsheet that has been adapted to fit the format of this report.

The purpose of the Risk Matrix is to determine if a General Authorisation of a License is applicable.

The methodology is set out in the Appendix. It has been copied directly out of the DWS webpage.

The risks to the aquatic environment are "Low".

The Risk Matrix indicate that a General Authorisation should be considered.

Table 17 Risk Matrix

No.	Activity	Aspect	Impact	Significance	Risk Rating
1.1	Construction phase	Entrench through drainage lines.	Soil and sediments in drainage lines river and pans.	26	Low
1.2		Entrench through Hartbees River		26	Low
1.3		Entrench on banks of pans.		28	Low
2	Construction phase	Destruction of stormwater management infrastructure	Sedimentation and erosion	28	Low
3	Operation of pipeline	Denuded or leaking pipeline	Habitat alteration	45	Low

Table 17 Continued   Risk Rating

No	Flow	Water Quality	Habitat	Biota	Severity	Spatial scale	Duration	Conse-quence
1.1	1	2	1	1	1.25	1	1	3.25
1.2	1	2	1	1	1.25	1	1	3.25
1.3	1	1	2	2	1.50	1	1	3.5
2	2	1	1	1	1.25	1	1	3.25
3	1	1	2	2	1.5	1	2	4.5

No	Frequency of activity	Frequency of impact	Legal issues	Detection	Likelihood	Significance	Risk Rating
1.1	1	1	5	1	8	26	Low
1.2	1	1	5	1	8	26	Low
1.3	1	1	5	1	8	26	Low
2	1	1	5	1	8	28	Low
3	2	2	5	1	10	45	Low

24 Resource Economics

The goods and services delivered by the environment, in this case the drainage lines, the Hartbees River and the R27 pan, is a Resource Economics concept as adapted by Kotze *et al* (2009). The methodology was designed for the assessments of wetlands, but in the case of these environments, the goods and services delivered are particularly applicable, hence it was decided to include it in the report.

The diagram (Figure 68 to 60 is an accepted manner to visually illustrate the resource economic footprint the drainage line, from the data in Table 18.

The Resource Economics footprint of the Orange River is not illustrated, as it will be a complete circle, with a score of 5 for all the parameters, as is the case with all South Africa's large rivers.

The proposed pipeline will add to the water supply for human use and will benefit the local agriculture, as a relatively small percentage of the water will be applied for other uses except industrial use. In this way the star shape of the spider diagrams will change, with an increased Resource Economics footprint. This, in turn, will increase the potential for agricultural return flow and wastewater. Which will have to be ameliorated once it becomes reality. A large industrial development such as this can be expected to have secondary impacts. These impacts have been addressed elsewhere in another EIA report, that specifically deals with the proposed energy plant.

The construction and operation of the pipeline through the drainage lines and the Hartbees River *per se* will predictively not alter the Resource Economics footprint.

Table 18. Goods and Services

Goods & Services	Drainage Lines	Hartbees River	R27 Pan
Flood attenuation.	4	5	1
Stream flow regulation	4	5	1
Sediment trapping	3	5	1
Phosphate trapping	1	4	1
Nitrate removal.	1	4	1
Toxicant removal	1	3	1
Erosion control	3	4	1
Carbon storage	1	4	1
Biodiversity maintenance	4	5	3
Water supply for human use	1	5	0
Natural resources	2	3	0
Cultivated food.	2	5	0
Cultural significance	1	2	0
Tourism and recreation	0	2	0
Education and research	1	4	1

