

**Footprint drilling Dolomite Stability
Investigation**
for the proposed single storey
residential development on
STAND 1211, Pierre van Ryneveld
Extension 2:
Centurion – City of Tshwane

DATE : May 2017
REPORT NO : LM 266D/17

Holland-Muter & Associates CC

Reg. No: 2001/000696/23



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ABSTRACT

This report serves as a subsequent footprint drilling dolomite stability investigation to previous investigations executed by Holland-Muter & Associates for Stand 1211 of Pierre van Ryneveld Extension 2, Centurion. The report details and comments on the results of additional percussion drilling conducted on the footprints of the proposed residential structures planned for the site.

The **purpose** of the investigation was to comment on the footprint stability of the proposed superstructures in terms of possible sinkhole and doline risk as well further enhancing the accuracy of the inferred stability zone boundaries.

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FOOTPRINT DRILLING DOLOMITE STABILITY INVESTIGATION FOR THE PROPOSED RESIDENTIAL SINGLE STOREY DWELLING UNITS TO BE CONSTRUCTED ON STAND 1211 OF PIERRE VAN RYNEVELD EXTENSION 2: CENTURION – CITY OF TSHWANE

Report No : LM 266D/17, May 2017
Our Ref : HM&A DOL PVV STAND PVR X2
FOOTPRINT DRILLING RE

1. INTRODUCTION

1.1 BRIEF

This report serves as a subsequent footprint drilling dolomite stability investigation to Report No: LM266C/02 executed by Holland-Muter & Associates for Stand 1211 of Pierre Van Ryneveld Extension 2, Centurion in 2002. The report details and comments on the results of additional drilling conducted on the footprints of the proposed residential structures and the inferred boundary between the various stability zones.

The purpose of the investigation was to comment on the footprint stability of the proposed superstructures in terms of possible sinkhole and doline risk as well further enhancing the accuracy of the inferred stability zone boundaries.

1.2 AVAILABLE INFORMATION

The following information sources were consulted:

- Geological Map on a scale 1:50 000 2528 PRETORIA.
- Topographical Map on a scale 1:50 000 2528 CC CENTURION.
- Google images.
- Report No. M92/725 conducted by Messrs. Johann van der Merwe Engineering Geologist during 1992.
- Report Nos. LM266/01, LM266A/02, LM266B/02 and LM 266 C/02 conducted by Holland-Muter & Associates CC.

2. METHODS AND PROCEDURES OF INVESTIGATION

The previous investigations were conducted to determine the general stability and geotechnical conditions of the terrain. Ten additional boreholes (BH FP01- FP10) were drilled at predetermined positions on the footprint of the proposed residential superstructures to define and characterize the stability zonation beneath the structures more accurately and also to enhance the accuracy of the stability zonation.

The percussion drilling was conducted to a minimum depth of 6 metres into solid dolomite bedrock. Samples were collected from the returning air stream through each one metre drilled by the rotary-percussion drill, while the penetration rates per metre were recorded using an electronic stopwatch. The borehole logs and drilling information recovered during the investigation are summarized in Appendix I. To confirm the geological conditions characterizing the various Inherent Risk Class zones, various cross-sections were prepared as presented in Figure 3, Sheets 1 – 6, Appendix IV to further enhance understanding of the subsurface geological conditions.

3. RESULTS

3.1 Drilling Results

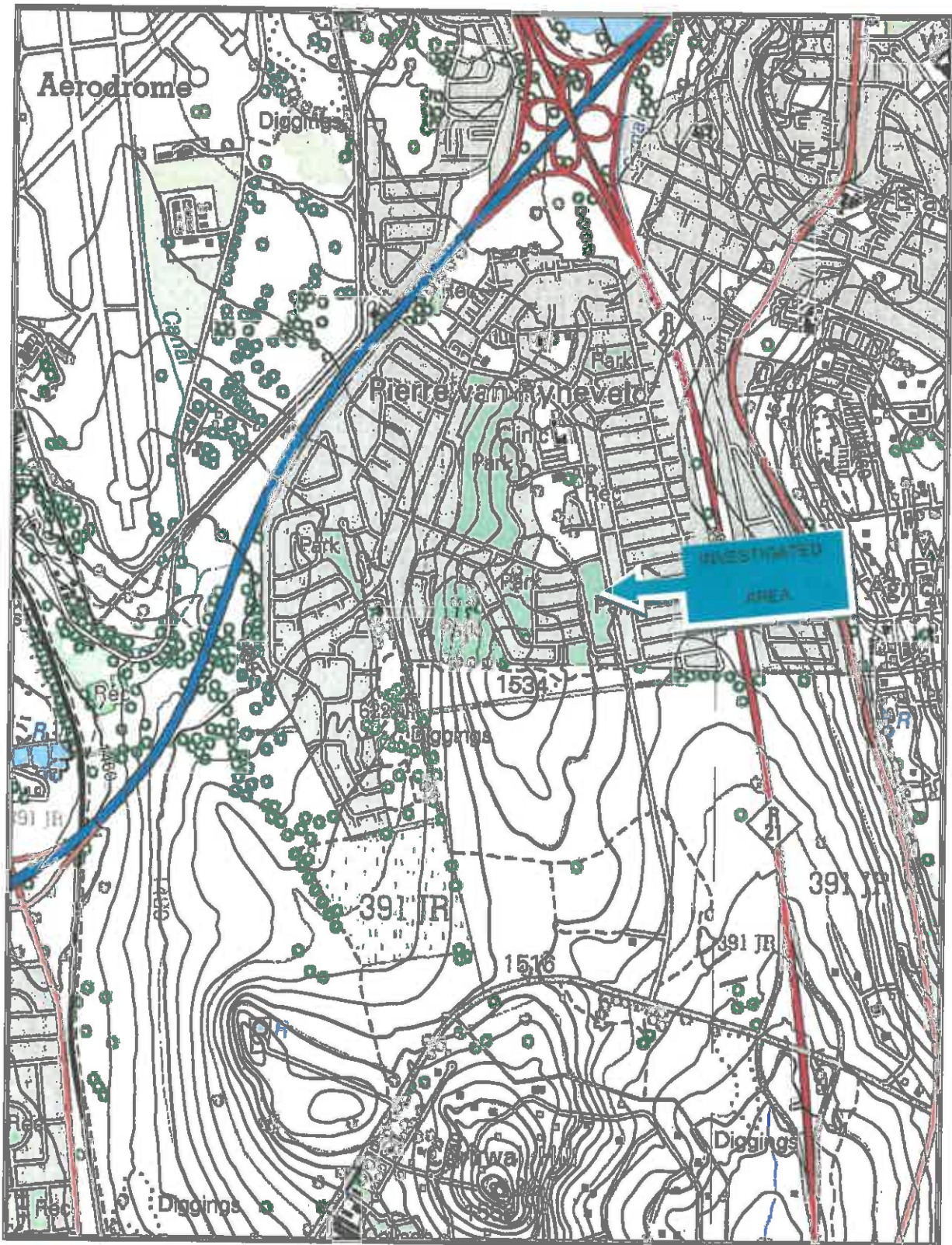
The boreholes drilled were used to characterise and confirm the bedrock conditions underneath the footprint of the structures. Dolomite rock was encountered in all the boreholes whilst three revealed shale as presented schematically in Figure 2, Sheet 2 – Appendix IV. Medium air-loss with medium sample return was encountered in boreholes FP05 and FP07 whilst FP10 revealed medium airloss with full sample return. A summary of the drilling results is presented in Table I below.

TABLE I : DRILLING RESULTS

| BH No. | CAVITY (m-m) | 0 - 4s/m (m-m) | 4 - 12s/m (m-m) | AIRLOSS (m-m) | COL-LAPSE (m -m) | WATER STRIKE (m) | ROCK DEPTH (m) | BH DEPTH (m) | SHALE/ QUARTZITE (m-m) |
|--------|--------------|----------------|-----------------|----------------------------------|------------------|------------------|----------------|--------------|------------------------|
| FP01 | | | | | | | 20 | 28 | |
| FP02 | | | | | | | 30 | 54 | |
| FP03 | | | | | | | 10 | 22 | |
| FP04 | | | | | | | 23 | 30 | |
| FP05 | | | | 21 – 22M 23 – 24M 25 – 27M | | | 34 | 47 | |
| FP06 | | | | | | | 9 | 16 | |
| FP07 | | | | 11 - 12M | | | 12 | 21 | |
| FP08 | | | | | | | 21 | 28 | 0 - 12 |
| FP09 | | | | | | | 41 | 49 | 3 - 15 |
| FP10 | | | | 20 – 21M | | | 34 | 43 | 6 - 15 |

S= Slight Air-loss M= Medium Air-loss T = Total Air-loss

To aid in the determination of the hazard and inherent risk classification of the site, the individual percussion boreholes were characterized as indicated in Table II:-



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FIGURE 1: LOCALITY MAP: STAND 1211 PIERRE VAN RYNEVELD EXTENSION 2,
CENTURION GAUTENG PROVINCE

