DRENNAN MAUD (PTY) LTD

GEOTECHNICAL ENGINEERS AND ENGINEERING GEOLOGISTS
Incorporating Drennan Maud & Partners (Est.1975) and GAP Consulting

Reg. No. 2014/038872/07

Durban Head Office
68 Peter Mokaba Ridge, Tollgate, 4001
P.O. Box 30464, Mayville, 4058
T: +27 31 201 8992 F: +27 31 201 7920

Info@drennanmaud.com
www.drennanmaud.com

Margate Office
Unit 7 Gayridge Business Park No. 2
13 Wingate Avenue, Margate 4275
T: +27 39 3122 588 F: 0866 0275 53

Our Ref : 91

Your Ref :

14th August 2017

IDM Consultants
P.O. Box 918
UMHLANGA ROCKS
4320

Attention: Mr. K. Wiggishoff Email: karlw@idmconsultants.co.za

Dear Sirs,

GEOHYDROLOGICAL ASSESSMENT FOR PROPOSED 'PENNY LODGE' DEVELOPMENT, ZULULAND RHINO RESERVE

1. INTRODUCTION AND TERMS OF REFERENCE

Drennan Maud (pTy) Ltd was requestyed to carry out a geotechnical investigation to determine the feasibility of the proposed 'Penny Lodge' development. An investigation was carried out during 2016 with our findings presented in the following various reports;

- Report to Lisa Rorich Architects titled "Geotechnical Assessment proposed 'Penny Lodge' Development Zululand Rhino Reserve", dated 18th March 2016.
- Report to Lisa Rorich Architects titled "Assessment of Waste Water Disposal 'Penny Lodge' Development Zululand Rhino Reserve", dated 26th May 2016.
- Report to Lisa Rorich Architects titled "Laboratory Addendum to Geotechnical Assessment proposed 'Penny Lodge' Development Zululand Rhino Reserve", dated 31st May 2016.

Following queries raised by the Department of Water Affairs (DWA), Drennan Maud (Pty) Ltd was requested by IDM Consultants to undertake a geohydrological assessment of the area to satisfy the DWA requiremnents prior to their approval being granted.

Drennan Muad carried out the geohydrological assessment of the proposed Penny Lodge Development site and surrounding area in July 2017, the results of which and relevant recommendations are presented hereunder in this report.

It is recommended that this report is read in conjunction with the above mentioned previous reports.

2. METHODOLOGY

2.1 Desktop Review

Prior to the field investigation the following information was reviewed;

- Google Earth imagery of the site and immediate surrounding areas
- All available information pertaining to the site (i.e. available survey plans, previous reports et cetera)

2.2 Field Work

The site was visited on the 27th July 2017, with the geohydrological assessment comprising the following;

- Site walk over and reconnaissance of receiving environment in particular in the vicinity of the proposed waste water disposal system and evapotranspiration area.
- Undertaking a hydro-census within a 500m radius of the site to assess purpose and importance of nearby water sources.
- Excavation of two inspection pits (IP1 and 2) within the Msunduzi river channel.
- Percolation test (PT1) carried out in accordance with SABS 1-400 1987 standards to determine the in-situ permeability of the near surface subsoils in the vicinity of the proposed evapotranspiration area.
- Sampling of surface water within the nearby water bodies as well as any nearby streams that may occur in the area at an upstream and downstream position for laboratory testing.

A total of four water samples were retrieved from various locations surrounding the Penny Lodge site, these included two samples from the existing small dam (Penny Lodge Dam - North and Penny Lodge Dam - South), a water sample from an old unused borehole well and an upstream sample taken from the Msunduzi river channel.

The approximate locations of the various testing/sampling positions are indicated on the site image and survey site plan drawings included as Drawings 31366-4/01 and Drawing 31366-4/02 of this report respectively, whilst the approximate GPS co-ordinates of the water sampling positions (accurate to +/-5m) are included below.

Dam - North:	27°46'22.65"S 32°04'51.68"E	**Dam - South:**	27°46'24.91"S 32°04'52.39"E
Unused Well:	27°46'22.04"S 32°04'54.55"E	**Msunduzi Upstream:**	27°46'26.80"S 32°04'53.38"E

The soil profiles were logged by an experienced engineering Geologist in accordance with the Guidelines for Soil and Rock Logging in South Africa, edited by A.B.A Brink and R.M.H Bruin, 2nd Impression 2002. The inspection pit profiles are included herewith in Appendix A.

The water samples were sent to B.N Kirk (Natal), Durban where they underwent testing in order to characterise the water properties for future reference. The results of these tests are presented in Appendix B of this report.

