The BLOODHOUND Project

TECHNICAL REPORT

WATER USE LICENCE APPLICATION

A requirement in terms of Section 21 (c) and (i)
of the
National Water Act (36 of 1998)

April 2017

Economic Development & Tourism

Department:
Economic Development & Tourism
NORTHERN CAPE PROVINCE
REPUBLIC OF SOUTH AFRICA

EnviroAfrica

WATSAN *Africa*

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1 Introduction

On 23 October 2008 the United Kingdom Minister of State for Science and Innovation Lord Drayson announced the Bloodhound SCC attempt on the world's land speed record. The vehicle driven by a Rolls Royce jet engine as well as a rocket is to be propelled to more than 1000 miles per hour or 1600 kmh. The car is being built in London (www.bloodhoundssc.com/)

Following an extensive search for a suitable site for the speed record attempt all over the globe, Hakskeenpan (Figure 1) in the Northern Cape was selected. The Northern Cape Provincial Government embraced the Bloodhound SCC project. It now gained prominence as an item in the official provincial Integrated Development Plan (IDP).

Figure 1 Hakskeenpan

As everything else that is happening in a country, it is mandatory that national legislation is being adhered to and that no laws of parliament or provincial ordinances are compromised. The national Department of Water Affairs and Sanitation (DWS)

recognises Hakskeenpan as a wetland, even though it is located in the arid Kalahari Desert.

Hakskeenpan and its catchment (watershed) are subject to occasional heavy thunderstorms. The pan subsequently floods with standing water (Figure 2) that may last for several weeks before all of it finally evaporates because of the intense desert heat. When it floods a unique and vibrant aquatic life with an intricate food web comes into being, of which the survival forms retract into the pan's soils during the prolonged arid phase. Scientifically there is very little if anything at all known about these aquatic life forms in Hakskeenpan.

Figure 2 Hakskeenpan Flooded
http://www.news24.com/Green/News/flamingos-turn-kalahari-pan-pink-in-once-in-a-lifetime-spectacle-20160307

2 Terms of Reference

The Bloodhound SCC may have environmental impacts. For such impacts an Environmental Impact Assessment is required according the National Environmental Management Act (NEMA, Act 107 of 1998). As Hakskeenpan has been identified as a wetland, the project triggers the conditions set by Section 21 (c) and (i) of the National Water Act (NWA, Act 36 of 1998).

Accordingly an application should be lodged with the DWS for the event. A Technical Report is required for this application. The provincial government appointed Enviro

Africa to conduct the EAI. Likewise, the provincial government appointed WATSAN Africa to compile the Technical Report and to subsequently deal with the S21 (c) and (i) application.

The drafting of the Technical Report is frustrated because an ephemeral pan in an arid landscape does not fit the general description of a wetland in various South African policy documents. The lack of scientific knowledge on the biota in the pan added more difficulties. Despite these problems, decision will have to be made with regards to the environmental feasibility of the Bloodhound SCC project.

Following numerous iterations the scope and format of the Technical Report, previously known as the Fresh Water Report, has developed roughly into a standard format with premeditated elements. The format has recently been even more specified and limited by Government Notice 267 of 24 May 2017 (p.196). This is the outline that is followed for this report. The report is now known as the Water Use License Application (WULA) Technical Report.

Role-players specifically requested that reports should be brief and to the point.

3 Hakskeenpan: The Study Area

Hakskeenpan is flat (Figure 1). Among other flat places on the planet, Hakskeenpan draws the attention as being even larger and flatter. The wide expanse of flatness makes it ideal for an attempt on the world land speed record.

It was created during geological times by the uplifting of the landscape to 800m above sea level. The rising of the land locked in runoff. Instead of flowing to the ocean a series of land-locked lakes were created, of which Hakskeenpan is one. Sudden and intense rain storms flooded the lake and suspended the fine sediments of the underlying shales. Re-deposited sediments levelled out the ground over a period of millions of years. Rocks that stuck out above the landscape were soft and were easily eroded by the harsh desert winds. This all contributed to the formation of Hakskeenpan and naturally engineered it into the long and uninterrupted track that today is required for the Bloodhound SCC.

Hakskeenpan (Figure 3) is located in the remoteness of the Kalahari Desert of the Northern Cape in South Africa close to the Namibian border. It is some 22 km long and 11 km wide. Its location in terms of longitude and latitude is given in Table 1.

Ground water movement is from the mostly dry Aoub River south westerly towards Mier and Hakskeenpan. Ground water is in the secondary aquifer in the Dwyka formation tillites. Yields differ widely, even 10 m apart. Ground water quality is very poor with high conductivity and exceeds the 60 mS/m drinking water level. The saltiness is mostly the results of high concentrations of chlorides. The formation

underlying Hakskeenpan is largely impermeable and floodwater evidently does not "leak" into the ground water.

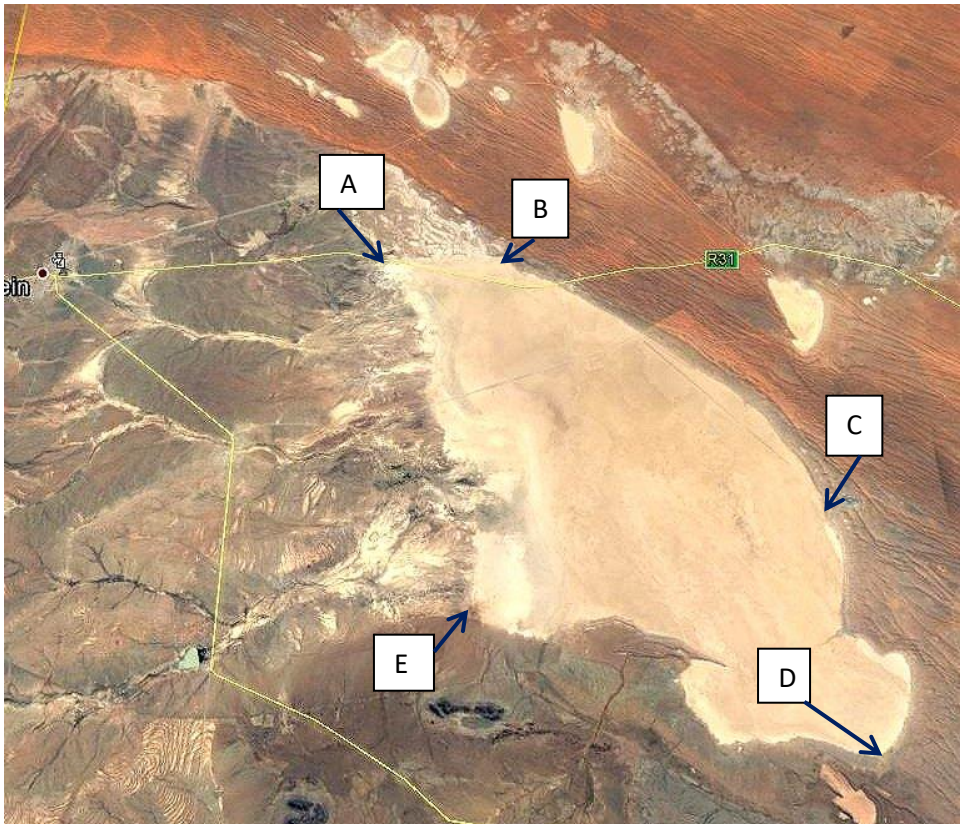

Figure 3 Hakskeenpan Demarcation

Table 1 Location of Hakskeenpan

Point	S	E	Distance km
A B C D E	26°44' 31.88" 26°44' 23.63" 26°49' 40.49" 26°54' 07.81" 26°51' 39.34"	20°08'32.64" 20°10'59.40" 20°16'32.74" 20°16'23.71" 20°10'09.91"	A to D 22.3 C to E 11.2

For a complete and inspirational explanation of the formation and distribution of pans in arid areas the reader is referred to the book edited by David Thomas (2011).

