SPECIALIST GIANT BULLFROG HABITAT ASSESSMENT OF REMAINDER OF PORTION 62 OF THE FARM WITPOORTJIE 177 IR

Compiled for EnviroGuard by:

Mr C.L.COOK (MSc. Zool.) *Pr.Sci.Nat.* 400084/08
Specialist Giant Bullfrog Consultant
Giant.Bullfrog@gmail.com
082 688 9585

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DETAILS OF SPECIALIST

Clayton Cook
P.O. Box 39357
Uvongo
4270

Telephone: 082 688 9585
Email: giant.bullfrog@gmail.com

Appointment of specialist

Clayton Cook was commissioned by Enviroguard to provide specialist consulting services for remainder of portion 62 of the Farm Witpoortjie 177 IR (henceforth called the Witpoortjie site). The consulting services comprise a Specialist Giant Bullfrog habitat assessment identifying important habitats (breeding, foraging, burrowing and dispersal) within the Witpoortjie site and as well as providing mitigatory measures for the above-mentioned species during the construction and operation phases of the project.

Summary of expertise

Clayton Cook:

- Registered professional member of The South African Council for Natural Scientific Professions (Zoological Science), registration number 400084/04.
- Faunal and Specialist Herpetological consultant since 1997.
- Conducted over 150 preliminary faunal surveys and 50 specialist herpetological surveys.
- Regional Organiser for Gauteng Province for the South African Frog Atlas Project 1999-2003.
- Published a scientific paper on *Pyxicephalus adspersus*, 8 scientific conference presentations, co-wrote the species accounts for the genus *Pyxicephalus* for the Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland South African
- Author. of the amphibian chapter in the W.R.C Report No. 1258/1/06 on “A Biophysical framework for The Sustainable Management Of Wetlands In Limpopo Province With Nylsvley as a Reference Model”.
- Attended 5 national and international herpetological congresses & 3 expert workshops, lectured zoology and botanical science at University of Limpopo (2001-2004).

- Lead researcher of a 3 year W.R.C. project on the status of frog species in the Kruger National Park as well as the impacts of water quality on tadpoles (2009-2012). Water Research Commission (WRC) report WRC PROJECT K5/1928: Assessment Of The Current Biodiveristy Of The Wetland Amphibians Associated With Major River Systems Of The Kruger National Park (And The Physical And Chemical Factors Affecting Their Distribution). VLOK, W[1], Fouche, P[2], Cook, C.L.[3] and Pieterson, I[4].

Independence

Clayton Cook has no connection with the developer and is not a subsidiary, legally or financially, of the proponents, remuneration for services by the proponent in relation to this proposal is not linked to approval by decision-making authorities responsible for permitting this proposal and the consultancy has no interest in secondary or downstream developments as a result of the authorisation of this project. The percentage work received directly or indirectly from the proponent in the last twelve months is approximately 0% of turnover.

Scope and purpose of report

The scope and purpose of the report are reflected in the “Terms of reference” section of this report below.

Indemnity and specific conditions relating to the report

The findings and recommendations in this report are based on best scientific practices, available information, professional experience and judgement. Due diligence has been observed throughout the preparation of the document. Clayton Cook accepts no liability for any claim, demand, cost or inconvenience arising from this report or its contents and by accepting this report recipients indemnify the author, contributors and collaborators from any such liability. This report must not be altered or added to without the prior written consent of the author. This also refers to electronic copies of this report which are supplied for the purposes of inclusion as part of other reports, including main reports. Similarly, any recommendations, statements or conclusions drawn from or based on this report must make reference to this report. If these form part of a main report relating to this investigation or report, this report must be included in its entirety as an appendix or separate section to the main report.

1. INTRODUCTION

The specialist herpetological survey and habitat assessment focused on the current status of threatened amphibian species namely the Giant Bullfrog, *Pyxicephalus adspersus* on portion 62 of the Farm Witpoortjie 177 IR.

Seasonal fluctuations in amphibian population sizes (especially Giant Bullfrogs) occur depending on certain environmental parameters such as amount of rainfall, temperature and humidity. Precipitation strongly influences amphibian activity, distribution and dispersion patterns, reproductive cycles, and rates of growth and development. Many species remain underground or in aboveground retreats except during wet periods. Therefore, the best time to survey an area is often during the wet season or following heavy rain.

The entire site was surveyed during the summer months of November 2007 until the beginning of February 2008 of the current 2007/2008 wet season. Special emphasis of the survey was placed on the current conservation status of Giant Bullfrogs on the site and immediate surrounding areas.

Rainfall in Gauteng is extremely variable and concentrated between October and March. Rain falls most frequently in the form of heavy diurnal thunderstorms of relatively short duration. Considerable fluctuations in rainfall occur from year to year. Rainfall is important for amphibians in that it initiates activity and reproduction. Levels of amphibian activity are influenced by the intensity and duration of rainfall as well as temperature and humidity.

Most of the amphibians in Gauteng are fossorial, avoiding desiccation during the dry winter months by burying underground. Certain species such as the Sand Frogs *Tomopterna sp.* and Giant Bullfrogs *Pyxicephalus adspersus* dig their own burrows whilst species such as the Bubbling Kassina use the burrows of other animals, natural crevices, under rocks and under rotting logs.

In Gauteng amphibian breeding activity is rain-dependent, and developmental times of larvae are often short (<30 days). Herpetological surveys must be undertaken during suitable weather conditions (after 60 mm rainfall), for Giant Bullfrogs the period is between October and the end of March. Heavy summer downpours (>60mm) results in adult migrations to suitable breeding habitat and the initiation of breeding events.

Following some form of courtship, adults of oviparous species deposit eggs in or near the water. Large numbers of eggs (up to 6000) are deposited to ensure survival of certain tadpoles. The eggs and tadpoles are adapted to theses ephemeral habitats and develop rapidly in the nutrient rich warm water. The tadpoles are major consumers in these seasonal aquatic environments. After a period of growth, the tadpoles undergo metamorphosis and move back to the terrestrial environment where they feed and continue to grow. When mature, they return to their specific aquatic environment or habitat to breed, completing the biphasic, complex life cycle.

Target Organisms and Habitat

The techniques described below can be adapted for the study of any amphibian that breeds in communal aggregations in temporary or permanent ponds, vleis, streams or rivers. Breeding site surveys can focus on adults or larvae. Adults are usually more conspicuous and easier to sample and identify than larvae. However, larvae are typically present at the breeding site for longer periods than adults. Sampling both adults and larvae is the best approach and the one used for this survey. Monitoring adults at a breeding site is easiest when breeding is concentrated in a narrow, well-defined period, but it can also be implemented when the breeding period is extended.

For short, infrequent surveys such as herpetological assessments for EIA's, larval sampling yields more complete species lists than adult surveys do. However, if there is any doubt as to larval identification the larvae should be reared through metamorphosis. Larval densities can be strongly influenced by local factors (e.g. climate and co-occurring predators) and can vary greatly over short periods. Larval densities are not good predictors of adult population size. Breeding site studies are most thorough in small, shallow bodies of water that are free of emergent vegetation and that can be surveyed by observers in a relatively short period. Recently laid eggs and small clutches of tadpoles are difficult to observe amongst the dense emergent vegetation. The clutches or aggregates of Giant bullfrog tadpoles become more visible as the tadpoles develop and schools reach larger sizes. This survey focused on both the adult and larval stages of the Giant Bullfrog. **No surface water was present during site investigation on the 17th of November 2018**. As the majority of suitable wetland habitats on the site are seasonal; more intensive surveys conducted throughout the 2018/2019 wet season will be required in order to ascertain the presence of the rather cryptic Giant Bullfrog.

QUANTATIVE SAMPLING OF TADPOLES

Most tadpoles occur in aquatic habitats including lenthic waters (streams and rivers) and lothic waters (ponds and dams). The majority of tadpoles in Gauteng occur in lothic waters such as inundated grassland, seasonal pans, ponds or backwater pools in rivers and streams. Tadpoles are often found in large concentrations at breeding sites over longer periods than the adults this is especially pertinent for Giant Bullfrogs as the majority of breeding adults migrate away from the breeding sites after the completion of breeding activities. As a result, sampling tadpoles rather than the adults may be a more efficient method for inventorying species at a site, even though eggs and larvae of many species are poorly known. In addition, the collection of tadpole voucher specimens is easier and has less impact on the population than collecting adults. There are various methods for sampling and identification of amphibian larvae (tadpoles) from water bodies. These methods include seining, dip-netting, trapping and enclosure sampling. These techniques provide a fast, relatively thorough, qualitative or quantitative sample with minimal personnel, material and time. In addition, the techniques generally do not harm the animals so can be used to monitor rare or threatened species such as the Giant Bullfrog.

1.1 Objectives of the specialist habitat assessment

- To provide a description of the prevailing environmental condition of the site with special emphasis on the current status of Giant Bullfrog populations on the site and immediate surrounding areas.
- To determine potential impacts of the development on the immediate environment of the proposed site.
- To provide management recommendations to mitigate negative and enhance positive impacts.

1.2 Scope of study

- A preliminary habitat assessment; focusing on the available or suitable habitat for Giant Bullfrogs on the site and immediate surrounding areas.
- An assessment of the ecological habitats, evaluating conservation importance and significance with special emphasis on the Giant Bullfrogs.
- Literature investigations, personal records and previous surveys conducted in similar habitat and the surrounding areas; with which to augment field data were necessary.
- Identification of potential ecological impacts that could occur as a result of the development and assess the significance of these, where possible.
- Investigate feasible and practical management recommendations that should be implemented to reduce or minimise the impacts on threatened species and sensitive habitats, should the project be approved.
- Documentation of the findings of the study in a report as well as a sensitivity map.

1.3 Constraints or limitations to the survey included*:*

- Limitation to a single season base-line ecological survey for only 8 hours during the early summer months.
- The majority of species associated with highveld grasslands and wetlands are extremely seasonal only emerging during limited periods of the year (after heavy summer rains). **Inadequate rainfall resulted in no surface water within seasonally inundated pans and valley bottom wetland. No amphibian breeding activity was noted during site visit on 17th of November 2018.**
- The majority of threatened faunal species are extremely secretive and difficult to observe during intensive field surveys conducted over several seasons; including Giant Bullfrogs.
- Due to high security risks surveys are restricted to certain areas.

