Bear GeoConsultants

TRANSNET

REPORT ON THE GEOTECHNICAL INVESTIGATION FOR THE POSTMASBURG HOUSING DEVELOPMENT

REPORT J13-066/1 OCTOBER 2013

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ABSTRACT

A geotechnical investigation has been completed of sites for the proposed Transnet Housing Development located on various stands in Postmasburg. The portion of township within which the development is situated is approximately 22 Ha in size but a major portion of this already has houses on. The remaining open stands will be developed by Transnet. Many of these had previously had houses on them which were demolished some time ago. The individual stands will be no less than approximately 350 m^2 in size.

The area is underlain by dolomite of the Campbell Rand Subgroup, Ghaap Group, Transvaal Supergroup. The rocks of this subgroup are blanketed by an alluvial gravel horizon, possibly associated with Kalahari Group deposits. Capping the dolomite in most instances is a hardpan calcrete horizon.

The investigation shows that the site has a low to moderate hazard rating in terms of the potential for sinkholes and subsidences (dolines) developing. The potential size of the sinkholes is generally small although in some areas there is potential for medium size sinkholes to develop. Reinforced conventional strip foundations may be employed on this site provided that stringent measures are adopted to reduce concentrated water infiltration into the soil profile. In addition a dolomite risk management system should be implemented by the local authority.

Keywords: Postmasburg, Northern Cape
Campbell Rand Group, Kalahari Group
dolomite, alluvium, gravel, calcrete
Low to medium inherent hazard class (IHC 1 and 3)
Small, medium sinkholes

Geographic Location: WGS84 Lo23
Y-005707 X3132947

POSTMASBURG HOUSING DEVELOPMENT

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1 INTRODUCTION

At the request of Mr T Vorster, Project Manager from Transnet Capital Projects, a geotechnical and dolomite stability investigation of Erf 3604 and 5284, Postmasburg has been executed as required for enrolment with the National Home Builders Registration Council (NHBRC). The site is to be developed for residential purposes.

As the site is underlain by dolomite, it was investigated for stability relating to the potential for sinkholes and subsidences (dolines) to develop in addition to a conventional geotechnical investigation aimed at establishing the geotechnical properties of the near-surface strata.

The objectives of the geotechnical investigation were to:

- Establish the site stratigraphy and the engineering properties thereof,
- Analyse the stability of the site with respect to the potential for sinkhole and subsidence (doline) development and zone the site accordingly,
- Identify potential problem soils and zone the site on this basis,
- Establish the potential for in-situ materials to be used in pavement layers, and
- Provide foundation recommendations for the proposed township development.

This report details the work carried out, analyses the results and gives our conclusions and recommendations.

2 SITE LOCATION AND DESCRIPTION

The site is located just south of the Postmasburg Station at the northern end of Postmasburg as shown on the Locality Plan, Drawing J13-066/1 in Appendix G. The portion of township within which the development is situated is approximately 22 Ha in size but a significant portion of this already has houses on. The remaining open stands will be developed by Transnet. Many of these had previously had houses on them which were demolished some time ago. The portions investigated are shown on the Geotechnical Plan, Drawing J13-066/2 in Appendix G.

At the time of the investigation, the site was unoccupied although, as mentioned above, portions of the site are already developed. There are old foundations scattered across most of the eastern portions of the site. The site is covered with veldt grasses and thorn bushes. The site slopes gently to the south, towards the R385 road to Beeshoek. The Kimberley-Sishen railway line occupies the northern border of the site.

3 INVESTIGATION PROCEDURE

3.1 FIELD INVESTIGATION

The investigation was carried out in accordance with SANS 634 (Ref.1).

3.1.1 Geophysical Survey

The dolomite stability investigation commenced with a gravity survey in September 2013. This investigation technique measures the earth's gravitational field and then uses the contrast between low density overburden and higher density bedrock to construct a contour map, measured in milligals, which roughly correlates with depth to bedrock. The gravity contour map is used to site boreholes and is ultimately an aid to zoning the area investigated. The normal requirement for this sort of survey is to take measurements on a grid spacing of 30 m. However, in this case the grid was narrowed down to a 20 m spacing in order to retrieve greater detail as the bedrock was expected to be fairly close to surface. The geophysicist's report on the gravity survey is included in Appendix C of this report. The gravity contour map and the positions of the boreholes and test pits are shown on the Geotechnical Map, Drawing J13-066/2, in Appendix G.

3.1.2 Percussion Drilling

Twenty-two boreholes were drilled in September 2013 at selected positions using a percussion drilling rig. The boreholes were terminated once 4 to 6 m of relatively unweathered dolomite had been intersected or once a satisfactory understanding of the profile at that position had been achieved. Samples from the boreholes were retrieved at one metre intervals and the nett time taken to advance each metre was recorded. The driller also recorded air and sample loss, an estimate of the hardness of the formation, the response of the hammer, the moisture condition, any water strikes and rough description of the strata.

The samples were subsequently logged by an engineering geologist using standard practices (Ref.2). Water rest levels in the boreholes were recorded 24 hours or more after completion of the drilling. The positions of the boreholes are shown on the Geotechnical Map, Drawing J13-066/2, in Appendix G and the borehole logs are included in Appendix A of this report.

3.1.3 Test Pitting

The near surface investigation was conducted in September 2013 and comprised the excavation of twenty test pits using a CAT 422E Tractor-Loader-Backhoe (TLB). An engineering geologist inspected the test pits and recorded soil profiles using standard procedures (Ref.2). Samples were retrieved from the sides of the test pits and these were tested by a commercial soils laboratory. The depths of the samples are indicated on the relevant profile sheets.

The positions of the test pits are shown on the Geotechnical Map, Drawing J13-066/2, in Appendix G and the soil profiles are included in Appendix A of this report.

3.2 LABORATORY TESTING

Disturbed soil samples, representative of the soils encountered, were retrieved from the test pits and submitted to a commercial soils laboratory for testing. The following tests were performed in order to determine the geo-mechanical properties of the relevant soil horizon. No oedometer tests were considered as the coarse nature of the overburden would prevent an undisturbed sample of the right size being cut to fit into an oedometer ring.

- **Indicator Tests**
  These tests are used to establish the soil type, its potential for heave and give an indication of its suitability for use in pavement layers.

- **Compaction Tests**
  These tests are used to assess the potential for materials to be used in pavement layers.

- **Corrosiveness Tests**
  These tests are used to assess the potential for soils to corrode concrete and steel.

The depths of the samples are indicated on the relevant profile sheets in Appendix A. The test results are included in Appendix B.

4 SITE GEOLOGY

The site is underlain by dolomite and chert formations of the Campbell Rand Subgroup, Ghaap Group, Transvaal Supergroup. Although only occasionally evident on this site, it would appear that Kalahari Group sediments occur as palaeo-infill within solution features found in the dolomite indicating that very little additional formation of karst has occurred subsequent to the Cenozoic. Extensive calcrete deposits occur within this area and Partridge et al. consider these to be deposits of end-Cretaceous to Palaeocene age which blanket the ancient African Surface (Ref.3).

Geotechnical profiling typically recognises the following elements in soil profiles:

- Transported Soils – these are recently deposited and are named after the agency which transported them e.g. alluvium for soils transported by rivers. This horizon is located at the top of the profile and is usually separated from the underlying residual soil profile by a layer of gravel, often referred to as the pebble marker.
- Residual Soils – these are derived from the weathering of the underlying rock and have not moved from the place of origin as with the transported soils. The residual soil horizon can be divided into two sub-horizons:
  - A reworked residual horizon where macro structure (joints, bedding) and micro structure (mineral grain boundaries) has been destroyed by biotic action, and
  - A residual horizon where the macro and micro structure inherited from the parent rock remains intact and visible.
- Pedogenic soil and rock layers sometimes form within the above horizons or, more often than not, at the interface between them. Pedogenisis is a process of cementation through the deposition of carbonates (calcrete) or various oxides, iron (ferricrete), manganese (manganocrete) or silica (silcrete).

The stratigraphy encountered during the investigation is detailed in the following sub-sections.

4.1 FILL

The site is littered with general household waste. In some area this is mixed with builders' rubble and is as thick as 300 mm.

4.2 TRANSPORTED SOILS

The site is blanketed by a transported horizon considered to be alluvium in origin. This horizon generally comprises sub-angular to sub-rounded gravel and cobbles in a red brown silty sand matrix. Although the horizon was profiled as having a dense consistency in the test pits it is noticeably friable, or cohesionless, and the test pit sidewalls collapsed in some instances. It is also noticeable that the percussion borehole penetration rates in this horizon are very rapid, being of the order of 10 to 15 seconds per metre. The horizon varies from 1,0 to 5,0 m in thickness although the friable nature of the gravel may mean that the samples at lower depths are heavily contaminated with material from higher up giving a false impression of the thickness of the horizon in the boreholes. In general the horizon is of the order of 1 to 1,5 m thick in the test pits.

4.3 PEDOGENIC HORIZON

As mentioned earlier, extensive calcrete deposits occur in this area and the TLB invariably refused on soft rock to medium hard rock hardpan calcrete. Refusal of the TLB occurred at depths between 0,60 and 1,80 m. The hardpan calcrete is fairly thick and reaches depths of up to 15 m in the boreholes although is typically only 3 to 4 m thick above dolomite bedrock.

4.4 RESIDUAL SOILS

No residual soils were encountered in the test pits and no residual soils typically associated with dolomite, wad in particular, were encountered in the boreholes. Across most of the site dolomite bedrock was encountered in the boreholes at an average depth of 5,0 m below surface. Although in some instances, particularly within gravity lows, bedrock was encountered at depths of between 7 and 16 m below surface.

5 GROUND WATER

5.1 REGIONAL GROUND WATER

Information regarding the regional water level was obtained from the Department of Water Affairs (DWA) and from this it appears that the current water level in the immediate area is located at an elevation of approximately 1300 m. It has not been possible to ascertain whether dolomite ground water compartments occur in the area. The results of the ground water monitoring carried out by the Department of Water Affairs are summarised in Table 5.1.1 below. The positions of the monitoring boreholes are shown on Figure 1 overleaf and graphs of the monitoring boreholes closest to the site follow below.

