A Full Palaeontological Impact Assessment of the Proposed Rehabilitation of the Old Tug Jetty at the Port of Port Elizabeth, Eastern Cape

Prepared for:

Transnet

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Executive Summary

Transnet has assigned Abantu Environmental Consulting to provide a detailed paleontological impact assessment (PIA) for a proposed rehabilitation of the old tug jetty at Port Elizabeth, Eastern Cape port. The National Heritage Resources Act (Act No 25 of 1999, section 38) outlined that a paleontological impact assessment (PIA) is essential to investigate the presence of fossil material within the proposed development. PIA serves the purpose of evaluating the potential impact of the rehabilitation and the operation of the development site on the paleontological resources.

The proposed rehabilitation area is mainly bedded by the Nanaga Formation (88%) and bounded at the southern and northern 5km radius by its underlay, the Peninsula Formation (12%). The Nanaga Formation is a calcareous aeolian formation deposited on the coastal dunes field in the Eocene to the Holocene geological time within the Algoa Group. Algoa Group is unconformably underlain by the tectonically emplaced Palaeozoic metasediments of the Cape Supergroup. The calcium enrichment of the Nanaga Formation was due to solution and precipitation-based inculcation of the comminuted marine shell materials. As a result, the Nanaga Formation compose of semi-solid calcareous sandstone deposited as an aeolianite cross-bed in the mid-Pliocene. The outcrops are invariably covered by the thin layer of sandy-loam soil of the Mizpah soil forms, dominantly Albic Arenosols.

The SAHRIS Palaeomap proposed that moderately sparse fossils and subfossil biota mainly characterize the study vicinity. The high palaeontological sensitivity could be due to the disconformable layering between the Nanaga Formation and the Alexandria Formation, which is richly fossiliferous within its arenaceous particulate. Moreover, the study point is bounded by the highly potential lithostratigraphic units at the north and south, thus, requiring a primary palaeontological assessment. The possibility of uncovering fossilized detrital in the proposed developmental layout depends on the in-depth geological field analysis of the area, the availability of exposed outcrops, and their accessibility. The biostratigraphy of the constituent lithostratigraphy is associated with different genres of land snails, calcretized rhizoliths, and termitaria.

Due to the high degree of urban encroachment and outcrop nonavailability to ascertain the area's geological attribute and substantiate the information on the envisaged footprint, a

sequence stratigraphy correlation (SSC) was conducted. Geosite information proximal to the proposed site comprises five exploration boreholes; 3324BA00003, 3325DC00004, and 3325DC00006. A digital elevation model obtained for elevation alignment provides the altitude ranging between 19 m, 124, and 198 m.a.s.l for the proposed developmental lane, relative to the enlisted geo-site depth; 70.71, 117, and 79.3 m. SSC revealed that a multi-story sandstone mainly buries the paleo-environment beneath a 0 to 15 m sandy-loam soil layer.

The detailed geologic survey showed that the fossiliferous strata lay at greater depth, deeply buried from the surface within a 4 km radius. The layering within the vicinity is the thick overburden, mainly boulders interspersed by rich sands and superficial sand cover. Within the extensively evaluated portion, sedimentary exposure was mostly unconsolidated, stabilized, or artificial surface, with no sight of fossil remains of any sort. The superficial sediments of the late Pleistocene to the Recent age, including the alluvium, the unconsolidated soil, calcrete, and silcrete hardpan, are unfossiliferous. Moreover, the impact risk assessment carried out showed that without (with) mitigations, the impact rating for the old tug jetty is 1.8 (0.6), suggesting a low (very low) risk assessment.

Considering the nonavailability of fossil content within the study portion, the paleontological condition allows the proposed rehabilitation of the old tug jetty at the Port Elizabeth port to move into the construction phase. However, extenuation measures such as preventive and exploratory excavation are advisable during foundation digging, considering the possibility of encountering new fossils. Moreover, should a substantially new fossil discovery be made during the development's construction phase, the South Africa Heritage Research Agency (SAHRA) must be duly alerted to ensure a prompt and appropriate extenuation overseen by a professional paleontologist. This is chiefly because of the potential impact of the development on the scientific research integrity of an environment. Fossils are of scientific value, as the proposed development will likely pose a significant regional threat to the local fossil heritage. The fieldwork and reports for palaeontological impact studies must conform to the minimum standards. The expert would need to obtain a collection permit from the SAHRA.

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1 INTRODUCTION

Abantu Environmental Consulting has been commissioned as the independent environmental practitioner concerning their proposed plan to rehabilitate the old tug jetty at the Transnet Port of Port Elizabeth, Eastern Cape. Abantu Environmental Consulting will deliver a non-negotiable full palaeontological impact assessment (PIA).

The proposed rehabilitation of the old tug jetty of the Transnet Port at Port Elizabeth provides the platform for ship mooring and loading particular or designated commodities. The point is a critical rest wall and constitutes support for its extension; hence, repairing such provides a solid framework for the surrounding end. Notably, the proposed rehabilitation will not only prevent environmental hazards but also reinforce commerce and socio-economic development within the city and support governmental revenue.

