Annexure G.4: Palaeontological Impact Assessment

Palaeontological Impact Assessment for the proposed upgrade of the Leeuwkuil Waste Water Treatment Works for Sebokeng, Vereeniging and Vanderbijlpark, Gauteng Province

Desktop Study (Phase 1)

For

Beyond Heritage

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Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf
Experience: 33 years research and lecturing in Palaeontology
25 years PIA studies and over 300 projects completed

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Beyond Heritage, Modimolle, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A Palaeontological Impact Assessment was requested for the proposed upgrade of the Leeuwkuil Waste Water Treatment Works for Sebokeng, Vereeniging and Vanderbijlpark by the Emfuleni Local Municipality, Gauteng.

To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The western catchment area lies on the moderately sensitive Quaternary sands and alluvium while the eastern catchment lies on the very highly sensitive Vryheid Formation (Ecca Group, Karoo Supergroup). Fossils were collected from the Leeuwkuil quarries along the northern bank of the Vaal River, more than a century ago but the site has since been filled and developed so no more fossils were found. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the contractor, environmental officer or other designated responsible person once excavations, drilling or mining activities have commenced. Since the impact will be low, as far as the palaeontology is concerned, the project should be authorised.

Summary of impact:
Leeuwkuil – very low to low – removal of fossils if found is required

Cumulative Impact: very low to low – removal of fossils if found is required

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1. Background

GIBB Environmental (Pty) Ltd has been appointed as the independent Environmental Assessment Practitioner by GIBB (Pty) Ltd on behalf of the Emfuleni Local Municipality (ELM) to undertake two (2) application processes for Environmental Authorisation, subject to Basic Assessment processes as part of the Sedibeng Regional Sanitation Scheme (SRSS) project. The SRSS project aims to create bulk sanitation capacity in the Sedibeng region, deliver effective solutions to prevent pollution of water resources and unlock development projects that require sanitation services within the Emfuleni and Midvaal Municipal areas including the Sebokeng, Vanderbijlpark, Vereeniging and Meyerton sewage catchments.

The two projects are:

1. The proposed upgrade of the Leeuwkuil Wastewater Treatment conveyances; and
2. The proposed upgrade of the Rietspruit Wastewater Treatment Works facility with associated conveyances.

Both projects are located within the ELM, Gauteng Province.

Leeuwkuil project description:
Approximately 32 km of sewage pipeline conveyances will be upgraded which will improve sludge management at the Leeuwkuil Waste Water Treatment Works (WWTW) and cater for future planned developments. This will accommodate sewage flows from the south Sebokeng catchment, Vereeniging catchment and Vanderbijlpark catchment to cater for the future planned development. The intention of the integration of the Vereeniging and Vanderbijlpark catchment is to create flexibility in the sewage system for both catchments, to allow for transfer of sewage from Vanderbijlpark catchment to the regional Rietspruit WWTW.

Rietspruit project description:
A total treatment capacity of 104 Mℓ/day is required by 2035 for the South Emfuleni catchment. Parts of the South Emfuleni catchment drains to Rietspruit WWTW and Leeuwkuil WWTW. The Rietspruit WWTW currently comprises a 20 Mℓ/day Biological Nutrient Removal Activated Sludge Plant and a 16 Mℓ/day Biofilter Plant. Future planning for the catchment has allowed for the decommissioning of the 16 Mℓ/day Biofilter Plant at Rietspruit WWTW and the existing 20 Mℓ/day BNRAS plant is to be upgraded to a regional works with a total capacity of 70 Mℓ/day.

ELM therefore intends to increase the Rietspruit WWTW capacity with an additional 70 Mℓ/day per day and construction of sewerage pipeline conveyances for approximately 51 km in length, which will improve sludge management at the plant and cater for future planned developments. This will accommodate sewage flows from the south Sebokeng catchment, Vereeniging catchment and Vanderbijlpark catchment to cater for the future planned development. The intention of the integration of the Vereeniging and Vanderbijlpark catchment is to create flexibility in the sewerage system for both catchments, to allow for transfer of sewage from Vanderbijlpark catchment to the regional Rietspruit WWTW.