Table 5.1.1: Summary of Water Monitoring Boreholes in the area

Borehole	Year		Elevation (m.a.m.s.l.)			Most recent reading	
	Start	End	Maximum	Minimum	Average	Date	Elevation
D4N0532	1974	1978	1319.6	1300.0	1313.8	21/08/78	1305.1
D7N0528	2006	2011	1328.2	1324.1	1325.9	15/06/11	1328.2
D7N0529	2002	2013	1305.7	1301.2	1303.1	20/02/13	1301.2
D7N0531	2004	2012	1316.0	1253.5	1264.6	20/02/12	1269.4
D7N0534	2004	2013	136.8	1355.1	1356.8	20/02/13	1358.8
D7N0535	2005	2011	1329.7	1279.1	1318.7	15/06/11	1329.7
D7N0553	2004	2013	1381.1	1354.9	1358.2	20/02/13	1358.9
D7N0692	2006	2007	1274.8	1262.8	1268.7	09/10/07	1268.5
D7N0697	2006	2006	1280.0	1266.7	1273.4	01/10/06	1266.7
D7N0832	2012	2013	1307.6	1304.1	1305.8	20/02/13	1304.1
D7N0833	2012	2013	1195.9	1193.9	1194.7	20/02/13	1193.9
D7N0834	2012	2013	1313.0	1310.4	1312.1	20/02/13	1310.4

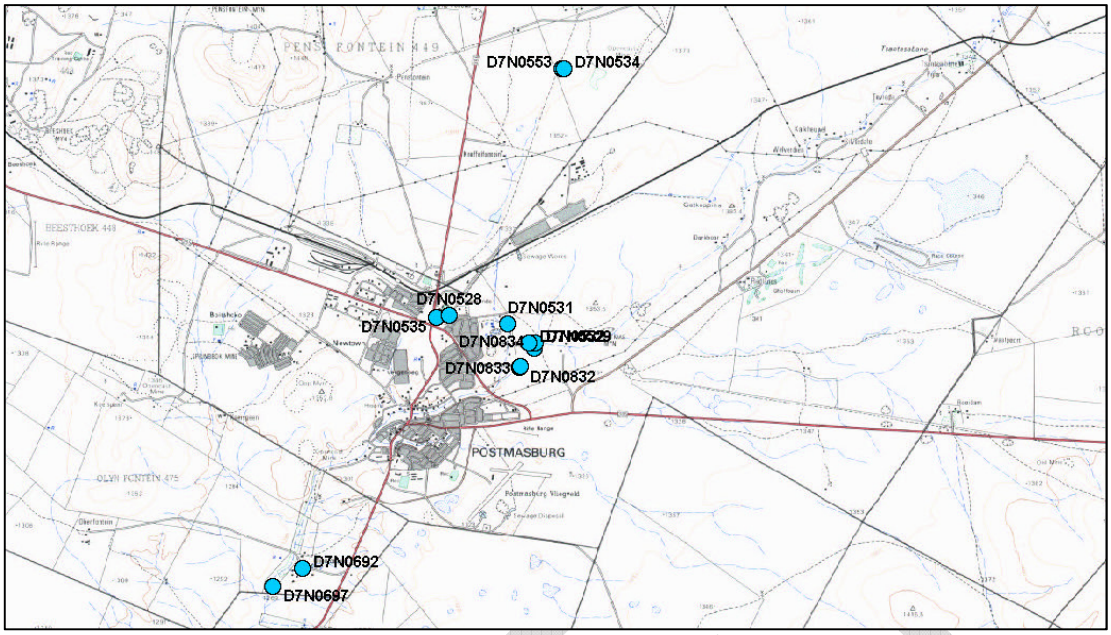
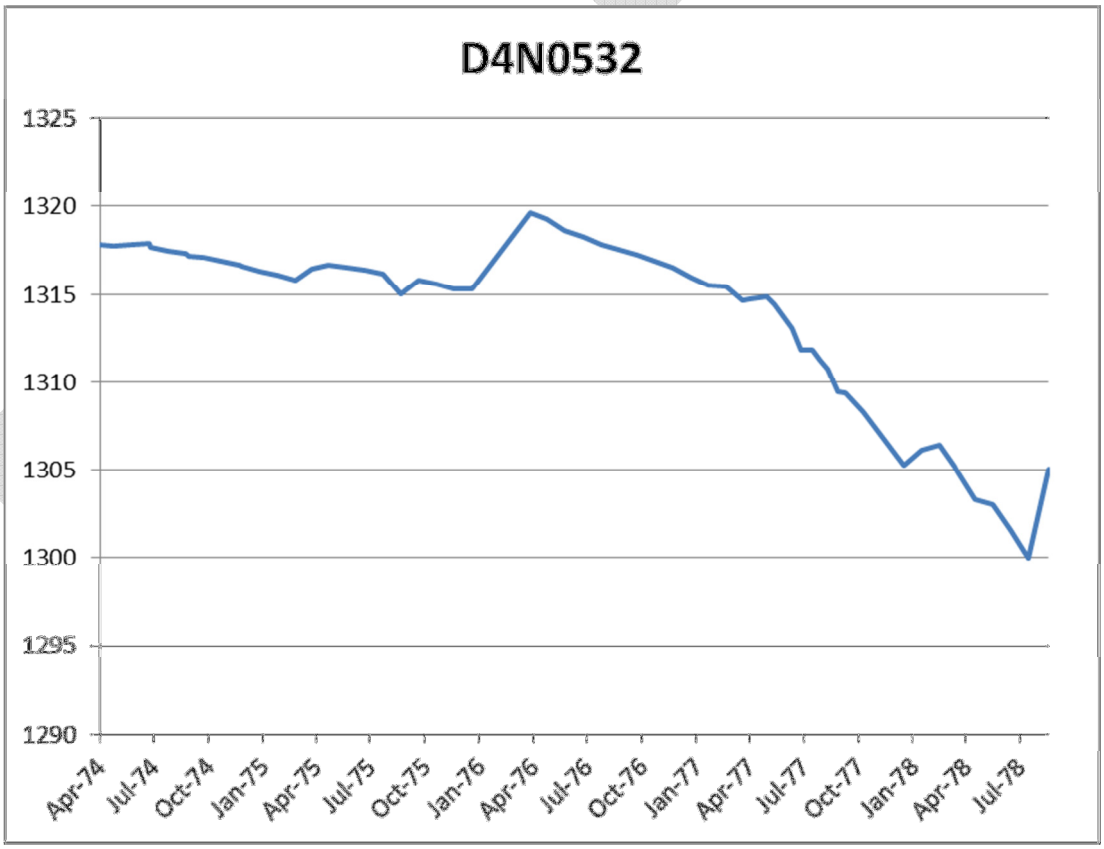
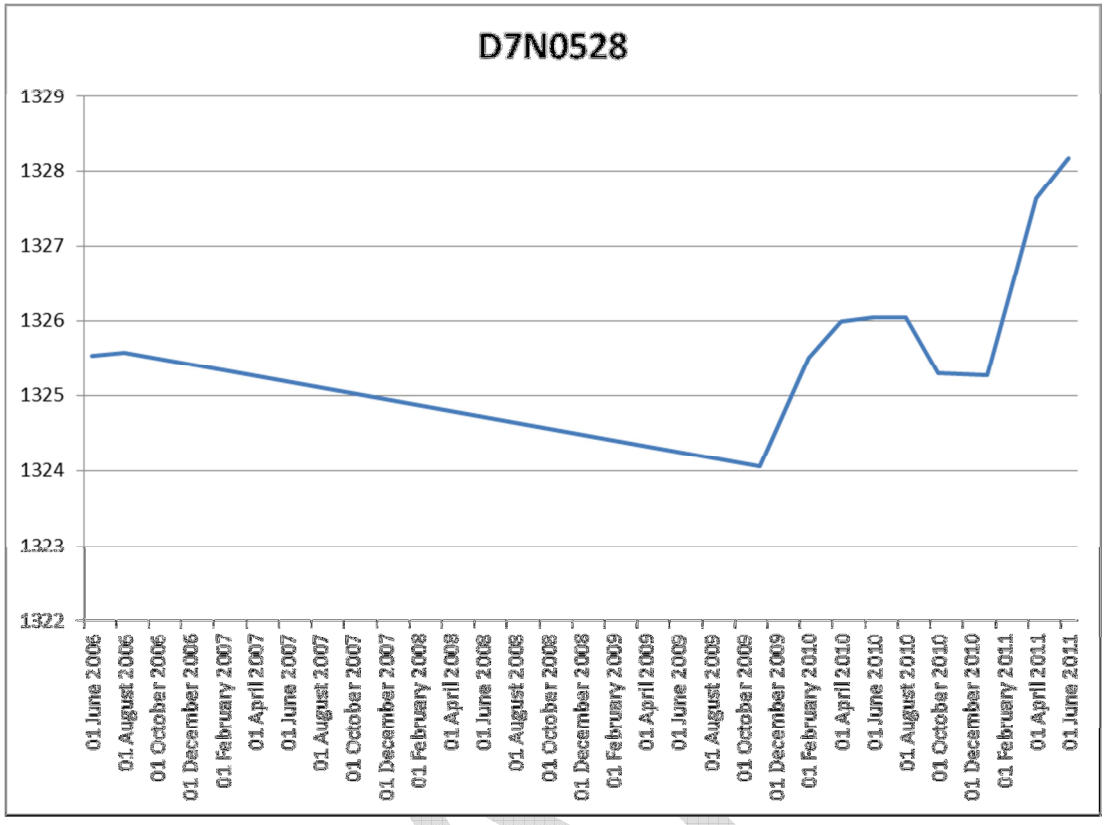


