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Environmental Science & Consulting

Specialist Assessment Report:

Afrixalus knysnae as Species of Conservation Concern

Village Ridge Development site, Erven 21028 & 21029, George

(Report to Inform on Impact Assessment requirements)

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1. INTRODUCTION

A Rapid Survey on frog community composition during October 2021 was reported on prior to this complete site assessment on Erven 21028 and 21029, George ("the site"). This site assessment was commissioned to inform on the impact of the current construction activity on a wetland-flat situated within the site and its ancillary impact on a larger bordering channeled valley-bottom wetland. The current construction activity is halted in order allow for a Species Impact Assessment in terms of the National Environmental Management Act 108 of 1998, as amended.

Declines in amphibian species globally have been highlighted in the rapid survey report with habitat fragmentation and loss being the largest contributor to these declines (Collins and Storfer, 2003; Mushet et al., 2014). The rapid survey confirmed the presence of various frog species within the construction site and specifically that of the Knysna leaf-folding frog, *Afrixalus knysnae* (EN). An image of the species appears in APPENDIX B: Figure 1. This endangered species has not previously been sampled at this locality. The significance of its presence requires an assessment of the impact of the proposed development on the species. *Afrixalus knysnae* would be defined as a Species of Conservation Concern (SCC) in terms of NEMA's Protocols for Specialist Assessment. This species is listed as Endangered by the IUCN (EN, B1ab (ii,iii,iv,v) (IUCN, 2018) and is reported to have an estimated Area of Occupancy (AOO) of less than 27 km^2 and estimated Extent of Occurrence (EOO) of just over 815 km^2. Conserving habitat for this species is therefore an important goal of the IUCN Amphibian Specialist Group, while simultaneously obtaining more data on the species to ensure future conservation efforts that may be required. The species however does not exist in isolation and the concurrent biodiversity factors present within recorded habitats must be considered to ensure an ecologically sound conservation process and effort.

1.1. Scope of Study

The current study firstly requires surveying the site and adjacent natural and built environments with the aim of providing an assessment report detailing the following aspects:

a. describing the frog species diversity occurring sympatrically with the SCC either at locality of the wetland-flat on the construction site or the related surrounding area;

b. assessing the current wetland-flat as anuran habitat locality within the construction site, its connectivity to the adjacent natural environments and distribution of the SCC in all these habitats;
c. providing relevant information regarding the life history and behavioural traits of the SCC as well as its habitat requirements and ecological niche;
d. advising regarding the extent and potential impact of the current activity at the site on the habitat locality of the SCC;
e. consider viability of conservation efforts for the SCC as it relates to the current activity on the site;
f. Advise on potential alternative development layouts and construction activity based on the above information.

Secondly, the study will require a Species Specialist Assessment in terms of the National Environmental Management Act 108 of 1998, as amended. This assessment will:

a. report and confirm the presence of *Afrixalus knysnae* as Species of Conservation Concern;
b. ascertain the population size of the SCC in the wetland-flat at the site and possible distribution within the adjacent environments;
c. Identify the possible impacts of the current activity and proposed alternative layouts of the development;
d. describe the importance of conservation of the SCC at the wetland-flat locality and adjacent larger connected wetland systems
e. Review literature and relevant databases and studies regarding conservation of the SCC and determine compliance of the construction and development activity with conservation guidelines and priorities of the SCC
f. Examine and describe dynamic ecological processes and connectivity within the study area and broader adjacent environment to inform on the impact of the activity on the SCC conservation and viability of its survival at the locality;
g. Assess these impacts during the construction phase and subsequent residential occupation phase and determine buffer zones or areas to minimise or avoid detrimental impacts for the SCC and it's habitat;
h. Make recommendations regarding suitability of the alternative layouts or advise on other layout proposals and management processes during the construction and subsequent residential occupation phases to achieve conservation of ecological processes for the SCC and its habitat;

i. Propose management and/or stewardship programmes for long-term conservation of the habitat and the species.

2. METHODOLOGY

2.1. Desktop study

2.1.1. Frog species

Data and information regarding frog diversity and anuran communities at the site and immediate vicinity was obtained from various online sources and literature. Global data sets available from the IUCN Red Data List of Species, GBIF, SANBI and the ADU FrogMap database provided information in this regard. Field guides (Du Preez and Carruthers, 2017) and The Atlas and Red Data Book of Frogs of South Africa, Lesotho and Swaziland (Minter *et al.*, 2004) ("The Frog Atlas") was consulted with regard to site relevant species information.

The SA Frog Atlas is currently the most comprehensive in mapping frog diversity and biogeography in South Africa and lists 19 frog species, representing six families of anurans that may be present in the Southern Cape Region. Du Preez and Carruthers (2017) furthermore closely followed The Frog Atlas in compiling their comprehensive field guide and extensive use was made of these guides during the collection of field data during the current study. The species composition as reported by Minter *et al.* (2004) is presented in **APPENDIX A: Table1**. Although the number of species may seem relatively small, compared to 167 frog species found in South Africa, the area is within an ecotonal environment, making the species assemblages somewhat unique. This include various fossorial species, stream dwelling and wetland species, with only so-called tree dwelling species lacking in the area.

2.1.2. Geography

Various imagery databases of the study site was consulted in obtaining historical and present day information to determine the extent and features of the area. The extent of the wetland-flat area in its original form as well as within the current disturbed landscape was extrapolated and recorded in GIS to ascertain dimensions and situation in relation to the construction activity. Proximity to the adjacent Camphersdrift wetland was calculated, aspect and slope was determined and distances investigated on these maps in order to indicate connectivity and possible ecological system cohesion. Landscape aspects

regarding vegetation or topography was not detailed but general aspects was obtained in order to determine the landscape characteristics. The current development footprint and layout was also interpolated onto the GIS to visually determine the extent of its area and relation to the wetland-flat habitat.

Proximity of the site to other natural areas, recreational facilities and residential areas was examined to design a field survey for investigation. Location of potential wetland or anuran habitat areas in close vicinity of the study site was preliminary identified from imagery for specific investigation during the study.

2.2. Field survey

A site survey was conducted between 31 October and 3 November 2021. The survey routes and its relation to the site and wetland systems are indicated in **APPENDIX B: Figure 2**. Other visits to the wetland-flat and surrounding area was also made up to submission date of this report. Two such site visits was conducted on 23 and 24 November 2021 after the extraordinary flooding events in George on 22 November 20221.

Potential suitable habitats for anuran species and specifically *A. knysnae* presence was investigated within the wetland-flat at the site and at/or around the Camphersdfrift wetland. Frog species diversity and presence was recorded through Visual Encounter Surveys (VES) and Acoustic Survey (AS), either directly or passively. The different habitats, biodiversity features and landscape units were recorded and their positions were recorded in the field. Field notes were transcribed onto publicly available satellite imagery and mapped in GIS. Active searches for *A. knysnae* were also conducted within areas likely to contain habitats suitable for this species within wetlands in the study area.