DATE: MAY 2017

DRAWING NO: 101

TABLE II : RISK CHARACTERIZATION OF BOREHOLES

| BH No | GENERAL CONDITIONS & NATURE OF MATERIALS | RECEPTACLE DEVELOPMENT | MOBILISING POTENTIAL | POTENTIAL DEVELOPMENT SPACE | RISK | INHERENT RISK CLASS |
|-------|---|------------------------|----------------------|-----------------------------|--------|---------------------|
| FP01 | Transported material, chert and wad overlying dolomite from 20m | Disseminated assumed | Low to Medium | Large | Medium | 4 |
| FP 02 | Transported material, chert and wad overlying dolomite from 30m | Disseminated assumed | Low to Medium | Large | Medium | 4 |
| FP03 | Transported material, chert & wad overlying dolomite from 10m | Disseminated assumed | Medium | Medium | Medium | 3 |
| FP04 | Transported material, chert and wad overlying dolomite from 23m | Disseminated assumed | Low to medium | Large | Medium | 4 |
| FP05 | Transported material, chert, and wad overlying dolomite from 34m | Disseminated assumed | Low to medium | Large | Medium | 4 |
| FP06 | Transported material, shale, chert and wad overlying dolomite from 9m | Disseminated assumed | Medium | Medium | Medium | 3 |
| FP07 | Transported material, chert and wad overlying dolomite from 12m | Disseminated assumed | Medium | Medium | Medium | 3 |
| FP08 | Transported material, shale, quartzite, chert and wad overlying dolomite from 21m | Disseminated assumed | Low to medium | Medium to Large | Medium | 4 |
| FP09 | Transported material, shale, chert and wad overlying dolomite from 41m | Disseminated assumed | Low to medium | Medium to Large | Medium | 4 |
| FP10 | Transported material, shale, chert and wad overlying dolomite from 34m | Disseminated assumed | Low to medium | Medium to Large | Medium | 4 |

4. EVALUATION PARAMETERS

4.1 GENERAL

4.1.1 Nature of Blanketing Materials

(The blanketing layer is that component of the overburden which overlies a potential receptacle or which rests on solid rock)

The overburden comprises the following:

- a. Colluvial, fresh to highly leached chert GRAVEL with reddish brown, sandy/clayey SILT. This material has a Moderate risk of mobilization.
- b. Dark red CLAY sometimes associated with Chert. This material has a Moderate risk of mobilization.
- c. Fresh to leached CHERT sometimes with minor wad with minor wad. This material has a Moderate to High risk for mobilization.
- d. Weathered light red to unweathered dark grey SHALE. This

material has a Low risk of mobilization.

4.1.2 Existing Unstable Conditions

From the study of sinkhole occurrences it has been found that the risk of sinkhole formation decreases with depth of the fissure, cavity or receptacle which may receive eroded materials from a progressively eroding or collapsing roof or cavity. This can only be achieved if the blanketing layer contains high concentrations of wad or materials sensitive to mobilising agents such as infiltrating water, ground vibrations or water table draw down. Intrusive bodies (e.g. syenite) or sedimentary rocks located above the dolomite residuum or intercalated with the dolomite bedrock are relatively stable formations which resist mobilisation. These layers have a stabilising influence on the substrata below which the intrusive/sedimentary rock occurs.

Disseminated receptacles with air-loss were encountered in only three of the boreholes drilled during this investigation (See Table I). Borehole FP05 revealed medium air-loss with medium sample loss while borehole FP07 indicated medium air-loss on the contact zone between the overburden and bedrock materials. Borehole FP10 revealed medium air-loss with full sample return between 20m and 21m. This is indicative of a localized closed disseminated receptacle of limited extent. The remainder of the boreholes did not encounter any sample or air-loss. It is assumed that there are disseminated receptacles present which can accommodate between 20% and 30% of the overburden materials, generally characterising the investigated area as prone to the development of sinkholes with sizes varying from medium to large. No surface manifestations of unstable conditions were observed on the site.

4.1.3 Existing Water Table

Groundwater was not encountered in any of the boreholes drilled and no perched groundwater conditions were encountered in any of the boreholes drilled. From the drilling results it appears that the general groundwater level occurs much deeper within underlying bedrock. Within either a non-dewatering or dewatering scenario the stability of the terrain is not expected to be affected by any fluctuation in the groundwater regime.

If dewatering should occur in the future, no stability conditions more severe than predicted will occur due to the expected deeper appearance of the groundwater within the bedrock materials.

However, it is recommended that de-watering should not be allowed within the proposed development area or its neighbouring areas.

4.1.4 Mobilisation Potential of the Blanketing Layer

Competent chert of the Rooihogte Formation was encountered in seven of the boreholes with shale of the Pretoria Group occurring in three of the boreholes drilled (See Table I and Figure 2, Sheet 2 – Appendix IV). The thickness of the Rooihogte Formation and Pretoria Group shale varied from 3m in borehole FP03 to more than 22m in borehole FP09. Considering the good sample return within these materials and generally slow penetration rates, the mobilisation potential of these blanketing layers can be considered as low. The remainder of the overburden materials comprise mainly of chert, silty clay, waddy clay and dolomite. The mobilisation potential of these materials is moderate but high in areas where the thickness of these materials is less than 5m.

4.1.5 Mobilising Agent

The only mobilising agencies which are assumed to have an influence on the over-burden are ingress water coming from leaking services and surface ponding and ground vibration caused by blasting or seismic activities. The lowering of the groundwater table is not considered to have an influence on the stability of this site.

4.1.6 Potential Development Space

Due to the occurrence of relatively deep dolomite bedrock head and the appearance of the Rooihogte chert and shale of the Pretoria Group as part of the overburden, only medium to large size sinkholes can potentially develop on the terrain.

4.2 STABILITY CHARACTERIZATION

4.2.1 Dolomite Stability

The existing and available information relating to the boreholes, geophysical and geohydrological data have been studied and reviewed to come to a characterisation of the sub-surface conditions underlying the site (See Table III). The following factors were given prominence during the evaluation:

- a. The occurrence of medium air-loss was encountered in three of the boreholes drilled, namely borehole FP05, FP07 and FP10.
- b. No groundwater was encountered in any of the boreholes which

may result in any erosion susceptible materials to be rapidly eroded in the presence of ingress water. The permanent ground water level is situated below the blanketing layer in the dolomite bedrock.

- c. A percentage ability to accommodate any draw-down material within the assumed receptacles or disseminated receptacles was ascribed to each sub-surface condition (as revealed in each borehole) which influences the calculated maximum potential sinkhole development space.
- d. Competent chert of the Rooihoogte Formation and Shale of the Pretoria Group capped the upper overburden materials to a considerable depth.
- e. Moderate surface slopes exist which allow surface water to drain freely towards the south western portion of the site.

4.2.2 Development in relation to Risk

The inherent risk classification of the various stability zones remains the same as for those described in Report No: LM266C/02. The developability of these zones were characterised according to the SANS 1936 Vol 1-2 document and represented in Figure 2, Sheet 1 - Appendix IV.

TABLE III : TERRAIN SUB-DIVISION INTO INHERENT RISK CHARACTERISTIC ZONES

| ZONE | RISK OF SINKHOLE FORMATION | INHERENT RISK CLASS (IRC) | APPROPRIATE TYPES OF DEVELOPMENT | | NHBC Area Designation |
|------|---|---------------------------|---|-----------------------|-----------------------|
| | | | LAND USAGE | | |
| | | | Description | Designation | |
| A | Medium risk for small size sinkholes and a medium risk for doline formation | 2 | Suitable for high rise dwelling units of > 3 storeys as per SANS 1936 requirements | RH3 | D2 |
| | | | Suitable for low rise dwelling units of < 3 storeys and dwelling houses as per SANS 1936 requirements | RL1 – RL2 & RN1 – RN3 | |
| B | Medium risk for medium size sinkholes and a medium risk for doline formation | 3 | Low rise dwelling Units: </-3 storeys with up to 80 units per hectare and a population not exceeding 400 people per hectare as per SANS 1936 requirements | RL2 | D3 |
| C | Medium risk for medium to large size sinkholes and a medium risk for doline formation | 4 | | | |
| D | | | | | |
| D1 | High risk for medium size sinkholes and a high risk for doline formation | 6 | Suitable for commercial developments of <3 storeys high as per SANS 1936 requirements | C3, C7 & C8 | |

The stability zone descriptions remain the same as those described in Report No: LM 266C/02.

5. DEVELOPMENT PROPOSAL

From a stability perspective, the site is suitable for the proposed single storey residential dwelling development.

However, it is **recommended that a low-rise (3 storey's or less) residential development** be considered for the site.

The precautionary measures as indicated in Appendix II in paragraphs 1, 2 & 3 remain applicable to this terrain.

An acceptable development risk can be expected to occur over a 20 year period should the development be allowed to proceed.

Zones A, B, C & D can be considered for the proposed residential use. The design criteria should be such that the foundations can withstand a loss of support over an area having a diameter of 5m occurring anywhere under the footprint of the structure.

6. PRECAUTIONARY MEASURES IN DOLOMITE

In a dolomitic environment the formation of sinkholes and dolines must always be expected. However, this expectation is much lower and the risk more acceptable if, during and after the township construction phase, certain drainage precautions are adopted and implemented in areas underlain by favourable geological conditions (See Appendix II). The purpose of these precautions are to reduce the potentially negative effects of the proposed development on the natural environment, drainage and other water related sub-surface erosion patterns. It is highly recommended that these precautionary measures be adopted and implemented as standard design procedures in the various recommended types of development in township development in dolomite bedrock to maintain the stable status quo of the insitu sub-surface conditions which are known to exist at present.

Additional recommendations are as follows:

- All trenches must be inspected by an engineering geologist to permit further detailed verification of soil and stability conditions.
- All stormwater must drain freely off the property and enter the stormwater system.

7. RISK MANAGEMENT PLAN

Concentrated water ingress into the ground should be avoided at all times prior, during and after construction. All the storm water, trenching and roads should be treated as described in Appendix II. A general risk management plan has been compiled which must be implemented at all times to ensure timely remedial action should any surface instabilities manifest (See Appendix III).

8. GENERAL

This investigation was done to serve as an additional footprint drilling dolomite stability investigation and a subsequent report to previous investigations executed for the proposed development.