2 LEGISLATION

South Africa's heritage resources are classified as part of the national estate due to their cultural or scientific impression on the community and future generations. As a result, the heritage resources are recognized within the operations of the heritage resources authorities and coordinated by the National Heritage Resources Act, NHA (Act 25 of 1999). Regarding Section 3 Act, the Heritage resources of South Africa include "all objects reclaimed from the soil or waters of South Africa, including the archaeological and palaeontological objects and material, meteorites, and rare geological specimens." Section 38 of the NHA posited that palaeontological environmental impact assessment, a part of the Heritage Impact Assessment, is vital for assessing any potential impacts on palaeontological heritage within a vulnerable site.

Section 35 of the National Heritage Resources Act 25 of 1999 provides the following highlights:

- The coordinated management and protection of archaeological and palaeontological sites, their materials, meteorites, and geological resources is the sole duty of a provincial heritage resources authority;
- The heritage resource authority (HRA) is mandated to nurture and conserve their heritage resources for bequeathal to future generations as a property of the province;
- The HRA can introduce an integrated system for the identification and assessment of the heritage resources of South Africa;
- The HRA can set the norms and maintain the essential national standards for the management of the heritage resources in the Republic;
- Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the discovery to the HRA or to the nearest local authority offices or museum, which must immediately notify such HRA;
- No person may, without a permit issued by the responsible heritage resources authority;-
    - Destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
    - Trade-in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
    - Bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assists in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

3 OBJECTIVE

As stipulated in the SAHRA guideline, the impact of a proposed rehabilitation of the old tug jetty on potential palaeontological material at an identified site must be assessed concerning the HRA requirement with a central aim on;

- The unraveling of the surficial, near-surface, and buried lithostratigraphical profile and their palaeontological information;
- The investigation of the palaeontological content and the potential of the formations;
- The estimation of the impact of the rehabilitation on the exposed and or potential fossil resources; and,
- The assertion and suggestions on the conservative measures and mitigations to forestall damage to the resources.

As a result, the palaeo-study undertook the review of the 1:250 000 geological maps of the Eastern Cape provided by the Councils of Geoscience Studies. Moreover, the exploration borehole lithologic logs were collated from the National Groundwater Archive portal to corroborate the downhole lithostratigraphic assessment. To ascertain the elevation difference during the sequence stratigraphy correlation, the elevation information was drawn from the Advanced Spaceborne Thermal Emission and Reflection (ASTER) Digital Elevation Model (DEM) downloaded from the Earth explorer USGS website. PalaeoMap of SAHRIS, through the fossil sensitivity maps and varying relevant technical reports, provides the initial information on the fossiliferous potential of the port of Port Elizabeth and its locality. The possible impact of the proposed structure on local fossil heritage is subsequently drawn from a perception based on field evaluation of the rocks, the rock's intrinsic properties, and the extent of the proposed development.

The palaeontological assessment may proceed into the second stage, whereby detailed scrutiny is employed if the current evaluation suggests a moderate to high palaeontological sensitivity. The stage would entail detailed field rock sampling,

retrieval, laboratory inspection of fossil assemblage and records, and other significant information regarding the sedimentary detrital. Under SAHRA requirements, the step is fundamental considering the destruction of the reconstruction and the operation of the site on the palaeontological heritage. Some extenuation measures may be appropriated before commencing the construction plan or synchronously when the overlying soil mass is removed, and the potentially fossiliferous bedrock is exposed. The retrieval of the fossil and fossiliferous assemblage must be preceded by due authorization of SAHRA while the recovered resources are moved to the assigned repository.

4 GEOGRAPHICAL LOCATION OF THE PROPOSED SITE

The proposed rehabilitation will be carried out at the old tug jetty of Transnet Port of Port Elizabeth, 25° 40' 52.6"E // 33° 59' 39.5"S, Eastern Cape (Figures 1 and 2).