2.2.1. Wetland-flat

The existing waterbody within the wetland-flat was surveyed and measured by walking close to the water edge while tracking the path by GPS. The resultant polygon indicated the actual size of the water body as at the date of fieldwork. The entire water body is also ideal habitat for many shallow pond and wetland breeding frog species. The wetland form and size at time of the field survey is graphically depicted in **APPENDIX B: Figure 3** and is compared to that of what the original wetland may have looked like as obtained from historical satellite imagery. (Google Earth, 2016). The approximate size of the current water body is 1 405 m^2, with an original estimation indicated as almost 2 330 m^2. No actual wetland delineation was done during this fieldwork or for the purpose of this report.

2.2.2. Construction footprint

The current construction activity on the site and the situation of the wetland within the main construction site footprint is indicated in APPENDIX B: Figure 4. The total construction site was further surveyed to verify the presence or absence of any other potential habitat for frog species. Searches for *A. knysnae* specifically centered around investigating waterbodies containing similar hydrophytes. Good rains over the fortnight prior to the survey produced large portions of standing water within the construction footprint and these were individually investigated. The water in these pools is however extremely turbid and silted up with many forming mainly mud-pools. No tadpoles or adult frogs seemed to occupy these pools at the time of survey.

Frog species occurring in the wetland-flat was determined at the Rapid survey stage of this study and the species list is updated hereunder in APPENDIX A: Table 2. Frogs do however exhibit different seasonal breeding patterns and thus occupy different ecological niches in this regard. Recorded species at the site during this study may not be present earlier in the wet summer season or alternatively not persist at the site towards the end of the summer season. Table 2 also indicate the occupancy type of the species that may typically inhabit the wetland as long as it persists, i.e. either permanent or seasonal. The reason for its presence is also indicated. Species represented herein are indicated as those observed at the site during the surveys and those that would normally occur at the locality during the summer season.

Afrixalus knysnae as SCC is present only in the wetland-flat within the site. Main breeding activity of the species occurs within the deeper water in the south-eastern section of the waterbody. This section contains the highest density of hydrophytes and subsequently the largest number of egg-containing folded-leaf nests. The hydrophytes consist of mainly young to medium height *Thypha* spp. around the edge and *Polygonum* spp. growing from within the water. Nests were all found on the *Polygonum* spp. within this section. The edges of the water body are encroached by various grass species.

2.2.3. Camphersdrift wetland system

The Camphersdrift is a channeled valley bottom wetland system situated on the site's eastern boundary, extending north-easterly and south-westerly from here. Surveys of this

adjacent large wetland system was undertaken as far as practically possible. Inspections of the riparian edges on both sides of the wetland was made as far as it relates to the construction site. The total surveyed area is indicated in Figure 2. A wetland system of this size will be refuge to various frog species occupying different ecological features and habitats present therein and in different abundances. Table 2 also indicates the species recorded by way of VES or AS in this larger wetland area as well as the typical habitat that would be occupied by the species. Suitable habitat within this system for *A. knysnae* would mainly consist of standing water pools with clear water and containing favoured vegetation for breeding purposes. These types of habitats would rather exist in or at the edges of the wetlands. The species habitat will not occur within main river bodies or riverine type systems as is the case in the middle of this wetland. *Afrixalus knysnae* individuals (either tadpoles or adults) were not observed either visually or acoustically during the survey in the Camphersdrift wetland area.

The connection between the wetland-flat in the construction site and the Camphersdrift wetland from a breeding and refugia perspective for *A. knysnae* does not seem to be of major importance. The two wetland systems will however mutually influence each other as breeding and refuge area for insect populations while avifauna from the Camphersdrift system may frequent the wetland-flat and participate in the trophic hierarchy therein. As refugia for some of the frog species found in the wetland-flat, the larger system may well play a more important role during the drier months with moisture being trapped within its abundant vegetation substrate. Various frog species may well use this area also as estivation locality and for foraging outside of the breeding season.

The topographical discrepancy between the area where the wetland-flat occurs in relation to the larger wetland area is indicated in APPENDIX B: Figure 5. This elevational difference of approximately 17 meters also indicates the large frictional zone between the two wetland systems. Almost 300m also separate the main waterbodies in the two systems, an essential part of amphibian survival. Larger toad species like *Sclerophrys capensis* and more mobile species such as *Hyperolius marmoratus* or *Strongylopus grayii* should not have difficulty in traversing these distances or barriers. The occurrence of these species in both systems as recorded during this survey also confirms this. A large discrepancy in elevation and distance however may not be conducive for *A. knysnae* to migrate between these areas and it is unlikely to use the wetland as refuge or as foraging grounds. Surveys during the dry season may well be required to confirm this but until this may be possible, it suffices to rely on data and observations from studies elsewhere in the area indicating these assumptions.

2.2.4. Survey and location of similar nearby wetlands

The Rooirivierrif Municipal sporting facility is within 500m of the construction site and separated by a residential suburb on its southern boundary. Recreational and leisure activities by the public within its vicinity are conducted here on a regular basis. A small wetland body indicated in APPENDIX B: Figure 6 as "Alternative Wetland Site 1" exist to the east of an abandoned short course Golf course. This wetland seems a possible remnant of excavations for a man-made water feature when the golf course was constructed. Inspection of the water body at time of this survey revealed some tadpoles of *Cacosternum* spp. The turbidity of the water, general depth as well as absence of typical hydrophyte species favoured by *A. knysnae* for breeding purposes indicated that this was not suitable habitat for the *A. knysnae*. Presence of domestic animal tracks and human footprints also indicated regular anthropogenic disturbance of the wetland.

A wetland situated on Erf RE/464, George and currently the subject of development applications and adjacent construction was also investigated. The locality of this wetland is indicated in APPENDIX B: Figure 6 as "Alternative Wetland Site 2 ", as well as its relative positioning to the sites in this report. Investigation of this wetland however revealed that the water is not clear but dark in colour most probably due to root systems of the surrounding tree stands of Black Wattle (*Acacia mearnsii*) and deeper than 400-500mm. Hydrophytes consisted of mainly *Typha* reeds and aquatic macro algae while no species of hydrophytes used for breeding by *A. knysnae* was observed. *Hyperolius marmoratus* was however audible as well as *S. grayii* during the survey of the site. The characteristics of the wetland will also be favourable as breeding area for *S. capensis* and *Xenopus laevis*, with adults of the latter observed during the inspection.

3. SPECIES OF CONSERVATION CONCERN: Afrixalus knysnae

3.1. Habitat requirements

3.1.1. General characteristics

Afrixalus knysnae typically inhabit endorheic wetland systems where the water body is no deeper than approximately 500 mm, very clear and contain enough hydrophytes used for breeding activity (De Lange and Du Preez, 2018). These water bodies can be easily identified visually, and all the localities identified so far within its distribution range exhibit similar water clarity, depth, and hydrophyte presence. The bottom substrate is usually highly compacted. Streaming or running water is not present at any of the recorded localities.