1.4 Reports reviewed for the survey included:

- Specialist Giant Bullfrog Survey of portions 1, 65, 3, 100, 101 and 103 of the farm Rietfontein 115 I.R. and remaining extent of portion 22 and 23 of the farm Weltevreden 118 I.R. Unpublished report compiled by Mr C.L.Cook (2008).

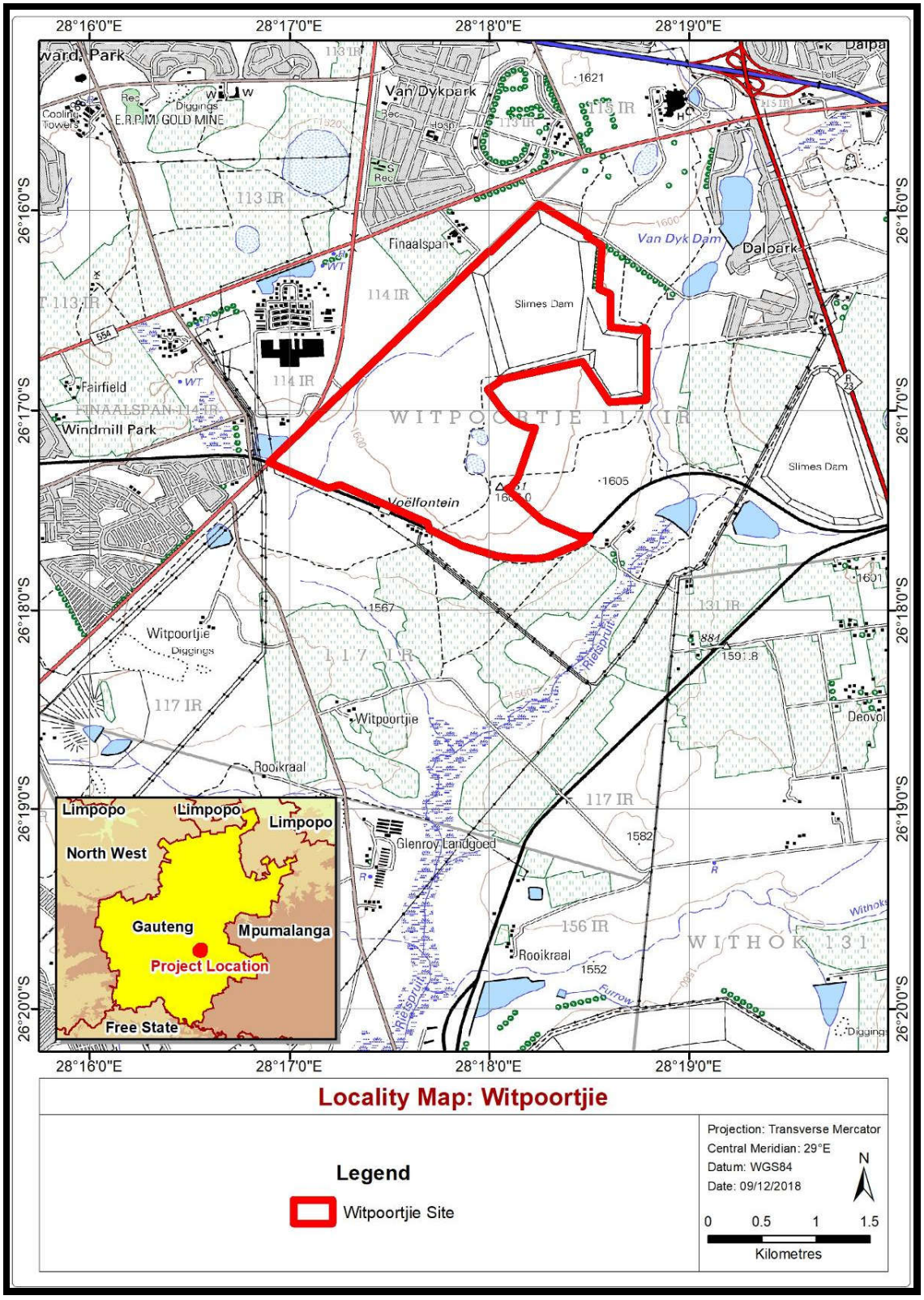

Figure 1. Locality map of the proposed Witpoortjie site.

Figure 2. The Witpoortjie site is dominated by Tsakane Clay Grassland in various stages of transformation and degradation. Situated within the lower-lying areas as well as shallow depressions are seasonally inundated pans. The adjacent open grasslands offer favourable foraging, dispersal and burrowing/aestivation sites for Giant Bullfrogs. The seasonally inundated pans and depressions offer suitable breeding habitat for remaining Giant Bullfrogs

2. GENERAL STUDY AREA

The Witpoortjie site is situated within the East Rand of Gauteng. The site is bordered to the west by the M43 (Sailfin), R554 and Van Dyk Dam to the north and open grasslands and Dalpark to the east and degraded open grasslands to the south (see Figure 1 above). Major bulk pipelines occur on the southern boundary of the site.

Figure3. An elevation profile of the site. The site has a gentle sloping topography from the north towards the east with an average slope of 1.3%. The major topographical features are the artificially created mine dumps (old slimes dam) on the northern portion of the site.

Vegetation composition in the area consists of Mesic Highveld Grasslands in various stages of transformation and degradation falling within the **Tsakane Clay Grassland (Gm 9)** vegetation unit (Mucina & Rutherford 2006; see Figure 4 below). The majority of grasslands have been historically transformed through agricultural activities as well as high-density residential developments and associated high levels of anthropogenic disturbances including extensive illegal dumping activities, littering, frequent fires (burning of waste) and harvesting of traditional medicinal plants. The grasslands to the south of the site comprise of degraded grassland with limited herb and forb diversity occur mainly within the existing powerline servitude. Patches of primary *Themeda triandra* grassland were observed on the southern as well as central portions of the site. Several patches of the hydrophilic *Imperata cylindrica* was observed within a mosaic in areas with elevated soil moisture throughout the site.

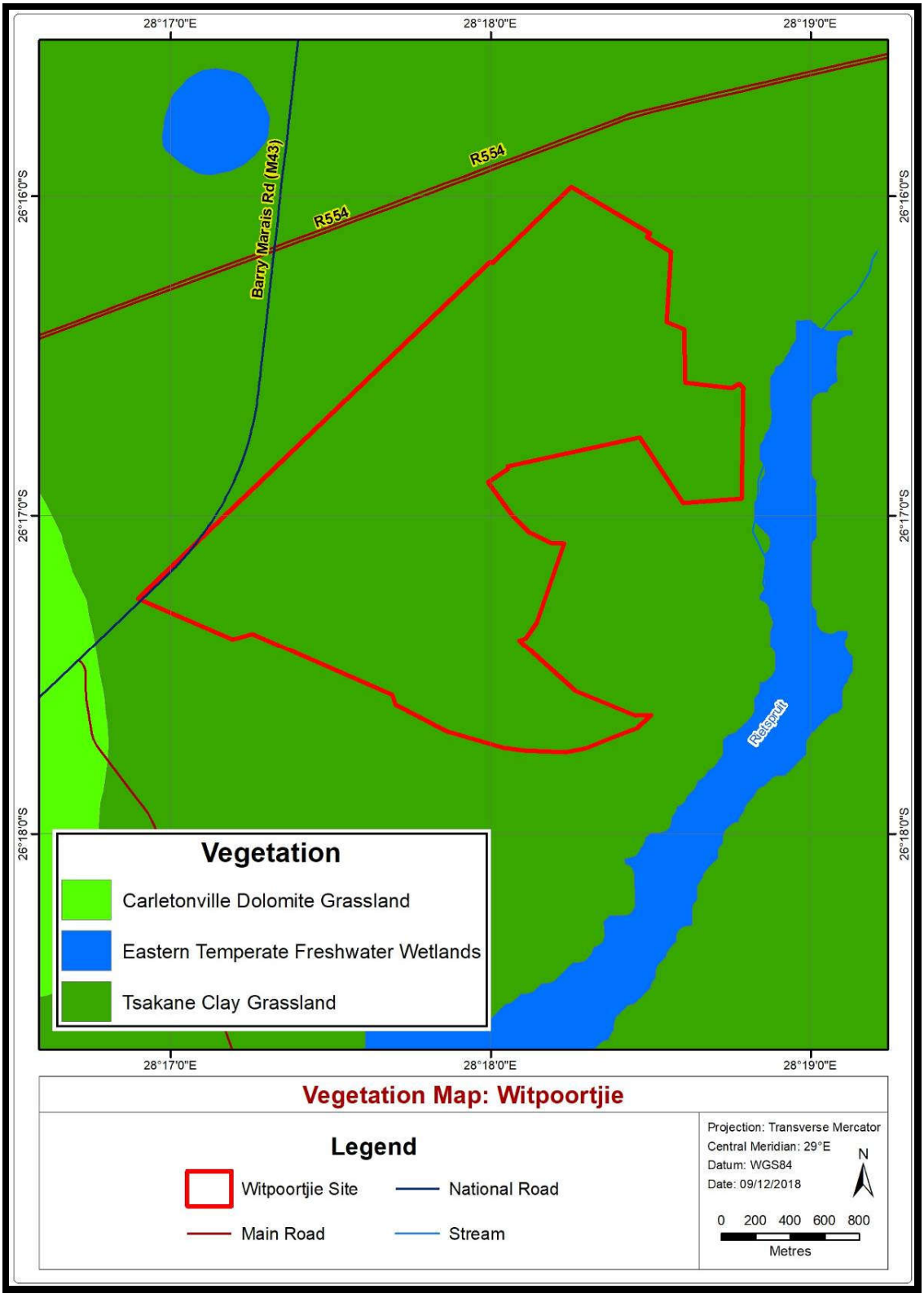

Figure 4. Vegetation map of the Witpoortjie site situated within Tsakane Clay Grassland (Gm9) (adapted from Mucina et al. 2006).