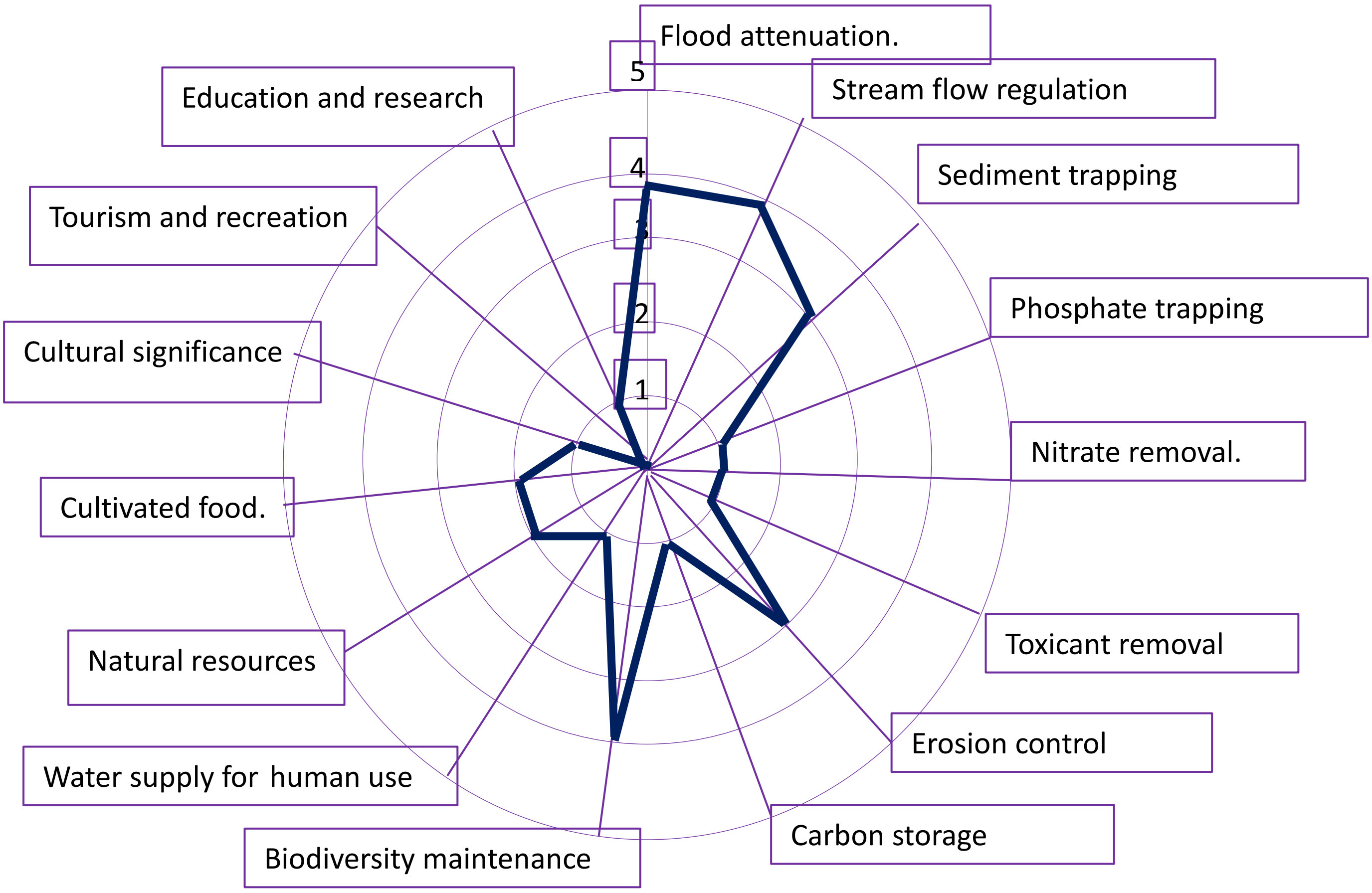


Figure 58. Resource Economics Footprint of the Drainage Lines

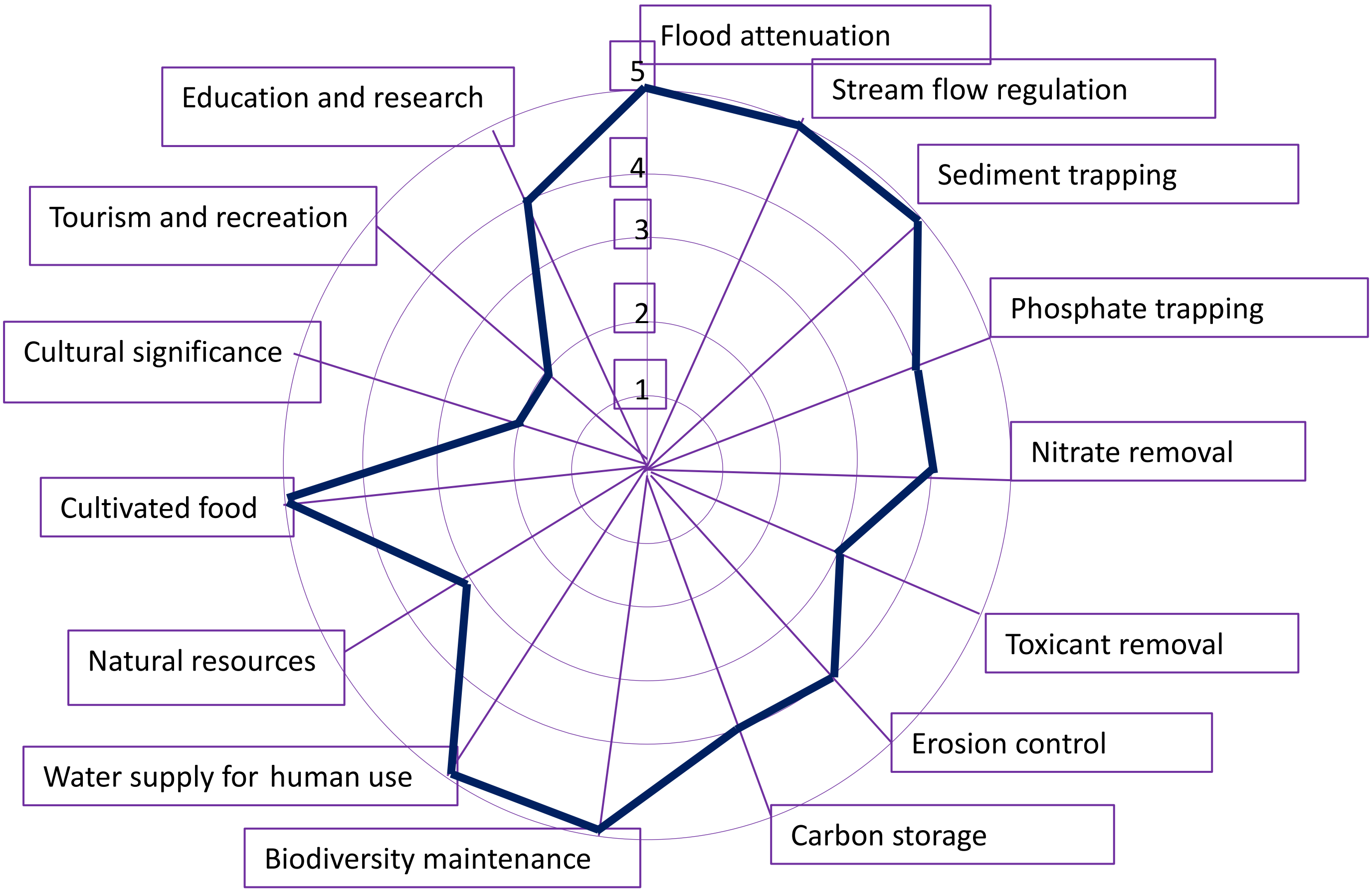


Figure 59. Resource Economics Footprint of the Hartbees River

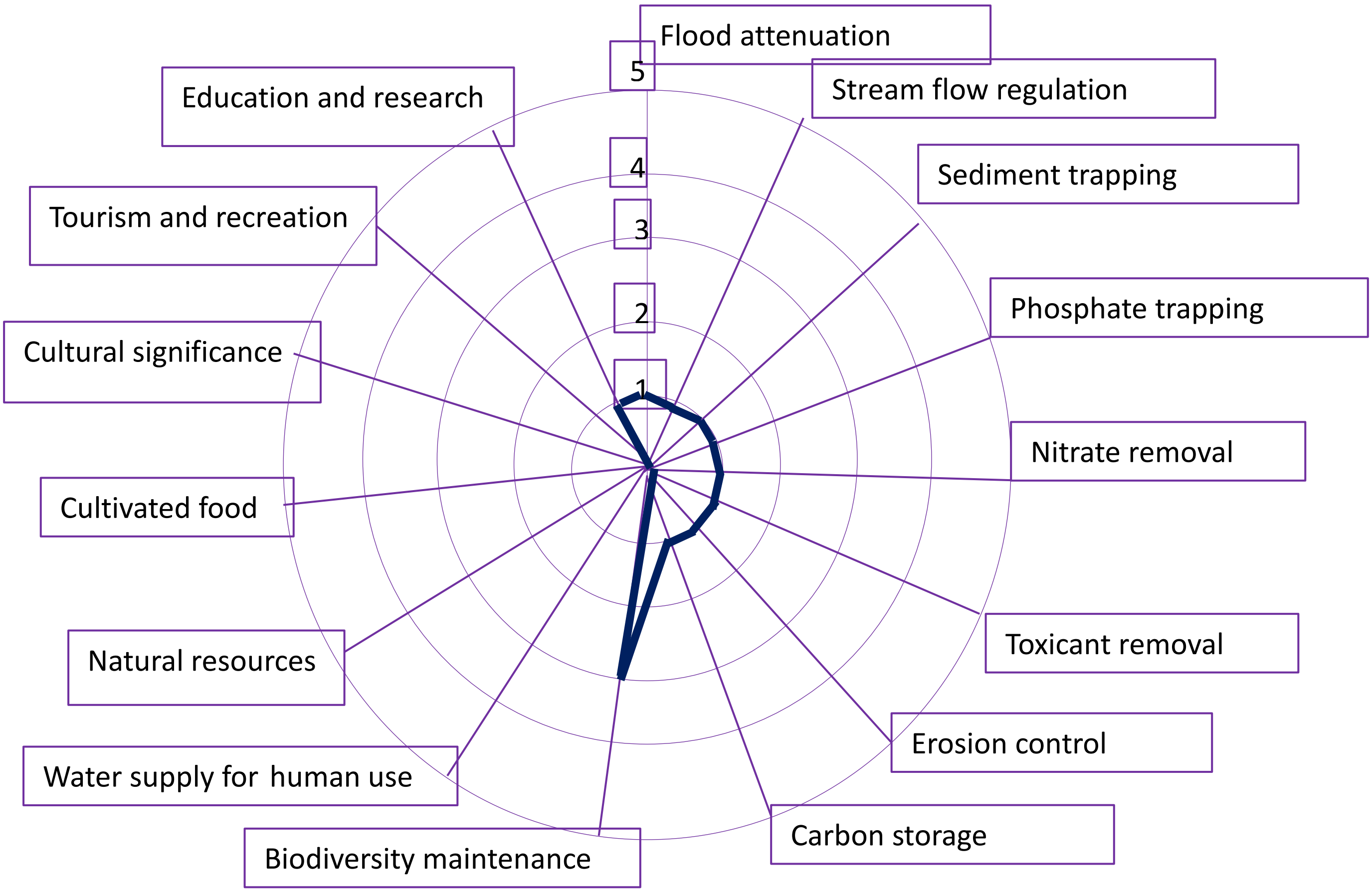


Figure 60. Resource Economics Footprint of the R27 Pan

The Resource Economics footprint of the R27 and Uitkyk Pans are extremely small, insignificant, because is a small pan that is a part of a much bigger system, which combined has a much larger footprint.