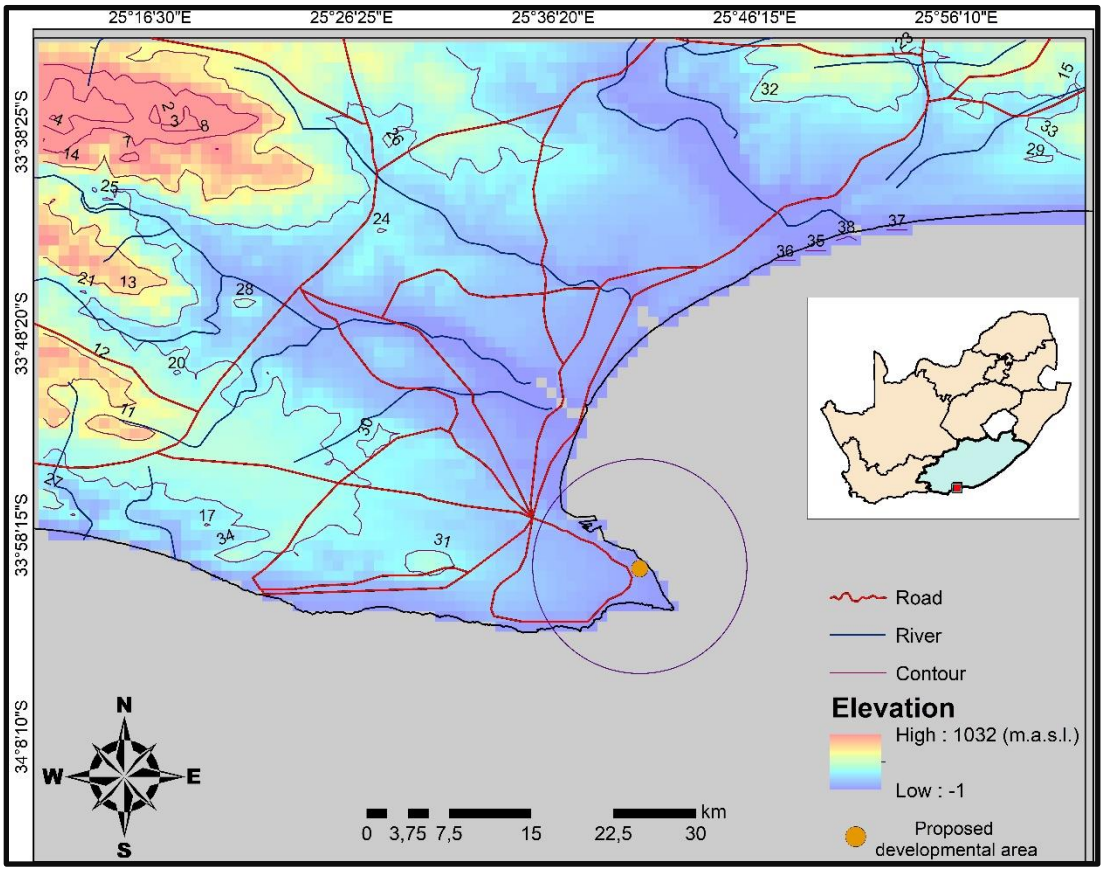

Figure 1. Map of the proposed developmental site.

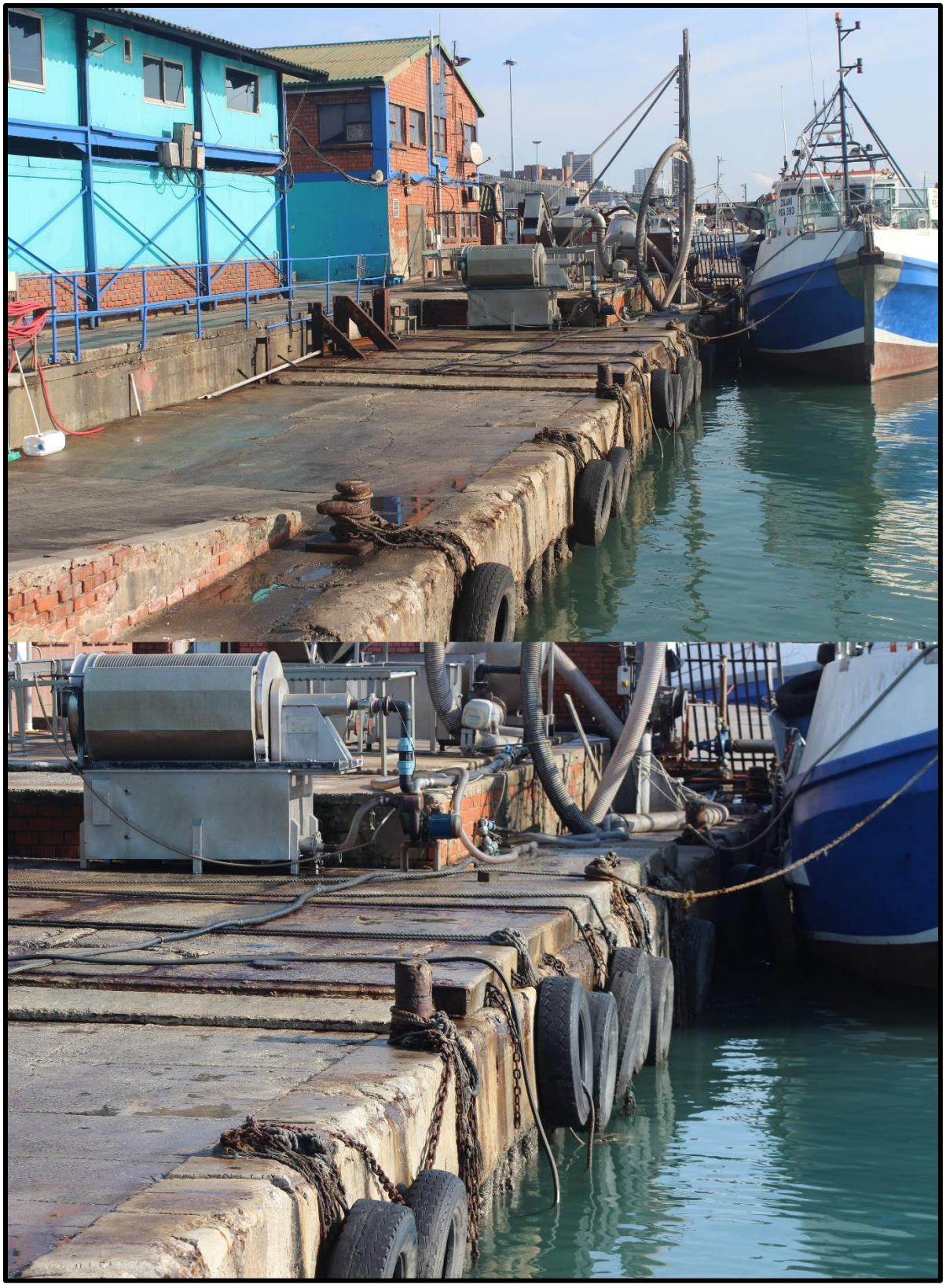

Figure 2. View of proposed rehabilitation spot at the old tug Jerry.