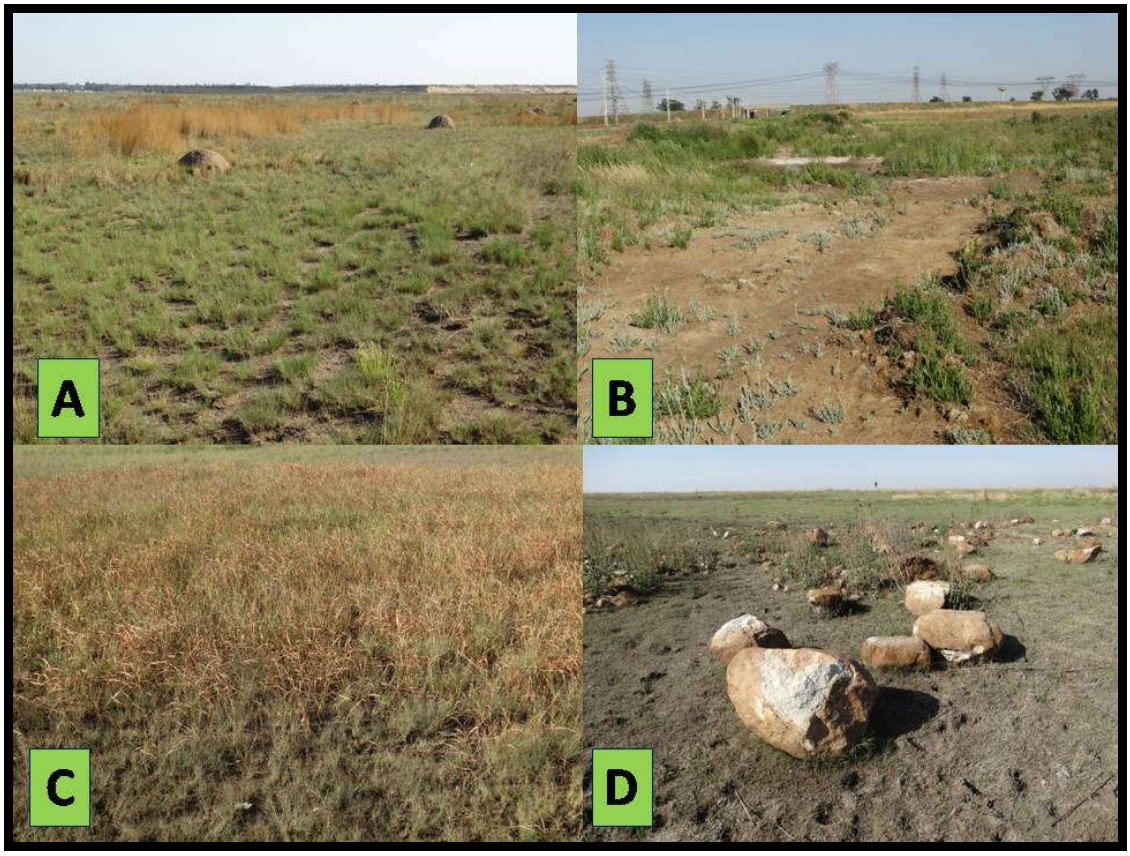

Figure 5. A collage of photographs displaying the major habitats observed within the proposed Witpoortjie site. A: The Witpoortjie site comprises of open Tsakane Clay Grassland in various stages of transformation and degradation. The previously disturbed areas on the site are dominated by patches of *Hyparrhenia hirta* and *Cynodon dactylon* secondary grasslands; Eucalyptus invaded areas, old slimes dam/mine dump, informal access roads and pedestrian pathways. **B**: Recent soil and vegetation clearance on the southern boundary of the site adjacent to the drainage line. **C:** A mosaic of temporary inundated *Imperata cylindrica* dominated patches were observed on the site. These areas are dominated by increased levels of soil moisture situated on a hard plinthite or ferricrete layer. **D:** Situated on the eastern portion of the site are seasonally inundated pans or depressions. These seasonal wetland habitats form the most suitable breeding habitat for remaining Giant Bullfrogs.

Mesic Highveld Grassland is found mainly in the eastern, precipitation-rich regions of the Highveld, extending as far as the Northern Escarpment. These are predominantly 'sour' grasslands and are dominated primarily by andropogonoid grasses. The different grassland units are distinguished on the basis of geology and other substrate properties, as well as elevation, topography and rainfall.

The vegetation of the site falls within the **Tsakane Clay Grassland (Gm 8)** vegetation unit (Mucina & Rutherford 2006). The vegetation on the site is transformed and does not reflect the natural species composition of the cool Highveld Grasslands.

Synonyms:
Cymbopogon-Themeda Veld (VT 48) (Acocks 1953) or **Moist Cool Highveld Grassland** (39) (Low & Rebelo 1995).

Locality & Physical Geography:
Mpumalanga and Gauteng Provinces: In patches extending in a narrow band from Soweto to Springs, broadening southwards to Nigel and towards Vereeniging, as well as north of the Vaal Dam and between Balfour and Standerton. Altitude is between 1 480-1 680 m.

Vegetation & Landscape Features: Flat to slightly undulating plains and low hills. Vegetation is short, dense grassland dominated by a mixture of common Highveld grasses such as *Themeda triandra*, *Heteropogon contortus, Elionurus muticus* and a number of *Eragrostis* species. Most prominent forbs are of the families Asteraceae, Rubiaceae, Lamiaceae and Fabaceae. Disturbances leads to an increase in the abundance of the grasses *Hyparrhenia hirta* and *Eragrostis chloromelas* (Mucina & Rutherford 2006).

Patches of natural *Themeda triandra, Heteropogon contortus, Elionurus muticus* grassland was observed on the western as well as central portions of the site. Several large clumps of *Hypoxis hemerocallidea* were observed on the southern portions of the site as well as adjacent to the seasonal pans. The grasslands on the site have low levels of anthropogenic disturbances due to the presence of security gaurds who mpatrol during the daylight hours. Activities noted included low-levels of harvesting of *Hyparrhenia hirta* and *Ergagrostis chloromelas* for thatch, removal of medicinal plants, frequent burning of grassland vegetation, scraping of vegetation and soils on the southern boundary, illegal dumping of building, litter and invasion of alien invasive vegetation (*Eucalyptus camaldulensis, Verbena bonariensis, Campuloclinium macrocephalum*).

Geology and Soils: The most significant rock is the basaltic lava of the Klipriviersberg Group (Ventersdorp Supergroup), together with the sedimentary rock of the Madzaringwe Formation of the Karoo Supergroup Group. Soils are typical of the Ba and Bb land types. Soils on the site were sandy to sandy-clay-loams. A few large boulders have been placed within the seasonal pan. No major natural rocky extrusions or outcrops on the site. The predominating soils along the adjacent Rietspruit (1km to the east) are very clayey, black vertic or near vertic, mostly of montmorillonitic clays.

IMPORTANT TAXA

Graminoids (Grasses): *Brachiaria serrata*, *Cynodon dactylon, Cynodon hirsutus, Digitaria ternate, Elionurus muticus*, *Eragrostis chloromelas*, *E. patentipilosa, E. plana*, *E. racemosa*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Michrochloa caffra*, *Setaria sphacelata*, Steraa *nigrirostris*, *Themeda triandra*, *Trachypogon spicatus*, *Andropogon schirensis, Aristida adscensionis, A. bipartita, A. congesta, A. junciformis* subsp. *galpinii, Cymbopogon caesius, Digitaria diagonalis, Diheteropogon amplectens, Eragrostis micrantha, E. superba, Melinis nerviglumis, Harpochloa falx, Microchloa caffra, Paspalum dilatatum.*

Herbs: Acanthospernum australe, Ajuga ophrydis, Eriosema salignum, *Euryops transvaalensis, Gerbera viridifolia, Helichrysum nudifolium* var. *nudifolium, H. rugulosum, Hermania depressa, Lotononis macrosepala, Nidorella hottentotica, Pentasia prunelloides subs. latifolia, Pseudanum caffrum, Rotheca hirsuta, Selago paniculata, Senecio coronatus, S. inornatus, Vernonia oligocephala.*

Geophytic Herbs: *Aspidoglossum ovalifolium, Hypoxis rigidula* var. *pillosissima.*

Semi-parasitic Herb: *Striga asiatica*.

Low Shrubs: *Anthospermum hispidulum, A. rigidum* subsp. *pumilum, Chaetacanthus setiger, Tephrosia capensis var. acutifolia.*

Semi-*parasitic Shrub: Thesium impeditum.*

Key Environmental Parameters*:*
This vegetation type is restricted to clayey soils of the high rainfall areas of southern Gauteng and southern Mpumalanga highveld.

Economic Uses*:*
The grasslands and soils are often ploughed as well as heavily utilised for grazing by cattle and sheep. The site is currently vacant and utilised for illegal dumping activities, pedestrian pathways, bush-toilets and limited grass harvesting.

Conservation Status*:*
Tsakane Clay grasslands are considered to be **Endangered**. The conservation target is 24%. Only 1.5% statutorily conserved (Suikerbosrand, Olifantsvlei, Klipriviersberg, Marievale) or privately conserved (Avalon Nature Reserves, Ian P. Coester, Andros). More than 60% of the area already transformed by cultivation, urban sprawl, mining, dam building of road infrastructure. Large portions of Alberton, Springs, Tsakane and part of Soweto were constructed in the area of this vegetation unit.

Urbanisation is increasing and further expansions especially in the southern suburbs of Johannesburg and towns on the East Rand (especially Boksburg and Brakpan) will bring further pressure on the remaining vegetation. Land invasion within open Tsakane Clay grassland is also a potential for further destruction of this Endangered vegetation unit. Erosion is generally very low (93%).