25 Summary

Table 19 Summary of assessments

Aspect	Status
DFFE Screening Tool	Sensitivity Medium, High and Very High
Pipeline path	CBA, ESA, Conservation Expansion Plan
Drainage lines aquatic habitat	NFEPA
Oranje River	NFEPA
R27 Pan	NFEPA
Lower Gariep Alluvial Vegetation	Endangered
Bushmanland Arid Grassland	Least Concern
Lower Gariep Broken Veld	Least Concern
PES of the drainage lines	Upper sub-catchments near-pristine
PES of the Orange River	Moderately impacted
PES Hartbees River	Moderately impacted
PES R27 Pan	Near pristine
Ecological Importance Drainage lines	Not important
Ecological importance Orange River	Most important
Ecological Importance Hartbees River	Important
Ecological Importance R27 Pan	Not important
Ecological Sensitivity Drainage lines	Sensitive
Ecological Sensitivity Orange River	Sensitive
Ecological Sensitivity Hartbees River	Sensitive
Ecological Sensitivity R27 Pan	Sensitive
EISC drainage lines	Low
EISC Orange River	High
EISC Hartbees River	Moderate
EISC R27 Pan	Low
Impact assessment	Mitigation measures adequate
Risk Matrix	General Authorization
Resource Economics drainage lines	Very small footprint
Resource Economics Orange River	Very large footprint
Resource Economics Hartbees River	Large footprint
Resource Economics R27 Pan	Insignificant footprint

Table 19 gives an overall and much condensed view of the evaluations and methodologies that have been applied to the drainage lines, the Orange and Hartbees River and to the R27. Terms such as Very High Sensitivity, CBA, NFEPA and Endangered as a first thought raises red flags. However, this must be seen against the facts that the envisaged pipeline will be trenched in a road reserve next to another existing pipeline.

26 Budget

Costing the construction of the pipeline was one of the Freshwater Report's aims, or at least to assist with the budget. Most of the information is not known at this stage of the project and what follows is visioning. In the past, with similar projects, experience learned that the Freshwater Report and its findings can assist with a first-round, preliminary budget. The costing engineer might find these thoughts helpful.

There are 452 Class 1 and Class 2 drainage line crossings, which probably won't cost more than the anywhere else where the pipeline is going to be trenched. Apart from the 150 and more berms at these crossings on both sides of the road. These berms will have to be rebuilt after the trench has been closed. This may add 10 to 15% of the costs.

There are 41 Class 3 crossings where the trench will have to be deeper. This might add another 30% to 40% to the cost, apart from the costs to repair berms.

Class 4 and Class 5 crossings are more challenging. Up to Piet Rooi se Berg, there is one larger bridge, there are 6 more up to Kenhardt and another huge bridge past Kenhardt, 8 in total, that demand deeper digging over a longer distance. This might double the costs.

The 3 clusters past Kenhardt are most challenging, because deep trenches over a kilometre or more may be required to effectively protect the pipeline. The damaged gabions will have to be rebuilt. The costs here may be up to 5 times more, perhaps even more.

The section of the pipeline through the Hartbees River at Kenhardt would probably costs twice as much, as it will have to be dug in much deeper.

The 8 flood control walls past Kenhardt must be rebuilt.

Keep in mind that at crossing, much attention is required for levelling and landscaping to prevent accretion or erosion.

Apart from the dolerite ridges, the very hard granite substrate past Kenhardt to the turnoff will be extremely challenging. A train of very heavy earth-moving machinery may not prove to be enough in some places, where blasting may be required.

This paints a very rough picture of what lies ahead for budgeting purposes. These must be refined, no doubt, as costing proceeds, in successive stages.

27 Conclusions

An anthropogenic activity can impact on any of the ecosystem drivers or responses and this can have a knock-on effect on all the other drivers and responses. This, in turn, will predictably impact on the ecosystem services (Figure 61). The WULA and the EAI must provide mitigation measured for these impacts.

Figure 61 has been adapted from one of the most recent DWS policy documents.

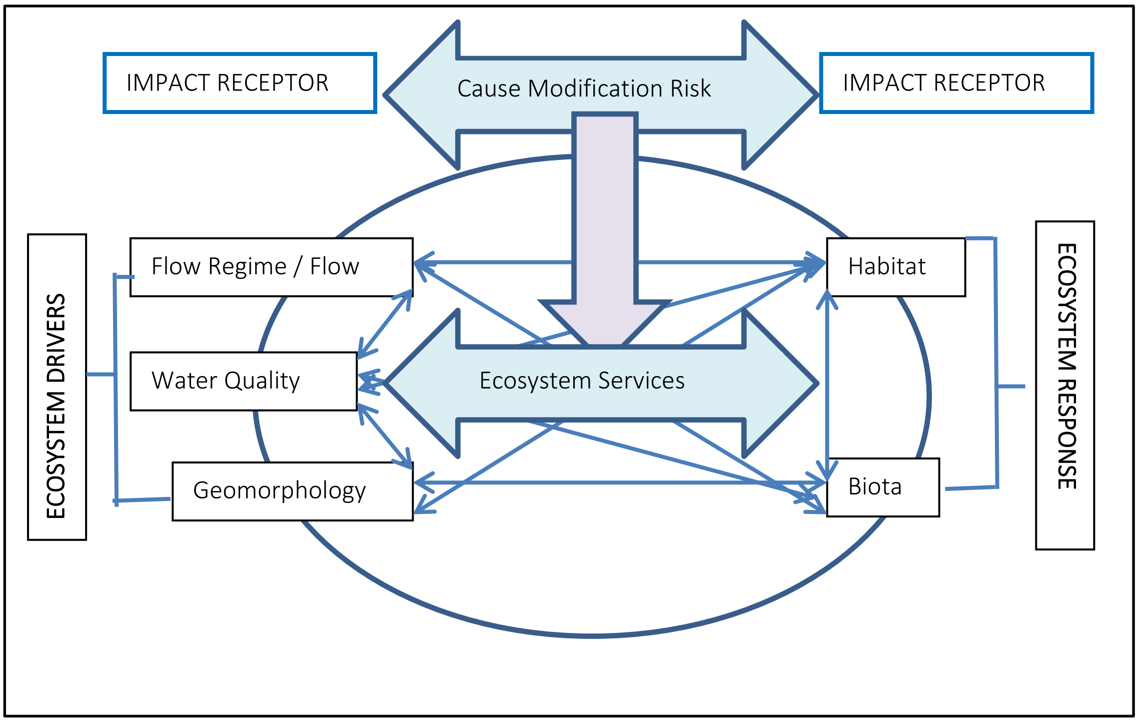


Figure 61 Minimum Requirements for a S21(c) and (i) Application

The driving force behind the Orange River is the runoff from the Lesotho highlands far away in the upper catchment. Thunderstorms in summer and snow melts during winter. This is where the massive runoff volumes originate that maintain the Orange River system.

The riverine habitat and aquatic organisms are adapted to perennial circumstances, with an adequate flow down the river all year round, even during drought conditions.

Human impact has become a driving force, with large dams and abstraction of water for irrigation. The river's water is used far and wide, piped long distances away for human use in many towns and villages.