Figure 1: Positions of DWA monitoring boreholes

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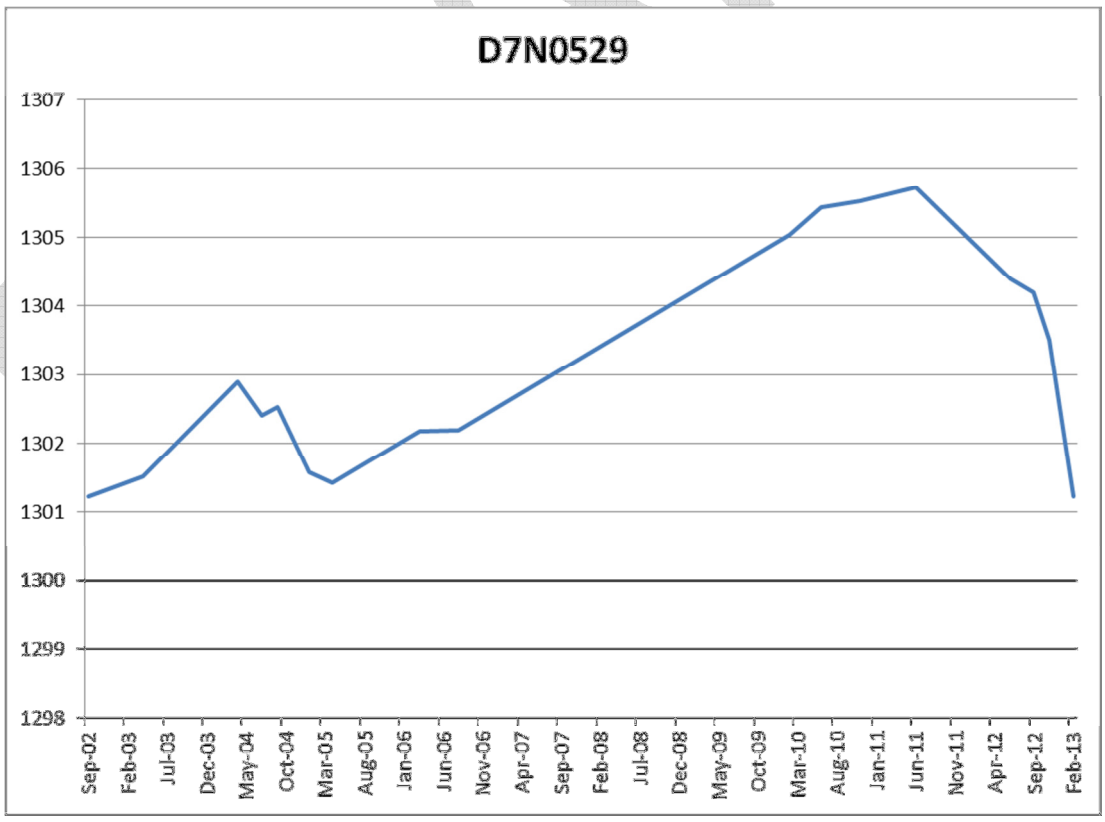
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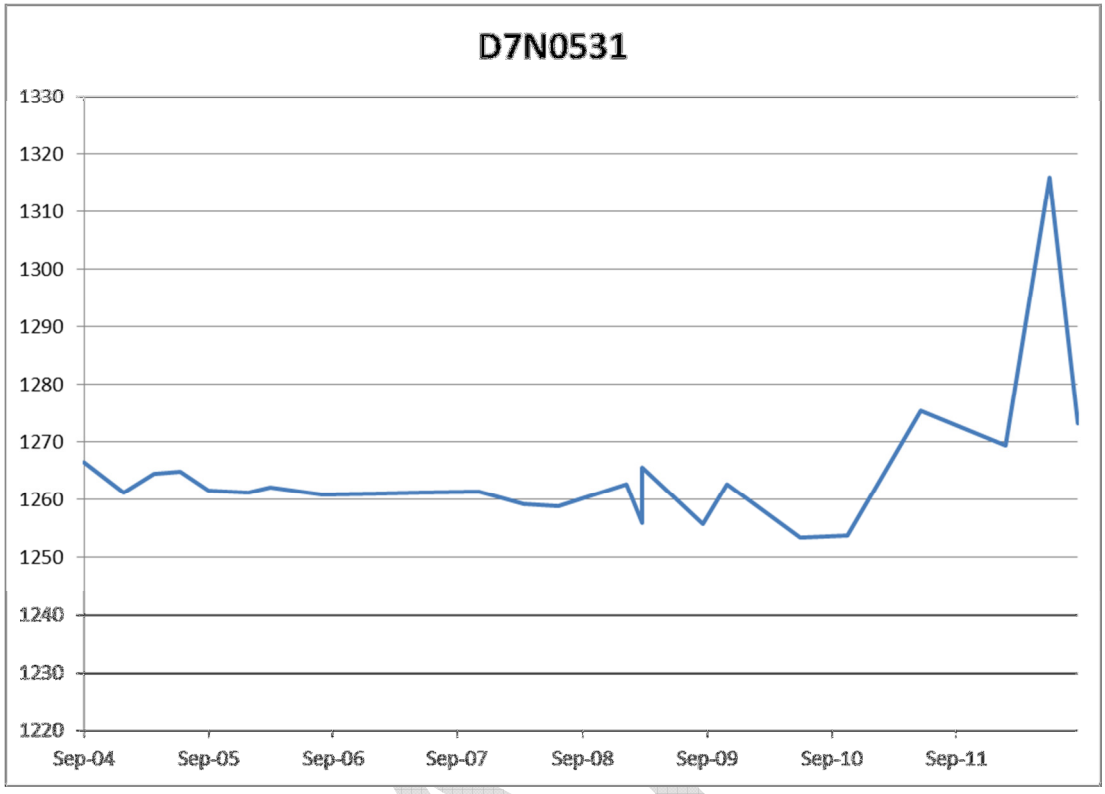
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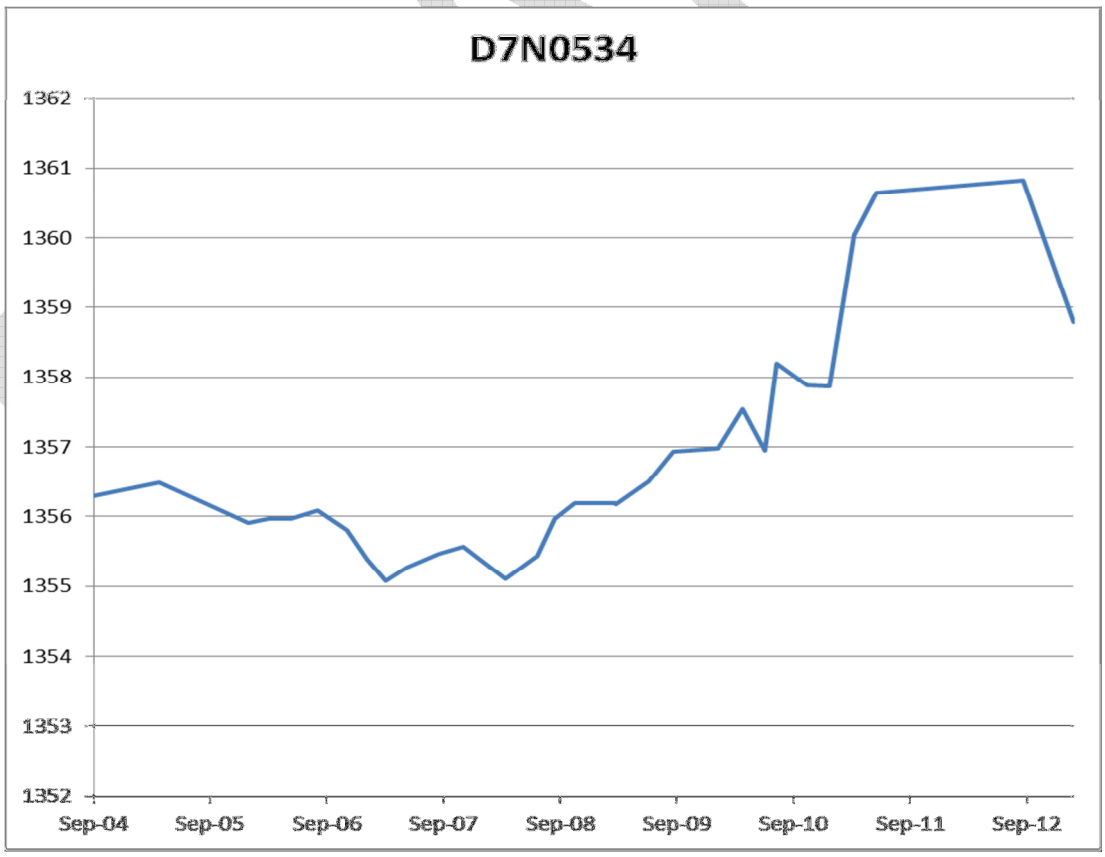
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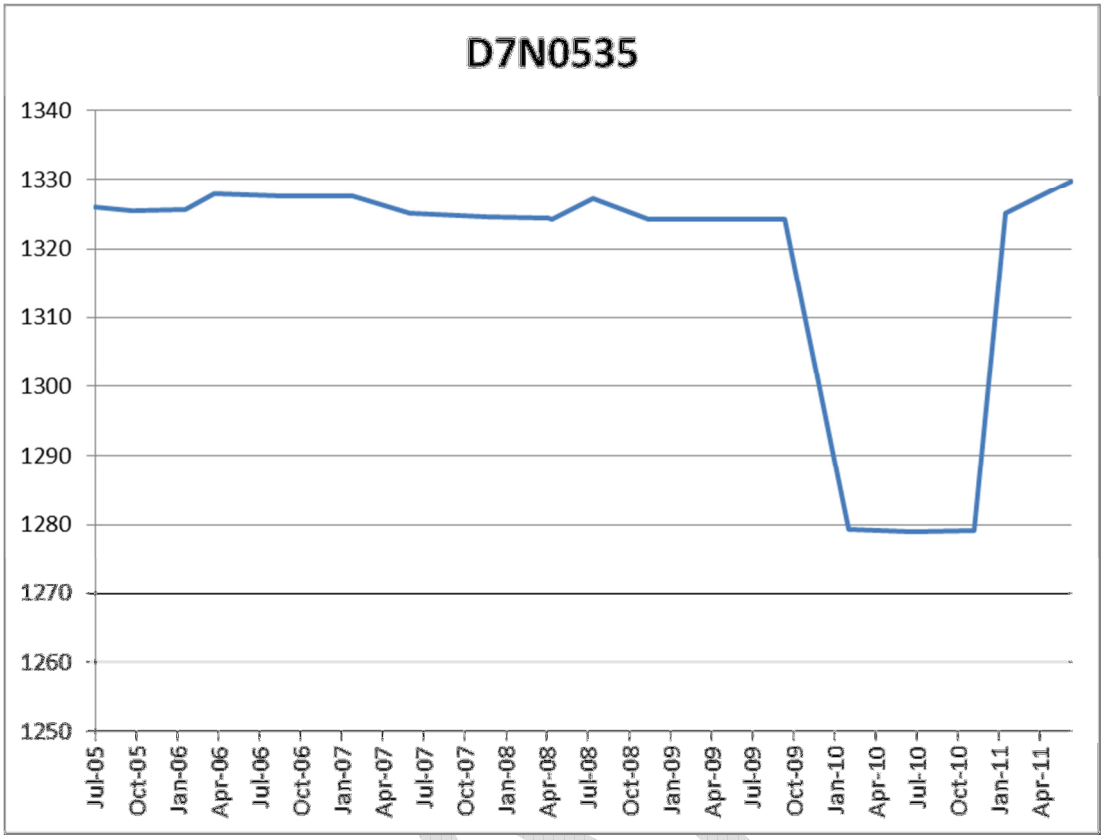
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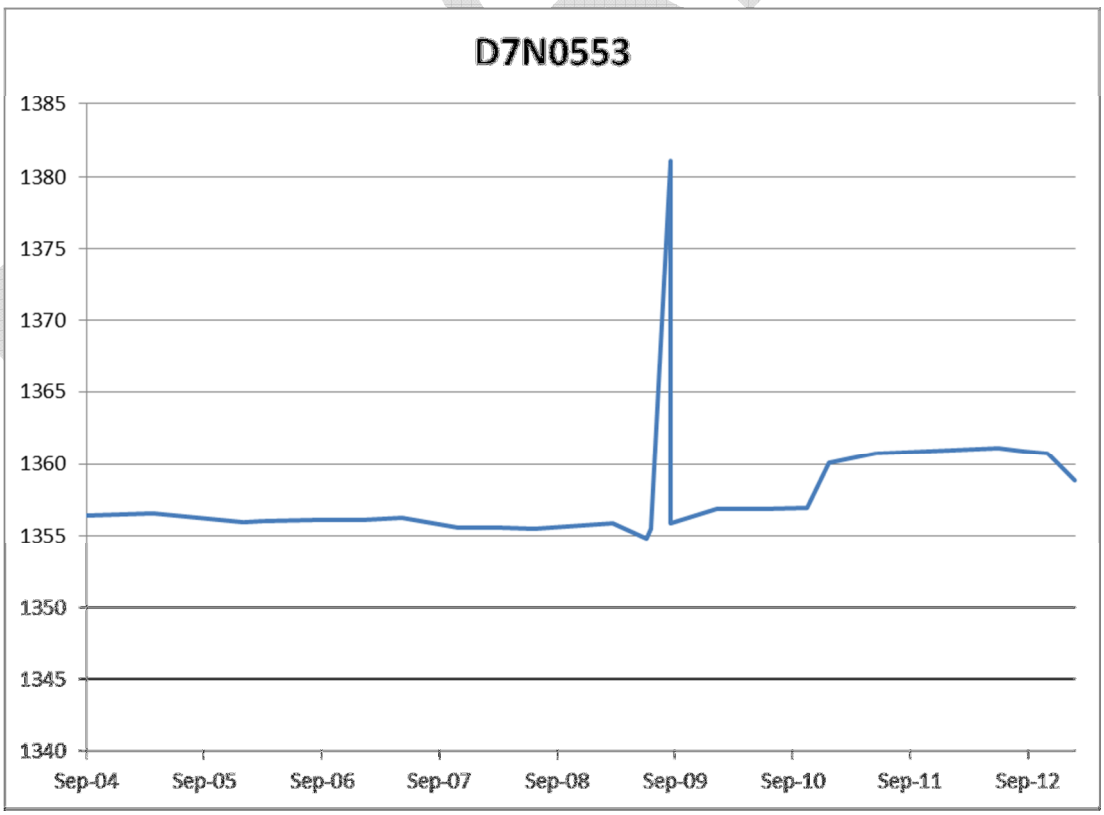