3. SITE DESCRIPTION

The site has been described in detail in our letter report Ref 31366 to Lisa Rorich Architects dated 18 March 2016, however, for ease of reference is summarised herewith below;

The site is located on the northern bank of the Msunduzi River which flows in a north easterly direction towards the inside curve of a prominent north west/south east striking spur around which the river flow changes direction by about 90°, such that below the proposed main lodge the river flows in a south easterly direction.

Below the ridge forming the outside bend is a relatively level area which forms part of the flood plain of the Msunduzi River. The lower slopes forming the flood plain are underlain by alluvial sediments likely to be overlying weathered bedrock.

In addition to weathered bedrock occurring locally along the access road to the area weathered bedrock is exposed at the base of the northern bank of the Msunduzi River near the location of the upstream water sampling position.

Based on the detailed survey of the development area coupled with our on-site visual assessment the proposed Lodge site occurs on a relatively gently sloping elevated plain above the Msunduzi River. The plain may be an ancient flood plain which is elevated approximately 8 m above the river bed level.

The natural ground across the elevated plain in the vicinity of the lodge slopes in a north westerly direction at approximately 3° or less with a planar to slightly concave to convex slope conformation. The riverbank below the plain is steep and may be vertical in some instances. The area to the north of the proposed development area slopes at approximately 5° in a south easterly direction with a planar conformation.

A drainage line crosses the northern portion of the elevated plain draining in a north easterly direction along a small stream valley channel into which a small dam to the north west of the Lodge site drains. A second north west - south east trending drainage line is present, adjoining with the Msunduzi river some 250m upstream (south east) of the Penny Lodge site.

The Msunduzi river was completely dry at the time of the assessment. Water sampled from the Upstream position was obtained via excavating some 1.5m below current ground level.

4. SITE GEOLOGY

The general location of the development, and the regional and general geology is described in our previous report, however for ease of reference is summarised below.

According to the 1:250 0000 St Lucia geological plan (Plan No.27½ 32) the regional geology of the immediate area is dominated by Jurassic basaltic bedrock of the Letaba Formation of the Lebombo Group and the colluvial and residual soils derived therefrom. However as the site is located adjacent to and within the flood plain of the Msunduzi River some alluvial sediments are likely to underlie the site.

Observations on site indicate that the immediate upper colluvial soils comprise a dark grey and very dark grey, firm to stiff, fissured, slightly sandy silty clay. This colluvial material derived from the basalt is likely to be highly active and is sometimes referred to as cotton soils. In the small elevated stream valley crossed by the access road the subsoils comprise a reddish brown to orange brown mottled and blotched grey and white, sandy gravel with rock corestones. This material comprises the residual materials overlying the basalt.

From available information in the area we consider it likely that underlying the residual soil is the weathered bedrock which is generally brown to orangish brown, highly to completely weathered, highly fractured, soft to medium hard rock basalt.

The weathered bedrock encountered locally within the Msunduzi river channel occurs as grey weathered brown, highly to medium weathered, close to widely jointed, medium hard to hard rock basalt.

The river channel is underlain by fine to coarse, loose, alluvial sand to likely considerable depth below the surface with the possibility of occasional boulders therein.

5. WATER ANALYSIS

As alluded to above four water samples were retrieved from various water bodies within a 500m radius of the site, namely a near by small dam, an old unused well and an upstream sample from the Msunduzi river.

The samples were sent to BN Kirk laboratories for analysis to determine the relative proportions of various constituents within the water samples, so as to serve as a baseline water quality measurement of the water bodies in the vicinity of the proposed new development in the highly unlikely event of a possible water contamination sometime in the future.

The results of the water testing are included in Appendix B of this report and discussed briefly hereunder.

It is apparent that in terms of selected chemical (nitrate, flouride, nitrite, chlorine, ammonia) and physical (Conductivity, pH) attributes the water samples collected generally fall within limits which would allow for domestic use of the groundwater and dam water samples.

However, in terms of the Faecal coliform and Ecoli levels measured it is clear that the samples are contaminated to varying degrees. The high levels recorded for the dam samples are attributed to likely animal droppings in the watering hole.

The sample of ground water taken from the upstream river sample indicates that there is eColi and faecal coliforms in the ground water, although of a much lower level, which is attributed to animal and or humans upstream of the site.

Lastly, the very high Feacal coliform and eColi levels recorded for the well point sample are largely attributed to the carcass of a dead rodent found decomposing at the base of the well post sampling which is thought to have negatively skewed the result. It is likely that the sample would generally coincide with levels of eColi/Faecal coliforms encountered within the upstream sample.

6. HYDROGEOLOGICAL ASSESSMENT

6.1 Surface Water Bodies

The location of water bodies within a 500m radius of the centroid position of the Penny Lodge site can be appreciated in Drawings 1 and 2 of this report and described further below;

Msunduzi River: The Msunduzi River at the time of the investigation was completely dry. Water was sampled from IP2 at a depth of 1.5m below river bed level.