This report is for the **Leeuwkuil** Waste Water Treatment project.

A Palaeontological Impact Assessment was requested for the Leeuwkuil Waste Water Treatment project. To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

Table 1: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report,	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Section 8, Appendix A

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Sections 6, 8
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
p	A summary and copies of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

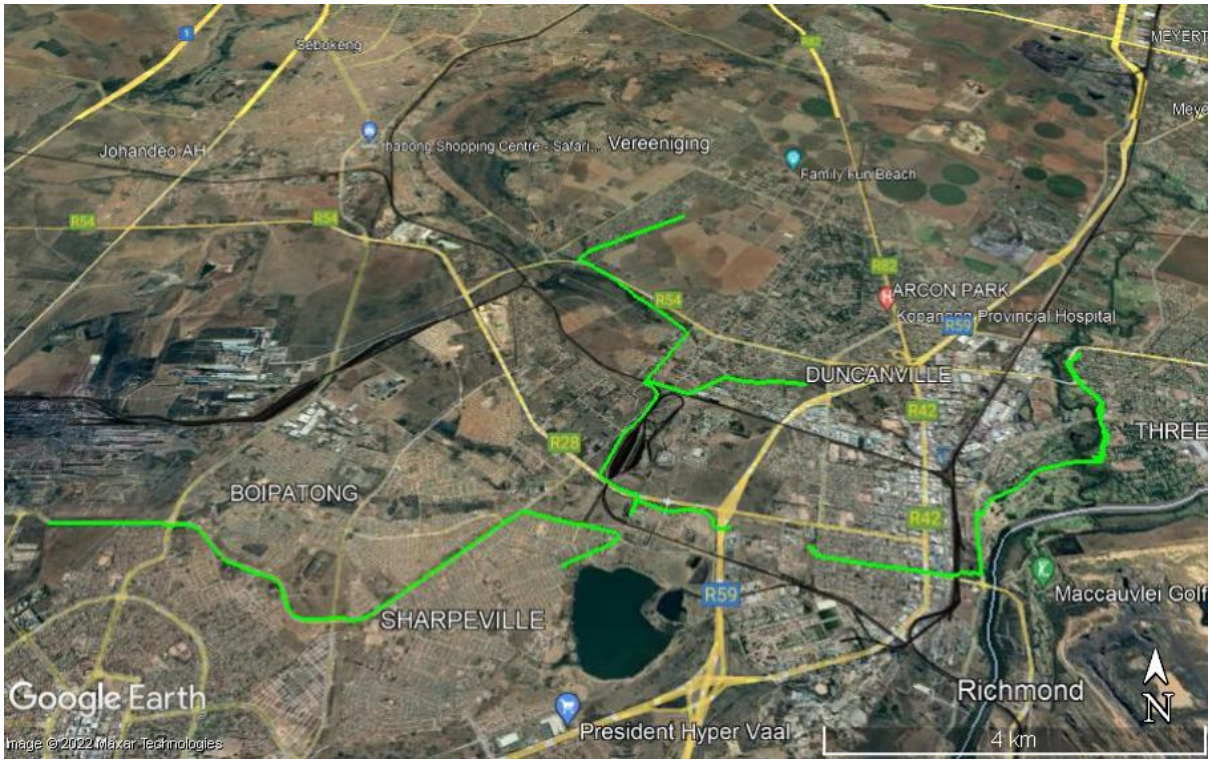

Figure 1: Google Earth map of the general area to show the relative landmarks. The green lines show the main-centre line for the Leeuwkuil conveyances.