Agricultural return flow, with its load of agrichemicals and silt is a significant impact. So is treated sewage effluent from cities and towns, including that of Upington.

Despite of this, the river maintained most of its ecological integrity and ecological functioning.

The low ground of the Lower Orange River does not contribute to the flow in the Orange River. The flow is seasonal, with peak flows and periodic flooding following high summer rainfall events and low flow in winter, when precipitation on the high ground is less. Low flow periods can be extended due to long periods of drought.

These drainage lines are driven by the very scant rainfall events, sudden and sometimes severe thunderstorms, spread out over millennia. Rainfall is interspersed by prolonged droughts. This gives rise to a sparse and drought resistant vegetation. The shallow ground water that migrates along these drainage lines provides just enough moist for higher vegetation to take root and to hold on under these very harsh climatic conditions. Drainage lines are ecologically important, as it provides denser and higher vegetation in an otherwise barren landscape, contributing to habitat variation, biodiversity and migration routes.

The upper sub-catchments of these drainage lines are mostly near-pristine, with grazing the only impact. The lower parts are heavily impacted by agriculture and sand winning. This stark contrast is evident all over the region.

The expected direct impact of the proposed pipeline on the drainage lines during the construction phase is going to be small, if mitigating measures are implemented. The impact during the operational phase is going to be negligible. Because of its scope and nature, the pipeline is not going to change any of the dynamics visualized in Figure 1

The Risk Matrix indicated that a General Authorization is the indicated level of official approval.

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29 Declaration of Independence

I, Dirk van Driel, as the appointed independent specialist hereby declare that I:

- Act/ed as the independent specialist in this application
- Regard the information contained in this report as it relates to my specialist input/study to be true and correct and;
- 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 NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management act;
- Have and will not have vested interest in the proposed activity;
- Have disclosed to the applicant, EAP and competent authority any material information have or may have to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the environmental Impact Assessment Regulations, 2010 and any specific environmental management act.
- Am fully aware and meet the responsibilities in terms of the NEMA, the Environmental Impacts Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R543) and any specific environmental management act and that failure to comply with these requirements may constitute and result in disqualification;
- Have ensured that information containing all relevant facts on respect of the specialist input / study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties facilitated in such a manner that all interested and affected parties were provided with reasonable opportunity to participate and to provide comments on the specialist input / study;
- Have ensured that all the comments of all the interested and affected parties on the specialist input were considered, recorded and submitted to the competent authority in respect of the application;
- Have ensured that the names of all the interested and affected parties that participated in terms of the specialist input / study were recorded in the register of interested and affected parties who participated in the public participation process;
- Have provided the competent authority with access to all information at my disposal regarding the application, weather such information is favourable or not and;
- Am aware that a false declaration is an offence in terms of regulation 71 of GN No. R543.

Signature of the specialist: D van Driel 7 November 2022

30 Résumé

Experience

USAID/RTI, ICMA & Chemonics. Iraq & Afghanistan **2007 -2011**
Program manager.

City of Cape Town **1999-2007**
Acting Head: Scientific Services, Manager: Hydrobiology.

Department of Water & Sanitation, South Africa **1989 – 1999**
Senior Scientist

Tshwane University of Technology, Pretoria **1979 – 1998**
Head of Department

University of Western Cape and Stellenbosch University 1994 - 1998 part-time

- Lectured post-graduate courses in Water Management and Environmental Management to under-graduate civil engineering students
- Served as external dissertation and thesis examiner

Service Positions

- Project Leader, initiator, member and participator: Water Research Commission (WRC), Pretoria.
- Director: UNESCO West Coast Biosphere, South Africa
- Director (Past Deputy Chairperson): Grotto Bay Homeowner's Association
- Past Member Dassen Island Protected Area Association (PAAC)

Membership of Professional Societies

- South African Council for Scientific Professions. Registered Scientist No. 400041/96
- Water Institute of South Africa. Member

Reports

- Process Review Kathu Wastewater Treatment Works
- Effluent Irrigation Report Tydstroom Abattoir Durbanville
- River Rehabilitation Report Slangkop Farm, Yzerfontein
- Fresh Water and Estuary Report Erf 77 Elands Bay
- Ground Water Revision, Moorreesburg Cemetery
- Fresh Water Report Delaire Graff Estate, Stellenbosch
- Fresh Water Report Quantum Foods (Pty) Ltd. Moredou Poultry Farm, Tulbagh
- Fresh Water Report Revision, De Hoop Development, Malmesbury
- Fresh Water Report, Idas Valley Development Erf 10866, Stellenbosch
- Wetland Delineation Idas Valley Development Erf 10866, Stellenbosch
- Fresh Water Report, Idas Valley Development Erf 11330, Stellenbosch
- Fresh Water Report, La Motte Development, Franschhoek
- Ground Water Peer Review, Elandsfontein Exploration & Mining
- Fresh Water Report Woodlands Sand Mine Malmesbury
- Fresh Water Report Brakke Kuyl Sand Mine, Cape Town
- Wetland Delineation, Ingwe Housing Development, Somerset West
- Fresh Water Report, Suurbraak Wastewater Treatment Works, Swellendam
- Wetland Delineation, Zandbergfontein Sand Mine, Robertson
- Storm Water Management Plan, Smalblaar Quarry, Rawsonville
- Storm Water Management Plan, Riverside Quarry
- Water Quality Irrigation Dams Report, Langebaan Country Estate
- Wetland Delineation Farm Eenzaamheid, Langebaan
- Wetland Delineation Erf 599, Betty's Bay
- Technical Report Bloodhound Land Speed Record, Hakskeenpan
- Technical Report Harkerville Sand Mine, Plettenberg Bay
- Technical Report Doring Rivier Sand Mine, Vanrhynsdorp
- Rehabilitation Plan Roodefontein Dam, Plettenberg Bay
- Technical Report Groenvlei Crusher, Worcester
- Technical Report Wiedouw Sand Mine, Vanrhynsdorp
- Technical Report Lair Trust Farm, Augrabies
- Technical Report Schouwtoneel Sand Mine, Vredenburg
- Technical Report Waboomsrivier Weir Wolseley
- Technical Report Doornkraal Sand Mine Malmesbury
- Technical Report Berg-en-Dal Sand Mine Malmesbury
- Wetland Demarcation, Osdrif Farm, Worcester
- Technical Report Driefontein Dam, Farm Agterfontein, Ceres
- Technical Report Oewerzicht Farm Dam, Greyton
- Technical Report Glen Lossie Sand Mine, Malmesbury
- Preliminary Report Stellenbosch Cemeteries
- Technical Report Toeka & Harmony Dams, Houdenbek Farm, Koue Bokkeveld
- Technical Report Kluitjieskraal Sand & Gravel Mine, Swellendam
- Fresh Water Report Urban Development Witteklip Vredenburg
- Fresh Water Report Groblershoop Resort, Northern Cape
- Fresh Water Report CA Bruwer Quarry Kakamas, Northern Cape
- Fresh Water Report, CA Bruwer Sand Mine, Kakamas, Northern Cape
- Fresh Water Report, Triple D Farms, Agri Development, Kakamas
- Fresh Water Report, Keren Energy Photovoltaic Plant Kakamas
- Fresh Water Report, Keren Energy Photovoltaic Plant Hopetown
- Fresh Water Report Hopetown Sewer
- Fresh Water Report Hoogland Farm Agricultural Development, Touws River