Discussions with Mr Ivor van Rooyan, the reserve manager, indicated that the Msunduzi river is an ephemeral river and constant flow therein ceased circa 2002. Flow within the river, following rainfall events is only nominal in volume and only lasts for several hours to a few days at most.

Small Streams: At the time of the investigation the small stream to the north east and south west of the Penny Lodge site were completely dry. As with the Msunduzi River these small streams are ephemeral in nature in that they likely only transport groundwater/surface run-off during and shortly after rainfall events.

The shallow incised nature of the streams suggests that only nominal flow generally occurs therein following rainfall events.

Existing Small Dam: The small body of water located approximately 150m west of the proposed Penny lodge site area comprises a small dam constructed some time in the past, possibly as part of the previous camp development and currently serves as a watering hole for local wildlife within the reserve. The dam is located such that effluent disposed of into the evapotranspiration area is highly unlikely to migrate in its direction given the prevailing topography of the site and surrounding area.

6.2 Groundwater

During the course of the geohydrological assessment an old disused well/borehole was encountered and provided an opportunity to encounter the ground water table present below the site.

The exact depth to the permanent/perched ground water table encountered within the well is unknown but was estimated at significant depth in the order of >10m below existing ground level below the site area.

Groundwater was also encountered at depths of approximately 1.5m depth below river bed level within the Msunduzi stream.

No other source of ground water abstraction (i.e. boreholes) were encountered within the 500m radius of the site. However, given the remote location of the site it is highly unlikely that there are ground water boreholes within a distance of the site that could be affected by ground water contamination through waste water disposal, especially given the nominal amount of effluent to be produced on site and the intermittent nature of the effluent loading.

6.3 Shallow Soil Permeability

After saturation of the subsoils, the percolation rate for PT1 into the clayey alluvial subsoils was measured to be approximately 45mm/hr drop in water level

As such the silty/sandy clay material encountered on site at depth ranging between 0.8 - 1.0m was found to have a low permeability and thus, coupled with the gentle gradient, effluent disposed therein is highly unlikely to migrate large distances or penetrate to considerable depth below the surface but rather be confined to the evapotranspiration area. As such the unsaturated zone below the evapotranspiration area and ground water table at depth will be considerable (>8m).

6.4 Summary

In terms of the above, the disposal of effluent via subsoil percolation is considered feasible on-site and highly unlikely to be a source of contamination for the following reasons;

- The low permeability of the prevailing subsoils on site
- The level gradient and thus inability of contaminants to migrate great distances
- The relatively low volumes of effluent to be produced on site.
- The topography of the site and proximity of the evapotranspiration area in terms of existing water bodies
- The depth to the permanent ground water table below the site.
- Relatively elevated Feacal and eColi levels occurring naturally within the ground water and watering hole dam.
- Lack of nearby ground water abstraction points (i.e. very low risk of contamination)
- Ephemeral nature of the nearby streams and the Msunduzi river.

In the event of a large scale flooding event, given the nominal volume of effluent to be produced on site and the volume of water associated with such a flooding event, the concentration of contaminants would be negligible. Furthermore, any system adopted on site, including a package treatment plant or conservancy tanks would be subject to the same flooding problem.

7. WASTE WATER DISPOSAL RECOMMENDATIONS

The following recommendations for waste water disposal on site are provided in our initial report Ref 31366-1, dated 26th May 2016, however have been augmented accordingly in line with the most recent percolation testing and geohydrological assessment carried out on site.

7.1 Effluent Loading

In terms of the layout provided and the likely maximum occupancy of the development, the effluent loading based on the Code of Practice for the application of National Building Regulations SABS 0400 of 1990 and the Building Standard Act No. 103 of 1997, is estimated to be the following;

- Bedroom Units, maximum occupancy 2 persons. Equivalent to hotel with private bath = 140l/per/day = 280 x 4 Units = **1120 l/day.**
- Main lodge including kitchen dining room back of house. Infer maximum occupancy = 8per x 3meals @ 20l/per (Restaurant, toilet and kitchen waste per person) = 480l + 4 x staff @ 90l/shift = 360/ = **840 l/day.**
- Total effluent loading per day for the development is equal to **1960 l.**

7.2 Septic Tanks

Based on the estimated effluent loading given above we recommend that an individual small septic tank be provided for each of the accommodation units. In this regard, we recommend a 600 l 'Roto tank' or similar approved septic tank be installed at each of the units.

For the main lodge which includes the back of house, kitchen, dining area and lounge the National Building Regulations require the septic tank to be designed of a capacity not less than three times the daily flow. As such, the septic tank for the main lodge area must have a capacity of in the order of 2500 l.