Existing impacts observed on the site during brief habitat assessment included:

- The vegetation of the site falls under the Tsakane Clay Grassland vegetation unit which is classified as Endangered as 60% is transformed and only 1.5% is conserved.
- Remaining open Tsakane Clay grasslands surrounding the site are mainly transformed into current residential and Finaalspan jail, mining activities or agricultural lands (maize) or are relic patches which are heavily impacted from previous agricultural and adjacent human activities as well as frequent fires, alien vegetation invasion, invasion of informal settlements, illegal dumping of rubble and waste products.
- The Tsakane Clay Grassland vegetation of the site has been previously impacted on by previous anthropogenic activities such as mining as well as agricultural activities such as overgrazing by cattle, frequent fires and poor grass and soil conservation.
- The remaining grasslands surrounding the site are severely fragmented due to several major road networks as well as increased residential developments.
- The northern portions of the site were previously excavated for gold mining activities and cleared of vegetation. Large poorly vegetated mine dumps and slimes dams occur.
- The majority of surrounding wetland habitats are severely degraded or contain altered hydrological patterns (seasonal pans to reed invaded permanent waterbodies).
- Several vagrants and informal settlements were observed adjacent to the site.
- Large scale dumping of solid and organic refuge in and alongside the adjacent open spaces especially along the informal dirt access roads adjacent to the residential areas. Low levels of previous dumping activities (building rubble) were observed on the south-western portion of the site.

- A high abundance of *Tagetes minuta* and *Pseudognaphalium luteo-album* were noted throughout the property especially in the old lands. Herbaceous weedy species, such as *Verbena bonariensis* and *Amaranthus hybridis* were also common, and the alien invasive Pom-Pom Weed (*Campuloclinium macrocephalum*) was observed adjacent to the seasonally inundated pan. A small plantation *Eucalyptus* spp. was observed in the central region of the site.
- Alien vegetation in and around open grassland areas and road reserves include Black Wattle *Acacia mearnsii*, *Eucalyptus* spp., Bugweed *Solanum mauritanium*, Pampas grass *Cortaderia selloana*, Blackjack *Bidens pilosa*, Tall khakiweed *Tagetes minuta*, *Verbena* sp, Kikuyu *Pennisetum clandestinum*, Large Cocklebur *xanthium spinosum,* White-flowered Mexican Poppy *Argemone ochroleuca*, Large Thorn-apple *Datura stramonium, Eucalyptus sp*., Purple Top *Verbena bonariensis*, Pom-Pom Weed *Campuloclinium macrocephalum*).
- Frequent burning of the open grassland destroys the natural vegetation and limits the amount of refuge areas and prey items (decrease in insect, reptile, amphibian and small mammal populations). The grassland on the site was burned prior to the site visit and grassland vegetation was starting to re-emerge. The natural hygrophilous and hydrophilic vegetation within the seasonal wetlands/pans had not emerged due to inadequate rainfall.
- Major road networks namely the M43 to the west, R554 to the north and R23 to the east restricts the natural migratory movements of remaining Giant Bullfrogs to the east, west and the north. These roads with high vehicular traffic result in major road fatalities of the majority of species especially Giant Bullfrogs and Owls.

The seasonal wetlands including the seasonal drainage line or valley bottom wetland on the western portion of the site have been severely impacted by local and surrounding activities including:

- The wetlands on the site have been affected severely by the encroachment of historic mining activities and agricultural activities in the past and present. This has led to altered surface areas of the wetlands as well as impacts on the sensitive wetland associated vegetation and hydromorphic soils.
- This feature is likely to significantly affect the integrity of the ecology of the seasonal pans and possibly the wetland habitats further down the gradient of the site.
- Hardened surfaces including roofs, roads, buildings as well as stormwater pipes and channels have disrupted the natural hydrological flow regime towards the western valley bottom wetland. Large amounts of water enter directly into the valley bottom wetland from the M43 during heavy downpours.
- The M43 on the western boundary affects the hydrological patterns of the seasonal drainage line or valley bottom wetland. Water is channelled through a concrete culvert.
- The creation of several artificial drainage channels directing water away from certain wetland habitats. Drainage channels were observed adjacent to the valley bottom wetland on the western boundary.
- Deterioration of water quality from surface runoff and possible leachate from surrounding poorly vegetated mine dumps.
- Informal dirt roads bisect the entire site as well as disrupt the natural hydrological regime towards the seasonal drainage line. The informal dirt road bisects the drainage line towards the northern boundary of the site.

3: BACKGROUND INFORMATION PERTAINING TO GIANT BULLFROGS (*PYXICEPHALUS ADSPERSUS*)

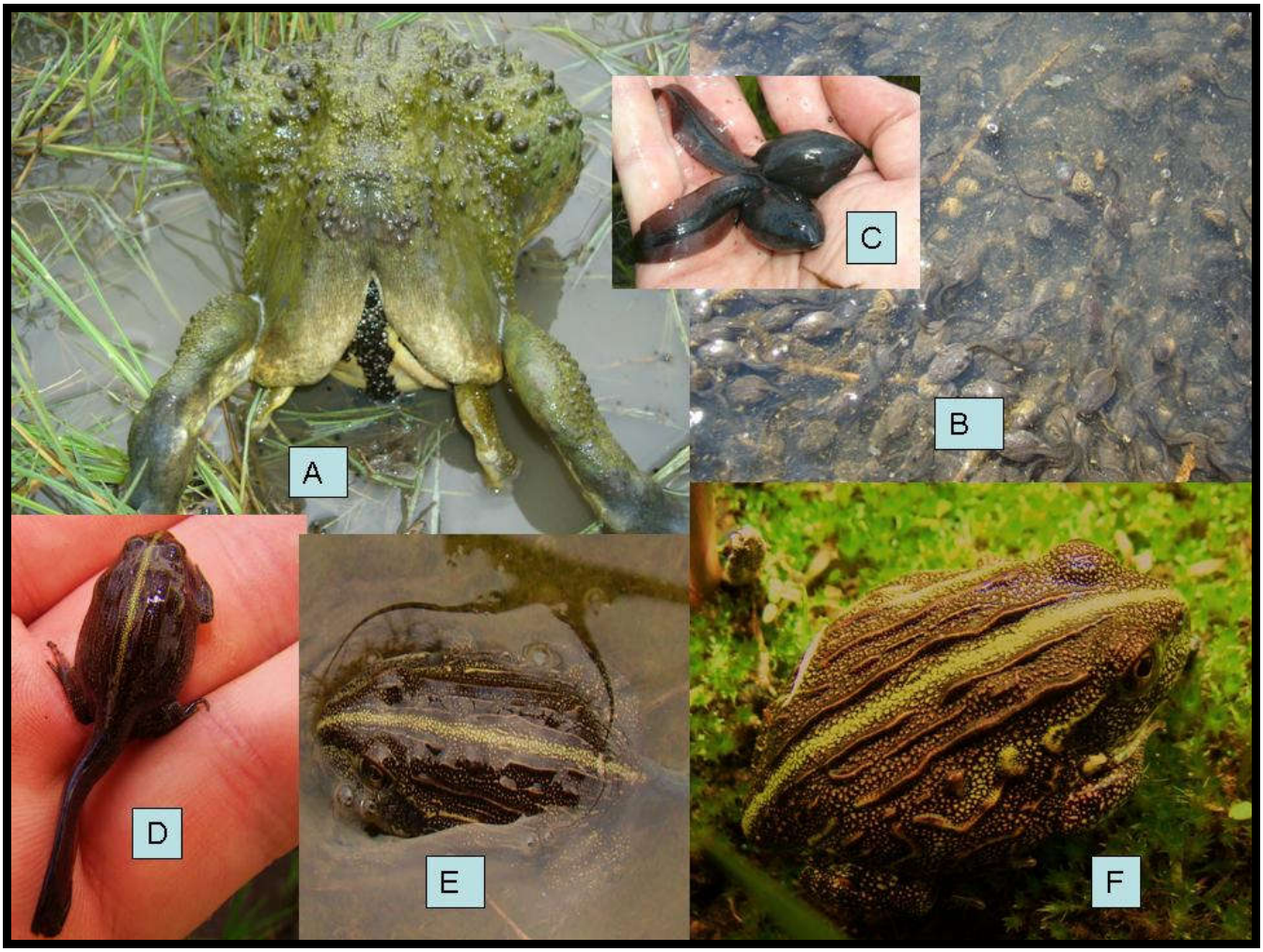

Figure 6: A collage of photographs displaying the reproductive cycle of the Giant Bullfrog: A: Mating or amplectant pairs lay eggs in shallow water between 2-5cm deep mainly within seasonal wetland habitats; **B:** Tadpoles form characteristic aggregates or schools in the shallow water and **C:** develop rapidly in the warm, nutrient rich water. **D:** The tadpoles reach Gosner stage 42 between 20 and 28 days; **E:** The tail is fully absorbed (Gosner stage 46) at approximately 30-32 days. **F:** The emerging juveniles disperse up to several kilometres (up to 4-6 km) away from the breeding localities. Adults usually burrow between 500 (males) and 800 m (females) from breeding sites and display philopatric tendencies, and return to the same burrow throughout their lifetime unless they are physically prevented from doing so.

3.1 GIANT BULLFROG (*PYXICEPHALUS ADSPERSUS*)

Giant Bullfrog, Bullfrog, African Bullfrog, Highveld Bullfrog, Giant Pyxi, Groot Brulpadda (Afrikaans), Letlametlu (Pedi, Shangaan), Marokolo (Sesotho), Lentsoeta (Sesotho)

The Giant Bullfrog (*Pyxicephalus adspersus*) is the largest Southern African frog and the second largest frog in the world, with adult males reaching over 250 mm in body length and weighing well over a kilogram. Bullfrogs emerge after the first heavy summer rains to breed and feed. Giant Bullfrogs occur over large areas ranging from Somalia in the north, through the eastern savannah regions of the continent, extending across to Angola and northern Namibia and south to Beaufort West in the Cape Province. Although they are well distributed they are rarely seen, spending the majority of their lives underground in a dormant state known as aestivation. During this dormant period, bullfrogs remain inactive in a water proof “cocoon” composed of several layers of its own sloughed-off skin. The entire body except for the nostrils are covered by the protective cocoon. The cocoon prevents water loss (evaporation) during the dry periods. Bullfrogs can remain buried in their cocoons for several years (over 7 years) before they emerge.

Figure 7. A juvenile bullfrog in aestivation showing the cocoon composed of several skin layers. Any aestivating or cocooned Giant Bullfrogs unearthed during excavations of the tower supports during the winter months should be placed within a cooler box filled with moist vermiculite and released in suitable habitat during the following summer wet season. Any unearthed during the wet summer months should be released in the evening in order to prevent desiccation.