- Fresh Water Report Klaarstroom Wastewater Treatment Works
- Fresh Water Report Calvinia Sports Grounds Irrigation
- Fresh Water Report CA Bruwer Agricultural Development Kakamas
- Fresh Water Report Zwartfontein Farm Dam, Hermon
- Statement Delsma Farm Wetland, Hermon
- Fresh Water Report Lemoenshoek Farms Pipelines Bonnyvale
- Fresh Water Report Water Provision Pipeline Brandvlei
- Fresh Water Report Erf 19992 Upington
- Botanical Report Zwartejongensfontein Sand Mine, Stilbaai
- Fresh Water Report CA Bruwer Feldspath Mine, Kakamas
- Sediment Yield Calculation, Kenhardt Sand Mine
- Wetland Demarcation, Grabouw Traffic Center
- Fresh Water Report, Osdrift Sand Mine, Worcester
- Fresh Water Report, Muggievlak Storm Water Canal, Vredenburg
- Fresh Water Report, Marksman's Nest Rifle Range, Malmesbury
- Biodiversity Report, Muggievlak Storm Water Canal, Vredenburg
- Strategic Planning Report, Sanitation, Afghanistan Government, New Delhi, India
- Fresh Water Report, Potable Water Pipeline, Komaggas
- Fresh Water Report, Wastewater Treatment Works, Kamieskroon
- Fresh Water Report, Turksvy Farm Dam, Upington
- Fresh Water Report, Groblershoop Urban Development, IKheis Municipality
- Fresh Water Report, Boegoeberg Urban Development, IKheis Municipality
- Fresh Water Report, Opwag Urban Development, IKheis Municipality
- Fresh Water Report, Wegdraai Urban Development, IKheis Municipality
- Fresh Water Report, Topline Urban Development, IKheis Municipality
- Fresh Water Report, Grootdrink Urban Development, IKheis Municipality
- Fresh Water Report, Gariep Urban Development, IKheis Municipality
- Fresh Water Report, Bonathaba Farm Dam, Hermon
- Botanical Report, Sand Mine Greystone Trading, Vredendal
- Botanical Report Namakwa Klei Stene, Klawer
- Fresh Water Report Buffelsdrift Quarry, George
- Fresh Water Report Styerkraal Agricultural Development, Onseepkans.
- Technical Report Arabella Country Estate Wastewater Treatment Works, Kleinmond
- Fresh Water Report Calvinia Bulk Water Supply
- Fresh Water Report Swartdam Farm Dams, Riebeeck Kasteel
- Fresh Water Report Erf 46959, Gordon's Bay
- Fresh Water Report Melkboom Farm Dam, Trawal
- Stormwater Management Plan, Bot River Bricks
- Freshwater Report, Bot River Bricks
- Freshwater Report Sanddrif Farm, Joubertina
- Freshwater Report Zouterivier Cell phone tower, Atlantis
- Biodiversity Report Birdfield Sandmine, Klawer
- Freshwater Report New Wave Dam, Klawer
- Freshwater Report Harvard Solar Energy Plant, Bloemfontein
- Freshwater Report Doorn River Solar Energy Plant, Virginia
- Freshwater Report Kleingeluk Farm, De Rust
- Freshwater Report, Solar Energy Plant, Klein Brak River
- Site Verification Report Laaiplek Desalination Plant
- Freshwater Report, CA Bruwer Quarry, Kakamas
- Freshwater Report, Orren Managanese Mine, Swellendam
- Freshwater Report Bakenrant Boerdery, Kakamas
- Freshwater Report C & A van Niekerk Boerdery, Marchant

31 Appendix

31.1 Vegetation

Lower Gariep Alluvial Vegetation

Distribution Northern Cape Province: Broad alluvium (floodplains and islands) of the Orange (Gariep) River between Groblershoop and the mouth into the Atlantic Ocean at Oranjemund (Namibia). This river stretch is embedded within Desert (Oranjemund to roughly Pofadder) and Nama-Karoo (further upstream as far as Groblershoop). Altitude ranging from 0–1 000 m.

Vegetation & Landscape Features Flat alluvial terraces and riverine islands supporting a complex of riparian thickets (dominated by *Ziziphus mucronata*, *Euclea pseudebenus* and *Tamarix usneoides*), reed beds with *Phragmites australis* as well as flooded grasslands and herblands populating sand banks and terraces within and along the river.

Geology, Soil & Hydrology Recent alluvial deposits of the Orange River supporting soil forms such as Dundee and Oakleaf. The river cuts through a great variety of Precambrian metamorphic rocks. Ia land type. Subject to floods, especially in summer, caused by high precipitation on the highveld.

Climate Region with very arid (desert) to subarid (semidesert) climate and erratic, unimodal (winter-rainfall) regime in the extreme west (near the Orange River mouth) to bimodal, equinoctial with major peak in March and less pronounced peak in November in the extreme east (near Upington). MAP 40–150 mm and MAT between 15.4°C (Alexander Bay) and 20.5°C (Upington). See also climate diagram for AZa 3 Lower Gariep Alluvial Vegetation (Figure 13.2).

Important Taxa **Riparian thickets** Small Trees: *Acacia karroo* (d), *Euclea pseudebenus* (d), *Salix mucronata* subsp. *mucronata* (d), *Schotia afra* var. *angustifolia* (d), *Ziziphus mucronata* (d), *Acacia erioloba*, *Combretum erythrophyllum*, *Ficus cordata*, *Maerua gilgii*, *Prosopis glandulosa* var. *glandulosa*, *Rhus lancea*. Tall Shrubs: *Gymnosporia linearis* (d), *Tamarix usneoides* (d), *Ehretia rigida*, *Euclea undulata*, *Sisyndite spartea*. Low Shrub: *Asparagus laricinus*. Woody Climber: *Asparagus retrofractus*. Succulent Shrub: *Lycium bosciifolium*. Herb: *Chenopodium olukondae*. **Reed beds** Megagraminoid: *Phragmites australis* (d). **Flooded grasslands & herblands** Low Shrubs: *Tetragonia schenckii* (d), *Litogyne gariepina*. Graminoids: *Cynodon dactylon* (d), *Setaria verticillata* (d), *Cenchrus ciliaris*, *Cyperus laevigatus*, *Eragrostis echinochloidea*, *Leucophrys mesocoma*, *Polypogon monspeliensis*, *Stipagrostis namaquensis*. Herbs: *Amaranthus praetermissus*, *Coronopus integrifolius*, *Frankenia pulverulenta*, *Gnaphalium confine, Pseudognaphalium luteo-album*.

Conservation Endangered. Target 31%. About 6% statutorily conserved in the Richtersveld and Augrabies Falls National Parks. Some 50% transformed for agricultural purposes (vegetables and grapes) or alluvial diamond mining. *Prosopis* species, *Nicotiana glauca* and *Argemone ochroleuca* can invade the alluvia in places.

References Acocks (1976), Werger & Coetzee (1977), Werger & Ellenbroek (1978), Werger (1980), Bezuidenhout (1996), Bezuidenhout & Jardine (2001), Jürgens (2004).

Bushmanland Arid Grassland

VT 29 Arid Karoo and Desert False Grassveld (36%), VT 32 Orange River Broken Veld (36%) (Acocks 1953). LR 51 Orange River Nama Karoo (51%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Spanning about one degree of latitude from around Aggeneys in the west to Prieska in the east. The southern border of the unit is formed by edges of the Bushmanland Basin while in the northwest this vegetation unit borders on desert vegetation (northwest of Aggeneys and Pofadder). The northern border (in the vicinity of Upington) and the eastern border (between Upington and Prieska) are formed with often intermingling units of Lower Gariep Broken Veld, Kalahari Karroid Shrubland and Gordonia Duneveld. Most of the western border is formed by the edge of the Namaqualand hills. Altitude varies mostly from 600–1 200 m.