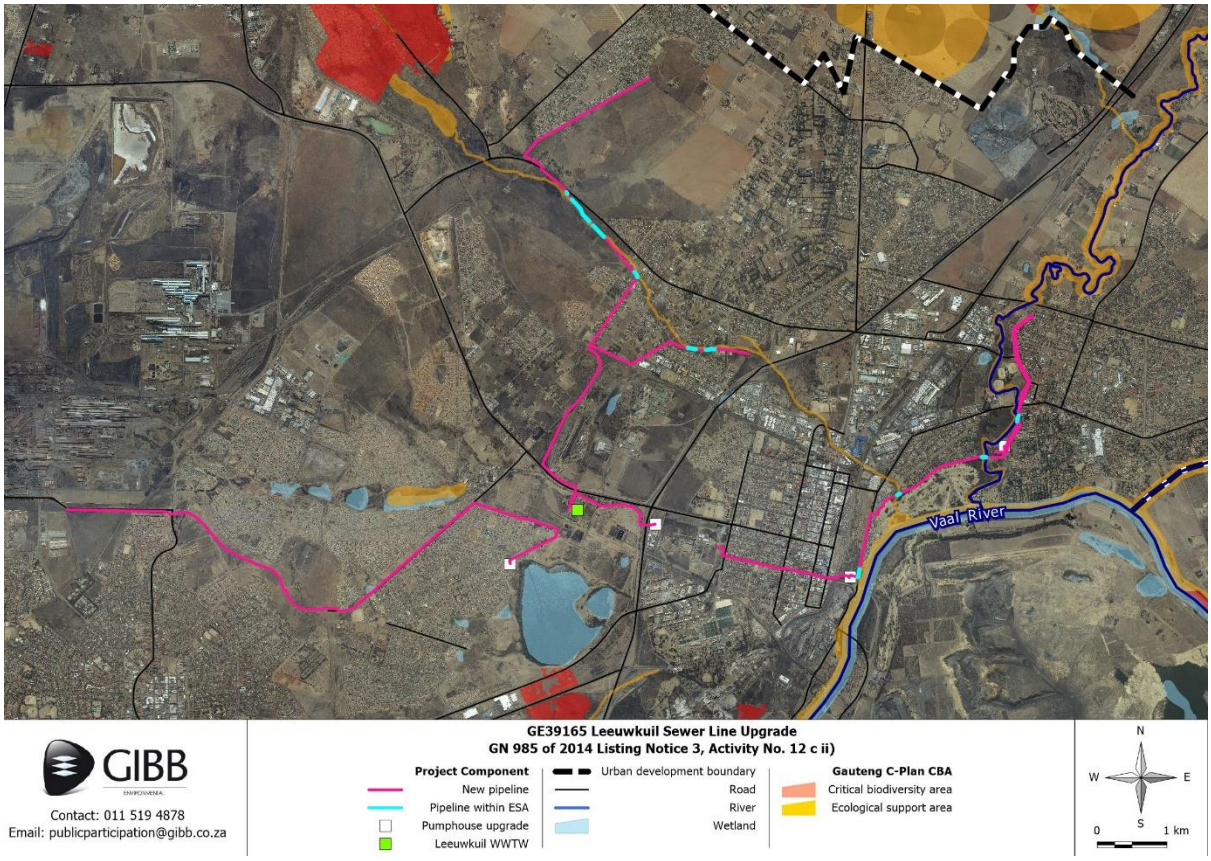

Figure 2: Google Earth Map of the proposed activities for the upgrade of the Leeuwkuil conveyances. Map supplied by GIBB Environmental.

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.
The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources include records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