Localities where *A. knysnae* have been recorded within the Garden Route region varies in size from approximately 1ha to as little as 20 sqm (Poynton and Broadley, 1987; De Lange and Du Preez, 2018). Foraging activities and refuge areas are mainly at or around the edges within wetlands while breeding occurs within deeper sections thereof, yet still close to the water body edge. Hydrophytes such as lily leaves or decaying *Typha* spp. stalks and leaves, occurring in such wetlands are often used as calling vantage points, again nearer the edge of the wetland. The locality containing the species at Groenvlei near Sedgefield for instance, is only within a 2-meter section along a 100-meter edge of the entire 360 ha lacustrine wetland leading to a man-made jetty area, thus illustrating the minimal extent of habitat within large wetland systems.

The recorded habitats are also mainly surrounded by grass species and typically *Pennisetum* spp. Forest habitats with larger trees do occur at some of the localities but are often separated from the wetlands by other friction zones such as roads or steep embankments. Movement of the species are seemingly restricted to the wetland and its immediate surroundings, and this is especially true during the height of the breeding season. Specimens of the species have not been found within the surrounding habitats of wetlands during the breeding season, unlike other Hyperoliidae species being found in residences and residential gardens or trees (Pickersgill, 2005).

Localities where *A. knysnae* are found are often also fed from precipitation and run-off water from steeper embankments on the outer edges of wetlands. This often ensures water bodies persists as long as the rainy season persist. Most of the water bodies is temporary in nature during the rainy season between September and December. Precipitation during January and February may extend the breeding season if the waterbodies maintain its relative depth and clarity. Some waterbodies at localities do persist until the next rainy season, depending on its size and the precipitation it is able to collect annually.

3.1.2. Water chemical composition

A basic water chemical composition was done on site, with handheld instruments measuring acidity (pH), Nitrates ($NO\bar{3}$), Conductivity (µS), temperature (°C) and turbidity (ppm). No studies exist regarding the exact chemical compositions of the water bodies where *A. knysnae* have been recorded. Chemical analysis of terrestrial aquatic environments wherein frog species abound, are usually only made where the known frog abundances have shown a decline to understand the drivers thereof. This basic analysis

was done with a sample from within the main water body and a comparison was made with a small pool of water disjunct from this main area yet within the wetland footprint. This small pool is approximately 2 sqm in size and a result of excavations on site. It however contained no nests and no tadpoles or adults of *A. knysnae*. *Cacosternum* spp. tadpoles was observed herein during the site survey. The depth and hydrophytes as well as relative clarity of the water was however similar to the main water body. The comparative measurements were recorded as:

Sample	pH	$NO\overline{3}$ (Nitrates)	µS (conductivity)	°C	Ppm (turbidity)
Main water body at study site	7,22	8	211	19	105
Disjunct pool within wetland footprint	7,03	12	304	20	150

The main discrepancies from the readings are with Nitrate concentrations, conductivity, and turbidity. These measurements are in no way conclusive results of the exact chemical tolerances required by *A. knysnae*, but it does give an indication of the sensitivity this species may exhibit towards its micro-habitat requirements. Adults may also still be able to tolerate areas with an altered chemical composition but may not use such a site for breeding purposes.

Comprehensive water analysis was commissioned for this site with the results from the examining laboratory in APPENDIX C. These results should therefore indicate a baseline of the ideal compositions of typical water bodies of the species' habitat. The detailed water sample analysis will as a result be used for future monitoring of the subject site as required from a habitat management perspective.

3.2. Population sizes and sympatric species

Various attempts have been made to establish population sizes of *A. knysnae* at recorded localities, but the cryptic size of the species and its very quick escape maneuvers makes this extremely difficult. Acoustic analysis in determining the relative abundance have been used as an indicator only, but as only males call, the number of females cannot be determined. Assumptions that one female is present for each male can also not be a true reflection as a single female will mate with various males during a breeding season, as is the case with many amphibian species (Woodruff, 1976). The acoustic analysis at the current site does however suggest that the relative abundance and population size is high relative to the available habitat. The large number of tadpoles observed in the water body

furthermore confirms this abundance. Absence of large numbers of predators of eggs and tadpoles further suggest that the site will produce larger numbers of progeny, making this an ideal breeding site for this species.

Frog communities at localities where *A. knysnae* is recorded consist of other Hyperoliidae species such as *Hyperolius marmoratus, Semnodactylus wealii* and Pyxicephalidae species *Strongylopus grayii, Strongylopus faciatus, Cacosternum nanum,* and *Cacosternum platys*, while *Xenopus laevis* have been observed at some of the localities. The Bufonid, *Sclerophrys capensis* are often found around the fringes of some of these wetland habitats. All these species occur abundantly across the distribution area of *A. knysnae* and is currently of least conservation concern. Some of these species are also indicated in Table 2 and is thus present at the current locality.

3.3. Species life history

3.3.1. Breeding biology and larvae stages

Members of the genus lay their eggs on soft-leaved hydrophytes. The male folds or rolls the leaf with his hind legs into a sheath following oviposition and fertilisation (Rose 1950; Wager 1954; Du Preez & Carruthers 2017), excreting an adhesive substance and enclosing the eggs within while the "glue" cures (Rose 1950, Wager 1954, authors pers. obs.) An example of such a folded leaf-nest is shown in the image in APPENDIX: Figure 1.

This unique breeding behaviour seems to be an attempt to ensure that maximum progeny survive to at least tadpole stage as larvae develop within the leaf sheath hidden from predators. The diminutive size of the species, with adults less than 25mm, forces them to use vegetation with small pliable leaves and as result only small numbers of eggs are deposited in this way during oviposition. Although a female may produce up to 150 eggs during a breeding period, only a small number at a time will be deposited per leaf to be fertilised during amplexus. Eggs are only 1mm in diameter, with hatchling tadpoles no bigger than 9mm. Tadpoles develop into metamorphs capable of leaving the water body at about 6 weeks.

Predator pressure on the egg-clutches and larvae of *A. knysnae* have not been studied adequately, but it is apparent that water birds, other frog species and macroinvertebrates prey on eggs and larvae as with many other amphibian species. No studies have been done on the fecundity or numbers of successful hatchlings from egg clutches in this species to determine the population potential after a breeding season. Personal

observations from a study site have indicated that in excess of 50 tadpole hatchlings emerged from one plant containing 3 folded-leaf nests. This indicates that a healthy population of the species may well exist at the site should the majority of tadpoles reach maturity.