The section's layout lies within the shoreline at an elevation of 12 m.a.s.l. and is mainly covered by sandy loam. Its soil forms comprise; Mi**z**pah (5%), Clovelly (40%), Shortland (20%), and Oakleaf (35%). The area receives about 550 to 600 mm of rainfall per annum and is characterized by a coastal tropical forest biome. The Baakens River drains the site, referred to as the Gqerberha River, which runs Southeastward, emptying into the Algoa Bay.

5 GEOLOGICAL AND PALAEONTOLOGICAL STUDY

5.1 GEOLOGIC BACKGROUND AND FIELD GEOLOGIC INFORMATION

The proposed rehabilitation section (old tug jetty) lies within the geological environment dominated by the Nanaga Formation, as documented in the 1: 250 000 sheets of 3324 Port Elizabeth (Council for Geoscience, Pretoria; Toerien & Hill, 1989) (Figures 3 and 4).

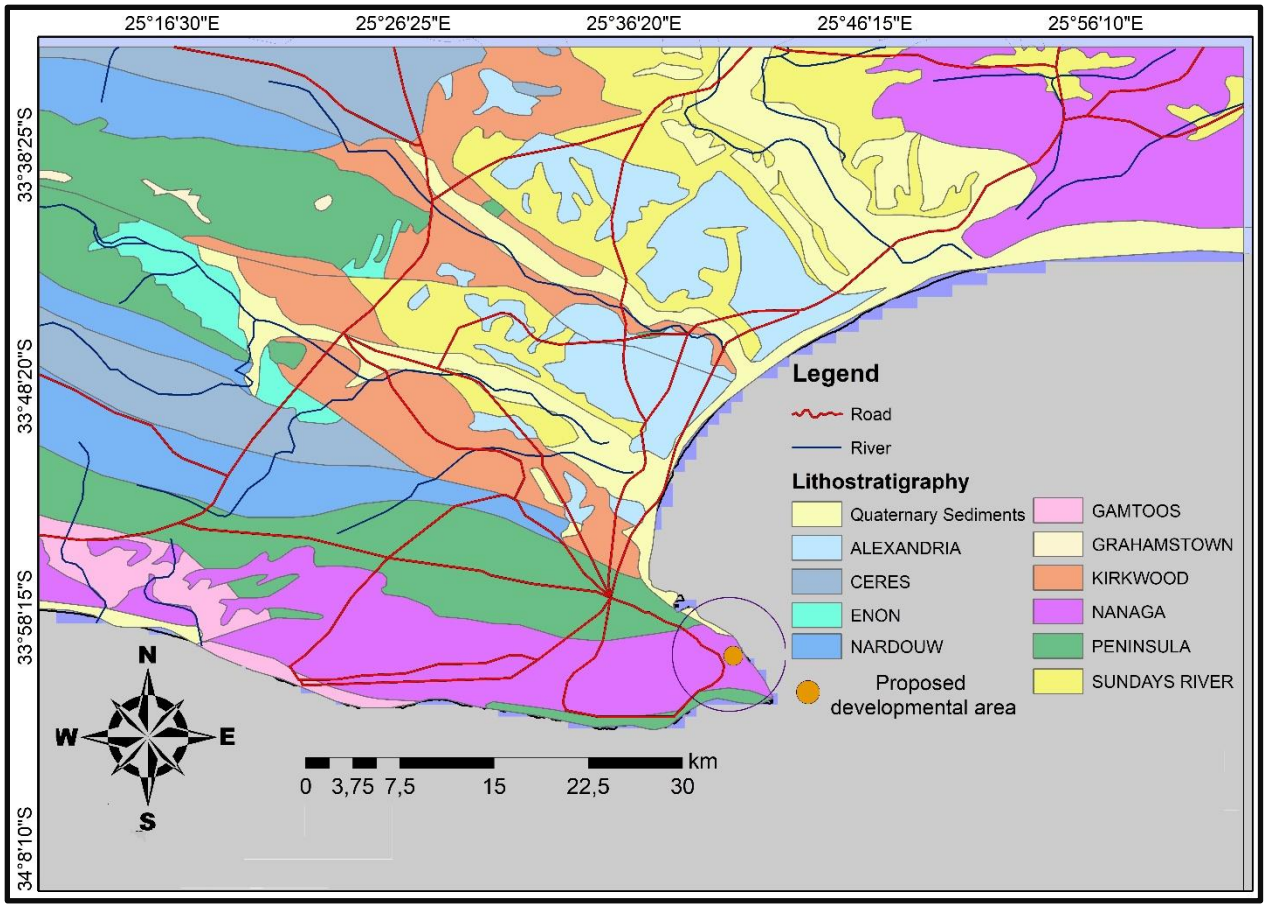

Figure 3. Map of Geology of the proposed developmental site.