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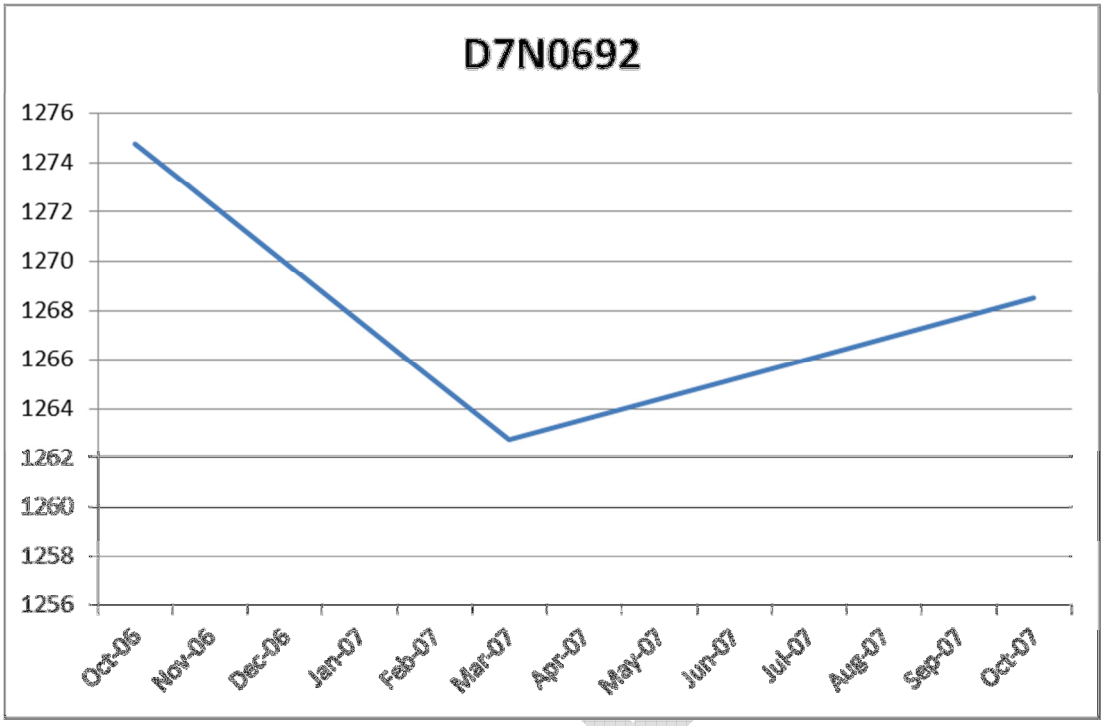
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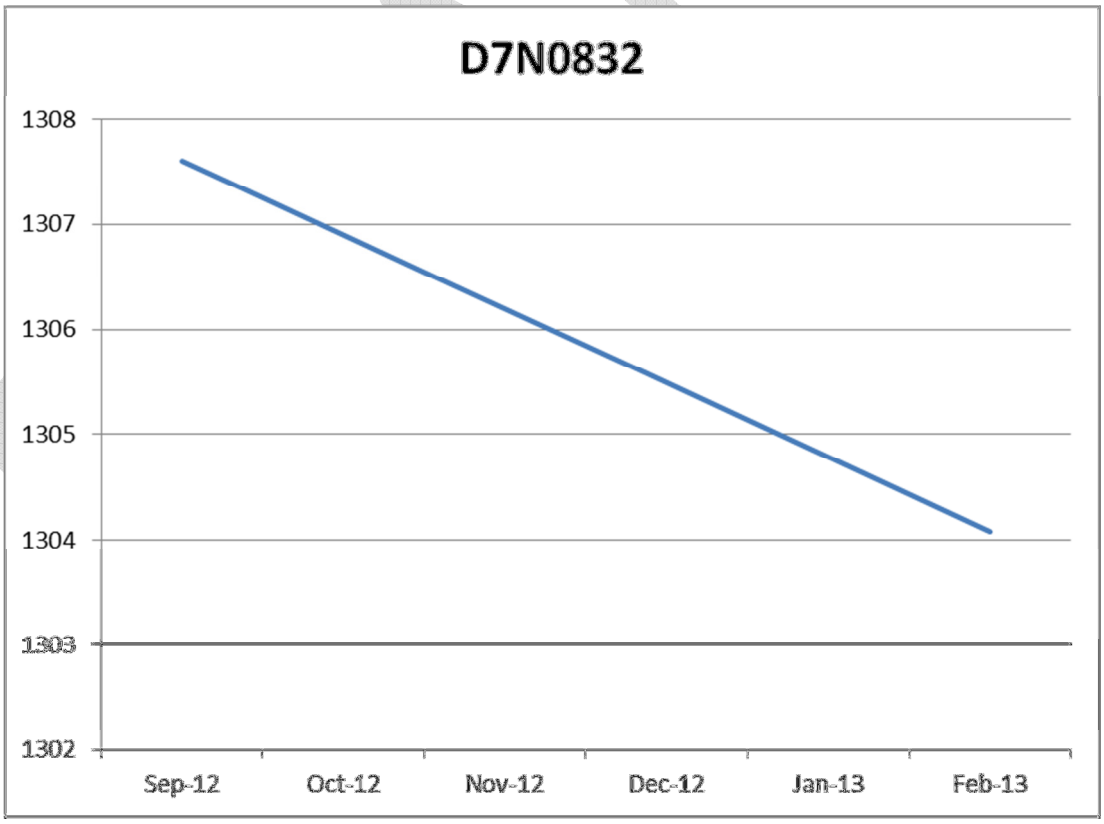
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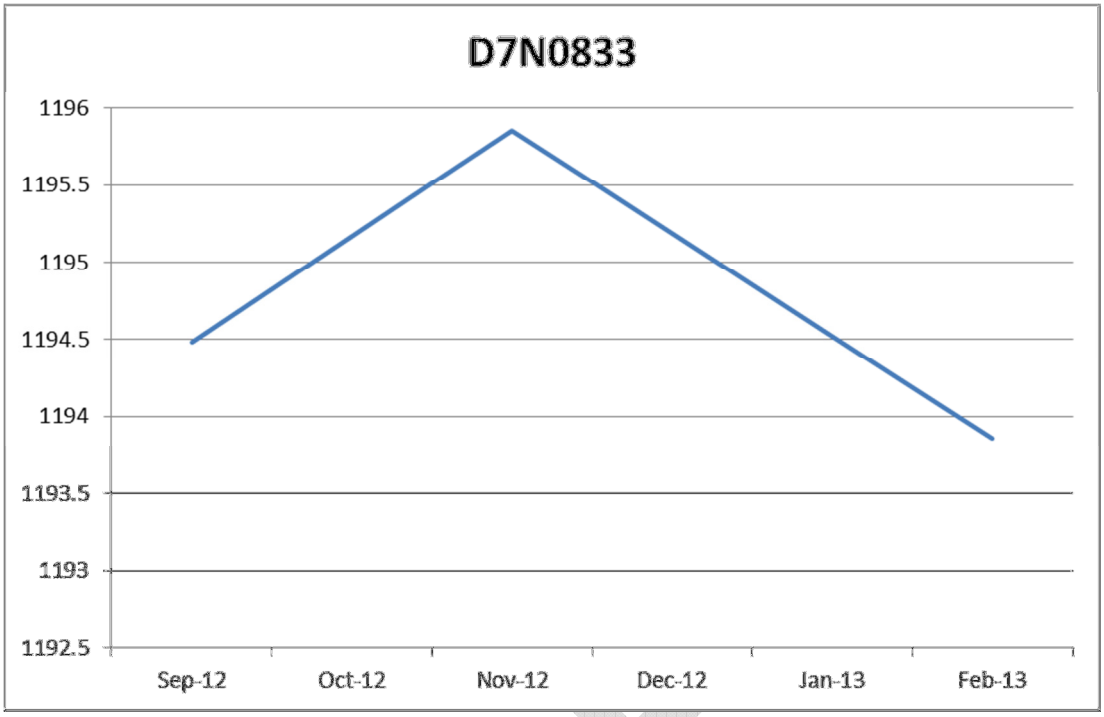
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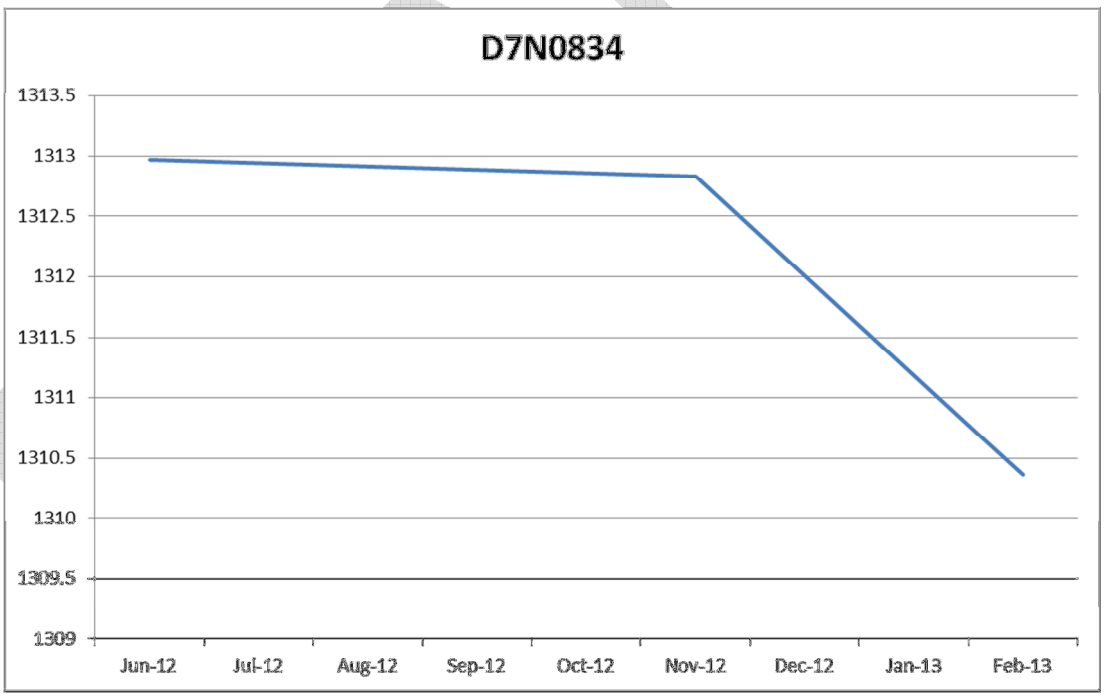
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5.2 SITE GROUND WATER