3.3.2. Adult behavioural traits

Male and female adults are very similar in body size with the female slightly slender than the male. The species also exhibit specific sexual dimorphism as well as colouration within the sexes. Both sexes do however have great diurnal and nocturnal colouration changes and this also seem to be seasonal. During the warmer daytime temperatures, the species seems to retreat into the undergrowth and hydrophyte root systems just outside the edge of the wetland with only its noses protruding above the substrate surface. During this time its colour changes to dark brown and is it easy to camouflage with the dark surroundings in the base of the vegetation. During the breeding season, the nocturnal colouration turns to bright yellow, with the males appearing brighter than the females. The gular sack of the males also has a bright yellow patch which probably aids in identification during calling bouts.

Adults will easily jump or slip into the water body surrounding its perching site when disturbed during the night. The bright yellow-coloured specimens can then often be seen swimming among the vegetation substrates. Predation of adults also seem to occur nocturnally when it is visually more pronounced where other frog species, mainly toads and African clawed frogs (*X. laevis*) as well as water snakes will prey on smaller or immature adults. Predation in the daytime by water birds and herons may well happen, but the species being incredibly immobile during the daylight hours will assist it in not excessively falling prey during this time like other more mobile toad species.

Foraging also occur during the night where the main prey items consist of insects within the vegetation. Tadpole diets consists of plant material, mostly decaying material within the water body, this usually starting with the leaf from which they hatch. Specialised apparatus around their mouth parts assists them in attaching to the leaves while feeding (Channing et al., 2012; De Lange and Du Preez, 2018).

3.3.3. Estivation, migration, and environmental triggers

As with most other frog species, estivation occurs during the dry months. Water is required for breeding purposes and the species are not observed during the dry months when

precipitation is very low. Scientific knowledge regarding *A. knysnae* estivation behaviour is lacking but personal observation during study of the species suggest that they merely retreat down into the muddy substrate and within the root structures of hydrophytes that persist during the dry months. No specimens have been observed outside the wetland localities where it has been recorded outside of the breeding season. This suggest that the species does not migrate to refugia away from the breeding site but may well stay hidden well below the muddy surface of a drying wetland. The existence of different populations at different localities are therefore not likely due to migration but some other mechanism not yet adequately investigated. The mere size of the species and its mode of movement will suggest that large distance cannot be covered without severe cost to its survival.

Breeding activity is triggered usually just after good rains within its distribution range. Studies have indicated that approximately 30mm of precipitation within a short period allows the wetlands at the recorded localities to fill up adequately to have the adults emerge (De Lange, 2018 unpublished MSc dissertation, Willem Mathee, NMU, Honours study 2015). Continued rain during the summer will then maintain the water levels, allowing the species to complete its reproductive processes and tadpoles transitioning to adults. The solid compacted substrate at the recorded localities also assists in the slow drainage of the water bodies thereby creating adequate time to complete breeding and metamorphosis cycles. The breeding season is however rather short not lasting much longer than 45-60 days.

4. CONSTRUCTION ACTIVITY IMPACT

4.1. General Impact on the frog species community

Anuran habitat will be irreversibly lost and destroyed for the entire frog community at the current locality should the development proceed as per the original approved layout. *Afrixalus knysnae*, forming part of this anuran community and as endangered species must be conserved through conservation of its habitat firstly. Large data deficiencies still exist regarding the life history and habitat utilization of this species and as such the precautionary principle is applicable in conservation strategies for the species.

4.2. Conservation considerations

4.2.1. *In Situ* conservation

Habitat preservation will always be the primary consideration to assist conservation efforts of endangered species. The current site has been modified from the original natural state and attempts to restore the main body of the system and halt the construction within the wetland area was timeous and allowed breeding to proceed relatively normal at the time of this study. The current disturbance may also have caused an increased accumulation of rainwater runoff being channeled into the wetland system assisting in increased water depth and favourable breeding area. Earthworks at the site have however changed the characteristic of the wetland-flat and will need to be restored as close as possible to its original state to preserve the natural habitat. Recent heavy downpours in George, with flooding events on a large scale, caused the wetland-flat to fill up completely. The disturbance within the wetland from construction earthworks caused the wetland to silt up and the water to become extremely murky as result of this deluge. This event underlined the importance of restoring the wetland and preserving of the habitat.

All the habitat requirements for *A. knysnae* are available within the site and the current breeding activity and number of tadpoles present during field surveys indicated a healthy system. Restoration of the habitat will however need to be done after the breeding season and well into the drier winter months. This restoration would need to be carefully designed and undertaken to ensure sustained habitat availability for the next season and at the same time not cause mortality of individuals based on the assumptions of its estivation strategy in the wetland substrate.

4.2.2. *Ex Situ* conservation

This strategy will involve capturing adults and tadpoles as well as collecting egg masses and then through a process of husbandry and under strict scientific protocols, attempt to increase the species survival rate away from the known habitat. Adults are later released back into suitable habitats or back to the habitat it was taken from after rehabilitation of such habitat (Visser, 2011). Direct re-location of adults is also often regarded as an *ex-situ* conservation attempt, where species are merely moved to another suitable habitat locality and out of a threatened situation. This practice is the subject of large debates especially with regards to amphibian species. (Dodd and Seigel, 1991). Some of the main arguments against such a conservation attempt is the spread of amphibian diseases such as Chytrid and Rana virus.

Re-locations are particularly difficult with cryptic species as capturing of adults is a challenge and may lead to injury and death. Frogs are also very territorial and as such will attempt to return to the breeding locality where it was hatched. Re-locations may thus only succeed by moving egg clutches or masses and tadpoles to alternative sites. Tadpoles are however extremely sensitive to any change in water composition, with the slightest change in temperature or pH having the potential of being fatal. Re-location of *A. knysnae* in this instance will entail the netting of as many tadpoles as possible and the collection of host plants on which leaf-nests are folded. This programme will need to be carried out with a myriad of precautions and will require specialised personnel taking great care not to damage the nests.

Surveys of the surrounding areas of the site investigating possible re-location sites as a conservation strategy and inspecting alternative wetlands (APPENDIX B: Fig. 5) have however been found to be inadequate as habitat for *A. knysnae*. Recorded localities at the Garden Route Botanical Gardens and at the NMU Campus in Saasveld are known habitat within the George area. Application of scientifically sound processes for re-location to these sites will require the obtaining of permits from Conservation Authorities which will be time consuming, detailed, and complicated and not realize during this breeding season. Re-location to other known species occurrence localities will also not address the IUCN conservation efforts for this species. Distribution of the species will diminish rather than conserving newly discovered localities with clearly suitable habitat. The effects on gene-pools are also not properly studied.

Ex situ conservation of the species from this site will not achieve success currently as is indicated by the various challenges and special interventions set out above.