i. Project location and geological context

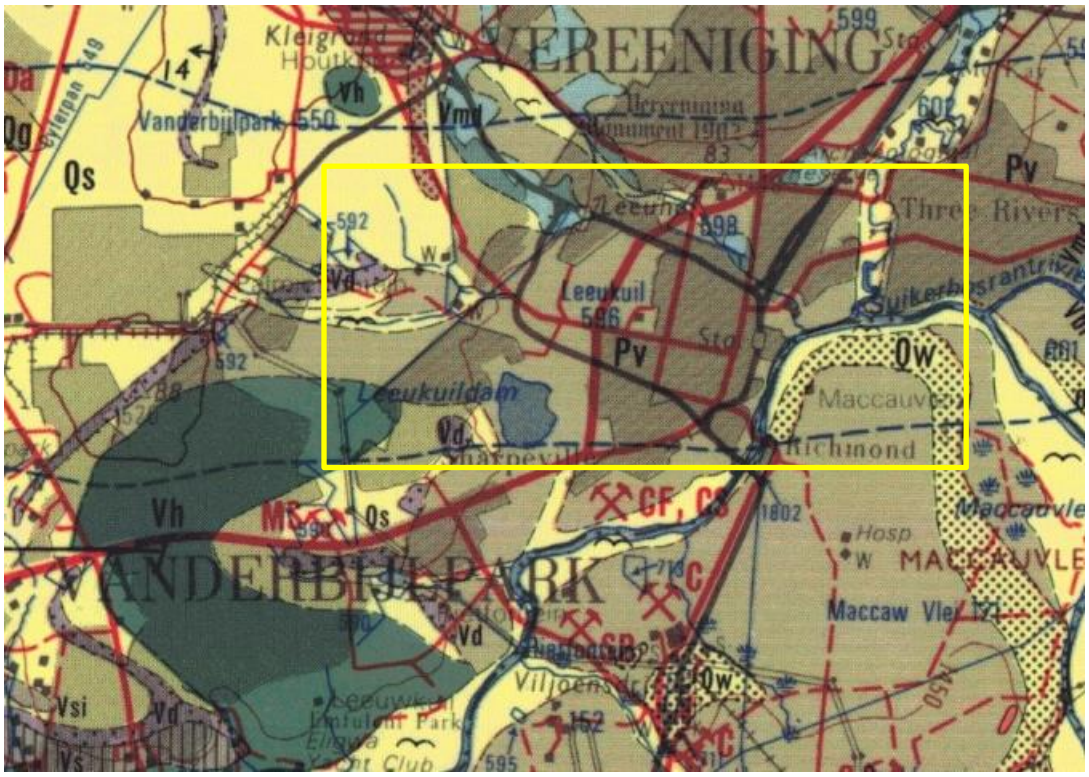

Figure 3: Geological map of the area around Sebokeng, Vereeniging and Vanderbijlpark. The location of the proposed project is indicated within the yellow rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2626 West Rand.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006; Johnson et al., 2006; Zeh et al., 2020). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Qs	Quaternary	Alluvium, sand, surface soils	Neogene, ca 1 Ma to present
Qw	Quaternary	Aeolian sand	Neogene, ca 1 Ma to present
Qg	Quaternary	Gravel, diamondiferous in places	Neogene, ca 1 Ma to present
Pv	Vryheid Fm, Ecca Group, Karoo SG	Shales, sandstone, coal	Early Permian, Middle Ecca
Vsi	Silverton Fm, Pretoria Group, Transvaal SG	Shale, interbedded quartzite, hornfels, limestone	Palaeoproterozoic Ca 2250 -2200 Ma
Vd	Daspoort Fm, Pretoria Group, Transvaal SG	Quartzite, shale, ferruginous in places	Palaeoproterozoic Ca 2250 Ma

Symbol	Group/Formation	Lithology	Approximate Age
Vh	Hekpoort Fm, Pretoria Group, Transvaal SG	Andesite, agglomerate, tuff	Palaeoproterozoic Ca 2224 Ma
Vmd	Malmani Subgroup, Chuniespoort Group, Transvaal SG	Dolomite, chert	Palaeoproterozoic Ca 2580 Ma

The project lies in the southern part of the Kaapvaal Craton and the Transvaal Basin that has the Transvaal sequence. It is unconformably overlain by the sediments of the Karoo Supergroup and much younger Quaternary sands and alluvium.

The Late Archaean to early Proterozoic Transvaal Supergroup is preserved in three structural basins on the Kaapvaal Craton (Eriksson et al., 2006). In South Africa are the Transvaal and Griqualand West Basins, and the Kanye Basin is in southern Botswana. The Griqualand West Basin is divided into the Ghaap Plateau sub-basin and the Prieska sub-basin. The Transvaal Supergroup comprises one of world's earliest carbonate platform successions (Beukes, 1987; Eriksson et al., 2006; Zeh et al., 2020). In some areas there are well preserved stromatolites that are evidence of the photosynthetic activity of blue green bacteria and green algae. These microbes formed colonies in warm, shallow seas.