4 Knowledge Gaps

The question is often asked if Hakskeenpan qualifies as a valid wetland, 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 fresh water habitats. In many ways science still has to find a spot as to where to position Hakskeenpan 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 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 is evident that there is very little known about the ecology of Hakskeenpan. This very much complicates the drafting of a WULA Technical Report, for which a whole lot of knowledge is required.

Nevertheless, it can be deducted from the advertisement that Hakskeenpan is mostly dry. When it rains the pan 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-invertabrates at the top of the food chain. These may be dense clouds of swimming fairy shrimps (Crustacea, Anacostraca).

The pan dries 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 Kalahari 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 pan, 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. Piscivorous pelicans have been noticed on a flooded Hakskeenpan, but these moved on within days as there was no fish to feed on.

For flamingos on the pan, visit http://www.news24.com/Green/News/flamingos-turn-kalahari-pan-pink-in-once-in-a-lifetime-spectacle-20160307. This was in January 2016, when the pan was flooded for several weeks following 100mm of rain in just 2 days.

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, but needs to be confirmed by meticulous scientific research.

Meanwhile there is little to go on to produce the required Technical Report.

Meanwhile we assume that Hakskeenpan is indeed a legitimate water resource that answers 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.

4.1 Salt Pans Concise Knowledge Overview

How credible will an impact assessment and a risk assessment be based on the current knowledge of Hakskeenpan? There is little scientific to go on for Hakskeenpan. The only alternative is to look at relevant research that has been done

for comparable habitats. This comparison will have to be very much limited to fit the scope and nature of this WULA Technical Report.

4.1.1 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, as in Hakskeenpan.

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

4.1.2 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 on Hakskeenpan 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 Hakskeenpan follows a similar pattern.

This base-line information prior to the further increase in the number of sport events on Hakskeenpan would allow for the assessment of these impacts in the future.

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.

4.1.3 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 Hakskeenpan'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, as opposed to approximately once a year at Hakskeenpan.

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

These habitats are different from that of Hakskeenpan and it will be interesting to see how organisms and community structures differ in the series of Cuvelai Pans and the isolated Hakskeenpan.

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. In contrast Hakskeenpan plants that could be branded as wetland indicator species were absent during the site visit.

During the Hakskeenpan site visit the dunes were covered with grass, albeit dry grass, but the grass cover did not reach the edge of the pan or made out a part of what could be branded as riparian vegetation or that could serve as wetland indicators.

According to the webpage Meteoblue, Etosha receives an average annual rainfall of 211 mm as opposed to the 145 mm of Hakskeenpan. Both pans are dry for long periods during which riparian vegetation cannot rely on surface water and is

dependent on precipitation. Evidently the somewhat higher rainfall in Etosha explains the presence of its sparse riparian vegetation.

This implies that the movement of vehicles on Hakskeenpan won't damage riparian vegetation, which is one environmental worry less. This, however, does not signify that the scant Hakskeenpan vegetation that is present should not be treated with respect, as it has conservation value.

Salt pans in the western Free State where 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. It is not known to what degree Hakskeenpan is eutrophied, if at all.

Only as little as 10 micrograms per litre of phosphorus is ample to spark off an algal bloom and the most obvious source of nutrients at Hakskeenpan would be sewage. This emphasised the need to take the utmost care with the sewage that will periodically be produced during events on Hakskeenpan.

4.1.4 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 Hakskeenpan would prove to be unique as well, given its location in the arid West and its isolation from other comparable habitats. This could emphasize its conservation value and press on the organisers of the Bloodhound SCC event to be careful with whatever they do at Hakskeenpan.

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 have such a marked effect on the hatching of branchiopod eggs, a fuel spill would result in mortality of macroinvertebrate survival stages at Hakskeenpan 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.

4.1.5 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).

From this it is clear that 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 Hakskeenpan is any different from that of the Australian situation. In order to assess any impact on the ecosystem is necessary this level of knowledge is available. Meanwhile we the need to assess Hakskeenpan remains and we will have to do with assumptions. Future research can prove these right or erroneous.

5 Aims and Objectives

The purpose of this report is to:

- Render adequate information for decision-makers to allow of disallow the Bloodhound SCC project on Hakskeenpan
- Briefly describe the aquatic environment of Hakskeenpan
- Describe possible impacts of the Bloodhound SCC on the aquatic environment of Hakskeenpan
- Propose measures to prevent undue environmental impacts on Hakskeenpan

- Briefly describe the level of knowledge about the Hakskeenpan aquatic environment that is required for informed decision-making
- Render adequate information to support the WULA application forms
- Follow the outline as set out in GN R267 of 2017, p196.

6 Methodology

6.1 Wetland Identification and Classification

Hakskeenpan can be clearly identified by simply using Google Earth Pro. The ruler function can be used to measure distances and to determine the size of the pan. The elevations are indicated on the Google Earth facility.

Dini *et al* (1999) classified wetlands as follows:

- Marine System
- Estuarine System
- Riverine System
- Lacustrine System
- Palustrine System
- Endorheic System

Hakskeenpan clearly is not marine, estuarine or riverine. In previous technical reports these where properly described under this heading, which obviously would serve no purpose in this event. It is for the most part not vegetated, so it cannot be lacustrine or palustrine.

An endorheic system is described as one that does not have an outflow. The inflow is contained within the system and can only leave by evaporation and / or penetration into the underlying soil.

Dini records sub-classes under the endorheic heading:

- Water Surface,
- Non-vegetated,
- Aquatic Bed,
- Emergent,
- Scrub-Shrub.

In the paragraphs dealing with the results Hakskeenpan will be classed in these appropriate sub-classes.

Hakskeenpan was subsequently classified according to its hydrogeomorphic unit setting. This system of classification was first proposed by Brinson (1993) and later modified by Marneweck and Batchelor (2002) and Kotze *et al* (2004).

According to this classification system the following classes of wetlands are recognised:

- Flood plain
- Valley bottom with a channel
- Valley bottom without a channel
- Hillslope seepage linked to a stream channel
- Isolated hillside seepage
- Pan

Hakskeenpan was subsequently classified into one of these classes.

6.2 Wetland Delineation

According to the procedures for the delineation of wetlands that have been set out on the DWS webpage (2005), the following parameters should be used to determine the boundaries of wetlands:

- Terrain Unit Indicator. His indicator focuses on the landscape and how the geomorphology of the area contributes to the formation of wetlands
- Soil Form Indicator. Soils that are temporary wet have characteristics that indicate the presence of wetlands
- Soil Wetness Indicator. This is an obvious indicator. Permanently or temporary saturated soils are indicators of wetlands
- Vegetation Indicator. Certain plants grow mostly or only on hydromorphic soils.

These indicators occur singly or more likely in a combination and can be applied to find the boundaries of wetlands.