4.2.3. Habitat protection

Protecting the habitat by physically isolating this area from deliberate or accidental human encroachment, domestic animals, and pollution will be the most effective manner to achieve its conservation. Cognizance must be taken of the behaviour of the typical frog species described herein. Built environments do not hamper frog movement or isolate them from other natural areas. Frog mortalities are mainly the result of habitats and environments being polluted or indiscriminately travelled through. Predation by domestic animals on amphibians is a major threat for amphibian survival. Human intrusion, effluent and pollutants into the wetland are the major habitat threat and must therefore be limited or completely avoided.

Long-term protection of a delimited habitat could be achieved by way of environmental management processes and stewardship agreements. Preservation of the habitat will be required through active measures being implemented during construction and ultimate occupation by end-users. This will entail amendment of the development footprint, protection of the wetland, management of the habitat and species locality, and such other measures as may be identified through proper impact assessment. Water quality, botanical management and species conservation will ensure the long-term viability of the site as anuran habitat. Management plans for the habitat will also require engagement with conservation authorities, resident associations, and specialists

4.3. Development layout amendment recommendations

The current development layout and development plan is indicated in APPENDIX B: Figure 7. A diagrammatic representation hereof is represented in APPENDIX B: Figure 8. The wetland is indicated as it was originally situated on the property prior to development. A buffer zone of 19m is indicated around the entire wetland. The development footprint as approved therefore clearly indicates that the entire wetland habitat is impacted by the development construction. Current disturbance as result of the earthworks for the development have altered this wetland form and topography.

Considering the immediate need of the species breeding season activities in the wetland, the current development suspension should allow for the rehabilitation of the wetland and construction planning around this rehabilitation. Amendment of the development layout and re-designed placement of the housing units, roads and reticulation infrastructure must be actively planned to allow the wetland's continued viability and protection. Recommendations for alternative development proposals based on the information from this assessment with a view of conserving the anuran habitat at the site and the SCC is stipulated as follows:

a. The wetland must be restored to function as originally situated on the site, slowly filling, and draining from ground water resources and rainwater runoff. Draining of the wetland system through alternative channeling systems cannot be designed or implemented. The wetland-flat character should be preserved. Drainage channeling, even extremely slow drainage, will not assist conservation of the SCC and other resident frog species but rather place pressure on tadpole survival. Restoration of the wetland-flat is the first phase to achieve habitat conservation, but this must only be commissioned in the drier months when frog breeding activity has ceased;

b. Incorporation of the wetland into the housing estate with facilities for recreational use by the residents cannot be designed. Uncontrolled human activities within the conserved area cannot be allowed. The area cannot be demarcated as public open space for the development as this will pre-suppose that the area would be available as recreational or green zone for the benefit of the housing estate. These types of areas are inevitably polluted, and cannot limit pollution and destruction, accidental or otherwise;

c. Pollutants contaminating the wetland originating from housing structures and the end-user occupants of the housing estate must be diverted away from this conserved area. The demarcated 19m buffer around the wetland is sufficient to allow the SCC and sympatric species to allow its normal ecological function as long as the habitat is protected. The buffer will only be of any practical value if no anthropogenic activities are allowed to encroach beyond this area. As indicated, the SCC does not seem to venture far from its breeding and foraging sites and does not require vast portions of land in this regard;

d. Construction of a berm structure demarcating the 19 m buffer will assist in avoiding pollutant runoff from the adjacent residential development into the conserved area if constructed carefully. The recent floods in George have indicated the need for properly designed and vegetation-covered berms for this purpose. Berms are not to be higher than 500mm or have exposed soil deposits that could run into the wetland during heavy precipitation. Runoff from these elevated portions could be attenuated by vegetation between the berm and the wetland water body;

e. A barrier structure, either in the form of a "see-through" fence with or without densely growing indigenous hedge type plants should be installed beyond the berm and around the wetland flat. This must however give adequate protection against human and domestic animal encroachment and be at least 1,8m high. Ensuring that fencing is not of a type designed to isolate either the wetland or perimeter of the development will allow all the species in the community to freely traverse the area;

f. Maintenance of the fencing structure around the conserved area is however important and the management thereof will need to be overseen throughout the lifespan of the development. Rules of Body Corporates and title conditions of the erven within the development should provide for this maintenance. The duty of maintenance of this wetland management structure will have to be entrenched in the Housing Development's adopted development Rules and regulations, most probably at property conveyancing stage. The location of the barrier should at a minimum be at or close to the outside of the constructed berm, but practicality need to be considered as illustrated in Figure 7. The exact final demarcation will be dictated by the re-designed development and is to be assessed at that stage;

g. All the identified species at the site save for the SCC have been observed and recorded in many residential gardens, the nearby Kingswood Golf Course and recreational parks and areas in the vicinity. Frog species resident in this area will however migrate to and from the wetland during its breeding seasons. None of the species at the site exhibit mass migratory behaviour and therefor does not require specifically constructed connectivity corridors to other refugia or natural habitats. Ultimate positioning of housing units with constructed "green lanes" to assist frog movement within the development are not to extend into the wetland buffer through openings in the fencing structure as this will also assist pollution ingress and domestic animal predation;

h. As the wetland will not form part of public open space for the development, green lanes/corridors within the estate will be required and this will assist wildlife movement in general. These corridors will create whatever connectivity may be required to areas beyond the wetland-flat without compromising protection of the wetland. Connectivity of the habitat locality to such other natural areas could be achieved by fencing structures at the development perimeter with large enough mesh patterns or walling with openings at ground level;

i. Access to the wetland area will be required to manage and monitor the wetland area, but not uncontrolled public access. Management plans in this regard may well prove to set precedent for future similar developments with sensitive habitats. Should successful stewardship roles and conservation programmes be implemented herein, this may benefit both development and endangered species;

One important aspect that needs to be understood in conservation of this habitat is the effect of the frog sounds, songs and calls during the breeding season. This wetland is a prolific breeding site for a myriad of species, and in seasons with high precipitation, the breeding activity induces an enormous acoustic response. The calls of large numbers of male frogs at this site was recorded on various evenings through this study and the volume intensity is spectacular. Frog calls have different effects on people and can become a hinderance to many residents in the development. Animosity towards the wetland site may have detrimental effects on the resident's willingness to conserve the habitat. The frog calling cannot be subdued and every resident's attitude towards the natural environment cannot be determined *ad-infinitum*. In this regard it suggested that the planting of a tree barrier be investigated along the edge of the fence barrier. These should be fast and tall growing species with the intention of dispersing the largest part of the sound emanating from the wetland. This will allow for even higher levels of "isolation" of the wetland and ease acoustic "nuisance" for residents and probably assist with achieving less animosity towards the conservation programme. Trees do however use large volumes of water, and this impact must first be investigated before a decision in this regard is taken.

Education and information regarding the frog habitat and the SCC should be made available to prospective residents at initial sales and marketing stage. This can either be done on the development website or by way of marketing literature add-ins. Ongoing educational and monitoring programmes will also be investigated and discussed with conservation and environmental groupings and the impact of this will also be investigated during the ongoing assessment.