In the Transvaal Basin the Transvaal Supergroup is divided into two Groups, the lower Chuniespoort Group and the upper Pretoria Group (with ten formations; Eriksson et al., 2006). The Chuniespoort Group is divided into the basal **Malmani Subgroup** that comprises dolomites and limestones and is divided into five formations based on chert content, stromatolitic morphology, intercalated shales and erosion surfaces. The top of the Chuniespoort Group has the Penge Formation and the Duitschland Formation.

Making up the lower Pretoria Group. The **Hekpoort Formation** is a massive lava deposit and is overlain by the Dwaalheuwel conglomerates, siltstone and sandstone (not present here). A hiatus separates the Strubenskop Formation slates and shales from the overlying quartzites of the **Daspoort Formation**. Upper Pretoria Group formations are the Silverton, Magaliesberg, Vermont, Lakenvalei, Nederhorst, Steenkampsberg and Houtenbek Formations

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 – 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

During the Carboniferous Period South Africa was part of the huge continental landmass known as Gondwanaland and it was positioned over the South Pole. As a result, there were several ice sheets that formed and melted, and covered most of South Africa (Visser, 1986, 1989; Isbell et al., 2012). Gradual melting of the ice as the continental mass moved northwards and the earth warmed, formed fine-grained sediments in the large inland sea. These are the oldest rocks in the system and are exposed around the outer part of the ancient Karoo Basin, and are known as the Dwyka Group. They

comprise tillites, diamictites, mudstones, siltstones and sandstones that were deposited as the basin filled (Johnson et al., 2006).

Overlying the Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group but they do not all extend throughout the Karoo Basin. In southern Gauteng, the Free State and KwaZulu Natal, from the base upwards are the Pietermaritzburg Formation, **Vryheid Formation** and the Volksrust Formation. All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep water settings, deltas, rivers, streams and overbank depositional environments.

Recent weathering and erosion have resulted in the deposition of much younger sands, soils and alluvium, particularly in low-lying catchments and long river valleys. These sediments are of **Quaternary** age.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The eastern site for development is in the Vryheid Formation that might preserve fossils plants of the *Glossopteris* flora (Plumstead, 1969; Anderson and Anderson, 1985).