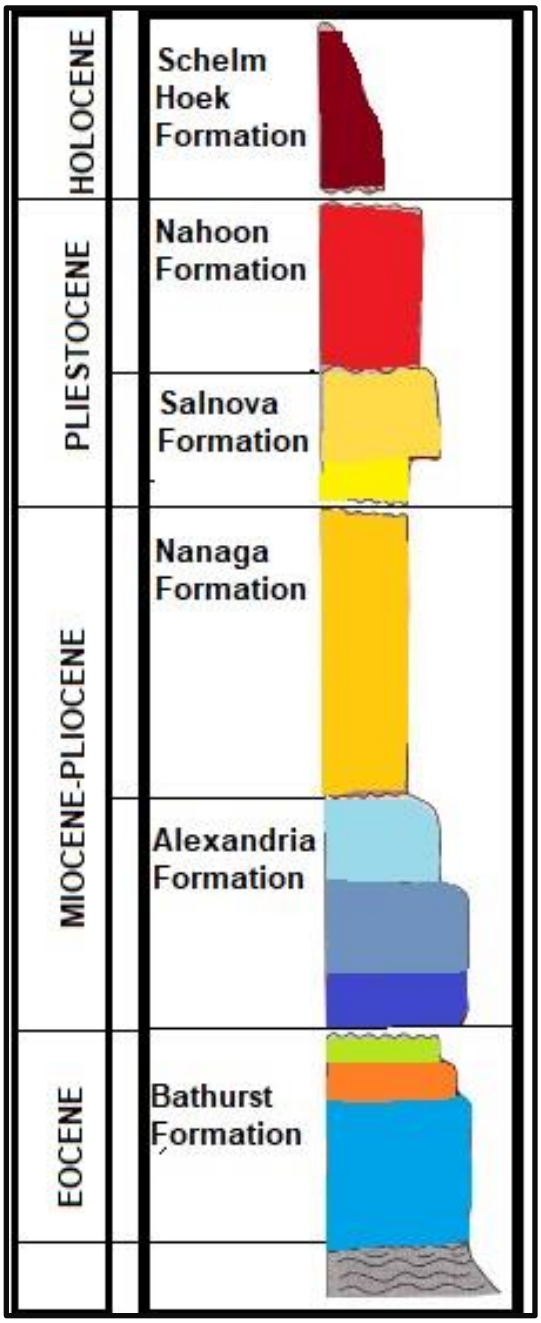

Figure 4. the Stratigraphy column of the Algoa group within the Cape Supergroup (Roberts et al., 2010).

The area's minor geological sections lie at the north and south extremes of about 5km to the study portion and comprise the Peninsula Formation. Meanwhile, the central part of the study area is dominated by Nanaga Formation, underlain by the Alexandria

Formation thinly as a horizontally laminated calcareous sandstone. The morphometric position of the Alexandria formation was described as a herringbone cross-bedding, 13 m thick, conformably intercalated with pebbly coquinite and basal conglomerate decked with dispersed oyster shells, according to Roberts et al. (2006) and Almond (2010). The Alexandria Formation initiated the Miocene epoch, preceded by the Bathurst Formation, which ended the Eocene era.

Figure 5. The underwater aeolianites within the study vicinity.

Nanaga Formation was bedded as aeolian sediments laid in the Pliocene to Early Pleistocene age, exposed at the west of Port Elizabeth (Le Roux, 1992). The Formation is primarily cross-bedded and composed of calcareous sandstone. Its high palaeontological sensitivity is mainly due to its organic sedimentary content concomitantly intercalated with sandy limestone and its lack of conformable bedding with the underlying organically decked twilled calcareous sandstone of Alexandria Formation. Nanaga Formation is semi-consolidated, possibly due to the hydration

condition of coastal dunes. Stemming from its calcium enrichment, the weathering equivalents of the Nanaga Formation are often the calcretes and the clay-rich soil. During the field investigation, the examined portion was padded and reworked. There was no visible or accessible outcrop in sight, as the study vicinity is highly urbanized. However, the streambed tends to provide a pictorial relief of highly hydrated dark assemblages of aeolianites (Figure 5).

On the Nanaga Formation flanks are the Peninsula Formation strips belonging to the Table Mountain Group. Peninsula Formation is bedded as a fluvial progression in the Middle to the late Ordovician age as a palaeoenvironment of prodelta shallow marine (Thamm and Johnson, 2006). Peninsula Formation comprises minor to conspicuously large-scale quartzite interbedded with subordinate shale. Due to the quartzite enrichment, the Formation is resistant to weathering. As a result, they form lofty ridges and retaining walls at the north and south boundary of the study vicinity, emerging above the semi-consolidated and recessive aeolianites of the Nanaga Formation.