In light of the findings of the stability investigation it is concluded that the proposed residential development constitutes an acceptable risk and that development should be allowed to proceed subject to the implementation of all recommendations made in the report as well as the prescribed precautionary measures. Though a single storey residential development is proposed, **it is recommended that a low-rise (3 storey's or less) residential development should be considered for the site.**

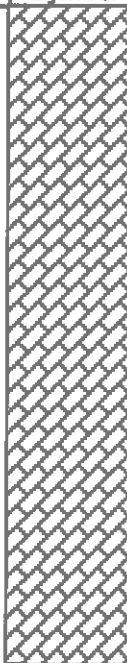
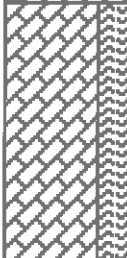
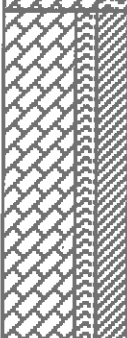

Any development on dolomite can never be deemed entirely risk free. There is always a risk of sinkhole formation due to leaking wet services and ponding of water due to poor storm water management which can trigger ground movements.

L.M. HOLLAND-MUTER (Pr Sci Nat)

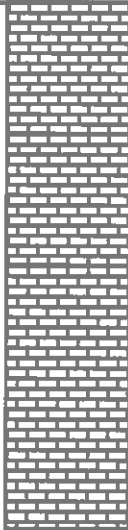
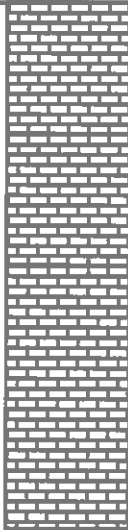
APPENDIX I

PERCUSSION DRILLING RESULTS

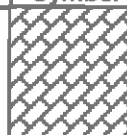
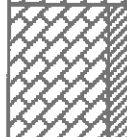
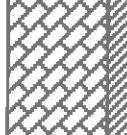
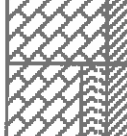
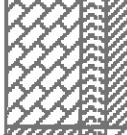
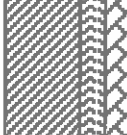
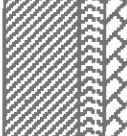
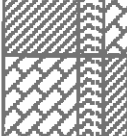
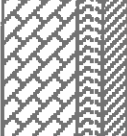
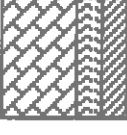
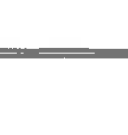

HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|---|--------------|---|---|
| BOREHOLE NO : | | FP 01 | Pg 1 of 2 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : ▼ Standing water Y Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetra- tion (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.31 | |  | 1.0_ | Dark grey, slightly leached CHERT (Breccia). | |
| 0.36 | | | 2.0_ | | |
| 0.43 | | | 3.0_ | | |
| 1.07 | | | 4.0_ | | |
| 1.03 | | | 5.0_ | | |
| 1.05 | | | 6.0_ | | |
| 1.00 | | | 7.0_ | | |
| 0.56 | | | 8.0_ | | |
| 0.49 | | | 9.0_ | | |
| 0.47 | | | 10.0_ | | |
| 0.42 | |  | 11.0_ | Light to dark grey CHERT with minor wad. | |
| 0.39 | | | 12.0_ | | |
| 0.40 | | | 13.0_ | | |
| 0.45 | | | 14.0_ | | |
| 1.07 | |  | 15.0_ | CHERT and waddy clay (<2%). | |
| 1.10 | | | 16.0_ | | |
| 1.12 | | | 17.0_ | | |
| 1.16 | | | 18.0_ | | |
| 1.20 | | | 19.0_ | | |
| 1.23 | |  | 20.0_ | Light to dark grey CHERT with minor wad. | |

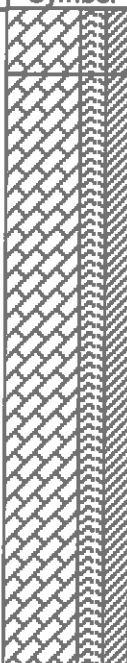
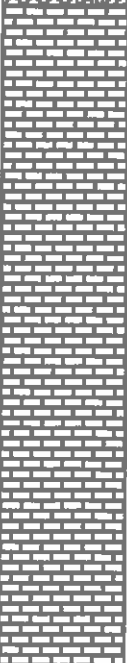
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| | | | | | | |
|--------------------------------|----------------------------------|--|----------------------|---|-------------------|--|
| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | | |
| BOREHOLE NO : | | FP 01 | Pg 2 of 2 | Drill Rig Type : | Rock Giant | |
| | | | | Drilling Pressure : | 18 Bar | |
| Drilled by : | |  | | KEY : | | |
| Date : | | | | Y | Standing water | |
| Logged by : | | | | Y | Water seepage | |
| | | | | EOH | End of Hole | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | | |
| 1.30 | |  | 21.0_ | Light to dark bluish grey, leached to slightly leached, medium hard rock DOLOMITE. | | |
| 1.48 | | | 22.0_ | | | |
| 1.56 | | | 23.0_ | Light to dark grey, slightly leached, hard rock DOLOMITE. | | |
| 2.09 | | | 24.0_ | | | |
| 3.04 | | | 25.0_ | Dark grey, fresh, very hard rock DOLOMITE. | | |
| 3.00 | | | 26.0_ | | | |
| 3.09 | | | 27.0_ | | | |
| 3.16 | | | 28.0_ | NOTES: 1. Full sample return with no airloss. 2. Dolomite from 20m with hard to very hard rock Dolomite from 22m. 3. No goundwater encountered. | | |
| | | 29.0_ | | | | |
| | | 30.0_ | | | | |
| | | 31.0_ | | | | |
| | | 32.0_ | | | | |
| | | 33.0_ | | | | |
| | | 34.0_ | | | | |
| | | 35.0_ | | | | |
| | | 36.0_ | | | | |
| | | 37.0_ | | | | |
| | | 38.0_ | | | | |
| | | 39.0_ | | | | |
| | | 40.0_ | | | | |

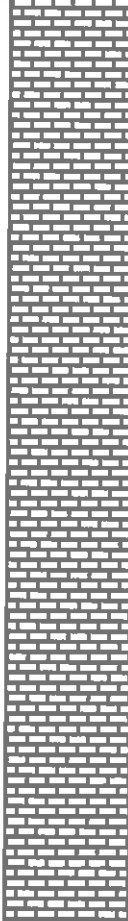
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|------------------------------|-------------------|---|-----------|---|--------------------------------------|
| BOREHOLE NO : | | FP 02 | Pg 1 of 3 | Drill Rig Type : Rock Giant | Drilling Pressure : 18 Bar |
| Drilled by : | | JK Developments | | KEY : √ Standing water √ Water seepage EOH End of Hole | |
| Date : | | March 2017 | | | |
| Logged by : | | L. Holland-Muter | | | |
| Borehole Co-ordinates | | See Figure 2 | | | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.22 | |  | 1.0_ | Light to dark grey leached CHERT (Breccia). | |
| 0.27 | |  | 2.0_ | | |
| 0.34 | |  | 3.0_ | Light to dark grey, leached CHERT with minor silty clay. | |
| 0.40 | |  | 4.0_ | | |
| 0.49 | |  | 5.0_ | | |
| 1.02 | |  | 6.0_ | | |
| 1.00 | |  | 7.0_ | Light to dark grey, leached CHERT with minor silty clay with traces of wad. | |
| 0.50 | |  | 8.0_ | | |
| 0.47 | |  | 9.0_ | | |
| 0.39 | |  | 10.0_ | Dark red CLAY with abundant chert and traces of wad. | |
| 0.43 | |  | 11.0_ | | |
| 0.41 | |  | 12.0_ | | |
| 0.32 | | | 13.0_ | | |
| 0.37 | | | 14.0_ | | |
| 0.39 | | | 15.0_ | | |
| 0.40 | | | 16.0_ | CHERT and waddy clay (<5%). | |
| 0.46 | | | 17.0_ | | |
| 0.42 | | | 18.0_ | | |
| 0.36 | | | 19.0_ | | |
| 0.30 | | | 20.0_ | | |

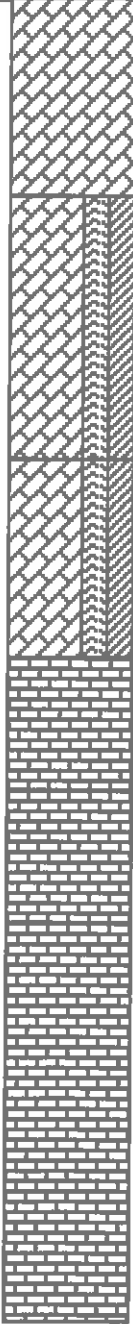
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|----------------------|-------------------|---|-----------|---|---|
| BOREHOLE NO : | | FP 02 | Pg 2 of 3 | Drill Rig Type : Rock Giant Drilling Pressure : 18 Bar | Borehole Co -ordinates See Figure 2 |
| Drilled by : | | JK Developments March 2017 L. Holland-Muter | | KEY : ▼ Standing water Y Water seepage EOH End of Hole | |
| Date : | | | | | |
| Logged by : | | | | | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.34 | |  | 21.0_ | CHERT and waddy clay (<5%). | |
| 0.37 | | | 22.0_ | CHERT and waddy clay (5 - 10%). | |
| 0.42 | | | 23.0_ | | |
| 0.44 | | | 24.0_ | | |
| 0.31 | | | 25.0_ | | |
| 0.27 | | | 26.0_ | | |
| 0.32 | | | 27.0_ | | |
| 0.24 | | | 28.0_ | | |
| 0.27 | | | 29.0_ | | |
| 0.25 | | | 30.0_ | | |
| 1.11 | |  | 31.0_ | Light and dark blue, leached, soft rock DOLOMITE. | |
| 1.09 | | | 32.0_ | | |
| 1.05 | | | 33.0_ | | |
| 1.07 | | | 34.0_ | | |
| 1.13 | | | 35.0_ | | |
| 1.10 | | | 36.0_ | | |
| 1.08 | | | 37.0_ | | |
| 1.05 | | | 38.0_ | | |
| 1.03 | | 39.0_ | | | |
| 1.01 | | 40.0_ | | | |