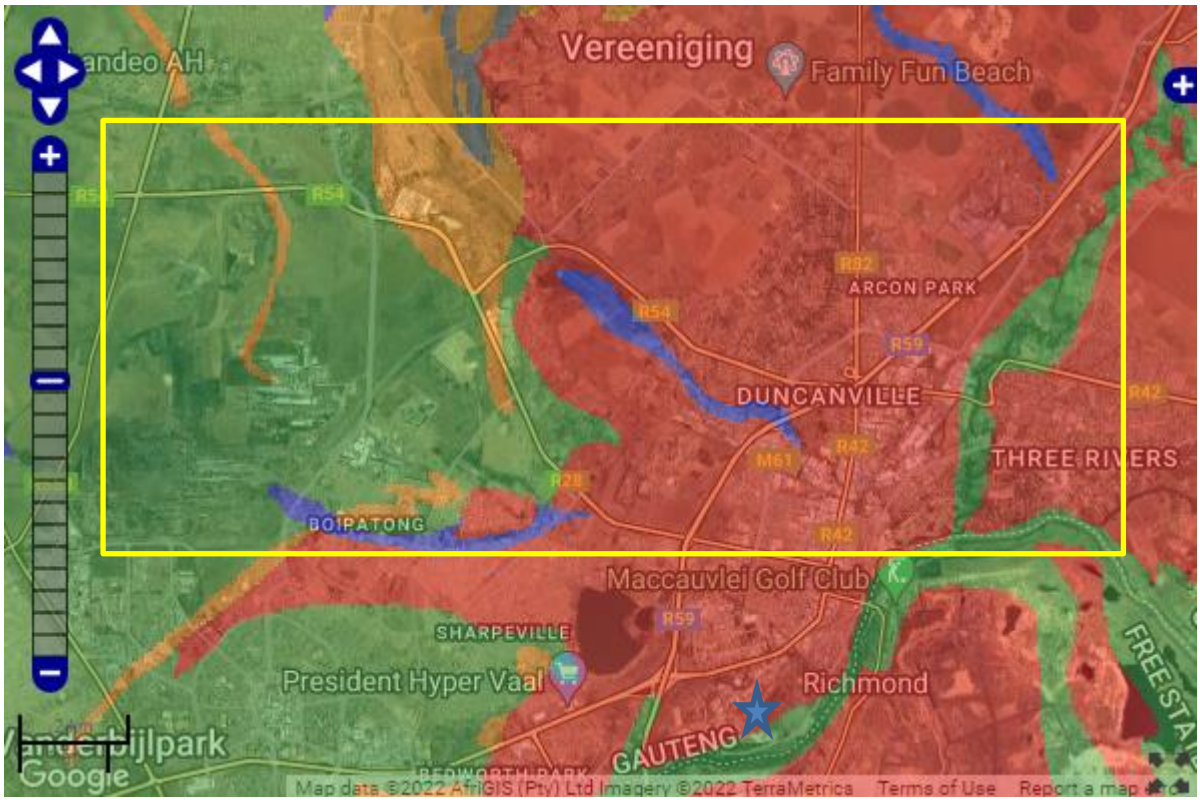

Figure 4: SAHRIS palaeosensitivity map for the area of the proposed upgrade of the Leeuwkuil conveyances water project shown within the yellow rectangle. Blue star = old Leeuwkuil Quarry. Background colours indicate the following degrees of sensitivity: red

= very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Fossils were collected by early geologists and road engineers from the sandstone and shale quarries alongside the Vaal River in the Vereeniging area. For example, Stow in 1879 and Leslie from 1892-1904, found *Glossopteris* and *Vertebraria*. A diverse flora was collected by Leslie, Le Roux and later Plumstead (overviews in Plumstead, 1969; Anderson and Anderson, 1985). The fossils are housed in the Palaeobotany Collection in the Evolutionary Studies Institute, University of the Witwatersrand. In 2002 Bamford, Adendorff and Richter revisited the sites but the quarries no longer exist and the area has become densely populated. We were unable to find a single fossil.

From the SAHRIS map above the eastern half of the Leeuwkuil catchment area is indicated as very highly sensitive (red) for the Vryheid Formation, while the western part is moderately sensitive (green) for the Quaternary sands. It should be noted, however, that the pipelines are along highly disturbed routes with roads, infrastructure and urban development.

4. Impact assessment

Since the potential impact on the palaeontology is on the ground only, i.e. the footprint and not the structure above ground, all the infrastructures can be treated the same in the assessment table.

Table 3A: Impact Assessment Criteria

Criteria	Rating Scales	Notes
Nature	Positive	An evaluation of the effect of the impact related to the proposed development
	Negative	
Extent	Footprint	The extent of the impact is rated as footprint as it only affects the area in which the proposed activity will occur
	Site	The extent of the impact is rated as site as it will affect only the development area
	Local	The extent of the impact is rated as Local as it affects the development area and adjacent properties
	Regional	The extent of the impact is rated as Regional as the effects of the impact extends beyond municipal boundaries
	National	The extent of the impact is rated as National as the effects of the impact extends beyond more than 2 regional/ provincial boundaries
	International	The extent of the impact is rated as International as the effect of the impact extends beyond country borders

Criteria	Rating Scales	Notes
Duration	Temporary	The duration of the activity associated with the impact will last 0-6 months and as such is rated as Temporary
	Short term	The duration of the activity associated with the impact will last 6-18 months and as such is rated as Short term
	Medium term	The duration of the activity associated with the impact will last 18 months-5 years and as such is rated as Medium term
	Long term	The duration of the activity associated with the impact will last more than 5 years and as such is rated as Long Term
Severity	High negative	The severity of the impact is rated as High negative as the natural, cultural or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease; and valued, important, sensitive or vulnerable systems or communities are substantially affected.
	Moderate negative	The severity of the impact is rated as Moderate negative as the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive or vulnerable systems or communities are negatively affected
	Low negative	The severity of the impact is rated as Low negative as the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected
	Low positive	The severity of the impact is rated as Low positive as the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally improved
	Moderate positive	The severity of the impact is rated as Moderate positive as the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive or vulnerable systems or communities are positively affected
	High positive	The severity of the impact is rated as High positive as the natural, cultural or social functions and processes are altered to the extent that valued, important, sensitive or vulnerable systems or communities are substantially positively affected.