5.4 Late Cenozoic superficial deposits

During the Late Caenozoic (from the Pleistocene to the Recent) age, numerous Pleistocene deposits were bedded across the Karoo region and in the study portion. These include the abundant pedocretes in the study area, the soil limestones and the present weathered version, calcretes, alluvium, surface gravel, loess, and colluvia (of sandstone screes and the downwasted pebbles) abundant in the north and southwest karoo (Cole et al., 2004) (Figure 6). The Pleistocene deposits constitute the overburden for the Palaeozoic bedrock, ranging between 0 – 13 m in the study area. Only an insignificant proportion of the Pleistocene to Recent sediments overlying the Algoa group is mapped on the 1: 250 000 scales of the 3324 geological maps (the pale yellow in Figure 3. According to the ground truth, the entire study portion is mantled by the superficial deposits, especially considering the essential engineering requirements for a high degree of settlements critical to stabilizing the heavily active port.

Figure 6. A section of thick overburden downwasted as colluvial of mudstone channel package, overlying the Mudstone along the river cut by the Road DR08017.

Several thicknesses of poorly sorted alluvial gravels, downwasted gravel, pebbles, cobbles, boulders, sandy-loam pedocretes, andy alluvium, fine stream gravel, and silts were found in the study vicinity. Vertical sections through the sequence stratigraphy correlation presented in Figure 7 showed the possible range of 0 to 24 m soil containing boulder clay, gravel, and clay. The superficial cover tapers as a thin veneer from the uplifted uphill section of the hinterland widespread towards the east Stutterheim.

5.5 SEQUENCE STRATIGRAPHY CORRELATION

Rockwork software further harnessed desktop hydrocensus information to assess the three-dimensional lithostratigraphy profile. The sequence stratigraphy correlation (SSC) is computed using the geosite information detailed in Table 2. The SSC enhances the visualization of the subsurface lithological profile shown in 2D and 3D below (Figure 6). The section shows that the geologic layout is covered by consolidated sandstone, which could be identified with the review of the Nanaga Formation.

Table 2. Information on the borehole censored for lithostratigraphic profiling of the proposed site

Borehole tag	Altitude (m.a.s.l.)	Longitude	Latitude	Depth (m)
3324BA00003	19	25°39'32.6" E	33°58'59.7" S	70.71
3325DC00004	124	25°31'57.8" E	33°59'58.6" S	117.6
3325DC00006	198	25°31'03.5" E	33°59'14.9" S	87.7