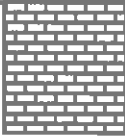
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------|-------------------|--|-----------|--|------------------------|
| BOREHOLE NO : | | FP 02 | Pg 3 of 3 | Drill Rig Type : Rock Giant | Borehole Co -ordinates |
| Drilled by : | | JK Developments | | Drilling Pressure : 18 Bar | See Figure 2 |
| Date : | | March 2017 | | KEY : | |
| Logged by : | | L. Holland-Muter | | ▼ Standing water ▼ Water seepage EOH End of Hole | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 1.03 | |  | 41.0_ | Light and dark blue, leached, soft rock DOLOMITE. | |
| 1.02 | | | 42.0_ | | |
| 1.03 | | | 43.0_ | | |
| 1.07 | | | 44.0_ | | |
| 1.04 | | | 45.0_ | | |
| 1.13 | | | 46.0_ | | |
| 1.18 | | | 47.0_ | | |
| 1.16 | | | 48.0_ | | |
| 1.09 | | | 49.0_ | | |
| 1.03 | | | 50.0_ | | |
| 1.01 | | | 51.0_ | | |
| 1.03 | | | 52.0_ | | |
| 1.02 | | | 53.0_ | | |
| 1.02 | | | 54.0_ | | |
| | | EOH | 55.0_ | NOTES: 1. Full sample return with no sample airloss. 2. Dolomite from 30m. 3. No groundwater encountered. | |
| | | | 56.0_ | | |
| | | | 57.0_ | | |
| | | | 58.0_ | | |
| | | | 59.0_ | | |
| | | | 60.0_ | | |

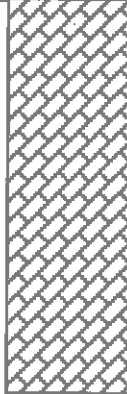
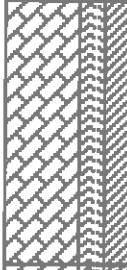
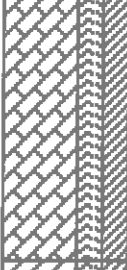
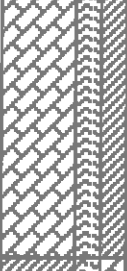
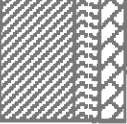
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| | | | | | |
|--------------------------------------|----------------------------------|--|--|---|-------------------|
| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
| BOREHOLE NO : | | FP 03 | Pg 1 of 2 | Drill Rig Type : | Rock Giant |
| Drilled by : | | JK Developments | | Drilling Pressure : | 18 Bar |
| Date : | | March 2017 | | Borehole Co -ordinates | |
| Logged by : | | L. Holland-Muter | | KEY : | |
| | | | | Y | Standing water |
| | | | | Y | Water seepage |
| | | | | EOH | End of Hole |
| Penetra- tion (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.27 | |  | 1.0_ | Light to dark grey leached CHERT (Breccia). | |
| 0.30 | | | 2.0_ | | |
| 0.36 | | | 3.0_ | | |
| 0.25 | | | 4.0_ | CHERT and waddy clay (<5%). | |
| 0.23 | | | 5.0_ | | |
| 0.21 | | | 6.0_ | | |
| 0.29 | | | 7.0_ | CHERT and waddy clay (<2%). | |
| 0.33 | | | 8.0_ | | |
| 0.35 | | | 9.0_ | | |
| 0.40 | | | 10.0_ | Light and dark blue, leached, soft rock DOLOMITE. | |
| 1.16 | | 11.0_ | | | |
| 1.22 | | 12.0_ | | | |
| 1.27 | | 13.0_ | Light to dark bluish grey, leached to slightly leached, medium hard rock DOLOMITE. | | |
| 1.30 | | 14.0_ | | | |
| 2.31 | | 15.0_ | | | |
| 2.40 | | 16.0_ | Dark grey, fresh, very hard rock DOLOMITE. | | |
| 3.04 | | 17.0_ | | | |
| 3.07 | | 18.0_ | | | |
| 3.10 | | 19.0_ | | | |
| 3.14 | | 20.0_ | | | |

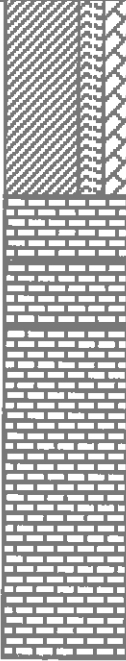
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|----------------------|-------------------|---|-----------|---|-------------------|
| BOREHOLE NO : | | FP 03 | Pg 2 of 2 | Drill Rig Type : | Rock Giant |
| | | | | Drilling Pressure : | 18 Bar |
| Drilled by : | | JK Developments | | KEY : Y Standing water Y Water seepage EOH End of Hole | |
| Date : | | March 2017 | | | |
| Logged by : | | L. Holland-Muter | | | |
| | | See Figure 2 | | | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 3.16 | |  | 21.0_ | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.20 | | EOH | 22.0_ | | |
| | | | 23.0_ | NOTES: 1. Full sample return with no airloss. 2. Dolomite from 10m with very hard rock Dolomite from 14m. 3. No groundwater encountered. | |
| | | | 24.0_ | | |
| | | | 25.0_ | | |
| | | | 26.0_ | | |
| | | | 27.0_ | | |
| | | | 28.0_ | | |
| | | | 29.0_ | | |
| | | | 30.0_ | | |
| | | | 31.0_ | | |
| | | | 32.0_ | | |
| | | | 33.0_ | | |
| | | | 34.0_ | | |
| | | | 35.0_ | | |
| | | | 36.0_ | | |
| | | | 37.0_ | | |
| | | | 38.0_ | | |
| | | | 39.0_ | | |
| | | | 40.0_ | | |

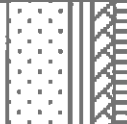
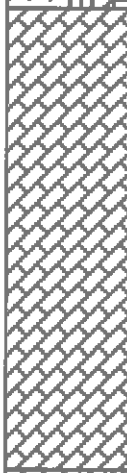



HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | | |
|---------------------------------------|-------------------------|---|--------------|---|----------------------|---------------------------|
| BOREHOLE NO : | | FP 04 | Pg 1 of 2 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar | Borehole Co -ordinates |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : Y Standing water Y Water seepage EOH End of Hole | | See Figure 2 |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | | |
| 0.26 | |  | 1.0_ | Light to dark grey leached CHERT (Breccia). | | |
| 0.28 | | | 2.0_ | | | |
| 0.34 | | | 3.0_ | | | |
| 0.30 | | | 4.0_ | | | |
| 0.37 | | | 5.0_ | | | |
| 0.39 | | | 6.0_ | | | |
| 0.45 | |  | 7.0_ | CHERT and waddy clay (<2%). | | |
| 0.42 | | | 8.0_ | | | |
| 0.47 | | | 9.0_ | | | |
| 0.39 | | | 10.0_ | | | |
| 0.46 | |  | 11.0_ | CHERT and waddy clay (<5%). | | |
| 0.54 | | | 12.0_ | | | |
| 0.39 | | | 13.0_ | | | |
| 0.37 | | | 14.0_ | | | |
| 0.29 | |  | 15.0_ | CHERT and waddy clay (<2%). | | |
| 0.28 | | | 16.0_ | | | |
| 0.20 | | | 17.0_ | | | |
| 0.24 | | | 18.0_ | | | |
| 0.27 | |  | 19.0_ | Dark brown waddy CLAY with abundant chert. | | |
| 0.23 | | | 20.0_ | | | |

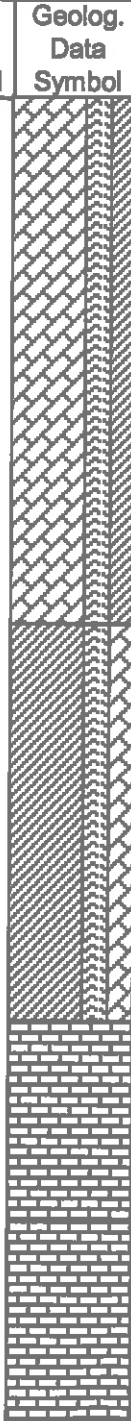
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|--|--------------|--|---|
| BOREHOLE NO : | | FP 04 | Pg 2 of 2 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : Y Standing water Y Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.21 | |  | 21.0_ | Dark brown waddy CLAY with abundant chert. | |
| 0.23 | | | 22.0_ | | |
| 0.22 | | | 23.0_ | | |
| 1.43 | | | 24.0_ | Light to dark bluish grey, leached to slightly leached, medium hard rock DOLOMITE. | |
| 1.59 | | | 25.0_ | Light to dark grey, slightly leached, hard rock DOLOMITE. | |
| 3.07 | | | 26.0_ | | |
| 3.05 | | | 27.0_ | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.11 | | | 28.0_ | | |
| 3.08 | | | 29.0_ | | |
| 3.06 | | | 30.0_ | | |
| | | EOH | 31.0_ | <p>NOTES:</p> <ol style="list-style-type: none"> 1. Full sample return with no airloss. 2. Dolomite from 23m with hard to very hard rock Dolomite from 24m. 3. No groundwater encountered. | |
| | | | 32.0_ | | |
| | | | 33.0_ | | |
| | | | 34.0_ | | |
| | | | 35.0_ | | |
| | | | 36.0_ | | |
| | | | 37.0_ | | |
| | | | 38.0_ | | |
| | | | 39.0_ | | |
| | | | 40.0_ | | |