Vegetation & Landscape Features Extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses (*Stipagrostis* species) giving this vegetation type the character of semidesert 'steppe'. In places low shrubs of *Salsola* change the vegetation structure. In years of abundant rainfall rich displays of annual herbs can be expected.

Geology & Soils A third of the area is covered by recent (Quaternary) alluvium and calcrete. Superficial deposits of the Kalahari Group are also present in the east. The extensive Palaeozoic diamictites of the Dwyka Group also outcrop in the area as do gneisses and metasediments of Mokolian age. The soils of most of the area are red-yellow apedal soils, freely drained, with a high base status and <300 mm deep, with about one fifth of the area deeper than 300 mm, typical of Ag and Ae land types.

Climate Rainfall largely in late summer/early autumn (major peak) and very variable from year to year. MAP ranges from about 70 mm in the west to 200 mm in the east. Mean maximum and minimum monthly temperatures for Kenhardt are 40.6°C and –3.7°C for January and July respectively. Corresponding values for Pofadder are 38.3°C and –0.6°C. Frost incidence ranges from around 10 frost days per year in the northwest to about 35 days in the east. Whirl winds (dust devils) are common on hot summer days. See also climate diagram for NKb 3 Bushmanland Arid Grassland (Figure 7.2).

Important Taxa ([W]Western and [E]Eastern regions of the unit only) Graminoids: *Aristida adscensionis* (d), *A. congesta* (d), *Enneapogon desvauxii* (d), *Eragrostis nindensis* (d), *Schmidtia kalahariensis* (d), *Stipagrostis ciliata* (d), *S. obtusa* (d), *Cenchrus ciliaris*, *Enneapogon scaber*, *Eragrostis annulata*[E], *E. porosa*[E], *E. procumbens*, *Panicum lanipes*[E], *Setaria verticillata*[E], *Sporobolus nervosus*, *Stipagrostis brevifolia*[W], *S. uniplumis*, *Tragus berteronianus*, *T. racemosus*[E]. Small Trees: *Acacia mellifera* subsp. *detinens*[E], *Boscia foetida* subsp. *foetida*. Tall Shrubs: *Lycium cinereum* (d), *Rhigozum trichotomum* (d), *Cadaba aphylla*, *Parkinsonia africana*. Low Shrubs: *Aptosimum spinescens* (d), *Hermannia spinosa* (d), *Pentzia spinescens* (d), *Aizoon asbestinum*[E], *A. schellenbergii*[E], *Aptosimum elongatum*, *A. lineare*[E], *A. marlothii*[E], *Barleria rigida*, *Berkheya annectens*, *Blepharis mitrata*, *Eriocephalus ambiguus*, *E. spinescens*, *Limeum aethiopicum*, *Lophiocarpus polystachyus*, *Monechma incanum*, *M. spartioides*, *Pentzia pinnatisecta*, *Phaeoptilum spinosum*[E], *Polygala seminuda*, *Pteronia leucoclada*, *P. mucronata*, *P. sordida*, *Rosenia humilis*, *Senecio niveus*, *Sericocoma avolans*, *Solanum capense*, *Talinum arnotii*[E], *Tetragonia arbuscula*, *Zygophyllum microphyllum*. Succulent Shrubs: *Kleinia longiflora*, *Lycium bosciifolium*, *Salsola tuberculata*, *S. glabrescens*. Herbs: *Acanthopsis hoffmannseggiana*, *Aizoon canariense*, *Amaranthus praetermissus*, *Barleria lichtensteiniana*[E], *Chamaesyce inaequilatera*, *Dicoma capensis*, *Indigastrum argyraeum*, *Lotononis platycarpa*, *Sesamum capense*, *Tribulus pterophorus*, *T. terrestris*, *Vahlia capensis*. Succulent Herbs: *Gisekia pharnacioides*[E], *Psilocaulon coriarium*, *Trianthema parvifolia*. Geophytic Herb: *Moraea venenata*.

Biogeographically Important Taxon (Bushmanland endemic) Succulent Herb: *Tridentea dwequensis*.

Endemic Taxa Succulent Shrubs: *Dinteranthus pole-evansii*, *Larryleachia dinteri*, *L. marlothii*, *Ruschia kenhardtensis*. Herbs: *Lotononis oligocephala*, *Nemesia maxii.*

Conservation Least threatened. Target 21%. Only small patches statutorily conserved in Augrabies Falls National Park and Goegab Nature Reserve. Very little of the area has been transformed. Erosion is very low (60%) and low (33%).

Remarks This unit has a large longitudinal extent, with some species common in only part of the unit. Further research may lead to the split of this unit at a later stage.

References Acocks (1953, 1988), Du Toit (1996), L. Mucina (unpubl. data).

NKb 1 Lower Gariep Broken Veld

VT 32 Orange River Broken Veld (70%) (Acocks 1953). LR 51 Orange River Nama Karoo (95%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Hardeveld along the Orange River from Onseepkans in the west, including the canyon below the Augrabies Falls and parts of Riemvasmaak and adjacent areas to Keimoes resuming from the Boegoeberg to around Prieska in the east. A series of inselbergs and koppies occurring between Keimoes and around Kakamas, and the ridge running west of Groblershoop from Karos in the north to around Marydale in the south. The unit also occurs in neighbouring Namibia. Most of the area varies from 400–1 200 m in altitude.

Vegetation & Landscape Features Hills and low mountains, slightly irregular plains but with some rugged terrain (e.g. downstream of the Augrabies Falls) with sparse vegetation dominated by shrubs and dwarf shrubs, with annuals conspicuous, especially in spring, and perennial grasses and herbs. Groups of widely scattered low trees such as *Aloe dichotoma* var. *dichotoma* and *Acacia mellifera* subsp*. detinens* occur on slopes of koppies and on sandy soils of foot slopes respectively.

Geology & Soils The region has a complicate geology: banded iron formation and amphibolites of the Asbestos Hills Subgroup are Vaalian and the carbonates and cherts of the Campbell Group are of the same Era. Metamorphic rocks of the Mokolian Erathem include quartzites and gneisses of the Korannaland Supergroup as well as the Riemvasmaak gneiss. Metamorphosed clastic sediments of the Uitdraai Formation are also Mokolian. The remaining half of the area is composed of many other stratigraphies, metamorphosed sediments and outcrops of the ultrametamorphic rocks of the Namaqualand Metamorphic Complex. The soils are shallow and skeletal (dominant soil forms are Mispah and Glenrosa), typical mainly of Ib and Ic land types, and to a lesser extent also of Fb land type.

Climate MAP ranges from about 70 mm in the west to 240 mm in the east. Mean maximum and minimum monthly temperatures for Kakamas are 41.3°C and –2°C for January and July respectively. Corresponding values for Prieska (near the eastern extremity) are 39.7°C and –4.1°C. Frost incidence varies from less than 10 days of frost per annum in the west to around 30 days in the east. See also climate diagram for NKb 1 Lower Gariep Broken Veld (Figure 7.2).