Water levels were measured in the boreholes drilled on the site 24 hours after completion of drilling and no water was encountered in any of the boreholes. It should be noted that the ground elevations of the boreholes have been calculated using relative ground levels measured during the gravity survey which were then corrected as far as possible using elevations taken from the 1:50 000 topo-cadastral map of the area. There is thus the possibility that an error of a few metres is present in the elevations of the water rest levels. The lack of water on the site correlates well with the regional water levels taken in the boreholes monitored by the Department of Water Affairs which show that the average water table is much lower than the level to which the boreholes were drilled. Dolomite bedrock is generally well above the water table at this site.

6 GEOTECHNICAL ASSESSMENT

The geotechnical assessment of the site is required to provide a broad overview and classification of the suitability of the land for the proposed development and outline geotechnical constraints to the development of the area. The following constraints, as proposed by Partridge, Wood and Brink (Ref.4), have to be considered for the classification of sites for urban development (see tabulated information in Appendix E for a summary of the constraints and classifications):

- Expansive soil profile;
- Collapsible / compressible soil profile;
- Erodability of the soil profile;
- Excavatability;
- Undermined ground;
- Instability of areas of soluble rock;
- Steep slopes;
- Unstable natural slopes;
- Seismic activity; and
- Areas subject to flooding.

The constraints listed above are discussed individually in the following sections. The potential for the soils to be used in layerworks are also discussed as a constraint.

6.1 EXPANSIVE SOIL PROFILE

Awaiting test results.

6.2 COLLAPSIBLE / COMPRESSIBLE SOIL PROFILE

As the soil horizons on this site comprise gravelly materials it was not possible to retrieve undisturbed samples suitable for testing in a laboratory. However, under light loads, the soils on this site will not be collapsible or compressible due to the closely packed nature of the gravel horizon. This was profiled as having a dense consistency. The gravel horizon is underlain by thick hardpan calcrete.

6.3 ERODABILITY OF THE SOIL PROFILE

The soil profile in the upper reaches of the profile is probably erodible if subjected to high water velocity, as it is cohesionless. Although no significant erosion channels were encountered during the investigation it is possible that erosion could become a problem on this site if the soil is stripped of vegetation. This is not likely to pose a significant problem to the proposed development provided that storm water run-off is properly controlled.

Table 6.1.1: Summary of Indicator Tests

Where: LL = Liquid Limit
PI = Plasticity Index
LS = Linear Shrinkage
G.M. = Grading Modulus
P.E. = Potential Expansiveness

6.4 EXCAVATABILITY

The excavation characteristics of the different soil horizons have been evaluated according to the South African Bureau of Standards standardised excavation classification for earthworks (SABS – 1200D) and earthworks (small works – SABS 1200DA) (Ref.6). In terms of this classification and the in-situ soil/rock consistencies as profiled, the relationships given below are generally applicable. For specific excavation requirements refer to the soil profiles in Appendix A.

1. "soft excavation" - very loose/very soft through to dense or stiff.
2. "intermediate excavation" - very dense/very stiff through to very soft rock.
3. "hard excavation" - soft rock or better.

The soils are classified as "soft excavation" to an average depth of 1,1 m below surface. A TLB similar to a CAT 422E should therefore suffice for the excavation of service trenches to these depths. Refusal of the TLB occurred on soft rock to medium hard rock hardpan calcrete or dolomite, these will be classified as "hard excavation" and power tools and blasting will be required to excavate this material. A trench was being excavated for a sewerage main line in the south eastern corner of the site at the time of the excavation and this required extensive blasting to reach the required depth of approximately 3 m.

6.5 UNDERMINED GROUND

As far as is known, this area is not undermined.

6.6 INSTABILITY OF AREAS OF SOLUBLE ROCK

6.6.1 Methodology used to assess the stability of the site

The site is underlain by dolomite, a soluble rock in which Karst features, such as dolines and sinkholes can develop. No sinkholes, on the site or in the vicinity of the site, are known to exist. The stability of the site with respect to subsidence (doline) and sinkhole development is analysed, as defined in SANS 1936 (2012) Parts 1 (Ref.7) and 2 (Ref.8), using a geological model combined with the method proposed by Buttrick et al (Ref.9) and is detailed in Appendix D of this report. Work by A'Bear and Richer (Ref.10) concerning the degree of hazard associated with shallow dolomite also has bearing on the assessment of this site.

The following factors are used to evaluate the degree of hazard associated with sinkhole and subsidence (doline) development:

- Mobilising agencies. The primary mobilising agency, or triggering mechanism, in developed areas is generally considered to be ingress water from leaking services or ponding of water on surface or within poorly backfilled trenches. Significant lowering of the water table may in itself provide a trigger for sinkholes or subsidences to develop. Other mobilising agencies, such as vibration (seismicity), should also be considered where necessary.
- Bedrock morphology. For sites underlain by shallow dolomite in particular, the bedrock pattern, involving the spacing (wavelength) and amplitude of the pinnacle and gryke development, plays an important role in understanding the potential for subsidence and sinkholes to develop (Ref.10).
- Cavities and fissures. The presence of cavities and the depth to them, as well as air and sample loss when drilling, has to be considered as the presence, or absence of this characteristic is considered to be a fundamental indicator of the stability of the site.
- Overburden. The nature of the blanketing layer, including its potential to erode into underlying cavities and its potential to absorb, or reduce the velocity of, water flowing vertically through it is a critical factor in assessing the stability of the site. The thickness of the overburden and it's geomechanical properties play a critical role in determining the size of a sinkhole or subsidence which could develop.
- Ground water. The depth to the current groundwater level and its position relative to bedrock and overburden is an important consideration as the ground water table essentially forms the base level of erosion in terms of overburden being washed downwards into a cavity. Drawdown of the ground water level as a triggering mechanism should be taken into account separately when considering this factor.

6.6.2 Stability assessment of the site

The results from the boreholes are summarised in Table 6.6.2 overleaf. The factors used to evaluate the hazard level of the site are discussed individually below:

- Mobilising agencies. As this site is to be developed, there will be water bearing services present on the site. This implies that at some point in the future it is very likely that water will enter the profile as the pipes age and develop leaks. For this reason alone it is assumed that a triggering mechanism or mobilising agency is present or will develop on this site.
- Bedrock morphology. The site has been divided into two geotechnical zones based on the depth to bedrock. In Zone A, typically located in the gravity high areas, pinnacle and gryke development is generally limited with a fairly shallow and uniform depth to bedrock. The average depth to dolomite bedrock is 3,5 m and the range is 2,0 to 6,0 m. This gives a standard deviation of 1,3 m and a variance of 1,6 m^2 (Ref.10). The bedrock morphology in this zone indicates a low potential for sinkhole development. Zone B, usually associated with gravity low areas, is more variable with an average depth to bedrock of 9,0 m and a range of 5,0 to 16,0 m. Zone B has a standard deviation of 3,9 m and a variance of 15,4 m^2 (Ref.10). Bedrock morphology indicates a medium potential for sinkhole development in this zone.
- Cavities and fissures. The boreholes did not encounter cavities although zones of air loss in the upper reaches of the profile were encountered. However, this is attributed to the loose nature of the gravels blanketing the site. While this does not imply that cavities do not exist in this area, it is a positive feature (Ref.10). It should also be borne in mind that Martini (Ref.11) considers this area to have few or no cave systems. In terms of assessing the potential for sinkholes to develop this factor would appear to present a low potential for sinkhole or subsidence development.
- Overburden. There is an absence of dolomite residuum on this site, possibly implying that the area has been scoured clean by erosive forces at some point in recent history, subsequent to which deposition of material, probably Kalahari Group sediments, occurred, filling in the exposed solution channels. The recent sands and gravels found at surface are the only loose and permeable materials encountered on the site and these are of limited depth. However, should there be shallow cavities in the bedrock, albeit highly unlikely, these materials could erode into them. The older sediments below this loose horizon have been cemented by calcrete and are highly competent. However, in many of the boreholes no calcrete was encountered above bedrock level. On the basis of the overburden assessment there appears to be a low to moderate potential for sinkholes or subsidences to develop.

Table 6.6.1: Summary of Boreholes

Hole No.	Overburden Characteristics						Depth to Dolomite Bedrock	Water Strike	Water Rest Level	Inherent Risk of Sinkhole and Subsidence Development			Zone	Dewatering Scenario Analysis
	Transported soil	Calcrete	Wad	Weathered dolomite or dolomite	Air Loss	Cavities				Sinkholes	Subsidence	Inherent Hazard Class		
PH001	0.0 - 2.0	2.0 - 3.0 4.0 - 5.0		3.0 - 4.0 5.0 - 15.0			5.0			Low	Low	1	A	Remains the same
PH002	0.0 - 2.0	2.0 - 3.0		3.0 - 10.0			3.0			Low	Low	1	A	Remains the same
PH003	0.0 - 2.0			2.0 - 10.0			2.0			Low	Low	1	A	Remains the same
PH004	0.0 - 1.0	1.0 - 2.0		2.0 - 10.0			2.0			Low	Low	1	A	Remains the same
PH005	0.0 - 2.0			2.0 - 10.0			2.0			Low	Low	1	A	Remains the same
PH006	0.0 - 2.0	2.0 - 7.0		7.0 - 15.0			7.0			Medium of small	Low	2	B	Remains the same
PH2056	0.0 - 1.0	1.0 - 12.0		12.0 - 13.0 13.0 - 16.0 16.0 - 20.0			13.0			Medium of medium	Low	3	B	Remains the same
PH2066	0.0 - 2.0	2.0 - 4.0		4.0 - 10.0			4.0			Low	Low	1	A	Remains the same
PH2108	0.0 - 2.0			2.0 - 10.0			2.0			Low	Low	1	A	Remains the same
PH2131	0.0 - 1.0	1.0 - 3.0 5.0 - 7.0		3.0 - 5.0 7.0 - 12.0			3.0			Low	Low	1	A	Remains the same
PH2147	0.0 - 2.0	2.0 - 3.0		3.0 - 10.0			3.0			Low	Low	1	A	Remains the same
PH2165	0.0 - 4.0			4.0 - 10.0			4.0			Low	Low	1	A	Remains the same
PH2201	0.0 - 1.0	1.0 - 7.0		7.0 - 10.0			7.0			Medium of small	Low	2	B	Remains the same
PH2206	0.0 - 1.0			1.0 - 5.0 5.0 - 10.0			5.0			Low	Low	1	B	Remains the same

Hole No.	Overburden Characteristics						Depth to Dolomite Bedrock	Water Strike	Water Rest Level	Inherent Risk of Sinkhole and Subsidence Development			Zone	Dewatering Scenario Analysis
	Transported soil	Calcrete	Wad	Weathered dolomite or dolomite	Air Loss	Cavities				Sinkholes	Subsidence	Inherent Hazard Class		
PH2241	0.0 - 5.0	7.0 - 9.0		5.0 - 7.0 9.0 - 15.0			9.0			Medium of small	Low	2	B	Remains the same
PH2261	0.0 - 1.5	1.5 - 5.0		5.0 - 12.0			5.0			Low	Low	1	B	Remains the same
PH2286	0.0 - 1.5	1.5 - 16.0		16.0 - 25.0			16.0			Medium of medium	Low	3	B	Remains the same
PH2294	0.0 - 2.0	2.0 - 12.0		12.0 - 17.0			12.0			Medium of medium	Low	3	B	Remains the same
PH2307	0.0 - 1.0	1.0 - 6.0		6.0 - 15.0			6.0			Low	Low	1	B	Remains the same
PH2335	0.0 - 2.0	2.0 - 4.0		4.0 - 10.0			4.0			Low	Low	1	A	Remains the same
PH2338	0.0 - 2.0	2.0 - 4.0		4.0 - 10.0			4.0			Low	Low	1	A	Remains the same
PH2505	0.0 - 2.0	2.0 - 6.0		6.0 - 12.0			6.0			Low	Low	1	A	Remains the same

* Should the water table be lowered there will be no change in the hazard level at the borehole position.