Wetland delineations demand site visits and field work. The soil profile must be established by the digging of test holes. Plant specimens should be collected for identification. The area should be inspected to check for any wetness. It usually requires the use of a GPS to mark the boundaries which then can be transferred to a map.

6.3 Present Ecological State (PES) of Wetlands

The Present Ecological State has been devised by Dr Neels Kleynhans (1999) of the DWS in Pretoria and is a deviation from the method that he has brought about for rivers and streams. Table 1 illustrates the methodology. The PES can be defined as the deviation from a pristine or reference state. The scores are given by a person with experience in wetlands, specifically with the severity of impacts and the effect of these impacts. A site visit is necessary to score the aspects listed in Table 1.

It was attempted to apply this methodology to Hakskeenpan and then produce a mean score that would put the pan into an ecological management class.

6.4 Ecological Importance and Sensitivity (EIS) of Wetlands

Likewise, Kleynhans (1999) has devised a method for determining what he termed the ecological importance and sensitivity. It is based on the presence of mainly the number of fish species that are endangered on a local, regional or national level.

However, Crystal Rowe (2014) of Digby Wells Environmental used the determinants as listed in the above table for assessing a wetland and the methodology was subsequently adapted for Hakskeenpan, simply on a scale from 0 to 5 where 0 is not sensitive and 5 is most sensitive to impThe mean score can be determined and then be linked to a management class in the same manner as the with the PES.

7 Results

7.1 Wetland Identification

According to the classification of Dini *et al* (1999) Hakskeenpan can be classified as an endorheic system. During flooding it can be sub-categorised as a water surface, which is short lived as the pan dries out quickly. Most of the time it can be sub-categorised as non-vegetated. Where the soil cover is thicker near the boundaries of the pan it can be sub-categorised as scrub shrub, consisting of only one species.

The more contemporary classification according to Kotze *et al* (2004), Hakskeenpan can obviously only be classified as a pan.

7.2 Demarcation

7.2.1 Vegetation

The tried and tested methodology for the demarcation of wetlands is based on plants that are adapted to hydromorphic soils. These hydrophytes are listed as indicator species.

The plants on Hakskeenpan are primarily ephemeral, like their environment and like their aquatic counterparts. They are able to complete their entire life cycle, from seed to seed, within a short few weeks. Their seeds germinate as soon as the flooded pan recedes and dry land appears. Then, before the soil is dried out completely, they already have flowered and produced seed. The seed remains dormant until the next wet cycle. A proper name will have to be devised for plants with a rapid life cycle. Perhaps ephemerophytes would do.

At the same time these plants are halophytes, as the soil and the moist it contains are salty.

Some of these plants have cylindrical succulent leaves which make them xerophytes.

It is obvious that the sparse stand of plants in Hakskeenpan does not conform in any way to the hydrophytes that are currently used to demarcate wetlands. It was not known if any plant that occurs on the Hakskeenpan expanse can be used to demarcate the pan. These species would occur within the boundaries of the pan and are absent from the surrounding land. It was hoped that the botanists that are currently investigation the biodiversity for the purpose of EIA scoping report can come up with some answers. Nicole Upton, one of the botanists, reported that all of the plants that occur on Halskeenpan do occur outside of the pan as well. This dashes any hope of finding a species that can be used for demarcation purposes.

Until more is known, vegetation cannot be applied to demarcate Hakskeenpan.

7.2.2 Soil

Temporary wetlands can be demarcated by soils. Most soil types have a concentration of iron oxides that are reduced under the anaerobic conditions in waterlogged soils. The reduced product typically shows up grey and these soils become increasingly mottled as waterlogged and dry conditions alternate. This is a process known as “gleying”.

The shallow soils of Hakskeenpan are derived from weathered tillite. When dry these soils typically crack (Figure 4). It feels spongy under foot. These are not the soils that have been described for temporary wetlands. It is a soil specific to the ephemeral pans of the Northern Cape, such as Hakskeenpan.

Van der Waals & Titus (2014) explained in deep scientific detail why there are no mottles in the soils of Hakskeenpan.

Again, the conventional wetland soil demarcation tool is not applicable to Hakskeenpan.

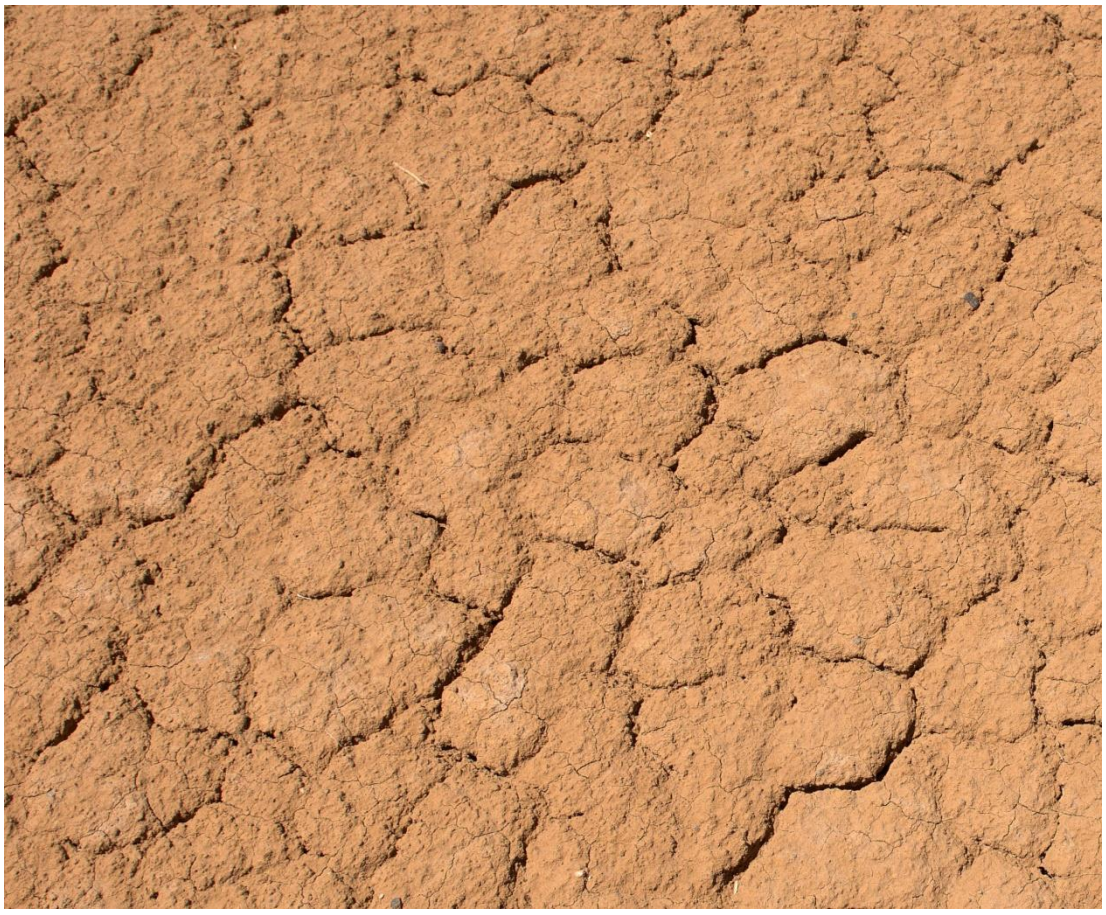

Figure 4 Cracked Soil

7.2.3 Landform

Hakskeenpan is strongly and naturally demarcated by landforms (Figure 3).