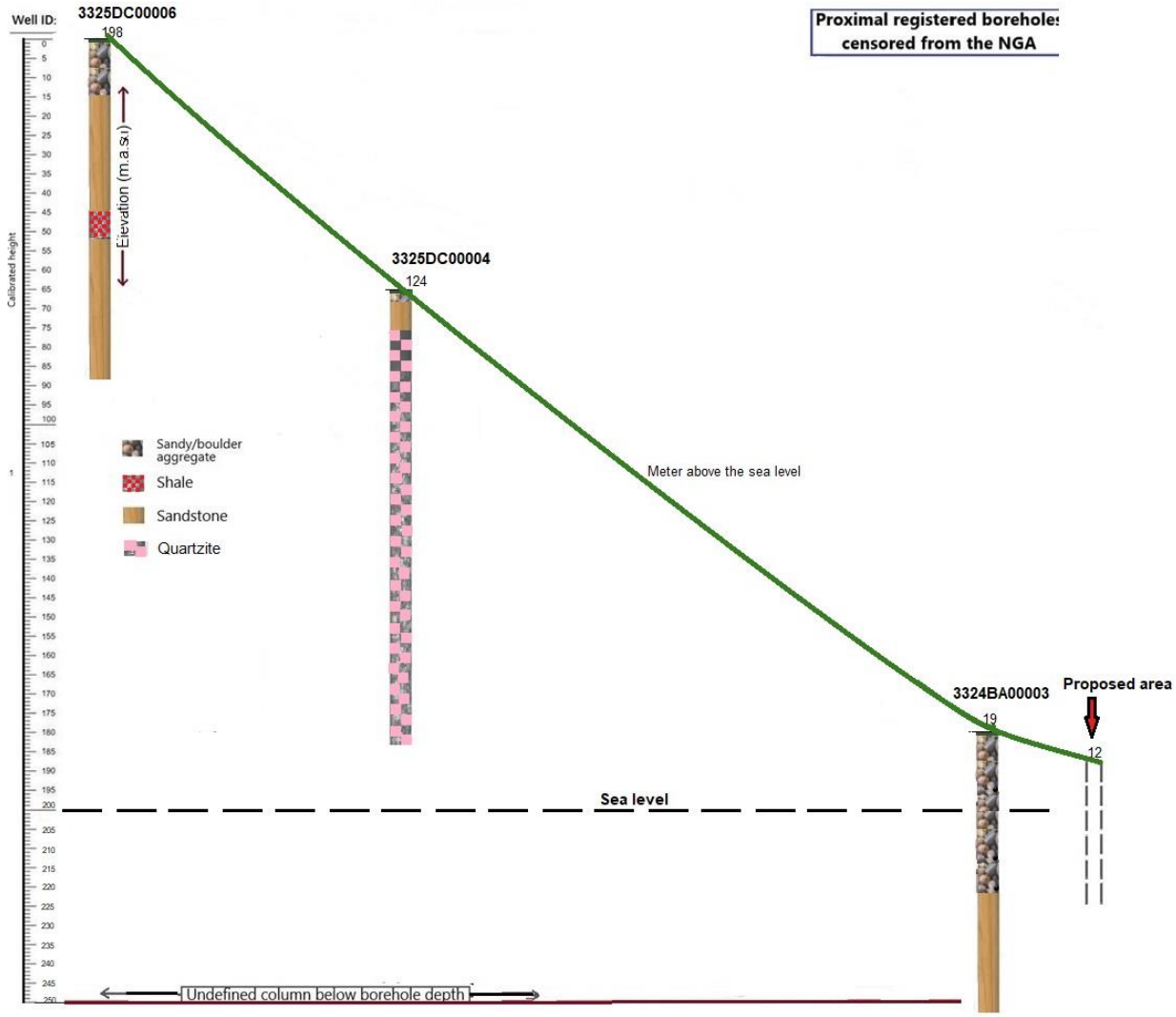

Figure 8. Stratigraphy correlation for predicting the proposed section profile (the dotted borehole), especially the overburden thickness and the possible surficial cover, suggested sandstone at 15 m deep.

5.6 PALAEONTOLOGICAL REVIEW

The palaeontological record of the Pliocene to the Early Pleistocene was sparse, although critical summaries were provided by Le Roux (1992) and Almond (2010). The vital biostratigraphy comprises the shelled protozoans, marine shells, Foraminifera (McMillan, 1990), Achatina, Tropidophora, Natalina, and Trigonephrus (terrestrial snails).

6 ASSUMPTIONS AND LIMITATIONS

The appropriateness and the dependability of desktop Paleontological Impact Assessments as a significant aspect of heritage impact assessments are commonly limited by the following restrictions:

a. Numerous old fossil records were not adequately updated or stored in a computerized repository.
b. Several palaeontological records were not correctly georeferenced.
c. Uncertainty about geochronological analysis due to insufficient technical support among the available professional paleontologists
d. Poor geographic information system knowledge during the compilation of information hampers quality paleo-map.
e. The ambiguity of fieldwork or field navigation planning inhibits the quality of palaeontological reports.
f. Many of the active hotspots of fossiliferous rock have not been adequately surveyed by the available professional paleontologist.

g. Several palaeontological reports were mapped on the poorly calibrated base map and inaccurate geology maps.

7 EVALUATION OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

The proposed developmental layout is located in an area highlighted as palaeontological interest due to the surficial geological cover with fossiliferous potential. The construction phase of the old tug jetty redevelopment will entail the removal of the previous concrete, cement plaster, cast, foundation, and pile and re-casting and framing on the underlying bedrock. Therefore, ground disturbance and strains on the environmental integrity and the potential palaeontological resources within the project vicinity are inevitable.

The assessment of the extent of the impact of the intended rehabilitation on the possible paleo resources is based on the highlighted accordingly.

7.1 NATURE OF IMPACT

The nature of the impact, interpreted as either positive or negative, describes the summed significance of the project on the palaeontological reserve. It is the net deduction drawn from the quantitative assessment of the palaeontological risk assessment.

7.2 EXTENT OF THE IMPACT

The extent of impact provides information on the three-dimensional magnitude of the effect on the footprint. The geometry of the construction, including its depth, is the significant element considered during impact and level estimations. The critical consideration for scalar assessment is outlined in Table 3.

7.3 DURATION OF THE IMPACT

Impact duration describes the lifespan of the indications associated with the rehabilitation impact on paleontological resources and their environment. The indexing of the impact duration is premised on the rationale of reversibility. That is, a much longer impact duration is more likely irreversible. The duration designations are presented in Table 4.

Table 3. Quantitative rating of the extent of the impact

Scale	Description	Rating
Site	The impact extent lies within the vicinity of the construction	1
Local	The area of impact is enclosed with an estimable dimension not far from the site of direct impact	2
Regional	The area of impact is defined in terms of a specific physical boundary (political boundary, geological, water management area, groundwater wellfield) far beyond the anticipated enclosed neighboring area of development.	3
National	This describes the impact area, which spans the entire country.	4
International	This describes a developmental impact that is of severe implications globally.	5

Table 4. Criteria for the rating of the duration of the impact

Duration	Description	Rating
Construction	When the impact timing occurs within the construction period, such timing implies that the effect could be reversed.	1
Short term	When the impact lags for 3 and 5 years, exceeding the construction time. With such timing, the effect is assumed to be reversible.	2
Medium-term	When the impact persists for 6 and 15 years, such timing suggests that it can be corrected when necessary mitigations are adhered to.	3
Long term	When the impact timing exceeds 15 years.	4

Permanent	When the impact remains indefinitely, it responds to the remedial correction, and the environment is irredeemable.	5

7.4 POTENTIAL INTENSITY OF THE IMPACT

The potential intensity of an impact, also referring to impact severity, is the measure of environmental sensitivity and effective changes in response to the causative agent in the environment. The severity of impact must be quantified using an index to inform stakeholders on the level of intervention required considering its possible effect on environmental health, as presented in Table 5. The impact severity index is based on irreplaceable loss, which could also be linked with its potential adverse effect on biodiversity.