Criteria	Rating Scales	Notes
Potential for impact on irreplaceable resources	No	No irreplaceable resources will be impacted.
	Yes	Irreplaceable resources will be impacted.
Consequence	Extremely detrimental	A combination of extent, duration, intensity and the potential for impact on irreplaceable resources
	Highly detrimental	
	Moderately detrimental	
	Slightly detrimental	
	Negligible	
	Slightly beneficial	
	Moderately beneficial	
	Highly beneficial	
	Extremely beneficial	
Likelihood of the impact occurring	Unlikely	It is highly unlikely or less than 50 % likely that an impact will occur.
	Likely	It is between 50 and 75 % certain that the impact will occur.
	Definite	It is more than 75 % certain that the impact will occur or it is definite that the impact will occur.
Significance	Very high - negative	A function of Consequence and Likelihood
	High - negative	
	Moderate - negative	
	Low - negative	
	Very low	
	Low - positive	
	Moderate - positive	
	High - positive	
	Very high - positive	

Table 3B: Explanation of Assessment Criteria for Palaeontology

Criteria	Explanation
Nature	Fossils occur in particular strata and rock types in many different parts of the landscape. They are protected by legislation and cannot be destroyed or removed without following certain protocols.
Extent	Fossils are relative small so will only impacted upon in the project footprint, i.e. where the foundations are excavated, trenches where pipes are to be laid, etc.
Duration	If fossils are present they could be destroyed by the process of excavating, while it is taking place. Thereafter there is no impact
Severity	The destruction of fossils does not affect the natural environment but it negatively affects the national heritage and contribution to

	science. The loss of common or abundant fossils is less severe than the loss of rare fossils or of previously unknown species.
Irreplaceability	Common fossils are replaceable but rare or new species are of great scientific importance and are irreplaceable.
Consequence	The loss of rare fossils has detrimental consequences to scientific knowledge while the loss of common or abundant fossils is negligible
Probability	The SAHRIS palaeosensitivity map has been developed from the geological maps for South Africa as well as input from palaeontologists so is a good indicator of the probability of finding certain fossils in certain strata. However, in most cases it in not known for sure if fossils are present without prior knowledge of the site or until excavations have commenced. The map gives a ranking of the probability from very probable (red) to no probability (grey).
Significance	The loss of rare fossils would have a negative significant impact on scientific knowledge and national heritage. The loss of common or abundant fossils would have a much lower significance. Without projects and excavations in new areas, any new or rare fossils would remain unknown but the discovery and removal of such fossils would have a low to high positive impact.
Mitigation	If fossils are removed from the project site and curated in a museum or palaeontology department in a university, then the project can proceed. In addition, the fossils can be studied and so will have a positive impact on scientific knowledge. The removal of fossils is regulated by SAHRA (South African Heritage Resources Agency) and the protocol for this is outlined in the Fossil Chance Find Procedure (Section 8). Once the footprint is cleared of fossils, there in no further impact.
Confidence	The SAHRIS map provides a high level of confidence but not certainty.
Cumulative Impact	Each site can be treated independently. Occasionally an outcrop or assemblage of fossils can be extensive but show subtle differences along its extent, then the cumulative impact would be relevant.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the correct type and age to contain fossils, however, the material to be excavated is soil and this does not preserve fossils. Since there is a chance that fossils from the Vryheid Formation may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is moderate.