Dr Steffen Büettner of the Rhodes University Geology Department described the geological processes that were responsible for the formation of Hakskeenpan. For the purpose of this report it is suffice to note that the shallow soils over bedrock in the absence of the typical Kalahari red sand dunes make up the Hakskeenpan floor. To the east the pan is demarcated by these dunes and to the west by a rocky formation. This leaves no doubt as to the dimensions and where the boundaries had been drawn during geological times and where they are maintained by current wind and water regimes (Figure 3).

Landform makes up for the inappropriateness of accepted DWS methodologies to Hakskeenpan.

7.2.4 **Catchment Area** (Watershed, Figure 5)

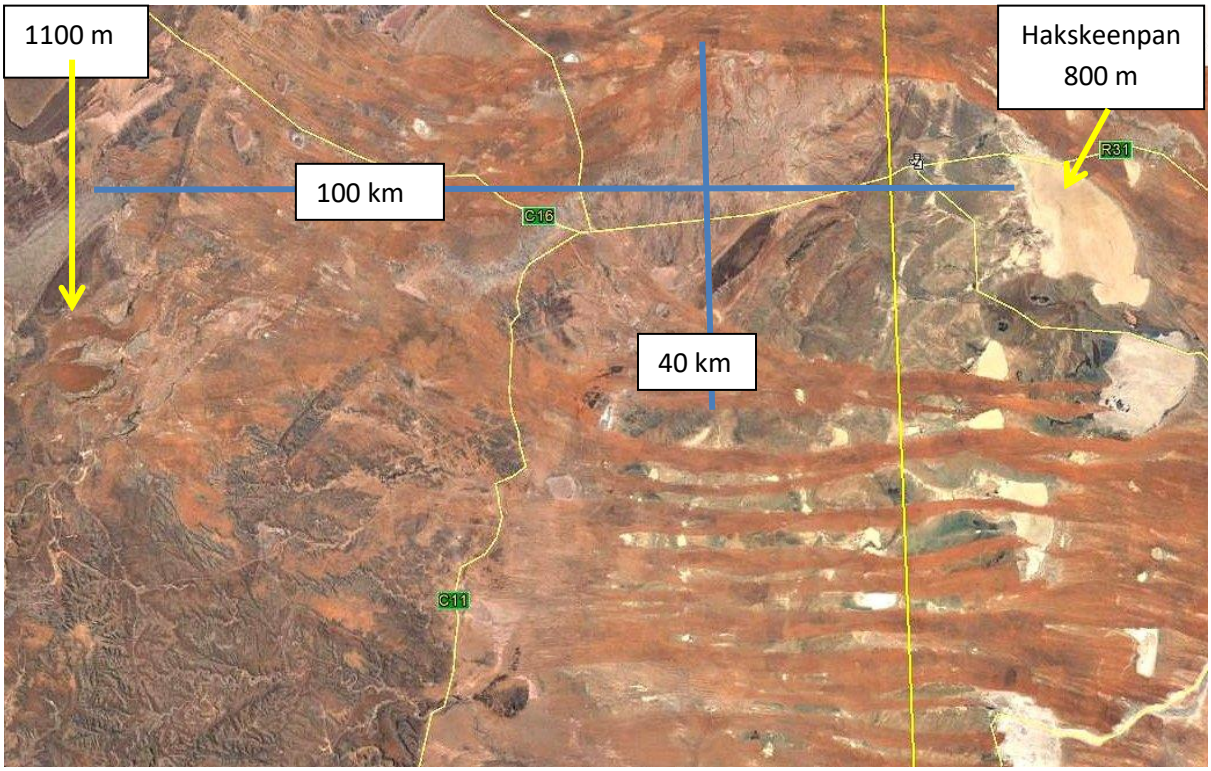

Figure 5 Catchment Area

The catchment area stretches towards the west for a 100 km to the high ground 1100m above sea level across the border into Namibia. It is approximately 40 km wide.

Most of the catchment is made up of Kalahari sand dunes with typical “streets” in between. The dunes are oriented from east to west.

To the west and adjacent to Hakskeenpan is a rocky area without dunes. A significant portion of the runoff probably originates from this area since there are no dunes to absorb and store a part of the rainfall as ground water.

7.3 Present Ecological State (PES)

Table 2. Wetland Habitat Integrity (After Kleynhans, 1999)

Attribute	Score
Hydrology	
Flow modification	1
Inundation	0.5
Water Quality	
Water quality modification	0
Sediment load modification	0
Hydrology / Geomorphology	
Canalization	0
Topographic Alteration	1
Biology	
Terrestrial encroachment	0
Removal of vegetation	0
Alien fauna	0
Over-utilisation of biological resources	0
Mean	0.25
Category	Pristine

0-1.0	Pristine
0.1-2	Near-pristine
2.1-3	Moderately impacted
3.1-4	Modified
4.1-5	Critically modified

The trunk road cuts through the northern part of Hakskeenpan and the old road embankments are still in place. This alters the flow paths and inundation patterns. It also represents a topographic alteration. These changes seem to have a limited effect on the overall ecological functioning of Hakskeenpan. The pan is close to pristine, despite these alterations.

7.4 Ecological Importance and Sensitivity (EIS)

Table 3 Ecological Importance and Sensitivity of Wetlands

Determinants	Rating 0 – 5
Primary determinants	
Rare and endangered species	5
Populations of unique species	5
Species / taxon richness	2
Diversity of habitat types or features	1
Migration route / breeding / feeding site for wetland species	5
Sensitivity to changes in the natural hydrological regime	2
Sensitivity to water quality changes	4
Food storage	4
Energy dissipation	1
Particulate / Element removal	2
Modifying determinants	
Protected status	3
Ecological Integrity	5
Mean Score/ Management Category	2.8

This is another term that was devised by Dr Neels of the DWS Kleynhans (1999) to assess water bodies and it is based on the number of endangered species on either a local, provincial or national basis. This metric is based on the number of fish species, of which there are none in Hakskeenpan during the hydroperiod, as far as is known.

This does not mean that Hakskeenpan is not important. We know too little about its biology to be able to assess exactly how important it really is

Most pans in the South African arid west are geographically isolated, with a long geological, zoogeographical and evolutionary history, each with a unique and current set of ambient climatological and other environmental circumstances and as a result with an expected high degree of endemism. Consequently, a number of species can be expected in each of these pans that are all worthy of conservation. Hakskeenpan is probably therefore ecologically important. It is not evident that these species are in any form of danger or being threatened and therefore not particularly ecologically sensitive.

Sensitivity can possible be defined as the ability of an aquatic system to bounce back at least in part to its original condition when an impact is removed. It seems as if Hakskeenpan was not materially affected when the roads were built, even though the new truck road cuts right through the pan. The flood still does, for the larger part, does what it always did, despite the old road embankments not being removed. If ever they were removed, it would obviously improve the situation, but it is doubtful if it would bring about a major change in the ecology, that is the little we know about it.

An attempt is nevertheless made by adapting the methodology of Crowe (2014). The result is based on pure speculation, because the ratings were awarded to similar pans where a relative small number of aquatic species are highly adapted and specialised to live and survive in these very specific habitats.

Hence Hakskeenpan should not be considered to be particularly sensitive, as the average score indicates.

However, because there might be endemic species, Hakskeenpan might be important from a conservation point of view. The presence of such species is still to be confirmed by scientific research.