Large-scale adult emergences occur after heavy summer downpours and adults breed explosively during daylight hours in shallow margins of temporary rain-filled depressions. Bullfrogs require these shallow seasonal habitats to breed successfully in as the eggs are fertilized externally. A typical breeding pond will contain numerous adult males who aggressively defend a small territory from other intruding male bullfrogs. This ensures that the largest, strongest males are able to defend the best breeding areas around the pan (Cook *et al*. 1996).

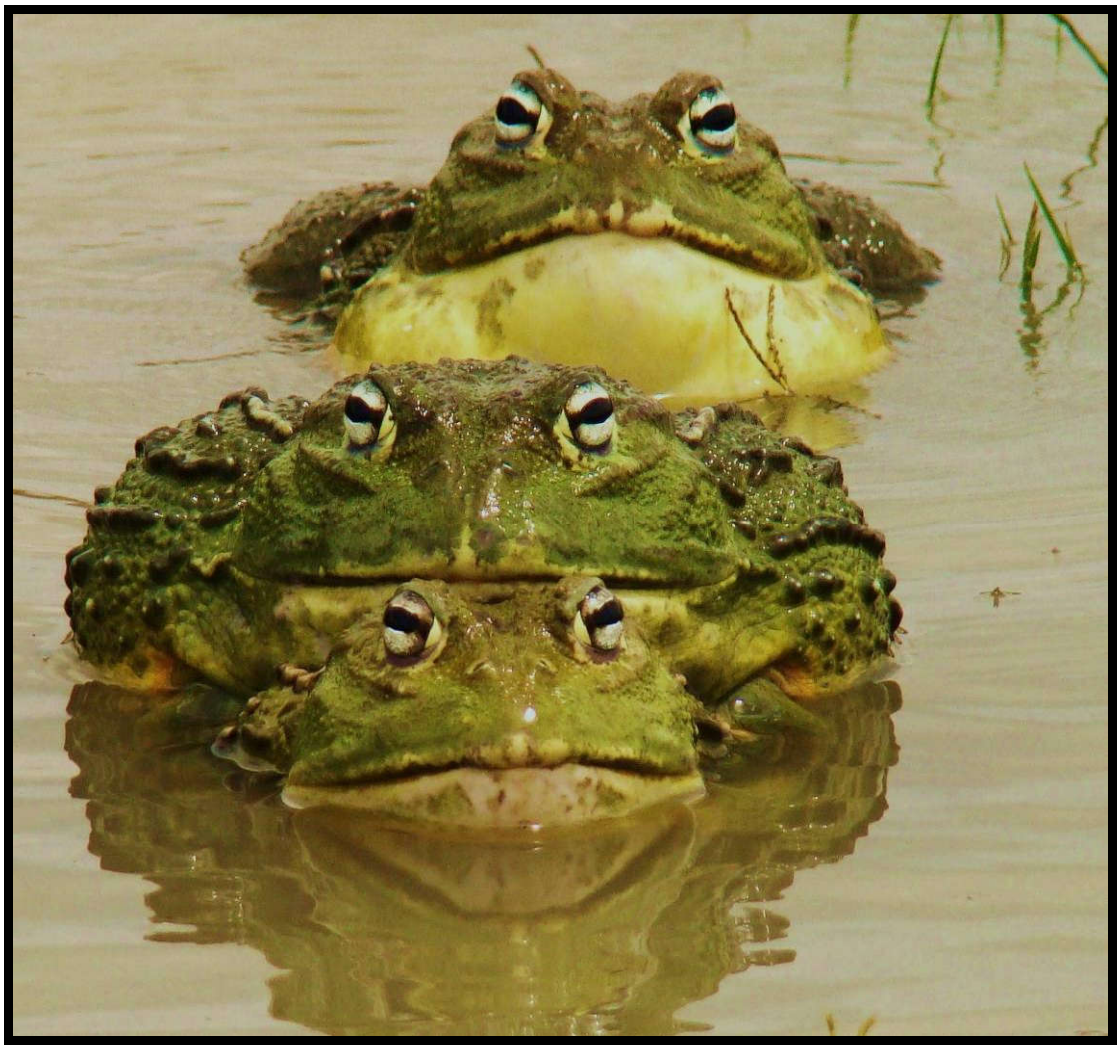

Figure 8. Giant Bullfrogs are extreme explosive breeders completing their short-duration breeding events usually within 10 hours. Bullfrog breeding activity is initiated by heavy downpours during the wet summer moths.

Bullfrogs have an extremely short breeding period which usually only lasts for a single day (10 hours or less). Giant Bullfrogs may breed more than once during a single wet season if climatic conditions (sufficient rainfall) are favourable. The eggs are laid in the males' territory and are guarded by the male against potential predators. Clutch sizes range between 2000-6000 eggs. The eggs develop quickly in the shallow warm water and tadpoles emerge after 48 hours. Adult male bullfrogs are known to remain with their tadpoles throughout their larval period (28-32 days). If the adult males are removed the tadpoles become extremely vulnerable to predation. Adult male bullfrogs also construct channels to allow cooler water to enter into the evaporating territories. These channels act as passages for the tadpoles to move into deeper sections of the pan.

Figure 9. Giant Bullfrog tadpoles form characteristic schools or aggregates within the shallow waters of selected breeding sites. Only other species of frog which form aggregates or schools are Red Toads *(Schismaderma carens*). Their tadpoles are usually found in deeper (>1m) reed invaded wetlands and are darker in colour and have a horse-shoe shaped skin fold from behind the eyes to the middle of the body.

Bullfrog tadpoles form characteristic schools or aggregates. The tadpoles are adapted to these harsh unpredictable seasonal habitats and develop quickly in the shallow nutrient rich warm water. Bullfrog tadpoles can tolerate extreme water temperatures of up to 40°C. When the seasonal ponds start drying up bullfrogs bury themselves backwards into the moist margins of the pans or migrate away from the pan to sandier soils. Bullfrog burrows may extend for well over a metre (Cook *et al*. 1996).

Figure 10. Typical Giant Bullfrog burrows within the moist well-drained sandy soils belonging to the Glenrosa Soil Form. Burrows depths vary between 30 cm up to a metre in depth depending on soil substrate. Bullfrogs may use the burrows of other faunal species including crabs and smaller rodents. Adult males and females show strong philopatric tendencies, i.e. they return to the same burrow throughout their lifetime unless they are physically prevented from doing so. This has important implications for conservation management (Yetman 2006).

Bullfrogs are opportunistic feeders and will prey upon any creature small enough to swallow including small mammals, birds, snakes, lizards even other frog species. Large invertebrates such as grasshoppers, millipedes and locusts form the majority of their staple diet. Bullfrogs feed intensively during the summer months to provide enough fat storage for their dormant period underground.

Our fragile ecosystem is ever increasingly being threatened by the onslaught of pesticides, fertilizers and pollutants, which in turn are killing the natural predators of problem animals such as grasshoppers, locusts, mosquitoes and rodents. A viable colony of bullfrogs will reduce the incidence of these pests. They are excellent bio-indicators for determining the condition of grasslands, as they are extremely sensitive to water quality and habitat integrity and will only reproduce successfully in suitable habitat (shallow seasonal pans or depressions). They require large areas of open grassland for foraging and migration. Bullfrogs have a potential pharmaceutical value as they have an incredibly effective fungicide protecting their injuries from bacterial infection.

Jacobsen (1982) reported that Giant Bullfrog numbers were declining in Gauteng, North West, Limpopo and Mpumalanga provinces, which at that time, formed part of the Transvaal Province. Boycott (2001) declared the species to be officially extinct in Swaziland. Harrison et. al. (2001) estimated that the area of its habitat and population sizes had declined by more than 50% over the past 100 years, particularly in regions subjected to extensive crop agriculture or urban and industrial development, such as Gauteng, Free State and North-West Provinces.

Major road networks bisect suitable breeding and foraging areas resulting in mass road fatalities of migrating adult and juvenile bullfrogs. Fences and walls also prevent the natural migration of adult and juveniles from foraging areas and suitable breeding sites (habitat fragmentation). Habitat deterioration due to changes in the seasonality of wetland sites (damming or increased surface run-off), deterioration of water quality due to pesticides and pollutants lead to the disappearance of bullfrog populations. Human predation of adult bullfrogs is another causal factor in population declines. This is especially prevalent in the rural parts of Southern Africa (Limpopo as well as in Gauteng/Hammanskraal). Bullfrogs are also caught illegally for the local and international pet industry.

The Giant Bullfrog is currently assigned as Least Concern globally and regionally as a lower risk '**near-threatened'** species (IUCN Red List category) (Minter *et al.* 2004). Giant Bullfrogs have been recorded around the Kimberley area during the South African Frog Atlas Project (SAFAP) conducted between 1996 until 2002 (Minter et al. 2004). More intensive long-term monitoring projects on viable Giant Bullfrog meta-populations are urgently required especially on a provincial level as well as in neighbouring countries.

4: RESULTS OF SPECIALIST GIANT BULLFROG HABITAT ASSESSMENT

Rainfall in Gauteng is extremely variable and concentrated between October and March. Rain falls most frequently in the form of heavy diurnal thunderstorms. Rainfall is important for amphibians in that it initiates activity and reproduction. Levels of amphibian activity are influenced by the intensity and duration of rainfall as well as temperature and humidity. Inadequate rainfall due to on-going El Nino weather system resulted in no amphibian breeding activity during site visit on the 17th of November 2018. No surface water within the western valley bottom wetland as well as seasonal pans on the eastern portion of the site.

Figure 11. The three ephemeral or seasonally inundated depressions on the eastern portion of the site provide the most suitable breeding habitat for the Giant Bullfrogs as well as the majority of frog species associated with the area. Bullfrogs require shallow seasonal standing wetland habitats (lothic) with little or no water movement/currents. Their tadpoles are not well adapted for flowing or lenthic water conditions. Marginally suitable breeding habitat occurs within the seasonal pools or depressions (old sand mining pits) as well as embanked areas on the southern boundary within the western valley bottom wetland or drainage line.