An impact assessment of the development features in any new proposed layout, such as driveways, stormwater paths and attenuation as well as recreational areas and open public spaces must be calculated. The tree-barrier will also require impact assessment to ensure that this does not alter the wetland ecology and species assemblages. These impacts must consider the quality of the water and sustainability of the wetland as a habitat for *A. knysnae* and other sympatric species with whom it fulfills its ecological services. This should inform all parties as to the appropriate conservation and construction processes and final development footprint and layout.

5. CONCLUSION AND SUMMARY

The current construction activity for new housing development on erven 21028 and 21029, George have been designed without cognizance of the impact on the wetland-flat that occurs within its footprint. This wetland is habitat to various anuran species of amphibians and in particular a Species of Conservation Concern, *Afrixalus knysnae*. The locality has not in the past been described as habitat for the species but have through this study now been confirmed.

The construction site is also bordering a large wetland system with a channeled valley-bottom wetland, with impacts on this system investigated by the appointed wetland specialists. Connectivity between this system and the wetland-flat on the construction site is limited to possible breeding sites for co-occurring insect and frog species and avifauna foraging in the two wetland systems. The life history of *A. knysnae* indicate that it possibly remains at or in the wetland substrate to estivate during the dry season, appearing only in the rainy season after good precipitation. The SCC will therefore only be resident in the wetland-flat and not use the larger wetland system as refugia or breeding locality.

The wetland-flat system has been altered in many aspects and will need to be rehabilitated to its original state if an attempt is to be made to conserve the habitat for the SCC and other sympatrically occurring frog species. Rehabilitation can only be actioned during the drier months as most frog species currently use the wetland as breeding site with egg masses and nests present throughout the water body. Rehabilitation will also need to be followed by conservation plans to preserve the site. *In situ* conservation of the species is the only strategy for this site and re-locations or *ex-situ* conservation will not be viable.

The design and layout of the housing development require a buffer zone around the wetland with a barrier or fencing system to act as deterrent to human and domestic animal intrusion in the conserved area. The barrier needs to allow movement and migratory behaviour of other frog species and wildlife into and out of the wetland area as well as towards the other natural areas around the development. These refugia and foraging areas for frogs exist in various recreational areas, golf courses and residential gardens beyond the development area and must be able to be accessed by the various anuran species identified at site. Allowing this normal traversing behaviour of the frog species will ensure the wetland-flat's continued viability as ecological service provider for these species and the SCC

Conservation of the SCC is however of paramount importance and the first step in this process is the conservation of the habitat. Pollutants and anthropogenic activities into the wetland must be avoided and largely stopped. Education and information on the SCC and frog activity in general should be disseminated to end-user residents of the development which may assist in long-term conservation of the habitat and species. A Species Impact Assessment Report based on the findings of this study and alternative development layout proposals must be finalised hereafter. It will further require the formulation of construction management plans to conserve the habitat as well as long-term management plans after construction completion and occupation.

APPENDIX A

Table 1: Frog species occurring in the Garden Route, Western Cape as indicated by Minter et al. (2004)

Family	Species	Common Name	Status
BREVICIPITIDAE	*Breviceps fuscus*	Plain Rain frog	LC
	Breviceps rosei	Sand Rain frog	LC
BUFONIDAE	*Sclerophrys capensis*	Raucus toad	LC
	Sclerophrys pardalis	Eastern Leopard toad	LC
	Vandijkophrynus angusticeps	Cape sand toad	LC
HELEOPHRYNIDAE	*Heleophryne regis*	Southern Ghost frog	LC
HYPEROLIDAE	*Afrixalus knysnae*	Knysna Leaf-folding frog	EN
	Hyperolius horstockii	Arum lilly frog	LC
	Hyperolius marmoratus	Painted Reed frog	LC
	Semnodactylus wealii	Rattling frog	LC
PIPIDAE	*Xenopus laevis*	African clawed frog	LC
PYXICEPHALIDAE	*Ametia fuscigula*	Cape river frog	LC
	Amietia delalandii	Common river frog	LC
	Cacosternum nanum	Bronze caco	LC
	Cacosternum boettgeri	Boetger's caco	LC
	Strongylopus bonaespei	Banded stream frog	LC
	Strongylopus faciatus	Striped stream frog	LC
	Strongylopus grayii	Clicking stream frog	LC
	Tomopterna delalandii	Cape sand frog	LC

Table 2: Species recorded at the wetland flat and channelled valley-bottom wetland during the study

Species	Recorded locality		Habiytat type	Habitat use
	Wetland flat	Campersdrift		
Cacosternum nanum	X	X	Small shallow pools, grassland	Breeding, Foraging (Seasonal)
Cacosternum plattys	X		Shallow pools in grassland	Breeding, Foraging (Seasonal)
Hyperolius marmoratus	X	X	Wetland reeds stands	Breeding, Foraging (Seasonal)
Afrixalus knysnae	X		Shallow wetlands, clear water	Breeding, Foraging (Permanent)
Strongylopus grayii	X	X	Shallow pools, under rocks	Breeding, Foraging (Permanent)
Xenopus laevis	X		Any water body, muddy pools	Breeding, Foraging (Seasonal)
Sclerophrys capensis	X		Wetlands, grass flats, rocky beds	Foraging, Breeding (Seasonal)
Amietia fuscigula		X	River systems	Foraging, Breeding (Permanent)
Breviceps fuscus		X	Soft moist Soil beds	Foraging, Breeding (Permanent)

APPENDIX B

Figure 2: Young male *Afrixalus knysnae* (left) and typical folded leaf-nest (right)

Figure 1: Field survey route around the site and the Campersdrift wetland

Figure 3: Graphic representation of current wetland waterbody compared to the extent of the historical wetland size

Figure 4: Situation of the current wetland water body within the construction footprint

Figure 5: Elevation profile and distance measurements between the wetland flat and channelled valley-bottom wetland