8 Possible Impacts

8.1 Vehicles

The soil at Hakskeenpan forms a efflorescent crust at the surface and when dry cracks appear (Figure 4). These cracks are some 2 cm deep. It is surmised that these cracks play an important part in the ecology of the pan. It is speculated that dormant spores and eggs of life forms end up in these cracks, where they are further mixed in with the soil and where they survive until the next wet cycle.

The role of these cracks in the ecology of the pan is perhaps one of the aspects that need to be researched.

Wind could possibly aid the process of transporting dormant life forms into these cracks.

This soil form is the dominant one on the pan. When dry it is exceedingly hard and it is evident that vehicle tires do not make much of an impression (Van der Waals & Titus, 2014). Hence it is not expected that vehicles crossing the pan during the dry season is about to have a discernible impact on the survival of life forms and on the ecology of the pan. As everything else, this is an assumption and is in need of verification with scientific research.

There are irregularly spaced patches of soil with a visible salt cover. These patches have a soft and puffy crust that disintegrates when crossed by vehicles. It is expected that research would show that the biota in this soil can be affected by trampling

vehicles. These patches are not the dominant soil type and the impact could be limited.

8.2 Bloodhound Supersonic Car

The wheels are solid. With a weight of 7.5 tons and solid wheels the car is bound to make some impression in the crust, even though the car has a technically advanced suspension.

The track is only a small portion of the vast expanse of the entire Hakskeenpan. Hence it is not expected that the Bloodhound SCC would have any discernible impact on biota in the soil. Exactly what the local impact right on the track might be needs to be established with scientific research.

It is expected that once the speed record event is over and once the pan is flooded again, the tracks of the Bloodhound SCC would be erased, the crust would crack as always and that there would be no trace of the event left. The impact is temporary.

It may impact more on soft salt cover patches, or the visible efflorescent crust, but these are only a small part of the track. To verify this assumption, the soft salt cover patches will have to be surveyed and mapped.

Since the pan will be utilised for ongoing racing events, decision-making would benefit from research focused on the effect of the breaking up of the crust on the survival stages of life forms in the pan's sediments.

8.3 Removal of stones

Figure 6 Larger rocks to be removed from the track

According to press reports some 16 tons of stones have been manually collected from the track. Bigger rocks (Figure 6) were moved with earth moving machinery. This is probably an ongoing exercise, as new stones emerge from under the surface. The question arises if the removal of these stones can have any detrimental impact on the aquatic environment.

There might be some loss of the survival stages of life forms not being able to reach the surface at the next flood because of the disturbance of the soil. This is especially of concern because of the removal of the bigger rocks, during which larger quantities of soil were turned over.

In comparison to the rest of the pan, the track is small and the area from which larger rocks had to be removed even smaller. Hence it is not expected that this would have significant impact.

The soils of the pan evidently possess remarkable self-restoration characteristics. When flooded the fine sediments in suspension re-settle on the surface when the water dries up. The settled sediments cover up, form a crust and harden to heal the "wounds" that have been created by removal of stones. This is anecdotal and needs to be verified with scientific observation.

Nevertheless, from a limnological point of view, it is doubtful if any significant impact can be scientifically illustrated because of the removal of the stones. Future research will hopefully render some answers.

8.4 Technical Camp

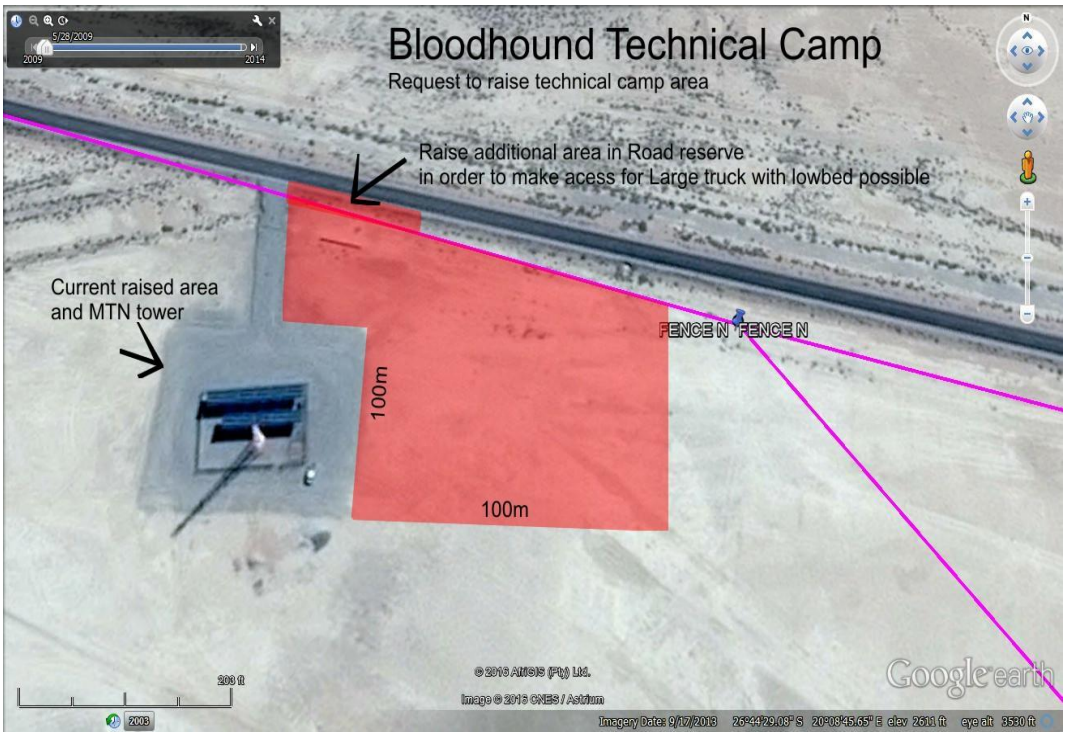

Figure 7 Technical Camp

Bloodhound requested to construct a raised area next to the MTN tower. The fuel is to be stored at this location, along with the technical camp. This paragraph only deals with the raising of the area. The activities on this site pose additional risks, which will be dealt with elsewhere in this report.

This area of 10 000 m^2 would be lost to Hakskeenpan once covered with filling material. Compared to the majestic proportions of the pan this area is insignificant. It would predictably not have any material effect on the overall ecological functioning of the pan.

The embankments of disused roads are still crisscrossing the pan. These have altered preferential flow paths and probably have altered the ecological functioning of the pan as well in ways that still have to be scientifically determined. It would probably be of ecological benefit if these embankments could be removed and the material used for the infilling of the raised area of the technical camp.

8.5 Water Provision

Borehole water is piped over a distance of 17 km from private land adjacent to the pan to holding tanks at the Speedweek complex (Figure 8).

Figure 8 Speedweek Complex

This pipe does not cross the actual pan.

It is planned to construct another pipeline that will have to be trenched into the pan. This pipe will have to provide potable water to the Speedweek complex as well as the technical camp. The pipeline is to be connected to the trunk water line that spans all the way from the Orange River to Rietfontein on the Namibian border. The trunk water line follows the R31 highway. Following the Hakskeenpan boundary the new pipeline will have to be at least 11.4 km long.

Bloodhound SCC is not to share water facilities with Speedweek. The connection with the trunk water line would be exclusively for the use of Bloodhound.