Sludge should be removed from the septic tanks before sludge levels build up to the extent that solids are carried over into the french drain. Such maintenance is normally required at three to four year intervals. As such, the tanks should be located so as to be accessible to the 'honey sucker' tanker.

7.3 French Drain Soak pit

Based on the outcome of the percolation testing carried out on site, a percolation rate of 35min / 25mm drop in water level was recorded within the clayey subsoils underlying the proposed evapotranspiration area.

In this regard the maximum rate of application of effluent to subsoil infiltration areas is limited to 33l/m^2/day.

Outflow from the septic tanks should be discharged into a french drain of a minimum length of 90m, increased from the initial 25m length due to the slower application rate. However, in order to achieve the minimum length within the confines of the evapotranspiration area, it is proposed that three rows of french drain of 25m, 30m and 35m 38m length are placed approximately 10m apart with a distribution pipe on alternating ends causing effluent to cascade through the french drain and down the slope.

An indicative layout of the french drain that should be installed to support the septic tank system is illustrated on Drawing No. 31366-4/02. The sides of the trench should be scarified to provide a natural infiltration surface.

If a traditional stone-filled french drain is used the slotted distribution pipe should be given a minimum fall of 1:100 along the length of the drain. Alternatively, a Kaytech Infiltration Chamber (or equivalent) may be used. The base of the trench must be level throughout. Typical details of the above alternatives are given in Drawing No. 31366-1, Figure 2 of report 31366-1.

The french drains should be embedded into similar material (similar permeability) clayey soils along its length. A soil depth of at least 700mm is considered necessary for the area to be considered part of the evapotranspiration area.

Immediately prior to being covered, the waste water system should be inspected and approved by the responsible Geotechnical Professional.

7.4 Evapotranspiration Area

In terms of the subsoil percolation characteristics of the area, a minimum evapotranspiration area of in the order of 700m^2 is required for subsoil percolation of effluent to be effective.

In this regard, sufficient area is available on the site for this purpose, such area having been indicated on the attached site plan Drawing No. 31366-4/02 and has been positioned a suitable distance and location away from natural water bodies.

7.5 General

Recommendations set down above represent the minimum requirements for satisfactory operation of percolation systems on this site and are made on the understanding that a risk of malfunction exists, and further, that should such a malfunction occur, it will be necessary to extend or amend the system to accommodate any problems which may arise from the indeterminate nature of the subsoils, seasonal effects and future developments.

Whereas it is possible to design the septic tank and french drain systems for potential effluent loading, it is not possible to increase the evapotranspiration capacity of a site beyond a practical limit which is dictated not only by the evapotranspiration area available, but also by other factors, which include :

a) Indiscriminate excavation for terraces;

b) Injudicious placement of stormwater soakpits which will introduce stormwater run-off into the soils of the evapotranspiration area and thereby overload the evapotranspiration area;

c) Natural seepage which can occur seasonally from the upper slopes and will also compete with the effluent for evapotranspiration capacity;

Stormwater from all roofed and paved areas should be piped and discharged into soakpits located well away from the french drain and evapotranspiration area. The site should be graded to allow rapid surface water run-off.

The infiltration area should be densely grassed and, in addition, hydrophilic (water loving) vegetation should be planted on and around the lower portion to increase evapotranspiration. Any existing mature trees on the site should be maintained where possible.

The ultimate occupiers of the completed lodge, guests and staff, should be informed that a french drain system exists, and that it is dependent on biological action for the breakdown of waste products.

Materials such as antiseptics, petrol, oil or other chemicals should thus not enter the system, since these may kill the bacteria, resulting in complete failure of the bacteriological process. In the kitchen, excessive quantities of fat, waste food, etc., should not be allowed to enter the drain. Periodic dosing with an approved bio-enzyme (generally available from supermarkets or hardware stores) should improve the long term viability of the system.

The introduction of materials such as newspaper or cloth into the system should be avoided, since these reduce the efficiency of the bacteriological processes.

8. CONCLUSION

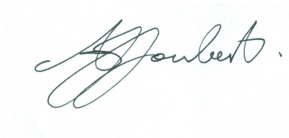
Based on the results of this assessment we consider that wastewater disposal by means of subsoil percolation is feasible on this site and that once implemented the risk of groundwater contamination as a result thereof is very low due to various inherent properties of the site and underlying subsoils/groundwater.

The recommendations given in that this report pertaining to on-site effluent disposal should be given to the design engineers to design the wastewater disposal services as per indicated on the site plan Drawing No. 31366-4/02.

We trust that this meets with your immediate requirements in this regard and look forward to any further correspondence in this matter.

Yours faithfully

DRENNAN MAUD (PTY) LTD



A. JOUBERT Pr.Sci.Nat.

/ Encl. Appendix A - Soil Profiles
Appendix B - Lab Results
Drawing 1 - Locality Plan
Drawing 2 - Site Plan

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