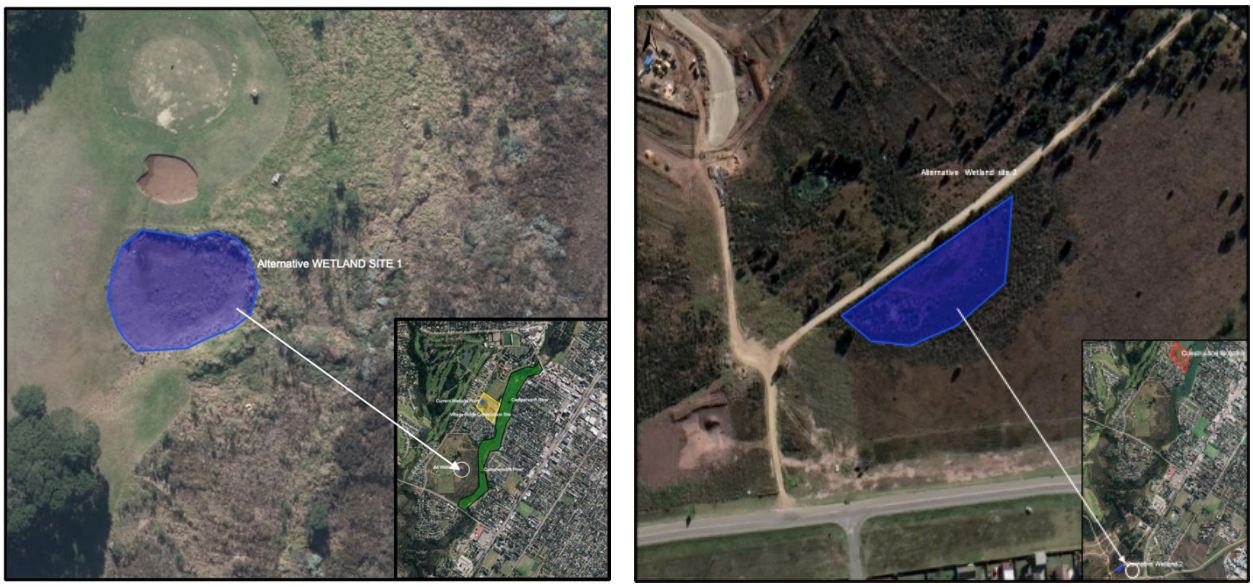

Figure 6: Localities of alternative wetlands within close proximity of the wetland flat and construction site

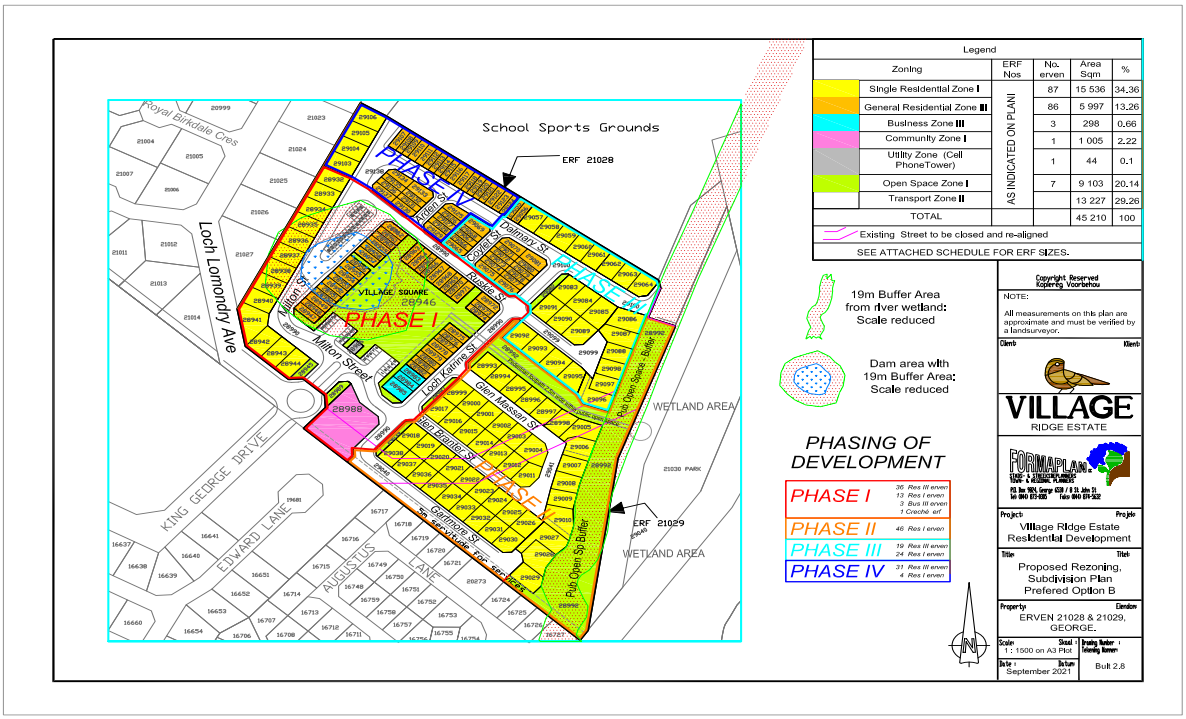

Figure 7: Current development approval diagram

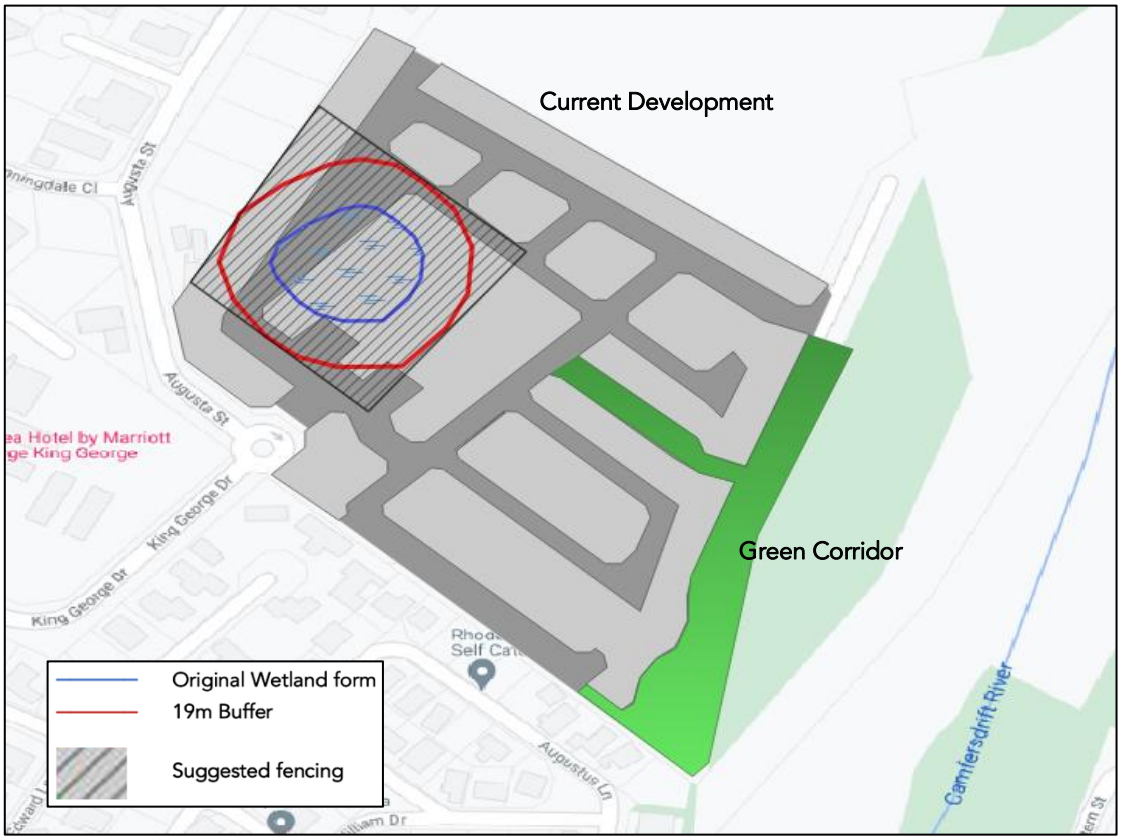

Figure 8: Wetland with buffer indicated and suggested area to be fenced around the habitat and berm buffer