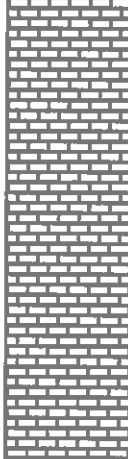
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|----------------------|-------------------|---|-----------|--|--------------------------------------|
| BOREHOLE NO : | | FP 05 | Pg 1 of 3 | Drill Rig Type : Rock Giant | Drilling Pressure : 18 Bar |
| Drilled by : | | JK Developments | | KEY : | |
| Date : | | March 2017 | | ▼ Standing water | See Figure 2 |
| Logged by : | | L. Holland-Muter | | ▼ Water seepage | |
| EOH | | End of Hole | | | |
| Penetration (mln/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.26 | |  | 1.0_ | Dark brown, silty SAND with abundant chert gravels and fragments of shale. | |
| 0.29 | | | 2.0_ | | |
| 0.34 | |  | 3.0_ | Light to dark grey leached CHERT (Breccia). | |
| 0.30 | | | 4.0_ | | |
| 0.38 | | | 5.0_ | | |
| 0.40 | | | 6.0_ | | |
| 0.45 | | | 7.0_ | | |
| 0.41 | | | 8.0_ | | |
| 0.38 | | | 9.0_ | CHERT and waddy clay (<2%). | |
| 0.46 | |  | 10.0_ | | |
| 0.54 | | | 11.0_ | | |
| 0.49 | | | 12.0_ | | |
| 0.37 | | | 13.0_ | Dark brown waddy CLAY with abundant chert. | |
| 0.33 | | | 14.0_ | | |
| 0.38 | | | 15.0_ | | |
| 0.27 | |  | 16.0_ | CHERT and waddy clay (<2%). | |
| 0.19 | | | 17.0_ | | |
| 0.22 | | | 18.0_ | | |
| 0.29 | |  | 19.0_ | CHERT and waddy clay (<2%). | |
| 0.27 | | | 20.0_ | | |

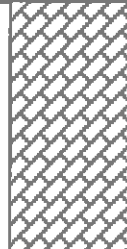
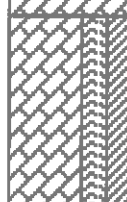
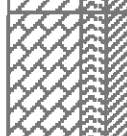
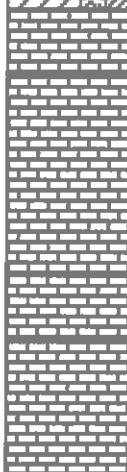
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| | | | | | | | |
|----------------------------|--------------------------|--|------------------|--|-------------------|---------------------|--|
| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | | | |
| BOREHOLE NO : | | FP 05 | Pg 2 of 3 | Drill Rig Type : | Rock Giant | | |
| | | | | Drilling Pressure : | 18 Bar | | |
| Drilled by : | |  | | Borehole Co -ordinates | | | |
| Date : | | | | KEY : ▼ Standing water Y Water seepage EOH End of Hole | | See Figure 2 | |
| Logged by : | | | | | | | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | | | |
| 0.25 | | | 21.0_ | CHERT and waddy clay (<2%). | | | |
| 0.21 | | | 22.0_ | | | | |
| 0.23 | | | 23.0_ | | | | |
| 0.22 | | | 24.0_ | | | | |
| 0.23 | | | 25.0_ | | | | |
| 0.21 | | | 26.0_ | | | | |
| 0.21 | | | 27.0_ | | | | |
| 0.23 | | | 28.0_ | | | | |
| 0.37 | | | 29.0_ | Dark brown waddy CLAY with abundant chert. | | | |
| 0.26 | | | 30.0_ | | | | |
| 0.27 | | | 31.0_ | | | | |
| 0.25 | | | 32.0_ | | | | |
| 0.29 | | | 33.0_ | | | | |
| 0.21 | | | 34.0_ | | | | |
| 1.34 | | | 35.0_ | Light to dark bluish grey, leached to slightly leached, medium hard rock DOLOMITE. | | | |
| 1.38 | | | 36.0_ | | | | |
| 1.42 | | | 37.0_ | | | | |
| 2.16 | | | 38.0_ | Dark grey, fresh, very hard rock DOLOMITE. | | | |
| 2.34 | | | 39.0_ | | | | |
| 2.46 | | | 40.0_ | | | | |
| | | | | | | | |

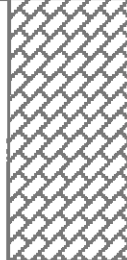
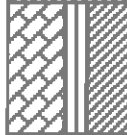
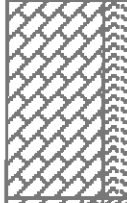
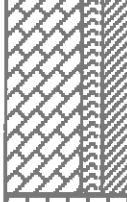
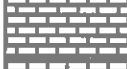
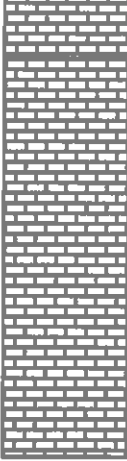
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|--|--------------|---|---|
| BOREHOLE NO : | | FP 05 | Pg 3 of 3 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : Y Standing water Y Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 2.49 | |  | 41.0_ | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.07 | | | 42.0_ | | |
| 3.11 | | | 43.0_ | | |
| 3.09 | | | 44.0_ | | |
| 3.13 | | | 45.0_ | | |
| 3.17 | | | 46.0_ | | |
| 3.19 | | | 47.0_ | | |
| | | EOH | 48.0_ | NOTES: 1. Medium sample return with medium airloss from 21m-22m, 23-24m and 25m-27m. 2. Dolomite from 34m with very hard rock Dolomite from 37m. 3. No groundwater encountered. | |
| | | | 49.0_ | | |
| | | | 50.0_ | | |
| | | | 51.0_ | | |
| | | | 52.0_ | | |
| | | | 53.0_ | | |
| | | | 54.0_ | | |
| | | | 55.0_ | | |
| | | | 56.0_ | | |
| | | | 57.0_ | | |
| | | | 58.0_ | | |
| | | | 59.0_ | | |
| | | | 60.0_ | | |


HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | | |
|------------------------|-------------------------|---|--------------------------------|--|----------------------|---------------------------|
| BOREHOLE NO : | | FP 06 | Pg 1 of 1 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar | Borehole Co -ordinates |
| Drilled by : | | JK Developments | | KEY : | | See Figure 2 |
| Date : | | March 2017 | | Y | Standing water | |
| Logged by : | | L. Holland-Muter | | Y | Water seepage | |
| | | EOH | | EOH | | End of Hole |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | | |
| 0.34 | |  | 1.0_ | Light to dark grey leached CHERT (Breccia). | | |
| 0.30 | | | 2.0_ | | | |
| 0.27 | | | 3.0_ | | | |
| 0.39 | | | 4.0_ | | | |
| 0.40 | |  | 5.0_ | CHERT and waddy clay (<2%). | | |
| 0.43 | | | 6.0_ | | | |
| 0.46 | | | 7.0_ | | | |
| 0.39 | |  | 8.0_ | CHERT and waddy clay (<5%). | | |
| 0.62 | | | 9.0_ | | | |
| 1.16 | |  | 10.0_ | Light and dark blue, leached, soft rock DOLOMITE. | | |
| 1.34 | | | 11.0_ | Light to dark bluish grey, leached to slightly leached, medium hard rock DOLOMITE. | | |
| 1.39 | | | 12.0_ | | | |
| 1.42 | | | 13.0_ | | | |
| 2.18 | | | 14.0_ | Light to dark grey, slightly leached, hard rock DOLOMITE. | | |
| 2.46 | | | 15.0_ | Dark grey, fresh, very hard rock DOLOMITE. | | |
| 3.04 | | | 16.0_ | | | |
| | | | 17.0_ | NOTES: | | |
| | | | 18.0_ | 1. Full sample return with no airloss. | | |
| | | | 19.0_ | 2. Dolomite from 9m with hard to very hard rock Dolomite from 13m-16m. | | |
| | | 20.0_ | 3. No groundwater encountered. | | | |





















HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|------------------------|-------------------------|---|--------------|--|-------------------------------|
| BOREHOLE NO : | | FP 07 | Pg 1 of 2 | Drill Rig Type : Rock Giant | Borehole Co -ordinates |
| Drilled by : | | JK Developments | | Drilling Pressure : 18 Bar | See Figure 2 |
| Date : | | March 2017 | | KEY : | |
| Logged by : | | L. Holland-Muter | | ▼ Standing water ▼ Water seepage EOH End of Hole | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.26 | |  | 1.0_ | Light to dark grey leached CHERT (Breccia). | |
| 0.33 | | | 2.0_ | | |
| 0.26 | | | 3.0_ | | |
| 0.24 | | | 4.0_ | | |
| 0.27 | |  | 5.0_ | Light to dark grey, leached CHERT with reddish brown silty CLAY. | |
| 0.26 | | | 6.0_ | | |
| 0.17 | |  | 7.0_ | Light to dark grey CHERT with minor wad. | |
| 0.19 | | | 8.0_ | | |
| 0.20 | | | 9.0_ | | |
| 0.27 | |  | 10.0_ | CHERT and waddy clay (<2%). | |
| 0.26 | | | 11.0_ | | |
| 0.21 | |  | 12.0_ | Light and dark blue, leached, soft rock DOLOMITE. | |
| 1.06 | | | 13.0_ | | |
| 1.59 | | | 14.0_ | | |
| 2.35 | |  | 15.0_ | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.07 | | | 16.0_ | | |
| 3.09 | | | 17.0_ | | |
| 3.12 | | | 18.0_ | | |
| 3.14 | | | 19.0_ | | |
| 3.08 | | | 20.0_ | | |