Table 5. Criteria for impact rating of the negative potential intensity of a negative impact

Potential intensity	Description of negative impact	Rating
Very high	Significant severity to human health with the propensity for death/ endemic habitat	5
high	Significant impact on lives, livelihood, and socio-economy	4
Moderate	Being unsafe for the environment can trigger ecological transformation and habitat loss.	3
Low	Worrisome impact and chronic effect on the eco-system.	2
Very low	Negative change with associated consequences.	1

7.5 IMPACT RISK RATING

The National Environmental Management Act (Act 107 of 1998) (NEMA) is employed in formulating the impact risk rating below. The entire environmental significance of any impact is 100. The rating is expressed on a scale of 1 - 5, as shown in Table 6.

The environmental significance of each identified potential impact was based on the formula below:

Impact risk assessment = (duration + extent + magnitude)/3 x probability/5.

Table 6. Criteria for impact risk rating of the likelihood of the impact occurring

Impact Risk rating	Description	Rating
Improbable	The chances of impact occurring are doubtful.	1
Unlikely	It is definite that impact will occur, although at an insignificant magnitude and effect.	2
Probable	The impact chance of occurring is considered significant and noticeable, though at a fair to moderate extent (10% to 40% chance of happening).	3
Highly probable	The chances of impact occurring are very high, with a 41% to 75% probability.	4
Definite	The likelihood of impact occurring is absolute.	5

Table 7. Criteria for interpreting the impact risk assessment

RATING	Ranks	Interpretation
0.1 – 1.0	1	Very low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very high

Impact evaluation of the proposed rehabilitation of the old tug Jetty, Transnet Port of the Port Elizabeth, Eastern Cape, is captured in the table below. The probability of discovery is considered likely (3) due to the information drawn from the SAHRIS palaeo-map and review, even though the field investigation suggests otherwise. The spatial extent is considered local as the impact would compromise the integrity of adequate representation only within the local area. The temporal dimension was rated long-term

due to the possible lifespan of hydrochemical alteration resulting from the disturbance of paleontological reserves.

Table 8: Parameters and calculation of the impact risk assessment of the old tug jetty.

Impact risk assessment	Potential Intensity	Spatial extent	Temporal extent	Probability	Rating
No mitigation	Moderate	Local	Long-term	Probable	
	3	2	4	3	1.8
With mitigation	Low	Study area	Construction	Probable	
	1	1	1	3	0.6

Table 9: Measures for extenuation of potential impacts on palaeontological resources

Construction phase	
	Extenuation measures for the potential impact of paleontological resources
Nature of Impact	The potential impact involves the damage and disruption of paleontological resources as preserved in its host rocks within the development footprints.
Extenuation measures	➢ The initial mitigation involves the detailed assessment of geological detrital for the paleontological footprints. ➢ The unearthing of the geological portion of the development area must be done with precautions and due observation, considering the possibility of discovering new paleontological data. ➢ Though the present deduction suggests the mutilation of the development footprints, should a fossil discovery be made, the SAHRA must be reached to oversee the extraction and safeguarding of the resource for sampling and preservation purposes. ➢ A licensed or professional paleontologist must extract and recover the fossil.

8 FINDINGS AND RECOMMENDATIONS

The present palaeontological study is a scoping to ensure thorough environmental screening of the study portion for a potential fossil heritage at Port Elizabeth, Eastern Cape, South Africa port. The pedocrete content of the Miocene calcareous sandstone cover is a typical red flag indicating the need for a detailed geo-palaeontological study considering the scientific relevance of the site. The proposition to rehabilitate the old tug Jetty at the Transnet Port of Port Elizabeth, Eastern Cape, is of high socio-economic importance. However, such a project renders the area's palaeontological significance non-available due to the resource's potential for mutilation.

The study vicinity's 3324 geologic maps showed the dominant overlying calcium-rich sandstone strata, thickly overlaid by downwasted calcrete entwined with the awash gravel. Validated by sequence stratigraphy correlation, the geologic portion of the study area was covered by weathered calcareous sandstone (Nanaga Formation) (88%) and quartzite (Peninsula Formation) (12%). The Nanaga Formation geologic cover mainly represents ancient dune sands, as purportedly documented in the regional map.

The detailed field geo-palaeontological study reviewed that the portion is thickly overburdened while the outcropping footprints were buried in great depth. Therefore, no fossil discovery was made in the entire layout. At the same time, the whole study area is padded by artificial sediments or reworked with superficial deposits due to the century-old constructions, which also ensures a careful packing of topsoil sediment for stability. There are, therefore, no objections to the proposed development for palaeontological conservation reasons. However, a substantial threat to the local fossil heritage is imminent should a fossil be recovered during the construction phase.

Consequently, the study recommends that a subsurface geological prognosis be carried out to address the paleontology integrity of the proposed footprint should fossil remains be discovered during the rehabilitation of the proposed intention. To ensure the detailed geological assessment, the EVO responsible for the developments would be

alerted immediately. A discovery of any palaeontological resource must be protected so that a professional paleontologist will make appropriate mitigation.

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