Important Taxa ([W]Western or [E]Eastern part of this unit only) Succulent Trees: *Aloe dichotoma* var. *dichotoma*. Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Commiphora gracilifrondosa*[W], *Ficus cordata*, *Pappea capensis*[W], *Rhus populifolia*[W], *Ziziphus mucronata* subsp. *mucronata*. Tall Shrubs: *Rhigozum trichotomum* (d), *Adenolobus garipensis*[W], *Antherothamnus pearsonii*[W], *Cadaba aphylla*, *Caesalpinia bracteata, Ehretia rigida* subsp. *rigida*, *Nymania capensis*, *Rhigozum obovatum*[E], *Rhus burchellii*. Epiphytic Semiparasitic Shrub: *Tapinanthus oleifolius*. Succulent Shrubs: *Ceraria namaquensis*, *Cryptolepis decidua*[W], *Euphorbia avasmontana*, *E. gregaria*[W], *Kleinia longiflora*, *Lycium bosciifolium*, *Zygophyllum dregeanum*. Woody Succulent Climber: *Sarcostemma viminale*. Low Shrubs: *Blepharis mitrata* (d), *Aizoon schellenbergii*, *Aptosimum albomarginatum*, *A. lineare*, *A. marlothii*, *Barleria rigida*, *Berkheya spinosissima* subsp. *namaensis*, *Dyerophytum africanum*, *Hermannia spinosa*, *H. vestita*, *Hibiscus elliottiae*, *Indigofera heterotricha*, *Limeum aethiopicum*, *Lophiocarpus polystachyus*, *Monechma spartioides*, *Phaeoptilum spinosum*, *Phyllanthus maderaspatensis*, *Polygala seminuda*, *Ptycholobium biflorum* subsp. *biflorum*, *Sericocoma avolans*, *Solanum capense*, *Stachys burchelliana*, *Talinum arnotii*, *Tetragonia arbuscula*, *Zygophyllum rigidum*. Semiparasitic Shrub: *Thesium lineatum.* Graminoids: *Aristida adscensionis* (d), *Enneapogon desvauxii* (d), *E. scaber* (d), *Eragrostis nindensis* (d), *Stipagrostis obtusa* (d), *S. uniplumis* (d), *Aristida congesta*, *A. engleri*, *Cenchrus ciliaris*, *Digitaria eriantha*, *Enneapogon cenchroides*, *Eragrostis annulata*, *E. lehmanniana*, *E. porosa*, *Schmidtia kalahariensis*, *Setaria verticillata*, *Sporobolus fimbriatus*[E], *Stipagrostis anomala*, *S. ciliata*, *Tragus berteronianus*, *Triraphis ramosissima*[W]. Herbs: *Forsskaolea candida* (d), *Acanthopsis hoffmannseggiana*, *Barleria lichtensteiniana*, *Chamaesyce glanduligera*, *Chascanum garipense*, *Cleome angustifolia* subsp. *diandra*, *Codon royenii*, *Dicoma capensis*, *Garuleum schinzii*[E], *Rogeria longiflora*, *Sesamum capense*, *Tribulus zeyheri*, *Trichodesma africanum*. Succulent Herbs: *Orbea lutea* subsp. *lutea*, *Stapelia flavopurpurea*.

Endemic Taxon Succulent Shrub: *Ruschia pungens*.

Conservation Least threatened. Target 21%. Statutorily conserved in Augrabies Falls National Park (4%). Only a very small part transformed. Erosion is low (58%), very low (27%) and moderate (14%).

References Acocks (1953, 1988), Werger & Coetzee (1977), Bezuidenhout (1996), Zietsman & Bezuidenhout (1999).

31.2 Biomonitoring Results

SASS5 Score Sheet										
Date	19 Oct 22	**Taxon**	**Weight**	**Score**	**Taxon**	**Weight**	**Score**	**Taxon**	**Weight**	**Score**
Locality	Orange River	Porifera	5		**Hemiptera**			**Diptera**		
	Keimoes	Coelenterata	1		Belostomatidae	3		Athericidae	10	
	Orange River 3	Turbellaria	3		Corixidae	3	3	Blepharoceridae	15	
	Pump station	Oligochaeta	1	1	Gerridae	5	5	Ceratopogonidae	5	5
Coordinates	28°44' 13.14"S	Huridinea	3		Hydrometridae	6		Chironomidae	2	2
	20°59'01.76"E	**Crustacea**			Naucoridae	7		Culicidae	1	
		Amphipodae	13		Nepidae	3		Dixidae	10	
DO mg/l	5.5	Potamonautidae	3		Notonectidae	3		Empididae	6	
Temperature °C	23.3	Atyidae	8	8	Pleidae	4		Ephydridae	3	
pH	7.9	Palaemonidae	10		Veliidae	5		Muscidae	1	
EC mS/m	43.6	Hydracarina	8		**Megaloptera**			Psychodidae	1	
		Plecoptera			Corydalidae	10		Simuliidae	5	
SASS5 Score	43	Notonemouridae	14		Sialidae	8		Syrphidae	1	
Number of Taxa	9	Perlidae	12		**Trichoptera**			Tabanidae	5	
ASPT	4,8	**Ephemeroptera**			Dipseudopsidae	10		Tipulidae	5	
		Baetidae 1 sp	4	4	Ecnomidae	8		**Gastropoda**		
Other Biota		Baetidae 2 sp	6		Hydropsychidae 1 sp	4		Ancylidae	6	
		Baetidae >3 sp	12		Hydropsychidae 2 sp	6		Bulinidae	3	
		Caenidae	6		Hydropsychidae <2 sp	12		Hydrobiidae	3	
		Ephemeridae	15		Phylopotamidae	10		Lymnaeidae	3	
		Heptageniidae	13		Polycentropodidae	12		Physidae	3	
		Leptophlebiidae	9		Psychomyidae	8		Planorbidae	3	
		Oligoneuridae	15		**Cased Caddis**			Thiaridae	3	
Comments		Polymitarcyidae	10		Barbarochthonidae	13		Viviparidae	5	
		Prosopistomatida	15		Calamoceratidae	11		**Pelecipoda**		
		Teloganodidae	12		Glossostomatidae	11		Corbiculidae	5	
		Trichorythidae	9		Hydroptilidae	6		Sphariidae	3	
		Odonata			Hydrosalpingidae	15		Unionidae	6	
		Calopterygidae	10		Leptostomatidae	10				
		Clorocyphidae	10		Leptoceridae	6				
		Chorolestidae	8		Petrothrincidae	11				
		Coenagrionidae	4		Pisulidae	10				
		Lestidae	8		Sericostomatidae	13				
		Platycnemidae	10		**Coleoptera**					
		Protoneuridae	8		Dyticidae	5	5			
		Aesthnidae	8		Elmidae Dryopidae	8				
		Corduliidae	8		Gyrinidae	5	5			
		Gomphidae	6		Haliplidae	5				
		Libellulidae	4		Helodidae	12				
		Lepidoptera			Hydraenidae	8				
		Pyralidae	12		Hydrophilidae	5	5			
					Limnichidae	10				
					Psephenidae	10				
Score				13			23			7

31.3 Methodology used in determining significance of impacts

The methodology to be used in determining and ranking the nature, significance, consequences, extent, duration and probability of potential environmental impacts and risks associated with the alternatives is provided in the following tables:

Table 31.3.1 Nature and type of impact

Nature and type of impact	Description
Positive	An impact that is considered to represent an improvement to the baseline conditions or represents a positive change
Negative	An impact that is considered to represent an adverse change from the baseline or introduces a new negative factor
Direct	Impacts that result from the direct interaction between a planned project activity and the receiving environment / receptors
Indirect	Impacts that result from other activities that could take place as a consequence of the project (e.g. an influx of work seekers)
Cumulative	Impacts that act together with other impacts (including those from concurrent or planned future activities) to affect the same resources and / or receptors as the project