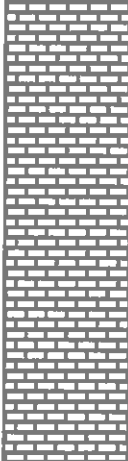
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| | | | | | |
|---------------------------------------|-------------------------|--|--------------|--|----------------------|
| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
| BOREHOLE NO : | | FP 07 | Pg 2 of 2 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | Borehole Co -ordinates | |
| | | | | KEY : | |
| | | | | Y Standing water Y Water seepage EOH End of Hole | |
| Penetra- tion (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 3.09 | |  EOH | 21.0_ | Dark grey, fresh, very hard rock DOLOMITE. | |
| | | | 22.0_ | <p>NOTES:</p> <ol style="list-style-type: none"> 1. Medium sample return with medium airloss from 11m-12m. 2. Dolomite from 12m with hard to very hard rock Dolomite from 13m. 3. No groundwater encountered. | |
| | | | 23.0_ | | |
| | | | 24.0_ | | |
| | | | 25.0_ | | |
| | | | 26.0_ | | |
| | | | 27.0_ | | |
| | | | 28.0_ | | |
| | | | 29.0_ | | |
| | | | 30.0_ | | |
| | | | 31.0_ | | |
| | | | 32.0_ | | |
| | | | 33.0_ | | |
| | | | 34.0_ | | |
| | | | 35.0_ | | |
| | | | 36.0_ | | |
| | | | 37.0_ | | |
| | | | 38.0_ | | |
| | | | 39.0_ | | |
| | | | 40.0_ | | |

HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|----------------------|-------------------|---|-----------|--|-------------------------------|
| BOREHOLE NO : | | FP 08 | Pg 1 of 2 | Drill Rig Type : Rock Giant | Borehole Co -ordinates |
| Drilled by : | | JK Developments | | KEY : ▼ Standing water ▼ Water seepage EOH End of Hole | See Figure 2 |
| Date : | | March 2017 | | | |
| Logged by : | | L. Holland-Muter | | | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.26 | |  | 1.0_ | Light orange yellow SHALE. | |
| 0.23 | |  | 2.0_ | | |
| 0.29 | |  | 3.0_ | Light grey SHALE. | |
| 0.32 | |  | 4.0_ | | |
| 0.34 | |  | 5.0_ | | |
| 0.49 | |  | 6.0_ | | |
| 1.34 | |  | 7.0_ | Light to dark grey, QUARTZITE with minor sandy clay. | |
| 1.56 | |  | 8.0_ | | |
| 1.48 | |  | 9.0_ | | |
| 2.13 | |  | 10.0_ | Light grey SHALE. | |
| 2.09 | |  | 11.0_ | | |
| 2.07 | |  | 12.0_ | | |
| 1.45 | |  | 13.0_ | Light to dark grey leached CHERT (Breccia). | |
| 1.40 | |  | 14.0_ | | |
| 1.48 | |  | 15.0_ | | |
| 1.51 | |  | 16.0_ | | |
| 1.50 | |  | 17.0_ | | |
| 1.49 | |  | 18.0_ | CHERT and waddy clay (<2%). | |
| 1.17 | |  | 19.0_ | | |
| 1.32 | |  | 20.0_ | | |



HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|--|--------------|---|---|
| BOREHOLE NO : | | FP 08 | Pg 2 of 2 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : ▼ Standing water Y Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 2.18 | |  | 21.0_ | CHERT and waddy clay (<2%). | |
| 2.42 | |  | 22.0_ | Dark grey, fresh very hard rock DOLOMITE. | |
| 3.09 | | | 23.0_ | | |
| 4.07 | | | 24.0_ | | |
| 4.03 | | | 25.0_ | | |
| 3.39 | | | 26.0_ | | |
| 3.28 | | | 27.0_ | | |
| 3.34 | | | 28.0_ | | |
| | | EOH | 29.0_ | <p>NOTES:</p> <ol style="list-style-type: none"> 1. Full sample return with no airloss. 2. Shale from 0m-6m and 9m-12m. 3. Quartzite from 6m-9m. 4. Very hard rock Dolomite from 21m. 5. No groundwater encountered. | |
| | | | 30.0_ | | |
| | | | 31.0_ | | |
| | | | 32.0_ | | |
| | | | 33.0_ | | |
| | | | 34.0_ | | |
| | | | 35.0_ | | |
| | | | 36.0_ | | |
| | | | 37.0_ | | |
| | | | 38.0_ | | |
| | | | 39.0_ | | |
| | | | 40.0_ | | |



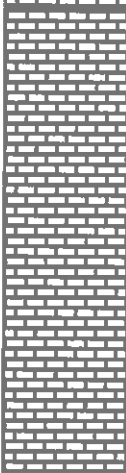
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|------------------------|-------------------------|---|------------------|--|------------------------------|
| BOREHOLE NO : | | FP 09 | Pg 1 of 3 | Drill Rig Type : Rock Giant | Borehole Co-ordinates |
| Drilled by : | | JK Developments | | Drilling Pressure : 18 Bar | See Figure 2 |
| Date : | | March 2017 | | KEY : | |
| Logged by : | | L. Holland-Muter | | Y Standing water Y Water seepage EOH End of Hole | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.22 | | | 1.0_ | Dark brown, silty SAND with abundant chert gravels and fragments of shale. | |
| 0.21 | | | 2.0_ | | |
| 0.24 | | | 3.0_ | | |
| 0.27 | | | 4.0_ | Light orange yellow SHALE. | |
| 0.30 | | | 5.0_ | | |
| 0.28 | | | 6.0_ | | |
| 0.21 | | | 7.0_ | | |
| 0.52 | | | 8.0_ | | |
| 0.54 | | | 9.0_ | | |
| 0.59 | | | 10.0_ | | |
| 1.59 | | | 11.0_ | | |
| 1.42 | | | 12.0_ | | |
| 2.09 | | | 13.0_ | | |
| 2.01 | | 14.0_ | Dark grey SHALE. | | |
| 2.10 | | 15.0_ | | | |
| 1.58 | | 16.0_ | | | |
| 1.49 | | 17.0_ | | | |
| 1.24 | | 18.0_ | | | |
| 1.19 | | 19.0_ | | | |
| 1.59 | | | 20.0_ | Light to dark grey CHERT. | |

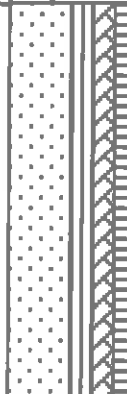


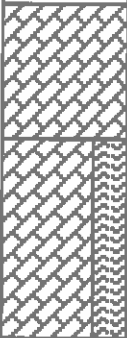
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|---|--------------|---|---|
| BOREHOLE NO : | | FP 09 | Pg 2 of 3 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : ▼ Standing water ▼ Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetra- tion (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 1.59 | |  | 21.0_ | Light to dark grey CHERT. | |
| 1.52 | | | 22.0_ | | |
| 1.09 | |  | 23.0_ | CHERT and waddy clay (<2%). | |
| 1.22 | | | 24.0_ | | |
| 1.05 | | | 25.0_ | | |
| 1.33 | | | 26.0_ | | |
| 1.01 | | | 27.0_ | | |
| 1.02 | | | 28.0_ | | |
| 1.22 | | | 29.0_ | | |
| 1.42 | | | 30.0_ | | |
| 1.14 | | | 31.0_ | | |
| 1.10 | | | 32.0_ | | |
| 1.25 | | | 33.0_ | | |
| 1.15 | | | 34.0_ | | |
| 2.30 | | | 35.0_ | | |
| 2.10 | | | 36.0_ | | |
| 2.25 | | | 37.0_ | | |
| 1.07 | | | 38.0_ | | |
| 1.10 | | | 39.0_ | | |
| 1.06 | | | 40.0_ | | |

HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|--|--------------|---|---|
| BOREHOLE NO : | | FP 09 | Pg 3 of 3 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : ▼ Standing water ▼ Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetra- tion (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 1.07 | |  | 41.0 | CHERT and waddy clay (<2%). | |
| 2.08 | |  | 42.0 | Light to dark grey, slightly leached, hard rock DOLOMITE. | |
| 2.10 | |  | 43.0 | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.01 | | | 44.0 | | |
| 3.07 | | | 45.0 | | |
| 3.09 | | | 46.0 | | |
| 3.08 | | | 47.0 | | |
| 3.06 | | | 48.0 | | |
| 3.04 | | 49.0 | | | |
| | | EOH | 50.0 | <p>NOTES:</p> <ol style="list-style-type: none"> 1. Full sample return with no airloss. 2. Hard rock Dolomite from 41m and very hard rock from 42m. 3. No groundwater encountered. | |
| | | | 51.0 | | |
| | | | 52.0 | | |
| | | | 53.0 | | |
| | | | 54.0 | | |
| | | | 55.0 | | |
| | | | 56.0 | | |
| | | | 57.0 | | |
| | | | 58.0 | | |
| | | | 59.0 | | |
| | | | 60.0 | | |

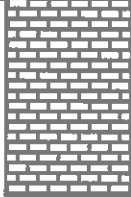
HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| | | | | | |
|----------------------------|--------------------------|---|------------------|--|--------------------------------------|
| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
| BOREHOLE NO : | | FP 10 | Pg 1 of 3 | Drill Rig Type : Rock Giant | Drilling Pressure : 18 Bar |
| Drilled by : | | JK Developments | | KEY : ▼ Standing water ▼ Water seepage EOH End of Hole | |
| Date : | | March 2017 | | | |
| Logged by : | | L. Holland-Muter | | | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 0.24 | |  | 1.0_ | Dark brown, silty SAND with abundant chert gravels and fragments of shale. | |
| 0.17 | | | 2.0_ | | |
| 0.21 | | | 3.0_ | | |
| 0.20 | | | 4.0_ | | |
| 0.28 | | | 5.0_ | | |
| 0.27 | | | 6.0_ | | |
| 0.29 | |  | 7.0_ | Light orange yellow SHALE. | |
| 0.26 | | | 8.0_ | | |
| 0.25 | | | 9.0_ | | |
| 0.28 | | | 10.0_ | | |
| 0.33 | | | 11.0_ | | |
| 0.30 | | | 12.0_ | | |
| 0.40 | |  | 13.0_ | Light grey SHALE. | |
| 0.39 | | | 14.0_ | | |
| 0.42 | | | 15.0_ | | |
| 0.59 | | | 16.0_ | | |
| 1.30 | | | 17.0_ | | |
| 1.42 | | | 18.0_ | | |
| 1.30 | |  | 19.0_ | Light to dark grey leached CHERT (Breccia). | |
| 2.18 | | | 20.0_ | | |

HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | | |
|---------------------------------------|-------------------------|--|--|---|---|--|
| BOREHOLE NO : | | FP 10 | Pg 2 of 3 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar | |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : ▼ Standing water Y Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 | |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | | |
| 2.39 | | | 21.0_ | Light to dark grey CHERT with minor wad. | | |
| 2.30 | | | 22.0_ | | | |
| 2.28 | | | 23.0_ | | | |
| 2.10 | | | 24.0_ | | | |
| 1.38 | | | 25.0_ | | | |
| 1.59 | | | 26.0_ | | | |
| 1.49 | | | 27.0_ | | | |
| 1.07 | | | 28.0_ | | | |
| 1.09 | | | 29.0_ | | | |
| 1.06 | | | 30.0_ | | | |
| 1.02 | | 31.0_ | Light to dark bluish grey, leached to slightly leached, medium hard rock DOLOMITE. | | | |
| 1.04 | | 32.0_ | | | | |
| 1.07 | | 33.0_ | | | | |
| 1.10 | | 34.0_ | | | | |
| 1.28 | | 35.0_ | | | | |
| 1.37 | | 36.0_ | | | | |
| 2.40 | | 37.0_ | | | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.07 | | 38.0_ | | | | |
| 3.09 | | 39.0_ | | | | |
| 3.40 | | 40.0_ | | | | |

HOLLAND-MUTER & ASSOCIATES - PERCUSSION DRILLING RECORD

| PROJECT : | | STAND 1211: PIERRE VAN RYNEVELD EXTENSION 2: CENTURION | | | |
|---------------------------------------|-------------------------|---|--------------|--|---|
| BOREHOLE NO : | | FP 10 | Pg 3 of 3 | Drill Rig Type : Drilling Pressure : | Rock Giant 18 Bar |
| Drilled by : Date : Logged by : | | JK Developments March 2017 L. Holland-Muter | | KEY : Y Standing water Y Water seepage EOH End of Hole | Borehole Co -ordinates See Figure 2 |
| Penetration (min/m) | Other Data Symbol | Geolog. Data Symbol | Depth (m) | Description | |
| 3.36 | |  | 41.0_ | Dark grey, fresh, very hard rock DOLOMITE. | |
| 3.27 | | | 42.0_ | | |
| 3.47 | | | 43.0_ | | |
| | | EOH | 44.0_ | NOTES: 1. Full sample return with medium airloss from 20m-21m. 2. Dolomite from 34m with very hard rock Dolomite from 36m. 3. No groundwater encountered. | |
| | | | 45.0_ | | |
| | | | 46.0_ | | |
| | | | 47.0_ | | |
| | | | 48.0_ | | |
| | | | 49.0_ | | |
| | | | 50.0_ | | |
| | | | 51.0_ | | |
| | | | 52.0_ | | |
| | | | 53.0_ | | |
| | | | 54.0_ | | |
| | | | 55.0_ | | |
| | | | 56.0_ | | |
| | | | 57.0_ | | |
| | | | 58.0_ | | |
| | | | 59.0_ | | |
| | | | 60.0_ | | |

APPENDIX II

PRECAUTIONARY MEASURES

PRECAUTIONARY MEASURES

1 General measures to be implemented on all dolomitic sites. General compliance is required with NHBRC Standards

Water acts as a triggering mechanism, in the majority of cases. It is therefore imperative that the concentrated ingress of water into the ground be avoided at all times, including in the construction period.

An emergency reaction plan should be in place in the event of a sinkhole or doline developing under a water-bearing service. Such a plan should consider the following question, 'Who should residents phone in case of such an emergency?' In the event of the sinkhole occurring in a townhouse complex, for instance, the Body Corporate must know the emergency procedures and residents should know how to get in contact with the acting members. In township developments use should be made of community awareness campaigns to involve residents and inform them of whom to contact and what to do. It is important that responsible persons know how to close the mains and then cordon the area off at least 3 - 5 m clear of the sinkhole edge.

- a. Brick and precast concrete walls must be so designed as to provide drainage ports at ground level permitting passage of maximum probable quantities of water.
- b. When courtyards are designed, the free flow of surface water should be ensured. Where gutter downpipes are to be found in such a courtyard, a lined canal should permit passage of water into a drain or onto the lawn away from the structure. The courtyard should preferably be paved and no garden beds should be created at gutter discharge points.
- c. Residents should be informed of where services traverse their garden so that accidental puncturing of pipes can be avoided.

Wet services of individual and entire development -

- a. All wet services should be of good quality in order to ensure low maintenance.
- b. Piping materials selected should also be appropriate to local subsurface conditions. If clay pipes are utilized in areas of shallow dolomite, a higher standard of pipe bedding is recommended, e.g. stabilized bedding or over excavation and recompaction with an approved material (minimum specification to be G7 material) in layers of 150 mm thickness, compacted to 93% mod AASHTO.

Some soils may have low pH values, which will render the use of ferrous material for underground services unsuitable. Chapter II in 'A Technical Guide to Good House Construction' NBRI of the CSIR (July 1984) should be consulted concerning the potential corrosion of pipes.

- c. The NHBRC¹ makes the following recommendations:

Waterpiping materials shall be one or more of the following:

- High impact PVC pipes with vitualic joints.
- Other flexible (as defined in SABS 0102, Part 1) water pipes with flexible, self anchoring connections.

Pipes having a diameter of less than 75 mm.

- HDPE type IV.

- Polypropylene.

Pipes should be flexible, while joints should be minimised.

- d. Water pipes entering buildings should either be fitted with flexible couplings or kinked with a Z to allow opportunity for relative movement. A flexible connection at the junction with all outlet pipes should be used, which includes WC pan connections.
- e. Pressure release systems tend to leak after a couple of years. This leaking water must flow directly into the storm- or sewerage water system.
- f. Water reticulation to houses should be kept at a minimum depth of 500 mm up to the structure and above ground wherever possible along the structure.
- g. As many services as possible should be placed within a single trench.
- h. Encasement of pipes in concrete or soilcrete should be avoided. Preferably place pipes in sleeves. If this cannot be achieved, care must be taken to ensure that differential movement can still be accommodated without the pipe breaking.
- i. All stormwater water, sewerage and water pipes and channels must be watertight. All laid wet services should be tested for leakage on installation using the air test (see NBRI Info Sheet X/BOU 2-34) for water pipes, and the water test for sewerage pipes.
- j. Placement of wet services below the footprint of structures must be avoided. No plumbing and drainage pipes should be placed under floor slabs, as far as practicable. Where this situation is unavoidable, specify piping materials of good quality and durability with a long anticipated life span.
- k. Where practical, pipes running parallel to structures should be kept at a distance of at least 5 m from the structure.
- l. Each stand should have a rodding eye or some similar access to the sewer connection in addition to the inspection eye.
- m. Each stand should have a water meter. Water leakage testing must be undertaken at least once every two years.
- n. The roots of trees planted in close proximity to the line of water-bearing services often cause leaks in or malfunctioning of the services. Care should therefore be taken to avoid the unfortunate positioning of trees and other plants.

Entire development

- a. The design of wet services should be governed by the need to create low maintenance systems. Wherever possible keep services above ground to facilitate detection of leaks, maintenance and repair.
- b. The stability of the center line of all bulk water services should be considered.
- c. Piping used in mains and communication pipes should be flexible, while joints should be minimised and, where required, self anchoring type (i.e. not reliant on thrust blocks for their anchorage at fittings, except at valves and end caps).
- d. The relevant provision of SABS 1200 DB, L, LB, LC, LD and LE shall be observed in the installation of all underground services.

- e. Water mains shall be laid only in road reserves.
- f. Provision for future connections shall be made in order to minimise the cutting into pipes to provide such connections.
- g. Water pipe entries into the building shall be in accordance with those of the JSD's code of practice.
- h. The use of pre-manufactured, unjointed manholes are preferred. The manhole should be placed on a properly prepared foundation.
- i. Use flexible couplings either side of manholes.
- j. Water-borne sewerage reticulation must be installed. French drains are unacceptable.
- k. A detailed sanitation plan should be drawn up for the development according to the local geological setting and engineering geological characteristics. The plan must be incorporated into the services management system of the local authority.

Stormwater drainage

- a. No accumulation of surface water is to be permitted and the entire development must be properly drained.
- b. A minimum gradient of 1:150 should be maintained along stormwater systems.
- c. In order to deal with rainwater run-off from the roofs of structures the following is recommended:
 - If guttering is required by the local authority, then the down pipes should discharge into a lined or precast furrow. This furrow should remove the water from the structure. The stormwater should be trained, without ponding, off the property and into the municipal stormwater system.
 - If no guttering is to be utilized, then it is recommended that a sealed surface with a width of 1,5 m be cast along those walls of the structure where water will be discharged from the roof. Roof water will cascade off this sloping roof onto the apron into a lined or precast furrow. The stormwater should be trained, without ponding, off the property and into the municipal stormwater system.
 - The ground immediately against the buildings shall be shaped to fall in excess of 75 mm over the first 1,5 m beyond the perimeter of the building, from where it shall drain freely away from housing units. Apron slabs, where provided shall have the same fall.
- d. All ponds, water courses and road surfaces should be rendered impervious.
- e. No trees shall be planted within 1,5 times their eventual height from the line of stormwater services.
- f. The stormwater drainage system shall incorporate measures to ensure water tightness of conduits and other compartments. Whenever possible, stormwater should be channeled in lined, surface canals.
- g. Concrete non-pressure pipes should be of the spigot and socket type with rubber ring seals. Joints in box culverts, channels etc. should be sealed.
- h. Stormwater drainage conduits shall be constructed at gradients which will not permit the deposition of silt, or sand, of the type present in the catchment area.