There are already 6 water tanks at the Speedweek site. Bloodhound is to add another 12. These tanks have a holding capacity of 5000 litres each.

Figure 9 Water tanks

The impact of trenching the new pipeline is of importance. Again, like all of the other aspects of the project that involves digging into the Hakskeenpan surface, followed by backfilling, levelling and smoothing over the disturbed surface, nature is relied upon to finally “heal” the wounds. Once the pan has flooded with resulting re-settlement of the suspended sediments, it is hoped that the original crust will form, without any sign left of the disturbance.

This is not regarded as an impact of critical importance.

8.6 Sanitation

At this stage it is not known how many people will live in the technical camp. It is not known how many visitors will attend the speed record attempt. As estimations firm up this aspect will be expanded upon.

At the moment the Speedweek facility is provided with a conservancy tank which is emptied with a tanker truck from time to time. The sewage then is taken off site. It is foreseen that the sewage from the Bloodhound facility at the Speedweek site as well as from the technical camp will be collected in conservancy tanks and moved off site. The treatment of sewage on-site at this stage of the project is deemed as environmentally risky and as not feasible.

The construction of conservancy tanks and the associated pipelines involves further digging into the Hakskeenpan surface, with similar impacts as has been described before.

The conservancy tanks will be constructed out of heavy concrete or similar water tight materials and would probably be of a permanent nature. It is not foreseen that these structures would be demolished after the event and could be seen as an asset that could be used in future for upcoming events.

There is always a change, albeit small, that a mishap could happen with the collection and transport of raw sewage. Hence the possible impact and the risks are rated at least as medium and perhaps high. This would probably trigger a formal licensing procedure, which then will have to be followed.

The conservancy tanks should be large enough and should be emptied in time and never be allowed to overflow. The sewerage system should be well managed and if a spill occurs, it should be cleaned up. Conservancy tanks should be emptied prior to the next flooding event. A level of management befitting the ever-present danger of eutrophication should be maintained on site.

8.7 Solid Waste

As has been stated before, at this stage it is not known how many people are to produce solid waste at the Bloodhound venue.

If solid waste is allowed to heap and then allowed to generate leachate it represents a significant environmental impact. This can be effectively prevented if managed properly according to accepted contemporary waste management principles.

Waste is to be collected and transported off-site, from where it can be separated, recycles and disposed of on a sanitary landfill. To conduct these actions on Hakskeenpan is deemed to be too risky, from an environmental impact point of view.

It is foreseen that general solid waste is to be collected on-site in conventional 240 litre wheelie bins, from where it is uploaded on compacter trucks provided with mechanical lifts. This is at both the technical camp and the Speedweek venue.

However, if larger numbers of visitors and spectators generate larger amounts of waste, perhaps the larger dumpster (locally known as “skips”) are appropriate, together with truck and lift that can handle this kind of equipment.

The current solid waste facility at Rietfontein seems to be inadequate and not well managed. Bloodhound SCC may be called upon to assist in creating an acceptable practice, wherever it is decided to dispose the waste.

Solid waste by its nature represents at least a medium risk and if in larger quantities, a large risk to the environment. On the other hand, if properly managed the risk is reduced to insignificant.

It is hoped that the experience gained with Bloodhound SCC will persist and that the local authority keep on providing a properly managed waste disposal system long after the project has been completed.

8.8 Storage of Fuel

Fuel, especially the brand of fuel that is required in large quantities for yet engines pose a potential threat to the environment. Evidently fuel is going to be stored in tanker trucks. Apart from bunds that should be built around the tanker parking area, no other hard structures would be necessary. These bunds are meant to retain fuel, should there be a leak. The bunted area should be large enough to contain the volume of the tank.

It would be preferable that the bunds are built at the very boundary of the pan or even outside of the pan. This would decrease the risk. Hard structures on the pan floor would not be a preferable option.

8.9 Presence of People

The mere presence of a large number of people on Hakskeenpan poses at least a medium risk. Visitors and spectators during speed record attempts should be limited to demarcated areas in order to prevent trampling.

This aspect poses a low to medium environmental impact. Proper crowd control could reduce this impact to insignificant levels.

9 Roads

Figure 10 R31 Trunk Road

The R31 trunk road (Figure 10) from Mier across the pan to Rietfontein on the Namibian border probably had and still has a larger environmental and especially limnological impact than the combined impact of the entire Bloodhound project. The road bisects the pan and cuts off the north eastern portion of the pan from the rest. The road changed the preferential flow paths. It is unknown exactly what the impacts on the pan's ecology are and these aspects need to be clarified by long-term scientific research.

Likewise, the old and currently disused roads across the pan probably have a serious impact of which the proportions are not understood at present. The embankments are still evident all over the pan. These embankments have been broken through, probably manually, perhaps by flood water.

Figure 11 Road Embankments

Environmentally speaking it makes no sense to harbour reservations about the Bloodhound SCC project, but then leave the embankments as they are.

Removing these embankments is a separate aspect and does not form any part of the Bloodhound project. It would nevertheless have raised question if not addressed in this report.

Again, the Hakskeenpan surface and its special qualities would be disturbed over a fairly large area. It seems possible that the self-remedying capacity of the pan in the long run would erase these impacts and an ecological regime much closer to the original would eventually and naturally be re-instated.

The actual action of removing the embankments cannot be rated as small and is at least medium from an impact and environmental risk perspective.

10 Impact Assessment

The impact assessment is to be carried out according to a premeditated protocol. The DWS demands that it addresses the drivers of an aquatic ecosystem such as the flow of water, water quality and the geomorphology. These drivers determine the habitat and biota.

The protocol has been modified to suit the Hakskeenpan situation. Apart from evaporation it is assumed that no water leaves the site.

- Local means the point of impact
- Regional means the entire Hakskeenpan
- Short term means the duration of the project
- Long term means past the duration of the project

Confidence levels are generally medium to low because it is unknown how impacts would affect the habitat and the biota due to a lack of scientific information. There is bound to be an impact when an area is filled up at the technical camp, which can be said with a high level of confidence.

The storage of fuel and the aspect of sanitation always have an element of high significance attached, but can be remediated to lower levels.

Table 4 Summary of possible impacts

Possible Impact		Extent	Duration	Intensity	Significance	Probability	Confidence
Vehicles	Without mitigation	Regional	Short term	Medium	Medium	Probable	Medium
	With mitigation	Local	Short term	Low	Low	Improbable	Medium
Bloodhound Supersonic car	Without mitigation	Regional	Short term	Low	Medium	Probable	Low
	With mitigation	Regional	Short term	Low	Medium	Probable	Low
Removal of stones	Without mitigation	Local	Long term	Low	Low	Probable	Low
	With mitigation	Local	Long term	Low	Low	Probable	Low
Technical Camp	Without mitigation	Local	Long term	High	Low	Probable	High
	With mitigation	Local	Long term	High	Low	Probable	High
Water Provision	Without mitigation	Local	Long term	High	Low	Probable	Low
	With mitigation	Local	Long term	High	Low	Probable	Low
Sanitation	Without mitigation	Local	Long term	High	High	Probable	Medium
	With mitigation	Local	Long term	High	Low	Improbable	Low
Solid waste	Without mitigation	Regional	Medium term	High	High	Probable	High
	With mitigation	Local	Short term	Low	Low	Improbable	High
Storage of fuel	Without mitigation	Local	Short term	High	High	Probable	High
	With mitigation	Local	Short term	Medium	High	Improbable	High
Presence of People	Without mitigation	Regional	Short term	Medium	Medium	Probable	Medium
	With mitigation	Local	Short term	Low	Low	Probable	Medium