Table 4A: Impact Assessment Matrix - Palaeontology

Impact	Pre-mitigation							Recommended Mitigation	Post-Mitigation							
	Duration	Extent	Severity	Irreplaceable	Consequence	Probability	Significance		Duration	Extent	Severity	Irreplaceable	Consequence	Probability	Significance	Confidence
Construction Phase																
Leeuwkuil	3	1	-2	1	-10	2	-20	Remove fossils	1	1	2	3	10	2	20	med
Rietspruit	3	1	-1	1	-5	1	-5	Remove fossils	1	1	1	2	6	6	12	med
Cumulative	3	1	-2	1	-10	2	-20	Remove fossils	1	1	2	3	10	6	20	med
Operational Phase																
Leeuwkuil	0	0	1	0	1	1	1	n/a	0	0	1	0	1	1	1	high
Rietspruit	0	0	1	0	1	1	1	n/a	0	0	1	0	1	1	1	high
Cumulative	0	0	1	0	1	1	1	n/a	0	0	1	0	1	1	1	high
Decommissioning Phase																
Leeuwkuil	0	0	1	0	1	1	1	n/a	0	0	1	0	1	1	1	high
Rietspruit	0	0	1	0	1	1	1	n/a	0	0	1	0	1	1	1	high
Cumulative	0	0	1	0	1	1	1	n.a	0	0	1	0	1	1	1	high

Table 4B- Summary from Assessment Matrix to obtain Residual risk and implications for decision-making for the whole Sedibeng Regional Sanitation Scheme (SRSS) project.

		Pre-Mitigation		
	Consequence	Likelihood	Residual Risk	Rating
Leeuwkuil	Low	likely	Low	Moderate
Rietspruit	Very low	unlikely	Low	Low
Cumulative	Low	likely	Low	Moderate
		Post-Mitigation		
	Consequence	Likelihood	Residual Risk	Rating
Leeuwkuil	Low	likely	Low	Low
Rietspruit	Very low	unlikely	Low	Low
Cumulative	Low	likely	Low	Low

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the siltstones, sandstones, shales and sands are typical for the country and might contain fossil plants and insects of the *Glossopteris* flora. Fossils were last collected from quarries along the Vaal River in the 1960s but the area has since been altered by urbanisation. Fossils may still be present but below ground. The

pipeline routes and proposed infrastructure are north of the old quarries. The sands and soils of the Quaternary period would not preserve fossils.

6. Recommendation

Based on experience and the lack of any recently recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the sands and soils of the Quaternary. There is a chance that fossils may occur in the unexposed shales of the early Permian Vryheid Formation so a Fossil Chance Find Protocol (Section 8) should be added to the EMPr. This is the mitigation required. If fossils are found by the environmental officer, or other responsible person once excavations for pipes and infrastructure have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. The impact on the palaeontological heritage for the Leeuwkuil project would be moderate but unknown prior to excavations opening new ground.

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8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone or coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossils must be provided to the developer to assist in recognizing the fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Figure 5). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

9. Appendix A – Examples of fossils from the Vryheid Formation

Figure 5: Photographs of fossils of the *Glossopteris* flora from the Vryheid Formation. Bottom right is an example of bone still embedded in the river bed.

10. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
January 2022

I) Personal details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa
Telephone	:	+27 11 717 6690
Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.
NRF Rating: C-2 (1999-2004); B-3 (2005-2015); B-2 (2016-2020); B-1 (2021-2026)

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative

ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees
All at Wits University

Degree	Graduated/completed	Current
Honours	13	0
Masters	11	3
PhD	11	6
Postdoctoral fellows	15	1

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 45 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12-20 students per year.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Associate Editor Open Science UK: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals
Reviewing of funding applications for NRF, PAST, NWO, SIDA, National Geographic, Leakey Foundation

x) Palaeontological Impact Assessments

Selected from the past five years only – list not complete:

- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for EnviroPro
- Skeerpoort Farm Mast 2020 for HCAC

- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for EnviroPro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe

xi) Research Output

Publications by M K Bamford up to January 2022 peer-reviewed journals or scholarly books: over 160 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 30; Google scholar h-index = 35; -i10-index = 92
Conferences: numerous presentations at local and international conferences.