Trenching

- a. Trenches and excavation works should be opened and closed as rapidly as possible. Avoid leaving trenches open over weekends or holidays. A berm should be created to divert surface water away from the trenches while they are open. All trenches and excavation works must be properly backfilled and compacted according to specifications given in subclause 5:2:4 of SABS 1200 DA, but specifically to ground surface to prevent them acting as french drains. Once services/cables are installed and backfilling is completed, it must be ensured that ground surface is graded to match the slope of the surrounding area. No rocks in the top layer.
- b. Berms should be constructed on the up-slope side of trenches to prevent the inflow of water during storms.
- c. The fall of trenches shall be away from buildings. Wherever practical, service trenches shall not be excavated along the length of housing units within the first 3 m beyond the perimeter of such units.
- d. No ponding of surface water is to be permitted over, in, or in the vicinity of trenches and excavations.

Roads

- a. Ensure that roadways are in fact placed below the site level so as to facilitate drainage. If the road network is the sole stormwater system, in a township, care must be taken that the roads are surfaced.
- b. Ponding of surface water on or next to roads that are not tarred should be avoided.
- c. Roadways which have a gradient of less than 1:80 shall be surfaced/sealed.
- d. The velocity of the 1 in 20 year stormwater, flowing along unsurfaced roadways shall not exceed 1,5 m/s.

Swimming pools

- a. The installation of swimming pools may only be considered with the permission of the Local Council, advised by an appropriately experienced person.
- b. Backwash from swimming pools must be piped to the stormwater system.

2 Additional precautionary measures for residential affordable, residential group housing (single and double storey) and gentleman's estates

These measures are to be considered additionally for areas that reflect an even greater degree of risk (of sinkhole or doline formation). The *degree of risk* is not the only factor that plays a role: The selection of precautions also depend on the *hazard type*, in other words, should precautions be considered in terms of the occurrence of small sinkholes, in which event a re-enforced mattress will suffice, or medium to large sinkholes, in which even concrete rafts or blanket banning of structures would apply. The *likely triggering mechanism* should also be considered i.e. in the event of the water table being at depth but bedrock being above the water table, the triggering mechanism will be infiltrating water. In such a case, emphasis would have to be placed on the prevention of such infiltration by, for instance, paving the entire area. In case where watertable drawdown is of consideration, emphasis must be placed on the blanket ban of borehole sinking or water table drawdown by mines etc. In the relevant dolomitic

groundwater compartment.

- a. Place bulk services in road reserves or servitudes with a minimum width of 5 m. Servitudes may be utilised as parks or 'bridle paths'. If these services are placed mid-block, a building line restriction of a minimum width of 5 m must be imposed. Place water and sewer connections of every two units along their common property boundary. Shared sewer connections should be implemented if this arrangement leads to a reduction in the meterage of service and minimizes the disturbance of the environment. Property and unit entrances should be placed at points furthest from the trenches of these water and sewer connections.
- b. It is recommended that structures be placed on earth mattresses, which serve to ensure load distribution and to prevent water ingress. A continuous mattress can be considered for high density development, where it is emplaced in strips for block lengths and with widths exceeding the house footprint by at least 2 m. This exercise must be completed prior to the installation of services.
- c. Water and sewer connections to households should be placed within the mattress of enhanced earth. The mattress will retard the flow of water from a leaking service but material will eventually be mobilised sufficiently for structural damage to occur. It is thus evident that testing of water-borne services on a regular basis is very important. Consideration should be given to the placement of sewer lines in inspectable canals as these are not so easy to test. If the mattress is penetrated, wet services must be placed in sleeves for 5 m beyond the structure so that leaking services immediately beyond the mattress cannot result in instability in close vicinity to the foundation.
- d. Roadways must be sealed and be constructed below the level of stands.
- e. Property and unit entrances should be placed at points away from the trenches of water and sewer connections.
- f. Each stand should either have a rodding eye or some similar access to the sewer connection in addition to the inspection eyes so that sensible monitoring may be possible.

3. Additional precautionary measures for High-rise, Light Industrial and Light Commercial sites

- a. It is recommended that structures be placed on stiffened rafts on earth mattresses, which serves to ensure load distribution and to prevent water ingress. The mattresses must be emplaced prior to the installation of services.
- b. The principal water bearing services must be placed either in the mattress or in sleeves for a distance of at least 5 m beyond the periphery of the building.
- c. The surfaces around buildings should be sealed and sloped so that no surface run-off water is allowed to pond against buildings.
- d. Downpipes bearing accumulated roof water can be discharged either onto the sealed surfaces to drain away from the structure, or into lined furrows and into stormwater systems.
- e. Roadways should be sealed.
- f. Portions should be identified at which 'plugs' can be installed to stop flow in sewer and water lines at short notice in the event of rupture or sinkhole formation underneath the service. The Local Authority must ensure that contingency plans are in place to deal with such emergencies.

- g. No swimming pools should be permitted in this zone.
- h. Lined channels are preferred to pipes for stormwater systems in these zones.
- i. Structures must be correctly and safely founded.
- j. A monitoring programme must be embarked upon by either the owner of the property/buildings, the appropriate Local Council or Metropolitan Substructure to regularly check for any leaks in services, unauthorized structures which could lead to concentration of water and, where necessary, monitor the groundwater level (refer to risk management systems).
- k. With respect to commercial, industrial or high-rise structures, the principal water-bearing services should preferably be placed above ground or in sleeves when within 5 m. of the structure.

4 Precautionary measures for sites unsuitable for development

- a. No buildings should be allowed in this zone.
- b. The entire site must be properly sealed.
- c. No water-borne services must be allowed in this area. Ablution blocks should be avoided.
- d. Surface water run-off management is critical in these areas.

APPENDIX III

RISK MANAGEMENT PLAN

RISK MANAGEMENT PLAN

1. INTRODUCTION

Since the impact from urban development may have a negative influence on the metastable conditions prevalent in a dolomitic environment it is of paramount importance that appropriate design and development be executed to ensure the long-term safety and stability of a potential development terrain.

Dolomite, when exposed to weakly acidic groundwater and tectonic forces, gives rise to a karst topography resulting in the formation of residuum which can be eroded into receptacles under the influence of a triggering mechanism such as water from a leaking wet service or ponding of water. It is therefore important to prevent damage to structures or loss of life through the development of sinkholes or dolines by the implementation of an **effective risk management plan**.

The aim of the Risk Management Plan is to emphasize the importance of a continuous assessment of the overall stability of the site in terms of the intended or existing development.

2. ELEMENTS OF IMPORTANCE

2.1 PRECAUTIONARY MEASURES AND REMEDIAL MEASURES

2.1.1 Precautionary Measures

All precautionary measures referred to in the report for the development zones as set out in the relative Appendix of the report, must be strictly adhered to during the design and construction of the development, especially the precautions with respect to the excavation of trenches during construction in the rainy season.

2.1.2 Remedial Measures

Since soil zones of low density may occur, it is necessary to provide for engineered soil mattresses to found on thereby rendering the ground less pervious and more compacted. This measure will decrease the possible damage to water bearing services by preventing potential settlement of the structures and thereby reducing the risk for the formation of sinkholes by means of water erosion.

2.2 MONITORING

After construction, **all water bearing services and ground surface** should be monitored on a regular basis to ensure the prescribed water precautionary measures remain effective and do not provoke any instabilities on the terrain. To execute the monitoring process in a systematic manner, the Managing Group/Authority must design a *Monitoring Programme* with specific tasks. It is recommended that a responsible person be appointed to supervise this process and to record the results in a databank.

The following is a list of criteria which should be included as part of the monitoring programme :

2.2.1 Visual inspection

- Check and ensure that the ground immediately against the structures remains shaped (fall of 75mm over forts 1,5m beyond the perimeter of the building) and that no obstacles are created by any inhabitants which will cause ponding of the storm water especially during the wet season.
- Check that drainage ports in the boundary walls remain open to prevent ponding of storm water
- Report the occurrence of any leaks, subsidence or cracks in structures or on the ground surface.
- Report any ponding of water on the property

2.2.2 Maintenance

- Check that sewer mains are tested for water tightness every 2 years
- Inspect and clean storm water systems once a year
- Inspect bulk services for water tightness once a year
- Repair any damaged or worn components of water bearing infrastructure
- Apply the maintenance tasks laid down by the Infrastructure Maintenance Plan
- Ensure any water courses located within 10m of any structure are rendered impervious
- Check that any backwash and other water from swimming pools be discharged into the storm water system

The responsible person must ensure that any defects exposed by the monitoring program are attended to without delay (leaks in water pipes must be repaired immediately; areas of water ponding should be re-landscaped as soon as possible). A continual written record of maintenance may provide a guide for future planning.

2.3 EMERGENCY PROCEDURES

A responsible person should be appointed through which all emergency procedures are supervised with appropriate written records. Pipe layouts, main valves and inspection manholes should be known to the responsible person. Contacts at the relevant Local Authority/Town Council should be fostered to ensure rapid reaction in the event of excessive instability. The use of professional consultants must always be considered to ensure proper understanding of the cause of instability.

2.4 REHABILITATION

Appropriate methods of rehabilitation must be sought if sinkholes or dolines manifest on the site. Poor rehabilitation may encourage further instability of more serious consequences. Professional help should be sought if back-filling of a sinkhole is required.

2.5 DATABANK

Written records of all the problems related to the overall stability of the site may allow for certain trends to be noticed before instability occurs or may allow for pro-active maintenance. The databank may be in the form of a book in which all aspects of stability are recorded. The recording of such information facilitates an audit trail in the case of injury.

2.6 RE-ASSESSMENT

A review of the properly kept records will allow existing procedures to be re-evaluated from time to time and immediate modification of the Risk Management Plan.