11 Risk Assessment

Table 5 Risk Assessment

No.	Activity	Aspect	Impact	Significance	Risk Rating
1	Vehicles	Trampling the surface	Habitat destruction	38.5	Low
2	Bloodhound SCC	Disturbing the surface	Habitat destruction	38.5	Low
3	Stone removal	Disturb surface	Habitat destruction	30	Low
4	Technical Camp	Infilling	Habitat destruction	76	Medium
5	Water provision	Trench	Habitat destruction	28	Low
6	Sanitation	Deal with sewage	Lethal to biota	48	Low
7	Solid waste	Leachate	Lethal to biota	42	Low
8	Fuel Storage	Spill	Lethal to biota	30	Low
9	People presence	Trampling	Habitat destruction	21	Low

The risk assessment as prescribed by GN1180 as applicable to Section 21(c) and (i) of the National Water Act has been compiled for a fresh water environment. Accordingly a spreadsheet has been published on the DWS webpage. Values are to be put into this spreadsheet in order to arrive at a risk rating for each activity.

Table 5 is an exact replica of the spreadsheet, but has been adapted to suit the format of this report. The spreadsheet is in PDF format and is not meant to be cut and pasted.

Numbers 1 to 9 in Table 5 (Continued) are those of the activities listed in Table 5.

Table 5 (Continued) Risk Rating

No	Flow	Water Quality	Habitat	Biota	Severity	Spatial scale	Duration	Conse-quence
1	1	1	2	2	1.5	1	1	3.5
2	1	1	2	2	1.5	1	1	3.5
3	1	1	3	2	1.75	1	1	3.75
4	3	1	5	5	3.5	1	5	9.5
5	1	1	2	2	1.5	1	1	3.5
6	1	1	1	1	1	1	2	4
7	1	1	1	1	1	1	1	3
8	1	1	1	1	1	1	1	3
9	1	1	2	2	1.5	1	1	3.5

No	Frequency of activity	Frequency of impact	Legal issues	Detection	Likelihood	Significan-ce	Risk Rating
1	2	2	5	2	11	38.5	Low
2	2	2	5	2	11	38.5	Low
3	1	1	5	1	8	30	Low
4	1	1	5	1	8	76	Medium
5	1	1	5	1	8	28	Low
6	5	5	5	1	16	48	Low
7	4	4	5	1	14	42	Low
8	2	2	5	1	10	30	Low
9	2	2	1	1	6	21	Low

A license or General Authorization would probably be required for the infilling of the technical camp, unless the decision-making authority rules otherwise.

The mere storage of fuel cannot pose a risk to the aquatic environment of such a magnitude that it justifies a license. There would be other reasons in terms of legislation that a license is required. Likewise with the wastewater in a conservancy tank that is carted away in a tanker truck. The risks are low. However, the wastewater treatment works were the tanker releases its load would probably need extra permission to deal with the extra load. The solid waste management creates very much the same risks. If allowed to heap it would create leachate with an unacceptable risk to the aquatic environment, but when removed according to a regular service, it

poses little risk. The off-site waste disposal facility would probably need extra permission to deal with the load.

The digging of trenches for the water supply pipeline and for the foundations of the fuel storage bund as well as the digging of holes for the waste water conservancy tanks pose the same level of risk as the removal of the larger rocks on the Bloodhound track. The risks are low. It remains for the authorities what level of approval is required for the digging.

This evaluation was done with the supposition that all preventative measures were in place and working properly, as the methodology is prescribed in GN1180.

The confidence level for this evaluation is low because of the lack of scientific information about the Hakskeenpan aquatic environment.

12 Resource Economics

Table 6. Goods and Services

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

0	Low
5	High

The goods and services delivered by the environment, in this case the Hakskeenpan, is a Resource Economics concept as adapted by Kotze *et al* (2009).

The diagram (Figure 12) is an accepted manner to visually illustrate the resource economic footprint the wetland.

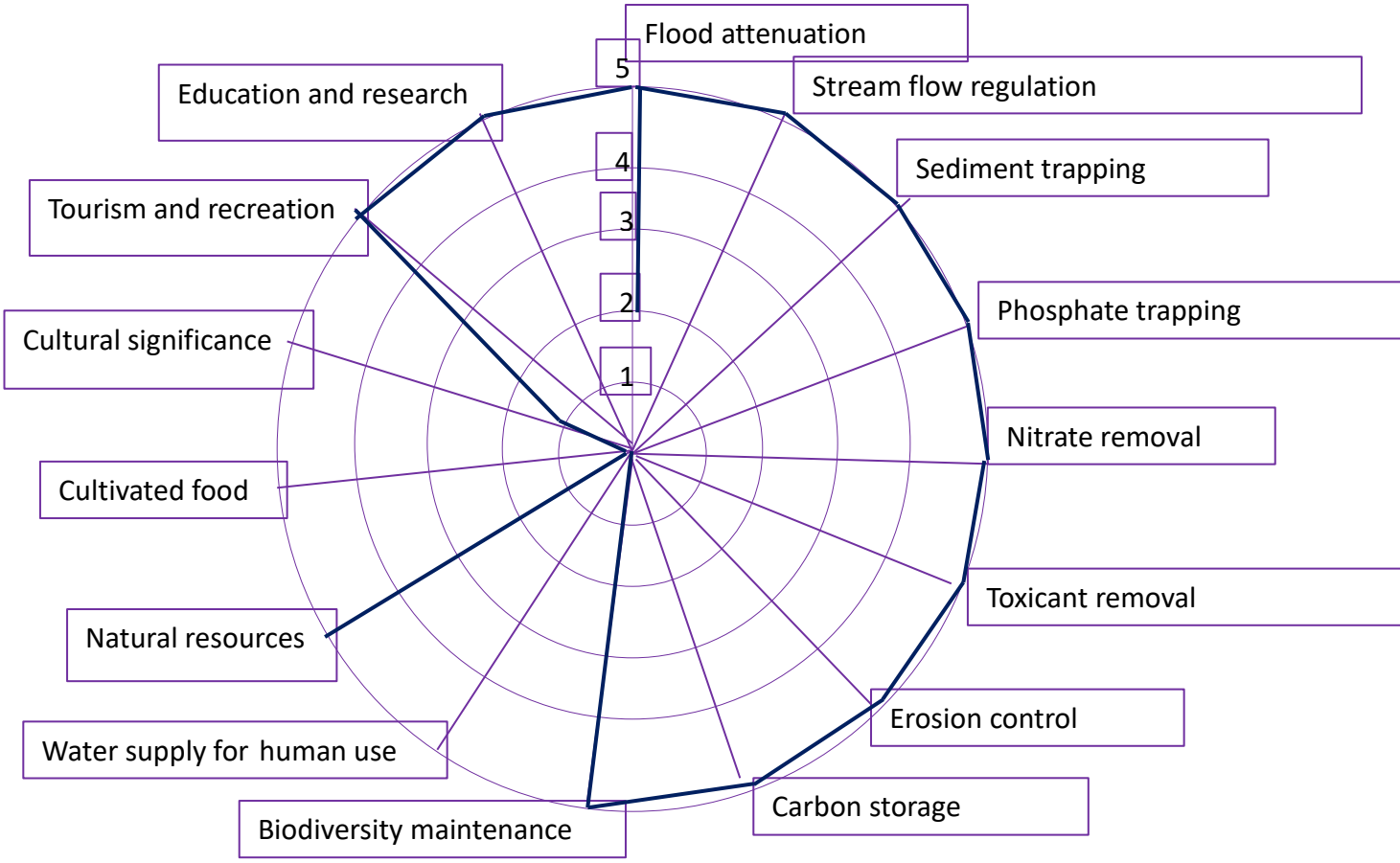

Figure 12. Resource Economics Footprint of Hakskeenpan

The star shape is rather large, with a few "gaps" on the left hand side. The size will will probably attract the attention of decision-makers, as it illustrates that Hakskeenpan is a significant resource with a notable conservation status.