- Ground water. No water was encountered in the boreholes on this site which correlates well with the regional water levels measured in the DWA monitoring boreholes. The regional water level is probably at or just below the depth at which the deepest boreholes were terminated. The water table is much lower than dolomite bedrock level.

Based on the above analysis the site has been divided into two zones in terms of the Inherent Hazard Class. Zone A has a low to moderate potential for small sinkholes to develop and Zone B has a moderate potential for small to medium sinkholes to develop. The Zones are shown on the Geotechnical Map, Drawing J13-066/2, in Appendix G.

Drawdown of the water table will not change the potential for sinkholes and dolines to develop on this site and it will remain unchanged both during and after dewatering has occurred.

Taking the above discussion into account, Zone A has been assigned an Inherent Hazard Class of 1 and Zone B an Inherent Hazard Class of 2/3.

6.7 STEEP SLOPES

This site does not have steep slopes and is therefore unaffected by this constraint.

6.8 UNSTABLE NATURAL SLOPES

No indication of the presence of unstable natural slopes was found during the investigation.

6.9 SEISMIC ACTIVITY

According to Fernandez and Guzman (Ref.12), the area investigated is classified as having a seismic intensity of between V and VI on the modified Mercalli scale (MMS) with a 90% probability of not being exceeded during a 100 year recurrence period. An earthquake with an intensity of V on the MMS is described as having the following characteristics:

- It can be felt outdoors and its direction estimated;
- Sleepers are awakened;
- Liquids are disturbed and some are spilled;
- Small unstable objects are displaced or upset;
- Doors swing, closed or open;
- Shutters and pictures move; and
- Pendulum clocks stop, start or change rate.

An earthquake of VI on the MMS is described as follows:

- All people, in- and outdoors feel it;
- Windows, dishes and glassware are broken;
- Pictures and books fall of walls and shelves;
- Furniture is moved and overturned; and
- Weak plaster and poorly constructed masonry structures crack.

The expected peak ground acceleration values associated with these magnitudes of earthquake are:

- Horizontal acceleration: 32 to 56 cm/s2
- Vertical acceleration: 9 to 18 cm/s2

The peak ground acceleration values indicate low intensity of seismic activity. No special seismic design measures are therefore required.

6.10 AREAS SUBJECT TO FLOODING

It is unlikely that the site will be flooded as no drainage channels of significance occur within or close to the site.

6.11 SUITABILITY OF SOILS FOR USE IN PAVEMENT LAYERS

Awaiting test results.

Table 6.11.1: Summary of Compaction Test Results

Where: M.D.D. = Maximum Dry Density CBR = Californian Bearing Ratio
OMC = Optimum Moisture Content

6.12 CORROSIVENESS OF SOILS

Awaiting test results.

7 CONCLUSIONS AND RECOMMENDATIONS

No adverse conditions prohibiting the construction of structures for residential, commercial and industrial development were observed on this site. From a geotechnical perspective, the site is considered economically and practically developable.

For urban planning purposes the site will be classified by combining the following two classification systems:

- Geotechnical Classification for Urban Development, after Partridge, Wood and Brink (Ref.3); and
- The NHBRC's Home Building Manual, Part 1 & 2 (Ref.13).

Where the zone is described, the NHBRC class is given in brackets immediately behind the soil zone title. The zones are described in the following sub-sections and the explanation for the relevant symbols given in Table 7.1 below. Note that symbols are only assigned to zones if the constraint is either intermediate or least favourable. In other words, a symbol of 1C is not assigned to the zones if active soils are not present.

Table 7.1: Interpretation of Classification Symbols

Classification code	Interpretation
Geotechnical Classification for Urban Development*	
2F	• Constraint = Excavation to 1,5 m requires removal of 10 to 40% rock or hardpan pedocretes. • Degree of constraint = Intermediate.
NHBRC**	
R	• Typical foundation material = dense residual soil or rock • Character = shallow or outcropping rock • Expected Range of Total Soil Movements (mm) = <5 • Assumed Differential Movement = 75 %
Dolomitic Area Designations***	
D3	• Precautionary measures, in addition to site and service precautionary measures, required

Legend:

* According to Partridge, Wood and Brink (Ref.5). Also refer to Appendix E.

** According to the NHBRC's Home Building Manual (Ref.12). Also refer to Appendix F.

*** According to current practice as defined in Appendix D.

The dolomite stability assessment concludes that there are two zones within this site. Zone A has a low to moderate potential for small sinkholes to develop and has an Inherent Hazard Class of 1/2. Zone B has a moderate potential for small to medium sinkholes to develop and is classified as having an Inherent Hazard Class of 2/3.

7.1 GEOTECHNICAL ZONE A (R/D3)

Geotechnical Classification for Urban Development – 2F

The principal geotechnical problems relating to this site are associated with the presence of shallow, hardpan calcrete and hard rock dolomite which will intrude into excavations for foundations and services.

7.1.1 Land usage

The site falls into an Inherent Hazard Class of 1/2 implying that there is a low to medium risk of small sinkholes developing. The desired development for this site is to have stands no less than 350 m^2. Based on the current SANS 1936 standards the site will have a land use designation of RN2 resulting in a dolomite area designation of D3.

A D3 classification for this site requires that precautionary measures in addition to those pertaining to the prevention of concentrated ingress of water into the ground are required. At present it is recommended that the measures for a D3 area, as recommended in SANS 1936 Part 3 (Ref.14) and the Department of Public Works' manual titled "Appropriate Development of Infrastructure on Dolomite: Manual for Consultants, PW344" (Ref.15), be adhered to for the entire site. This applies in particular to the installation of services and the backfilling of all trenches. Measures to capture and effectively remove stormwater from the site must be implemented.

7.1.2 Foundations

Reinforced strip foundations capable of spanning a 2 m loss of support should be employed for single and double storey buildings built of load bearing brickwork. These should be founded on medium dense or better, gravel, calcrete or dolomite and may utilise a bearing pressure not exceeding 100 kPa. Excavations must be inspected for any soft areas and these should be over-excavated and backfilled with G5 gravel compacted to 95% mod AASHTO in 150 mm layers.

All boulders or pinnacles projecting into the foundation excavations must be removed and any resulting void similarly backfilled with compacted G5 gravel. Soilcrete or mass concrete may also be employed. All ground floors must be lightly reinforced with mesh to ensure that the slab is able to span a 2 m loss of support without collapsing into it. The mesh must be tied into the load bearing walls. Cracks may develop in the event of a sinkhole developing but this measure would ensure the safety of the occupants and allow remedial measures to be implemented. The measures detailed under Section 7.3 must be adhered to.

7.1.3 Excavatability

Blasting and power tools will be required to remove hardpan calcrete and dolomite pinnacles from foundations and trenches below depths greater than 0,30 m on average.

7.1.4 Material Usage

Awaiting test results.

7.2 GEOTECHNICAL ZONE B (R/D3)

Geotechnical Classification for Urban Development – 2F

The principal geotechnical problem relating to this site are associated with the presence of shallow, hardpan calcrete and hard rock dolomite which will intrude into excavations for foundations and services.

7.2.1 Land usage

The site falls into an Inherent Hazard Class of 2/3 implying that there is a medium risk of small to medium sinkholes developing. The desired development for this site is to have stands no less than 350 m^2. Based on the current SANS 1936 standards the site will have a land use designation of RN2 resulting in a dolomite area designation of D3.

A D3 classification for this site requires that precautionary measures in addition to those pertaining to the prevention of concentrated ingress of water into the ground are required. At present it is recommended that the measures for a D3 area, as recommended in SANS 1936 Part 3 (Ref.14) and the Department of Public Works' manual titled "Appropriate Development of Infrastructure on Dolomite: Manual for Consultants, PW344" (Ref.15), be adhered to for the entire site. This applies in particular to the installation of services and the backfilling of all trenches. Measures to capture and effectively remove stormwater from the site must be implemented.

7.2.2 Foundations

Reinforced strip foundations capable of spanning a 5 m loss of support should be employed for single and double storey buildings built of load bearing brickwork. These should be founded on medium dense or better, calcrete or dolomite and may utilise a bearing pressure not exceeding 100 kPa. Excavations must be inspected for any soft areas and these should be over-excavated and backfilled with G5 gravel compacted to 95% mod AASHTO in 150 mm layers.

All boulders or pinnacles projecting into the foundation excavations must be removed and any resulting void similarly backfilled with compacted G5 gravel. Soilcrete or mass concrete may also be employed. All ground floors must be lightly reinforced with mesh to ensure that the slab is able to span a 5 m loss of support without collapsing into it. The mesh must be tied into the load bearing walls. Cracks may develop in the event of a sinkhole developing but this measure would ensure the safety of the occupants and allow remedial measures to be implemented. The measures detailed under Section 7.3 must be adhered to.

7.2.3 Excavatability

Blasting and power tools will be required to remove hardpan calcrete and dolomite pinnacles from foundations and trenches below depths greater than 0,30 m on average.

7.2.4 Material Usage

Awaiting test results.

7.3 GENERAL

The measures for a D3 area recommended in At present it is recommended that the measures for a D3 area, as recommended in SANS 1936 Part 3 (Ref.14) and the Department of Public Works' manual titled "Appropriate Development of Infrastructure on Dolomite: Manual for Consultants, PW344" (Ref.13) should be adhered to for the entire site. This applies in particular to the installation of services and the backfilling of all trenches. Measures to capture and effectively remove stormwater from the site must be implemented. This may require landscaping the ground in some areas.

A dolomite risk management system must be implemented by the local municipality to ensure that regular inspections are carried out of the municipal infrastructure. This will ensure that defects are identified and repaired and the necessary upgrades implemented. This system will ensure the continued safe operation of the facility in the future.

The following precautionary measures should be adhered to on this site:

- All yard walls, steps etc. should be isolated from main structures to allow independent movement.
- All wet services should be flexible in design and should specifically be designed to accommodate movement where entering or leaving structures.
- Stormwater should be effectively captured and led well away from all structures.
- No ponding of surface water should be able to occur adjacent to foundations both during and after construction.
- Brickforce should be incorporated in all layers of plinth wall for load bearing brickwork and in every fourth layer thereafter. At least three layers of brickforce should be placed above all openings such as windows and doors.

It should be borne in mind by the developer that NHBRC regulations presently require additional geotechnical work to be done for residential developments to confirm the findings of this report, modify geotechnical zone boundaries and give stand specific classifications. The additional work is best done once excavations for service trenches are underway and the soil profile is exposed over long stretches. Certification of structures' foundations by a competent geotechnical professional is required once buildings are under construction before the NHBRC will issue completion certificates.

On no account should the density of development exceed that described under the sub-section entitled land usage in the sections of this report describing the individual Geotechnical Zones. All foundations should be inspected by a competent person to ensure that the desired founding medium has been attained and that recommendations made in this report have been adhered to.