The well-defined life history pattern and specific habitat requirements of *P. adspersus* allows for easy identification of critical environmental requirements necessary to sustain populations. The following are critical habitat components for the species:

1. **Temporary pools or pans that are large enough to hold water for approximately a month**: Wetlands including seasonally inundated grassland, pans or depressions should be shallow, at least in part, because the adult males require a water depth of approximately 5 to 10 cm for calling and for territorial defence. Giant Bullfrogs have external fertilisation and therefore the water must be shallow enough to permit the considerably smaller females to lift her abdomen and cloaca out of the water (2-5cm). Wetlands should ideally be temporary, as permanent water attracts permanent predators and also prohibits the territorial male frogs from burrowing into the wetlands substrate for aestivation. Ideally, wetlands should hold water for about 30-35 days a year and filling of wetlands must be associated with heavy downpours. The seasonal pans on the eastern boundary should contain adequate surface water for more the 30 days required for tadpole development. It must be noted that the pans may be temporary in nature only filling during good rainfall years. Bullfrogs breed after the early heavy summer downpours when the pan collects surface rainwater as well as possible groundwater seepage.
2. **Breeding pans must be accessible to frogs**: At least a portion of the wetland or pan edge must be devoid of reed-beds and other bullfrog barriers. (e.g. *Phragmites australis, Arundo donax** and *Typha capensis* reed-beds can act as an impenetrable barrier, prohibiting *P. adspersus* gaining access to the water.) All of the ephemeral pans on and surrounding the site are easily accessible for Giant Bullfrogs and are surrounded by open Tsakane Clay grassland areas (to the east and south). The M43 to the west, R554 to the north and R23 to the east restricts the natural migratory movements of remaining Giant Bullfrogs to the east, west and the north. These roads with high vehicular traffic result in major road fatalities.

Figure 12. The sandy soils within the southern and central portions of the site provide suitable burrowing or aestivation habitat for adult and juvenile bullfrogs. Several animal burrows such as the Highveld Gerbil as well as colonies of Natal Multimammate Mouse were observed within the site. Giant Bullfrogs may use the abandoned burrows of animals including crab holes and rodent burrows.

3. **The substrate must be suitable for aestivation**: Adult as well as juvenile *P. adspersus* spend most of their time below ground in a torpid state. They dig their own burrows or utilise other animal burrows such as crabs or gerbils. Burrow depth varies according to soil type and may measure between 30cm to a metre in depth. Bullfrogs often bury themselves in the soft sand soils adjacent to secondary roads making them extremely vulnerable to scraping activities. The soils on the site are sandy to sandy loams with varying levels of moisture retention. These sandy soils are particularly suited for burrowing by Giant Bullfrogs for underground hibernation-aestivation during the dry, non-breeding season. Burrowing generally takes place some distance away from the breeding site with females travelling further to burrow. Certain larger territorial males may burrow within the clay soils within pan basins. The high clay content retards water loss from the cocooned frogs. Several animal burrows including Highveld Gerbils colonies of Natal Multimammate Mouse were observed on and surrounding the site. Burrowing generally takes place some distance away from the breeding site with females travelling further to burrow. Adult males and females show strong philopatric tendencies, i.e. they return to the same burrow throughout their lifetime unless they are physically prevented from doing so. This has important implications for conservation management (Yetman 2006).

Table 2. Distances of burrows from breeding sites according to Yetman (2006).

Distance from Breeding Site	Percentage of Population Tracked		
	♀	♂	**Total**
0 – 200 m	35 %	75 %	55 %
200 – 400 m	50 %	100 %	75 %
400 – 600 m	75 %	-	75 %
600 – 800 m	90 %	-	90 %
800 – 1000 m	95 %	-	95 %

Figure 13. The open Tsakane Clay grasslands surrounding the seasonal pans offer suitable foraging and dispersal habitat for remaining Giant Bullfrogs. Several large termite mounds were observed within the study site; especially where agricultural activities had ceased. The termite mounds increase in numbers towards the west and east of the seasonal pans.

4. **Frogs must have sufficient foraging areas**: Bullfrogs require large open grassland habitats in which the actively move in search of potential prey items. Bullfrogs may either actively search for food in surrounding grasslands or remain motionless and ambush prey. Adults are often found several kilometres (up to 2 km pers. obs.) from suitable breeding habitat migrating through open habitat searching for potential food. Bullfrogs are opportunistic predators and will consume insects, arachnids, reptiles, amphibians (cannibalistic, feeding on smaller Bullfrogs), birds and mammals. Generally, open grassland with termite mounds is the preferred habitat for foraging, and ideally, this should be adjacent to the breeding habitat. **The remaining open Tskane Clay grasslands offer suitable foraging areas for Giant Bullfrogs**. The pans on the eastern boundary of the site contain high densities of termite mounds. The number of termite mounds increase outside the temporary wet zones of the pans.

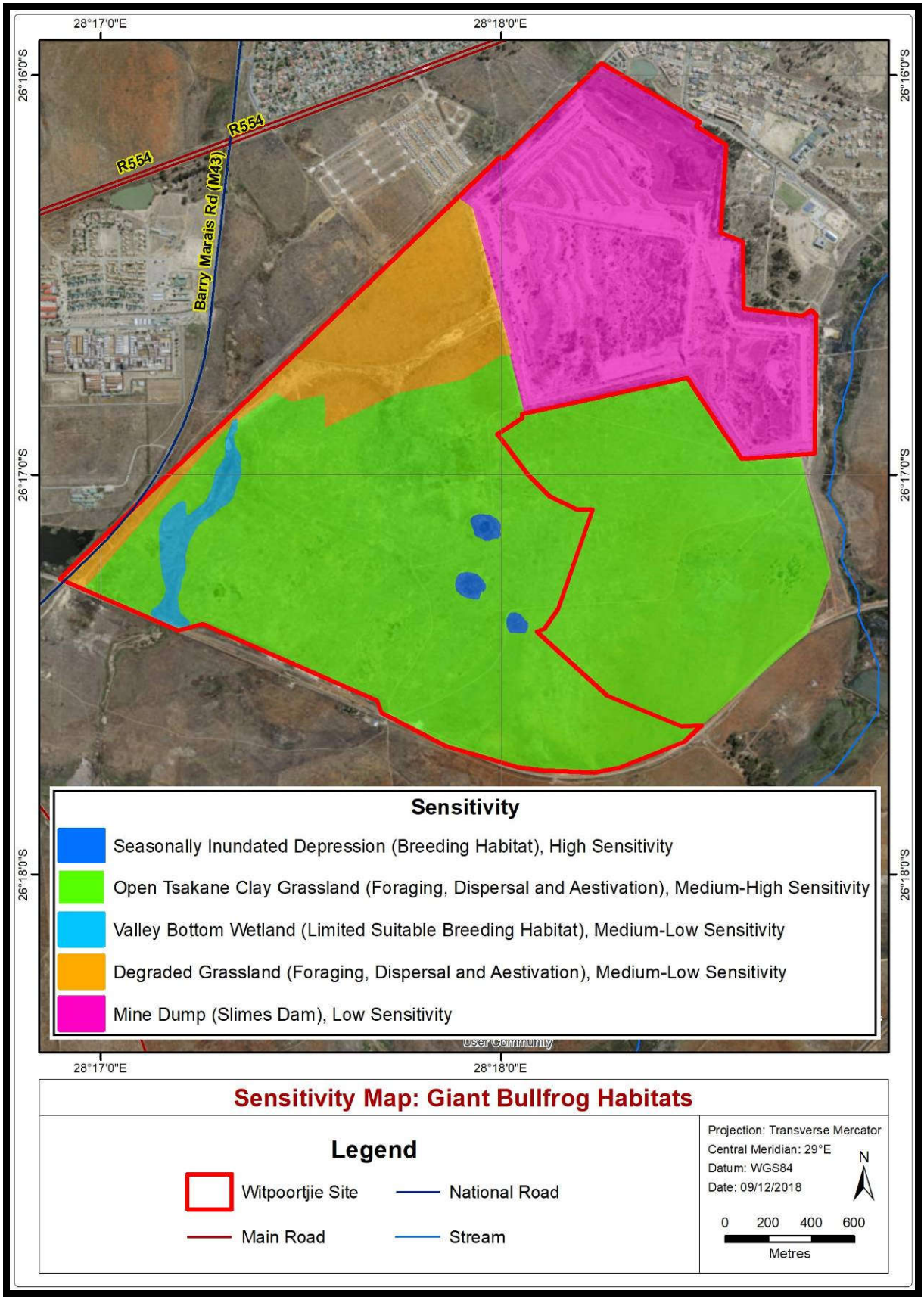

Figure 14: Preliminary sensitivity map for suitable Giant Bullfrog habitat occurring within the Witpoortjie site.

5. POTENTIAL IMPACTS ON THE GIANT BULLFROGS (*PYXICEPHALUS ADSPERSUS*)

Findings of the Giant Bullfrog habitat assessment indicate that suitable breeding habitat in the from of seasonally inundated depressions or pans occur for Giant Bullfrogs on the eastern portions of the site and suitable dispersal, foraging and burrowing (aestivation) habitat remains within the open Tsakane Clay grasslands around the pans. All remaining open Tsakane Clay Grassland must be assessed by a suitably qualified vegetation specialist. The conservation of remaining Giant Bullfrogs is directly correlated with the conservation of all remaining Tsakane Clay Grasslands and seasonally inundated wetlands within the study area. The conservation of the seasonal pans and the 50m buffer zone according to GDARD's biodiversity requirements for Giant Bullfrogs is totally inadequate to conserve the remaining Giant Bullfrogs on the site and adjacent areas. Bullfrogs require large open grassland areas to forage and burrow as well as for juveniles to disperse. The adult bullfrogs may bury themselves up to a kilometre from breeding sites and the juveniles have been observed migrating over six kilometres away from breeding sites (pers.obs.)

During the construction phase of the project environmentally sensitive practices must be implemented in order to reduce potential impacts on any Giant Bullfrogs occurring within the proposed development footprint on the site. Due to the large size of the site the implementation of a rescue and recovery programme within the open grasslands will not practical. A precautionary approach needs to be implemented during the vegetation clearances and soil excavations of the project. As a precautionary mitigation measure it is recommended that the developer and construction contractor as well as an independent environmental control officer should be made aware of the possible presence of certain threatened animal species (Giant Bullfrog) prior to the commencement of construction activities.