13 Conclusions

Figure 13 has been adapted from one of the most recent DWS policy documents.

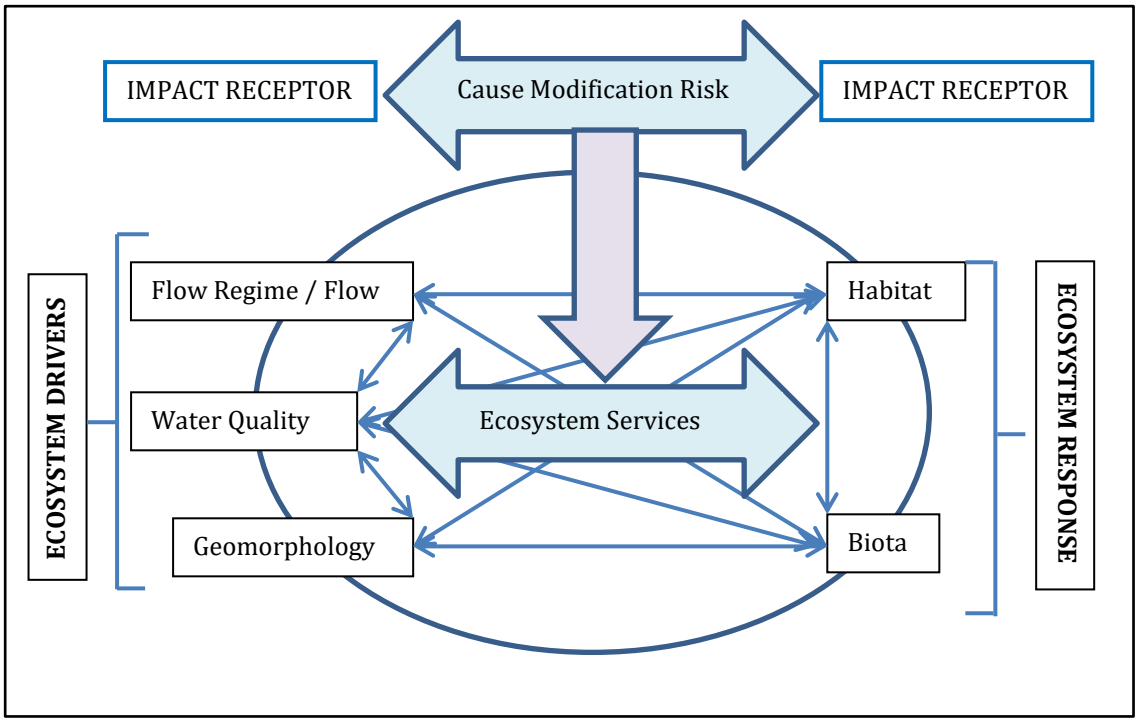

Figure 13 Minimum Requirements for a S21(c) and (i) Application.

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

The conclusions can be structured along the outline that is provided by Figure 13.

The catchment area is entirely undeveloped with no human impact at all. The Bloodhound SCC is not going to change that. The volume and the quality of the runoff will be naturally, as it always was.

The geomorphology of the pan has been changed by the R31 trunk road and the embankments of previous roads that have not been removed. The effect on flow during floods needs to be investigated. The entire Bloodhound SCC impact would be much less than that of the roads. The filling in of an area in the pan for the technical camp has a small impact. It could be beneficial if the material for the road embankments are used for the infilling. A number of test holes have been dug, filled in and the surface has been rehabilitated. How exactly these impacts on the geomorphology changed the habitat and the biota is not known and need to be scientifically researched. Many trenches have previously been dug into the Hakskeenpan surface for various purposes. It is not known what effect these habitat disturbances have on especially the survival stages of life forms during the arid phase

of the pan. Until conclusive scientific research has been done the impact and risk assessments will remain at a low level of confidence. All of these impacts on the geomorphology together compared to the immense surface area of the pan are insignificant with no material impact.

The precautionary principle comes to mind. On account of the lack of knowledge about the geomorphological impacts and it's possible on habitat and biota decision-makers could agree not to allow to proceed until scientific evidence proves that impacts are negligible. The environmental footprint of the Bloodhound SCC project is small in comparison to the vast expanse of the pan and the existing road and disused roads probably have a much larger impact than the Bloodhound SCC. Against this background new scientific evidence would probably not be adequate to disallow the project.

The provision of potable water, sanitation services and solid waste management has a negligible impact. It is probably necessary that an offsite landfill and wastewater treatment works requires extra official approval on top on what has already been approved.

Nevertheless, there is no indication that the Bloodhound SCC should not go ahead on the grounds of possible deleterious impacts on the aquatic environment.

The project probably qualifies for a General Authorisation, were it not for the wastewater, that probably stands to be licensed. GN509 states that waste water connections from sites close to water courses cannot be generally authorised. In the event of Hakskeenpan wastewater is removed with tanker trucks and not with pipe connections to main sewers. It remains for the authorities to decide how they want to deal with this particular wastewater case.

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15 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: 

Name of the company: WATSAN Africa Date: 26 April 2017

16 Expertise of the Specialist

Dirk van Driel, PhD, MBA.

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 (Deputy Chairperson): Grotto Bay Home Owner's Association
- Member Dassen Island Protected Area Association (PAAC)
- Consortium for Estuary Research and Management (CERM), Member

Membership of Professional Societies

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

Recent Reports

- Effluent Irrigation Report Tydstroom Abattoir Durbanville
- River Rehabilitation Report Slangkop Farm, Yzerfontein
- Fresh Water and Estuary Report Erf 77 Elands Bay
- Ground Water Revision Report, Moorreesburg Cemetry
- 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 Demarcation 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 Report, Elandsfontein Exploration & Mining
- Fresh Water Report Woodlands Sand Mine Malmesbury
- Fresh Water Report Brakke Kuyl Sand Mine, Cape Town
- Wetland Demarcation, Ingwe Housing Development, Somerset West
- Water Report, Suurbraak Wastewater Treatment Works, Swellendam
- Wetland Demarcation, Zandbergfontein Sand Mine, Robertson
- Storm Water Management Report, Smalblaar Quarry, Rawsonville
- Storm Water Management Report, Riverside Quarry
- Water Quality Irrigation Dams Report, Langebaan Country Estate
- Wetland Demarcation Farm Eenzaamheid, Langebaan
- Fresh Water Report Wiedouw Sand Mine, Vanrhynsdorp
- Fresh Water Report Brandwag Sand Mine, Hartenbos
- Storm Water Management Plan, Brandwag Sand Mine, Hartenbos
- Fresh Water Report, Groenvlei Crusher, Rawsonville