L.R. Richer (Pr.Sci.Nat.)

For Bear GeoConsultants

8 REFERENCES

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APPENDIX A

BOREHOLE LOGS AND SOIL PROFILES

Bear GeoConsultants

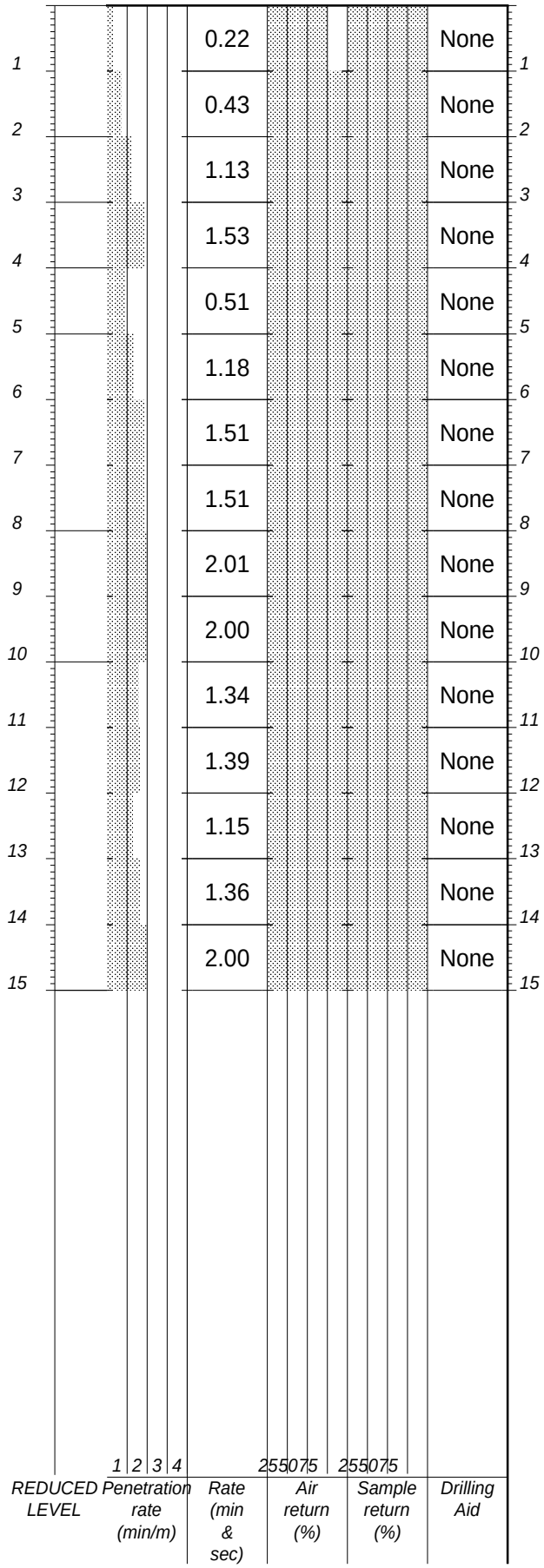
TRANSNET

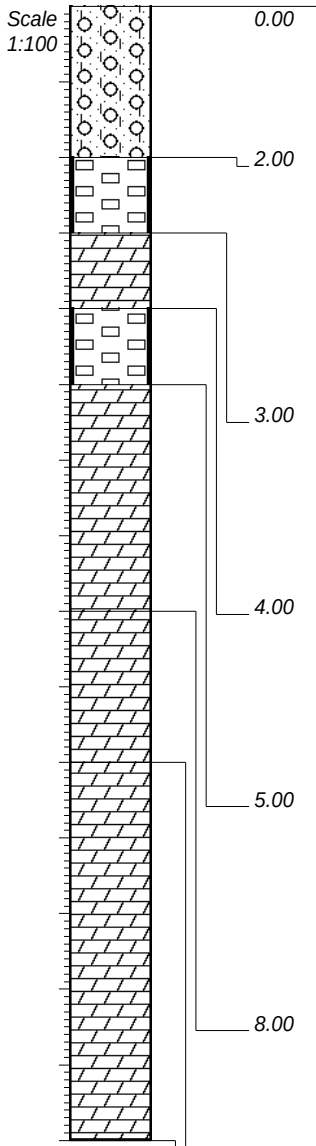
Postmasburg Housing Development

HOLE No: PH001

Sheet 1 of 2

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix. Transported.

Pink and white speckled and mottled grey, HARDPAN CALCRETE with traces of slightly weathered dolomite.
Minor gravel - possibly contaminated with material from above.

Purple, slightly weathered, DOLOMITE.
Abundant gravel - possibly contaminated with material from above.

Pink speckled and mottled black, HARDPAN CALCRETE.
Abundant gravel - possibly contaminated with material from above.

Purple and grey, slightly and moderately weathered, DOLOMITE.
Minor gravel - possibly contaminated with material from above.

Purple and grey, slightly weathered, DOLOMITE.
Traces of gravel - possibly contaminated with material from above.

Grey and light grey, slightly weathered, DOLOMITE.
Minor grey brown, moderately weathered, dolomite.
Traces of gravel - possibly contaminated with material from above.

TRANSNET
Postmasburg Housing Development

HOLE No: PH001
Sheet 2 of 2

JOB NUMBER: J13-066

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

REDUCED LEVEL	1 2 3 4 Penetration rate (min/m)	Rate (min & sec)	255075 Air return (%)	255075 Sample return (%)	Drilling Aid

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ
REVISION :
SETUP FILE : BGC_PERC.SET

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

ELEVATION :
X-COORD : 3133237
Y-COORD : -6380

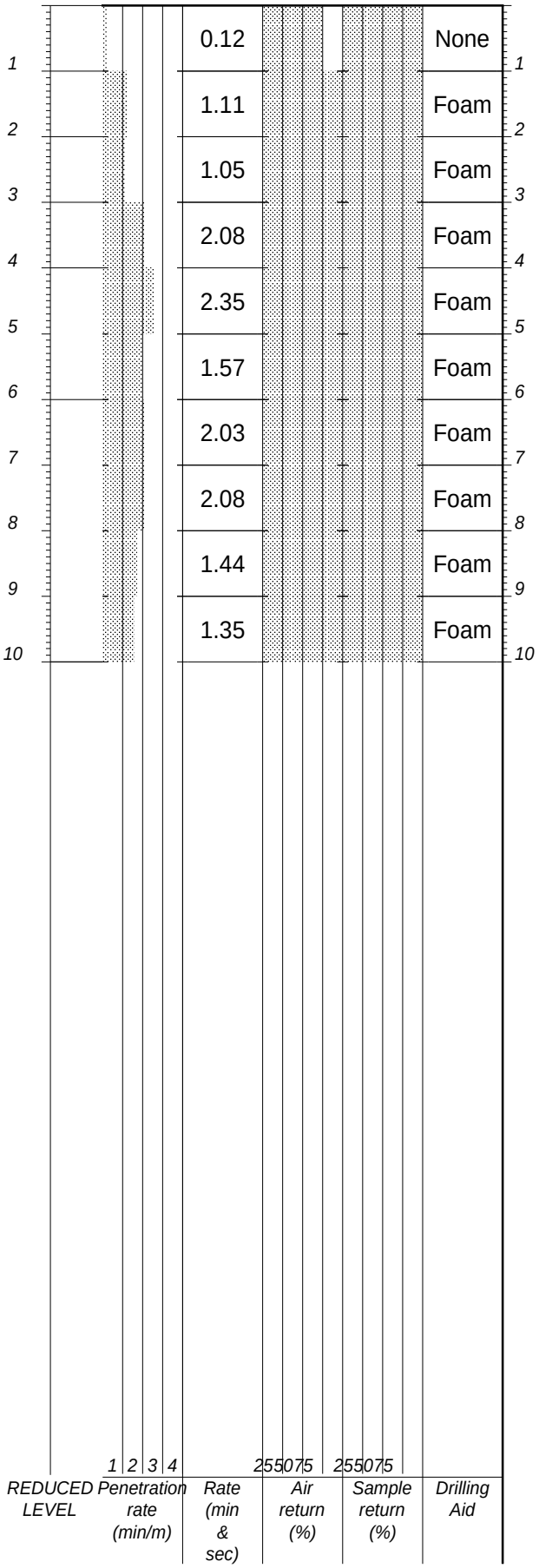
HOLE No: PH001

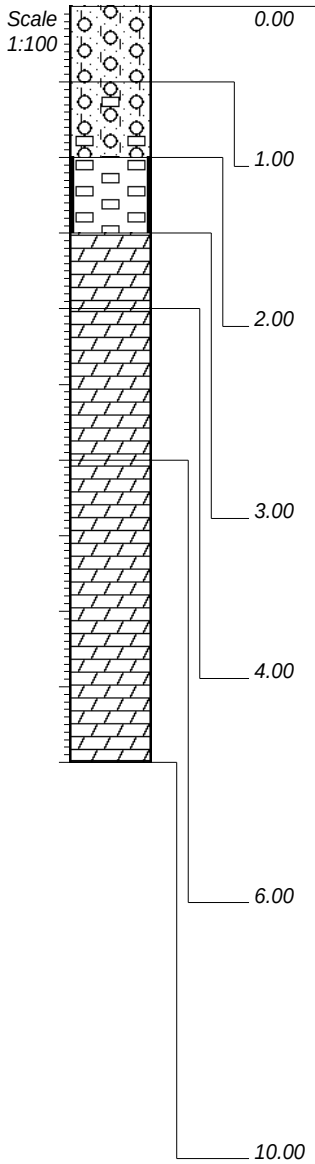
Bear GeoConsultants

TRANSNET
Postmasburg Housing Development

HOLE No: PH002
Sheet 1 of 2

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix. Transported.

As above but with abundant white and pink, hardpan calcrete.
Minor grey, slightly weathered, dolomite.

White and pink speckled and mottled grey, HARDPAN CALCRETE with traces of gravel - possibly contaminated with material from above.

Grey and light grey banded red, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.

Red, slightly weathered to moderately weathered, DOLOMITE with traces of grey, slightly weathered, dolomite.
Abundant evidence of joint faces.