APPENDIX C

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T0654

CERTIFICATE OF ANALYSIS

Client	: Confluent Environmental (Pty) Ltd	Report No	: WT2021-05654	Delivery Date	: 21/10/2021
Address	: 50 Bokmakierie Straat Eden	Samples	: 2	Order No/Ref	: N/A
Phone	: 0832563159	Department	: Water		
Contact	: Jackie Dabrowski	Sample Type	: Unknown		
Email	: jackie@confluent.co.za				

Lab number:	WT21-12704
Sampling Date:	19/10/2021
Sampling Time:	14:00
Sampling temperature upon receipt (°C):	16.5
Sampling ID:	Power Wetland

Physical & Aesthetic Determinands	Method ID	Unit	Results	UoM %	0	Compliance Statement
pH (Titrando Method) at 20°C	3777	pH Units	7.8	0.16	Not Applicable	Not Applicable
Alkalinity as CaCO3 (Titrando)	3777	mg/L	145		Not Applicable	Not Applicable
Suspended Solids *	4993	mg/L	<5.0		Not Applicable	Not Applicable
Macro Chemical Determinands	**Method ID**	**Unit**	**Results**	**UoM %**	**0**	**Compliance Statement**
Chloride (Cl) Titrando	3778	mg/L	10.8	8.00	Not Applicable	Not Applicable
Ammonia (NH3) as N	4511	mg/L	<0.05	6.30	Not Applicable	Not Applicable
Nitrate (NO3) as N	4511	mg/L	<0.18	2.39	Not Applicable	Not Applicable
Ammonium (NH4+) as N (Ionised Ammonia)	4511	mg/L	0.137		Not Applicable	Not Applicable
Nitrite (NO2) as N *	4511	mg/L	<0.01	1.72	Not Applicable	Not Applicable
Sodium (Na)	3132	mg/L	12.7	3.39	Not Applicable	Not Applicable
Calcium (Ca)	3132	mg/L	39.0	2.56	Not Applicable	Not Applicable
Magnesium (Mg)	3132	mg/L	6.6	3.00	Not Applicable	Not Applicable
Potassium (K)	3132	mg/L	8.7	7.30	Not Applicable	Not Applicable
Sulphur (S)	3225	mg/L	0.49	5.11	Not Applicable	Not Applicable
Sulphate (SO4) *	Calc	mg/L	1.5	5.11	Not Applicable	Not Applicable
Phosphorus (P) Total	3132	mg/L	<0.20	4.83	Not Applicable	Not Applicable
Micro Chemical Determinands	**Method ID**	**Unit**	**Results**	**UoM %**	**0**	**Compliance Statement**
Copper (Cu) Total	3132	mg/L	<0.05	4.30	Not Applicable	Not Applicable
Manganese (Mn) Dissolved	3132	mg/L	<0.05	3.99	Not Applicable	Not Applicable
Manganese (Mn) Total	3132	mg/L	<0.05	3.99	Not Applicable	Not Applicable

Date Analysed: 21/10/2021 Date Analysis Completed: 27/10/2021 Date Reported: 28/10/2021 Page 4 of 6

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Email	: jackie@confluent.co.za				

Lab number:	WT21-12704
Sampling Date:	19/10/2021
Sampling Time:	14:00
Sampling temperature upon receipt (°C):	16.5
Sampling ID:	Power Wetland

General Chemistry	Method ID	Unit	Results	UoM %	0	Compliance Statement
Fluoride (F) *	5534	mg/L	<0.20		Not Applicable	Not Applicable
Orthophosphate (PO4) as P *	4511	mg/L	<0.08	1.88	Not Applicable	Not Applicable

Terms and Conditions

Recommendations included with this report are based on the assumption that the samples were representative of the source from which they were taken. To ensure sample integrity - Water samples are only stored for two weeks after release of the report, thereafter they are disposed of and a fresh sample will be required if additional analyses are requested. The information supplied by the client (or lack thereof) may affect the validity of the results. This information includes but is not limited to client details, sample reference, the date and time of sampling, the sampler, and transportation of the sample to the testing laboratory.
Results marked with "Not SANAS Accredited" or "Subcontracted" in this report are not included in the SANAS Schedule of Accreditation for this laboratory. Opinions and interpretations expressed herein are outside the scope of SANAS accreditation. These results relate to the items tested. This test report shall not be reproduced except in full, without written approval of the laboratory. Uncertainty of Measurement and method references available on request.

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Sample condition:

Samples for analysis must be kept cool (<10°C) and reach the laboratory within 24 hours of sampling. Chemical parameters that can be affected by exceeded temperature and sampling times includes: Acidity, Alkalinity, BOD, CO2, Chlorine, Chlorophyll, Cyanide, Chromium VI, Dissolved Oxygen, Odor, pH & Turbidity. The effect on the microorganisms is unknown, treat microbiological results with reserve.

Additional Information including: Testing date & time for all analysis are available on request

**** - Not SANAS Accredited*** ***** - Outstanding*** ****** - Insufficient Sample*** ***# - Subcontracted***

UoM - Uncertainty of Measurement ***Not Detected* = <1 cfu's /mL or <1 MPN/100mL was detected**

(R) - Test parameter has been Repeated to confirm value

Date Analysed: 21/10/2021 Date Analysis Completed: 27/10/2021 Date Reported: 28/10/2021 Page 5 of 6

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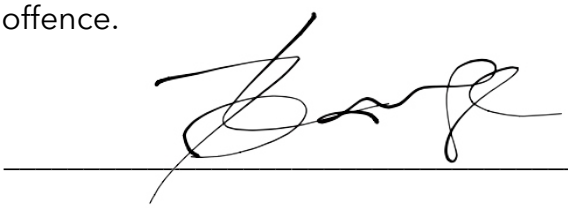
DECLARATION OF INDEPENDENCE BY SPECIALIST

I, Ferdi de Lange, hereby declare that I:

- acted as the independent specialist in compiling this document;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- I 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 and any specific environmental management Act;
- have no and will not have any vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations and any specific environmental management Act;
- am fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations 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 in 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 was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- have ensured that the names of all 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, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offence.



Signature

Date: 25 November 2021