Environmentally sensitive management practices must implemented during construction activities preventing further erosion and habitat degradation. Timing of vegetation clearing operations should preferentially be undertaken during dry winter months minimizing potential disturbances to the seasonal pans and valley bottom wetland. During the construction phase habitat destruction will inevitably take place during the vegetation clearance and soil excavations. This will impact directly on the bullfrogs which have burrows or are aestivating in these areas.

Any Giant Bullfrogs that are unearthed in a state of torpor (dormant within a cocoon) should be kept individually in cooler boxes filled with moist vermiculite. The frogs must be kept in a cool room (<25°C) until the first heavy summer rains usually in October. The frogs should them be thoroughly wet with rainwater until they emerge from the cocoon and released in suitable habitat away from the construction site; such as around the pans. They should ideally be released in the evening after a rainfall event or emergence of winged termites (alates). If any Bullfrogs are injured they should be taken to a suitably qualified vet. Any dead specimens should be frozen and sent to a local museum or University of the North West (Prof. Louis Du Preez) and used for research purposes. A record should be kept by the ECO on number of injuries and fatalities.

It is imperative that the water quantity and quality is maintained within the seasonal or ephemeral pans. All of the pans on the site are ephemeral or seasonal and are only inundated after heavy rainfall events. The current hydro-periods must be maintained as Giant Bullfrogs breed in seasonally inundated wetlands with no permanent predators. The water quality of the pans must be ensured. Pollutants from the adjacent mine dump/slimes dam and any bulk-sewer lines in the area must not enter into any of the pans or groundwater system. Soil stockpiles must be sufficiently placed away from the drainage areas towards the valley bottom wetland and seasonal pans on the site.

Driving of vehicles in the adjacent open Tsakane Clay grasslands should be prevented and access of people should be controlled, both during the construction and operational phases. Speed limits should be restricted along all formal and informal access roads. In the highly unlikely event any adult or dispersing juvenile Giant Bullfrogs are observed dispersing along the open access roads they should be allowed to move freely and not run-over. Giant Bullfrogs usually disperse after heavy-rainfall in the late afternoon and evening.

Alien invasive and weedy plant species must be prevented from colonizing bare soil and eroded patches around the site and spreading throughout the site during the earth clearing and construction phases of the project.

The Giant Bullfrog is a protected frog species under the National Environmental Management: Biodiversity Act and the relevant permits must be applied for from the relevant authorities namely GDARD. No Giant Bullfrogs may be collected or captured without these permits. It will be the responsibility of the ECO to ensure that these permits are in place where necessary.

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GDARD's Minimum Requirements for Biodiversity Studies: Amphibians

Under C-Plan version 3 (latest version i.e. version 3.3), no specialist studies for any species of amphibian are requested for consideration in the review of a development application. The Giant Bullfrog (*Pyxicephalus adspersus*) has been removed following re-assessment of the species' status in South Africa. The species is not truly Near-Threatened in South Africa (no quantitative analysis of the Giant Bullfrog distribution against the IUCN criteria can consider them as such) and the most recent evaluation of the status of the Giant Bullfrog in December 2009 did not consider the species sufficiently threatened to be listed as Near Threatened (G. Masterson pers. comm. with Prof. Louis du Preez)[*].

Given the current objectives of Gauteng's C-plan i.e. to be used to protect representative habitat and generate specialist studies for threatened faunal species, the Giant Bullfrog does not qualify for inclusion as a species-specific layer requiring specialist assessments. As per the C-Plan approach, the conservation of the Giant Bullfrog and of amphibians in general will be met by the protected area network as well as the designation of priority habitats i.e., pans or quaternary catchments, with associated restrictions on land use (refer to "Wetlands" section).

The wetland and a protective buffer zone, beginning from the outer edge of the wetland temporary zone, must be designated as sensitive (GDARD Requirements for Biodiversity Assessments: Version 2; 2012). The current buffer zones around wetlands (30m for wetlands occurring inside urban areas and 50m for wetlands occurring outside urban areas) are totally in adequate to conserve core terrestrial habitat for the majority of frog species occurring in Gauteng Province; especially the Giant Bullfrog which requires large open areas to forage in. The proposed development of the open Tsakane Clay grasslands which dominate the site will have a **medium-high, short-long term impact** on the relic populations remaining on the site and adjacent areas.

[*] It is the opinion of the specialist consultant that dramatic population declines have occurred within Gauteng Province over the past 25 years and Giant Bullfrogs are worthy of conservation efforts.

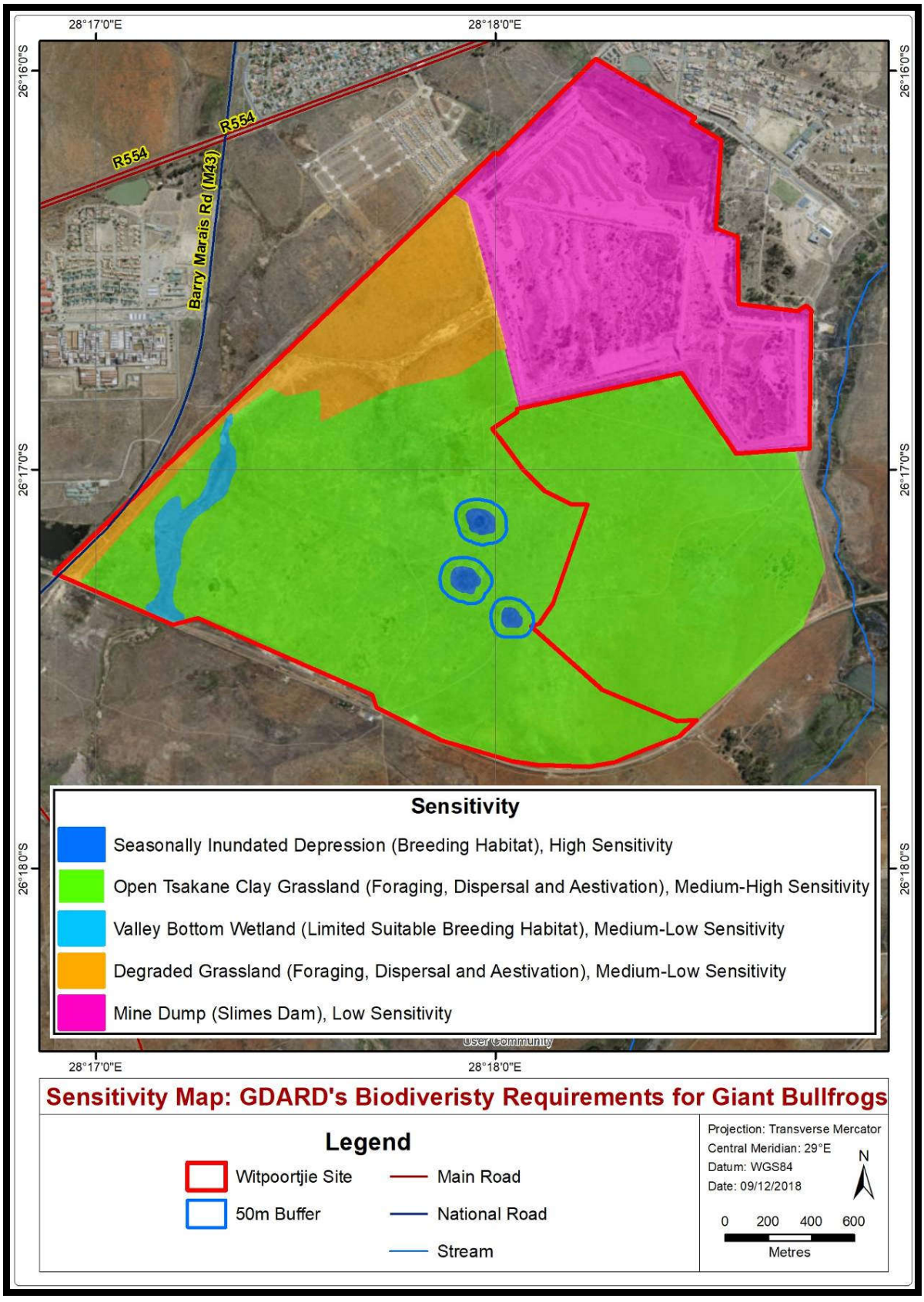

Figure15. GDARD's Biodiveristy requirements for Giant Bullfrogs require the conservation of the seasonal pans as well as a 50 m grassland buffer (outside the urban edge). **The open Tsakane Clay grassland and wetland areas must be assessed and delineated by suitably qualified vegetation and wetland specialists**.

6: GIANT BULLFROG MITIGATORY MEASURES FOR THE CONSTRUCTION ACTIVITIES

TABLE 3: Mitigatory measures to be implemented into the EMP.