Table 31.3.2 Criteria for the assessment of impacts

Criteria	Rating	Description
Spatial extent of impact	National	Impacts that affect nationally important environmental resources or affect an area that is nationally important or have macro-economic consequences
	Regional	Impacts that affect regionally important environmental resources or are experienced on a regional scale as determined by administrative boundaries or habitat type / ecosystems
	Local	Within 2 km of the site
	Site specific	On site or within 100m of the site boundary
Consequence of impact/ Magnitude/ Severity	High	Natural and / or social functions and / or processes are severely altered
	Medium	Natural and / or social functions and / or processes are notably altered
	Low	Natural and / or social functions and / or processes are slightly altered
	Very Low	Natural and / or social functions and / or processes are negligibly altered
	Zero	Natural and / or social functions and / or processes remain unaltered
Duration of impact	Temporary	Impacts of short duration and /or occasional
	Short term	During the construction period
	Medium term	During part or all of the operational phase
	Long term	Beyond the operational phase, but not permanently
	Permanent	Mitigation will not occur in such a way or in such a time span that the impact can be considered transient (irreversible)

Table 31.3.3 Significance Rating

Significance Rating	Description
High	High consequence with a regional extent and long-term duration High consequence with either a regional extent and medium-term duration or a local extent and long-term duration Medium consequence with a regional extent and a long-term duration
Medium	High with a local extent and medium-term duration High consequence with a regional extent and short-term duration or a site-specific extent and long-term duration High consequence with either local extent and short-term duration or a site-specific extent with a medium-term duration Medium consequence with any combination of extent and duration except site-specific and short-term or regional and long term Low consequence with a regional extent and long-term duration
Low	High consequence with a site-specific extent and short-term duration Medium consequence with a site-specific extent and short-term duration Low consequence with any combination of extent and duration except site-specific and short-term Very low consequence with a regional extent and long-term duration
Very low	Low consequence with a site-specific extent and short-term duration Very low consequence with any combination of extent and duration except regional and long term
Neutral	Zero consequence with any combination of extent and duration

Table 31.3.4 Probability, confidence, reversibility and irreplaceability

Criteria	Rating	Description
Probability	Definite	>90% likelihood of the impact occurring
	Probable	70 – 90% likelihood of the impact occurring
	Possible	40 – 70% likelihood of the impact occurring
	Unlikely	<40% likelihood of the impact occurring
Confidence	Certain	Wealth of information on and sound understanding of the environmental factors potentially affecting the impact
	Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact
	Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact
Reversibility	Reversible	The impact is reversible within 2 years after the cause or stress is removed
	Irreversible	The activity will lead to an impact that is in all practical terms permanent
Irreplaceability	Replaceable	The resources lost can be replaced to a certain degree
	Irreplaceable	The activity will lead to a permanent loss of resources.

Table 31.4 Numerical Significance

Table 31.4.1 Conservation Value

Conservation Value		
Refers to the intrinsic value of the area or its relative importance towards the conservation of an ecosystem or species or even natural aesthetics. Conservation status is based on habitat function, its vulnerability to loss and fragmentation or its value in terms of the protection of habitat or species	Low 1	The area is transformed, degraded not sensitive (e.g. Least threatened), with unlikely possibility of species loss.
	Medium / Low 2	The area is in good condition but not sensitive (e.g. Least threatened), with unlikely possibility of species loss.
	Medium 3	The area is in good condition, considered vulnerable (threatened), or falls within an ecological support area or a critical biodiversity area, but with unlikely possibility of species loss.
	Medium / High 4	The area is considered endangered or, falls within an ecological support area or a critical biodiversity area, or provides core habitat for endemic or rare & endangered species.
	High 5	The area is considered critically endangered or is part of a proclaimed provincial or national protected area.

Table 31.4.2 Significance

Significance	Score	Description
Insignificant	4 - 22	There is no impact or the impact is insignificant in scale or magnitude as a result of low sensitivity to change or low intrinsic value of the site.
Low	23 - 36	An impact barely noticeable in scale or magnitude as a result of low sensitivity to change or low intrinsic value of the site, or will be of very short-term or is unlikely to occur. Impact is unlikely to have any real effect and no or little mitigation is required.
Medium / Low	37 - 45	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved. Impacts may have medium to short term effects on the natural environment within site boundaries.
Medium	46 - 55	Impact is real, but not substantial. Mitigation is both feasible and fairly easily possible but may require modification of the project design or layout. These impacts will usually result in medium to long term effect on the natural environment, within site boundary.
Medium High	56 - 63	Impact is real, substantial and undesirable, but mitigation is feasible. Modification of the project design or layout may be required. These impacts will usually result in medium to long-term effect on the natural environment, beyond site boundary within local area.
High	64 - 79	An impact of high order. Mitigation is difficult, expensive, time-consuming or some combination of these. These impacts will usually result in long-term change to the natural environment, beyond site boundaries, regional or widespread.
Unacceptable	80 - 100	An impact of the highest order possible. There is no possible mitigation that could offset the impact. The impact will result in permanent change. Very often these impacts cannot be mitigated and usually result in very severe effects, beyond site boundaries, national or international.

Table 31.4.3 Scoring system

Parameter	1	2	3	4	5
Conservation value Likelihood Duration Extent Severity	Low Unlikely Temporary Site specific Zero	Medium /Low Possible Short term Local Very low	Medium More possible Medium term Regional Low	Medium / High Probable Long term National Medium	High Definite Permanent International High

Significance = Conservation value (Likelihood + Duration + Extent + Severity)

31.5 Risk Matrix Methodology

RISK ASSESSMENT KEY **(Referenced from DWA RISK-BASED WATER USE AUTHORISATION APPROACH AND DELEGATION GUIDELINES)**

Negative Rating

TABLE 1- SEVERITY

How severe does the aspects impact on the environment and resource quality characterisitics (flow regime, water quality, geomorfology, biota, habitat)

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means	

TABLE 2 – SPATIAL SCALE

How big is the area that the aspect is impacting on?

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighbouring areas (downstream within quaternary catch	3
National (impacting beyond seconday catchment or provinces)	4
Global (impacting beyond SA boundary)	5

TABLE 3 – DURATION

How long does the aspect impact on the environment and resource quality?

One day to one month, PES, EIS and/or REC not impacted
One month to one year, PES, EIS and/or REC impacted but no change in status
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation
Life of the activity, PES, EIS and/or REC permanently lowered
More than life of the organisation/facility, PES and EIS scores, a E or F

TABLE 4 – FREQUENCY OF THE ACTIVITY

How often do you do the specific activity?

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

TABLE 5 – FREQUENCY OF THE INCIDENT/IMPACT

How often does the activity impact on the environment?

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

TABLE 6 – LEGAL ISSUES

How is the activity governed by legislation?

No legislation
Fully covered by legislation (wetlands are legally governed)
Located within the regulated areas

TABLE 7 – DETECTION	
How quickly can the impacts/risks of the activity be observed on the environment (water resourc	
Immediately	
Without much effort	
Need some effort	
Remote and difficult to observe	
Covered	

TABLE 8: RATING CLASSES		
RATING	**CLASS**	**MANAGEMENT DESCRIPTION**
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands may be excluded.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale
A low risk class must be obtained for all activities to be considered for a GA		

TABLE 9: CALCULATIONS

Consequence = Severity + Spatial Scale + Duration
Likelihood=Frequency of Activity + Frequency of Incident +Legal Issues + Detection
Significance \Risk= Consequence X Likelihood