Objectives	Management Action (What, Where and How)	Responsibility for Implementation (Who?)	Time Period for Implementation (WHEN?)	Frequency (HOW OFTEN?)	Performance Based Outcomes
ENVIRONMENTAL AWARENESS AND TRAINING					
To ensure that the Giant Bullfrog mitigatory measures are implemented throughout the construction phase.	Appoint a suitably qualified ECO with a minimum of a BSc. Honours who is aware of the Giant Bullfrog's ecology.	Contractor	Pre-Construction	ECO should be present on the site during vegetation clearance and soil excavations.	**Impacts on the Giant Bullfrogs as well as other faunal species occurring within the site are kept to a minimum.**

To ensure that all members of the workforce are aware of the possible presence of Giant Bullfrogs and the sensitivities of the adjacent suitable breeding habitats	All members of the construction workforce especially the bulldozer and excavator operators are to undergo an environmental induction pertaining to the possible presence of Giant Bullfrogs) within the identified suitable Giant Bullfrog habitat (open grasslands and seasonal pans). A procedure for relocation of Giant Bullfrog and other faunal species must be explained. A clear laminated A4 photograph displaying an adult male Giant Bullfrog and juvenile should be suitably positioned within the construction camp as well as construction areas.	ECO	Pre-construction phase or site establishment.	As required	**The seasonal pans as well as proposed 50m grassland buffer zones are adequately fenced-off prior to construction activities. All members of the construction workforce are able to identify an adult and juvenile Giant Bullfrog and are aware of the procedures to follow if a Giant bullfrog is observed alive/injured or dead within the site.**

PROTECTION OF GIANT BULLFROG HABITAT					
To ensure that impact on natural vegetation is kept to a minimum. This will ensure conservation of suitable foraging habitat.	No disturbance to natural grassland vegetation adjacent to the ephemeral pans which have large numbers of termite mounds.	Contractor as well as ECO	On commencement of construction	At all times	**No disturbance to areas of natural vegetation as well as termite mounds outside of the construction footprint.**
To prevent establishment of alien vegetation	Re-seeding of cleared areas adjacent to the towers. Indigenous (to the area) grassland vegetation must be used. Vegetation establishment must be monitored by ECO and alien plants cleared from the servitude.	Contractor	On commencement of construction	At all times	**The implementation of a successful alien vegetation removal programme. No further alien vegetation invasion within the seasonal pans and buffer zones. Invaded areas are appropriately rehabilitated/re-vegetated with indigenous (to the area) vegetation.**

To ensure that impact on Giant Bullfrogs is kept to a minimum	Any dormant Bullfrogs recovered (highly unlikely) must be released in suitable habitat away from the construction areas. Dormant bullfrogs should be stored in a cooler box filled with moist vermiculite and released after the first summer rains.	Contractor and ECO	Prior to construction activities within suitable burrowing habitats	During the construction phase of the project	**The successful rescue and recovery of any dormant bullfrogs adjacent to suitable breeding habitat as well as other burrowing faunal species and the release of any rescued fauna in suitable habitat away from the construction areas.**
To ensure that connectivity between suitable Giant Bullfrog breeding habitat and foraging, aestivation and dispersal habitat is maintained around the site.	A migratory palisade fence (minimum 15cm gap) should be erected adjacent to the seasonal pans as well as valley bottom wetland allowing for the movements of adult and juvenile Bullfrogs to and away from the site and the adjacent seasonal pans and open grasslands.	Contractor	Prior to construction activities within suitable Giant Bullfrog foraging and dispersal habitats	At all times	**The natural migratory or dispersal areas for adult and juvenile bullfrogs are maintained between the site and the pans to the south and east of the site. The fence however will restrict access of motor vehicles, livestock, people and dogs onto the site which is a potential positive**

					impact for remaining Giant Bullfrogs.
To treat any injured Giant Bullfrogs and collection of dead specimens for museums.	Records of Giant bullfrog injuries or deaths within construction servitude must be kept by the ECO. Any injured Giant Bullfrogs must be treated appropriately by a suitably qualified vet and any dead individuals must be preserved and sent to the nearest museum. Any severely injured frogs must be humanely euthanized.	ECO and Contractor	During all phases of the project	During all phases of the project	**The successful treatment of any injured frogs as well as number of fatalities and provision of museum specimens for research such as genetic work, diets, age determination etc.**
To prevent possible disturbances to Giant bullfrog breeding activities.	Preventing the unnecessary disturbances of the breeding activity of the Giant Bullfrog.	Contractor and ECO	Throughout breeding period (November-March)	During all phases of the project	**No disturbances to the short-duration breeding events of any Giant Bullfrogs adjacent to the construction site as well as their associated tadpoles and any emerging juveniles.**

To prevent habitat degradation/deterioration of suitable Giant Bullfrog breeding habitats	Soil stockpiles must not be placed in water flow paths or seepage areas. Disturbed areas are to be rehabilitated as soon as possible. The use of the top-soil containing the seeds and roots of indigenous (to the area) grasses must be used (see attached list).	Contractor and ECO	Prior to and during construction activities	During all phases of the project	**No increased levels of siltation and sedimentation within seasonal pans and valley bottom wetland habitats and the appropriate re-vegetation of disturbed areas within the 50m buffer zones.**
To prevent alteration of the hydro-period or seasonality of the pans.	Stormwater runoff from the servitude will drain within the deep sandy soils. No impact on adjacent seasonal pans. The adjacent seasonal pans are situated within fenced-off private properties which restricts access.	Contractor	During the construction phase of the project especially during the Giant Bullfrog breeding period between November and March	Throughout all stages of the project	**No alteration to the hydrological regimes or seasonality of the pans. Pans remain ephemeral with no impact from the adjacent alteration of catchment area.**

To ensure that the there is no deterioration in water quality within the pans	No pollutants associated with the construction of the site must enter into the pans or groundwater. The poorly vegetated slimes dam/mine dump should be appropriately rehabilitated. Vehicles must be regularly checked for oil or hydraulic leaks during the construction phase. Areas where fuels are either kept or transferred will need to be bunded so as to contain spillage. Cement mixing sites will also need to be strategically designated and at least 100m away from the wetland areas. Ablution facilities must be provided to prevent workers urinating or defecating in the open grasslands.	Contractor	At all times	At all times	**No pollution of the pans and maintenance of present water quality. Water quality should be monitored during the construction phase as well as at least once annually during the operational phase of the project.**

To prevent unnecessary road fatalities of Giant Bullfrogs on newly established access roads	Speed limits (maximum 20 km) and/or traffic calming measures should be implemented within all internal access roads within the site.	Contractor/Client	During construction phase as well as operational phase	Through all stages of project	**No increased road fatalities of adult or juvenile bullfrogs which often migrate along open roads.**
To maintain a natural fire regime for the open grasslands	No open fires allowed on the construction site. A natural fire regime needs to be implemented for all conserved open grasslands. The fire regime should be determined by a suitably qualified grassland specialist/ecologist.	Contractor/Client	Through all stages of project	Operational Phase	**No unnatural fires within the open grasslands areas.**

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8. APPENDIX

Table3. Grass species recommended for the rehabilitation. Species with ☺ occur naturally within the area and should ideally only be used for rehabilitation purposes. Seed can be harvested from the adjacent grassland areas or alternatively top-soil removed from the adjacent grassland areas should be used.

BOTANICAL NAME	COMMON NAME	GROWTH	DROUGHT	FROST	SOILS	DESCRIPTION	MISCELLANEOUS
☺ *Andropogon eucomus*	Snowflake grass	*	*	*	Wet areas, Heavy clay (ouklip)	Densely tufted, upright, stemmy perennial	Indicator of poorly drained soils. Very important for stabilizing disturbed moist soil.
☺ *Aristida congesta*	Spreading Three-awn	*	*	*	All types of soil, but mostly in loam soil	A weak perennial tufted grass	Hardy grass which can effectively stabilizing disturbed area
☺ *Bothriochloa bladhii*	Purple-Plumed grass	*	*	*	All types of soil	Robust perennial forming large tufts	Occurs where water accumulates
☺*Brachiaria serrata*	Velvet signal grass		**			Loosely tufted perennial	
Bromus willdenowii	Rescue grass			*	Well drained soils	Winter growing perennial	
☺ *Chloris gayana*	Rhodes grass	*	*	*	Loam	Tufted, stoloniferous perennial	Good for stabilizing disturbed soils.
Cymbopogon validus	Giant turpentine grass					Robust, tufted perennial	
☺*Cynodon dactylon*	Couch grass	*	*	**	Sandy	Variable, creeping perennial	
☺*Digitaria eriantha*	Smuts finger grass		**			Robust, tufted perennial	
Digitaria swazilandensis	Richmond finger-grass		**	**	All soils	Perennial with creeping rhizomes	Easily affected by drought and cold
Echinochloa crus galli	Barnyard millet		**		Moist, well-drained	Tufted annual	Fully grown in 6 - 8 weeks
☺*Eragrostis*	Heartseed	*	**		Shallow	Loosely tufted	

capensis	love grass					perennial	
☺*Eragrostis curvula*	Weeping Love Grass	*	*	*	Well-drained fertile soils	Tufted, variable perennial	Most important cultivated pasture and easy to establish
☺*Eragrostis plana*	Fan love grass				Compact soils	Densely tufted perennial	Occurs on abandoned, arable lands
Hemarthria altissima	Red swamp grass				Wet soils	Perennial, underground rhizomes	Good soil binder, hardy
☺*Imperata cylindrica*	Cotton wool grass	*	*	*		Perennial, underground runners	
☺ *Ischaemum fasciculatum*	Hippo grass	*	*	*	Heavy clays and often found in flowing water	Perennial with creeping rhizomes	Average grazing grass utilised for thatching in Mozambique
☺*Leersia hexandra*	Wild rice grass	*	*	*		Perennial, long underground stems	
☺ *Loudetia simplex*	Common Russet Grass	*	*	*	Poor, coarse sandy soil	Perennial tufted grass with creeping stolons	
Miscanthidium capense	East coast broom grass		**			Robust perennial	Good firebreak
☺*Monocymbium ceresiiforme*	Wild oat grass	*	*	*	Leached soils	Loosely tufted perennial	Indicator of acid soils
Paspalum dilatatum	Common Paspalum		*	*	Moist soils	Tufted perennial	Lack of consistently good seed
Paspalum notatum	Lawn Paspalum	**		**	Moist, fertile soil	Sod-forming perennial	Aggressive invader
Paspalum urvillei	Giant Paspalum	**		*	Wet soils	Tall, tufted, upright perennial	Invades naturally
Poa annua	Annual bluegrass	**	**		Waterlogged soils	Small, bright green annual	Weed throughout the world.
Setaria megaphylla	Broadleaf Setaria				Waterlogged soils	Robust perennial	Found in shade
☺ *Sporobolus africanus*	Ratstail Dropseed		*	*	Moist soils	Perennial Tufted	Found in compacted soils

Stenotaphrum dimidiatum	St Augustine grass	*					
Stenotaphrum aconitum	Coastal buffalo grass				Sandy	Creeping perennial, extensive runner	Persisting under hard conditions
☺ *Themeda triandra*	Red Grass	*	*	*	Any type of soils, but mostly clay	Perennial Tufted	Most important grazing grass in SA
☺ *Trachypogon spicatus*	Giant Spear Grass	*	*	*	Sandy and Gravely soils	Dense, leafy tufted grass	Important role in protection of soil from erosion in high rainfall areas
☺ *Tristachya leucothrix*	Hairy Trident Grass	*	*	*	Sandy Soil in marshy places	Dense perennial tufted grass	Reasonable leaf production which sheep are particularly fond of.

* Good Characteristic

** Bad Characteristic