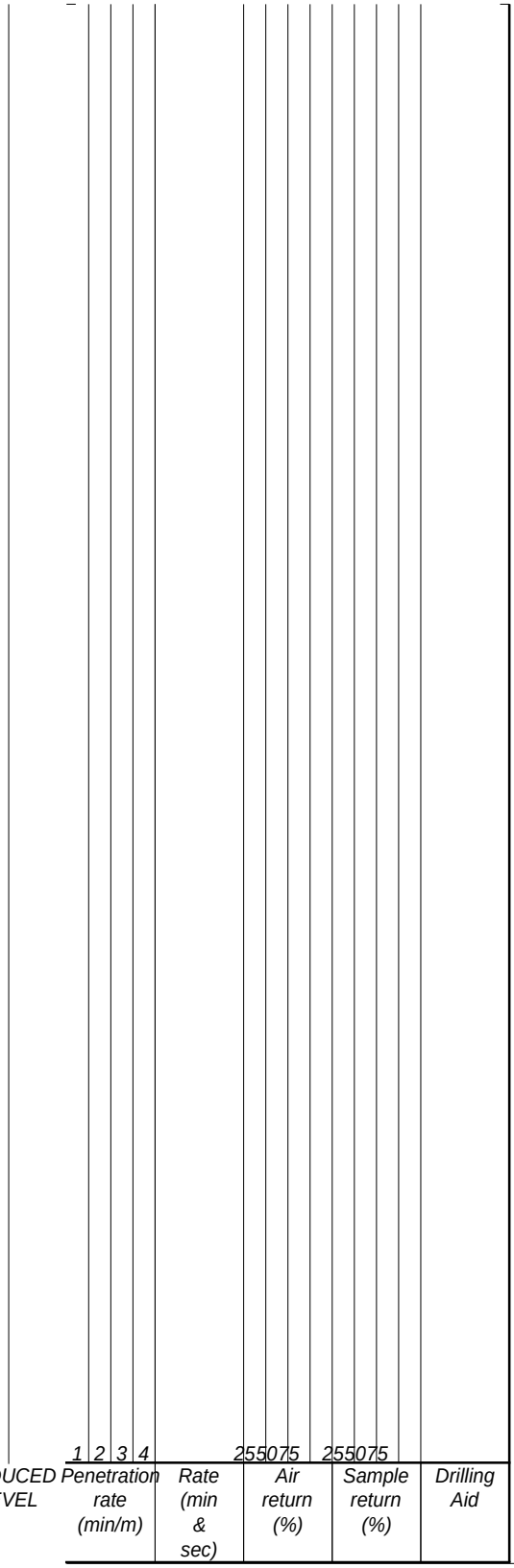
Grey banded red, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.
From 8 - 9 m; predominantly red and grey, slightly weathered, dolomite.

End of hole.

TRANSNET
Postmasburg Housing Development

HOLE No: PH002
Sheet 2 of 2

JOB NUMBER: J13-066



REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133418
Y-COORD : -6224

HOLE No: PH002

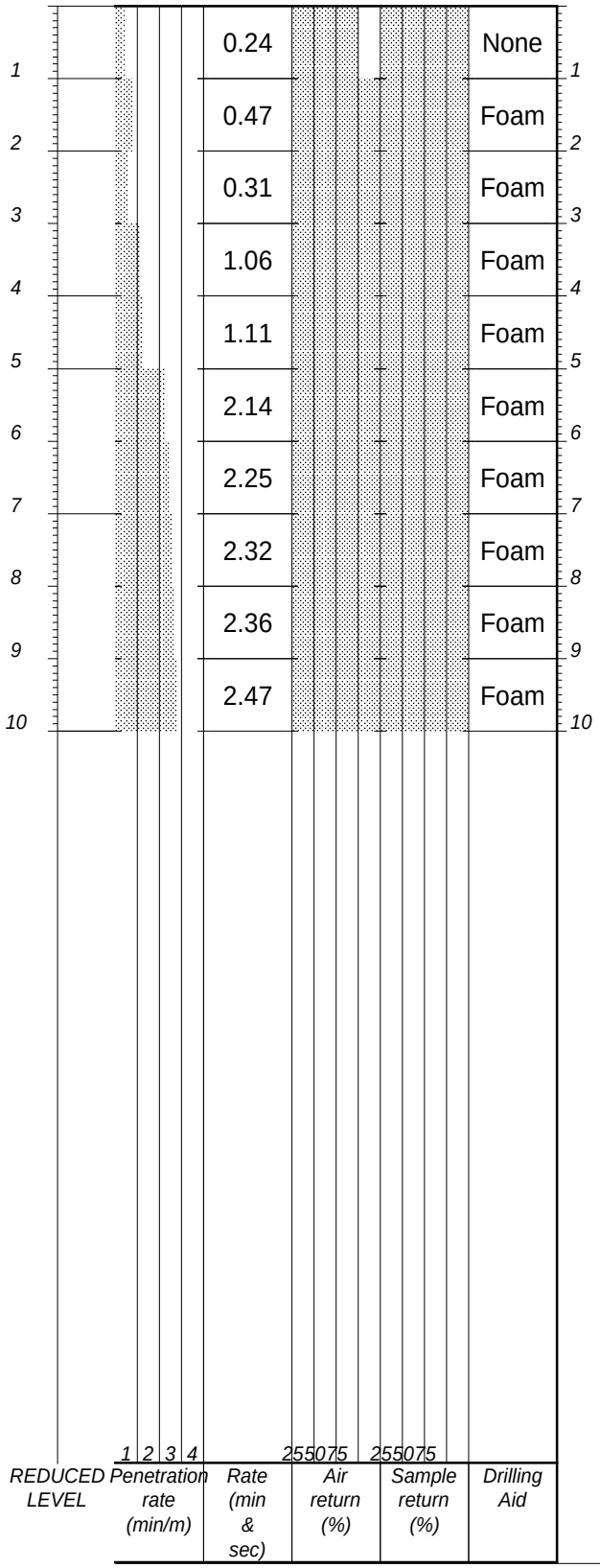
REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

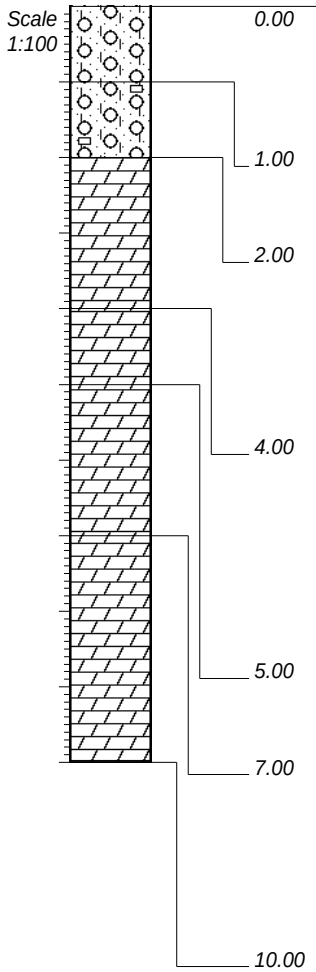
TRANSNET
Postmasburg Housing Development

HOLE No: PH003
Sheet 1 of 1

JOB NUMBER: J13-066



REDUCED LEVEL | *Penetration rate (min/m)* | *Rate (min & sec)* | *Air return (%)* | *Sample return (%)* | *Drilling Aid*



GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

As above but with traces of dolomite and minor calcrete.

Grey, moderately weathered, DOLOMITE.
Minor gravel and calcrete - possibly contaminated with material from above.

Grey, slightly weathered, DOLOMITE.
Some evidence of joint faces.
Traces of gravel and calcrete - possibly contaminated with material from above.

Purple and grey, slightly weathered, DOLOMITE.

Grey banded red, slightly weathered, hard rock, DOLOMITE.
Abundant evidence of joint faces.

End of hole.

NOTES

1) No water strikes noticed.

2) F

3) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133442
Y-COORD : -6262

HOLE No: PH003

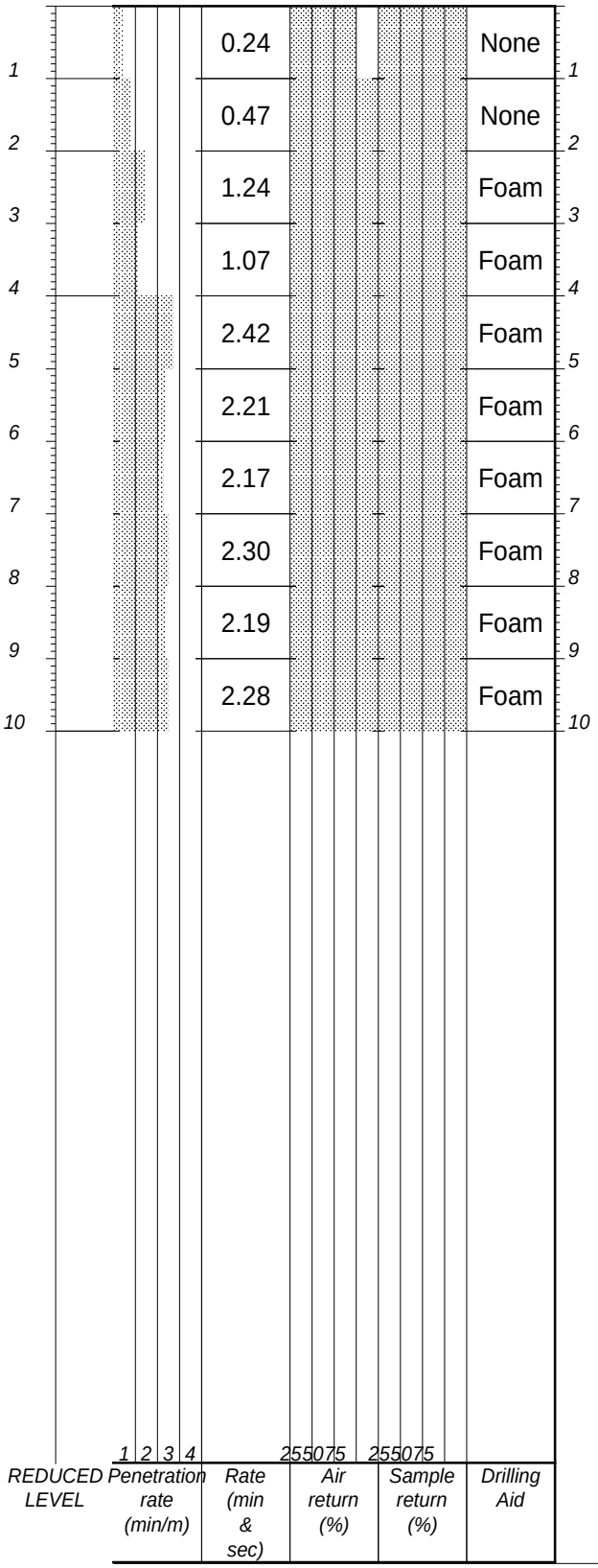
REVISION :
SETUP FILE : BGC_PERC.SET

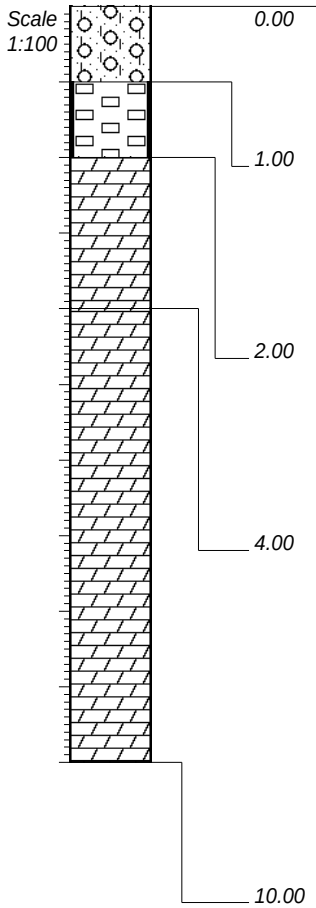
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH004
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

Pink speckled and mottled grey, HARDPAN CALCRETE with abundant gravel - possibly contaminated with material from above.

Purple speckled grey, highly weathered, DOLOMITE.
Traces of gravel and calcrete - possibly contaminated with material from above.

Grey light grey and red, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.
From 6 - 8 m; predominantly red, slightly weathered, dolomite.
From 9 - 10 m: Abundant grey brown, moderately weathered, dolomite.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133466
Y-COORD : -6295

HOLE No: PH004

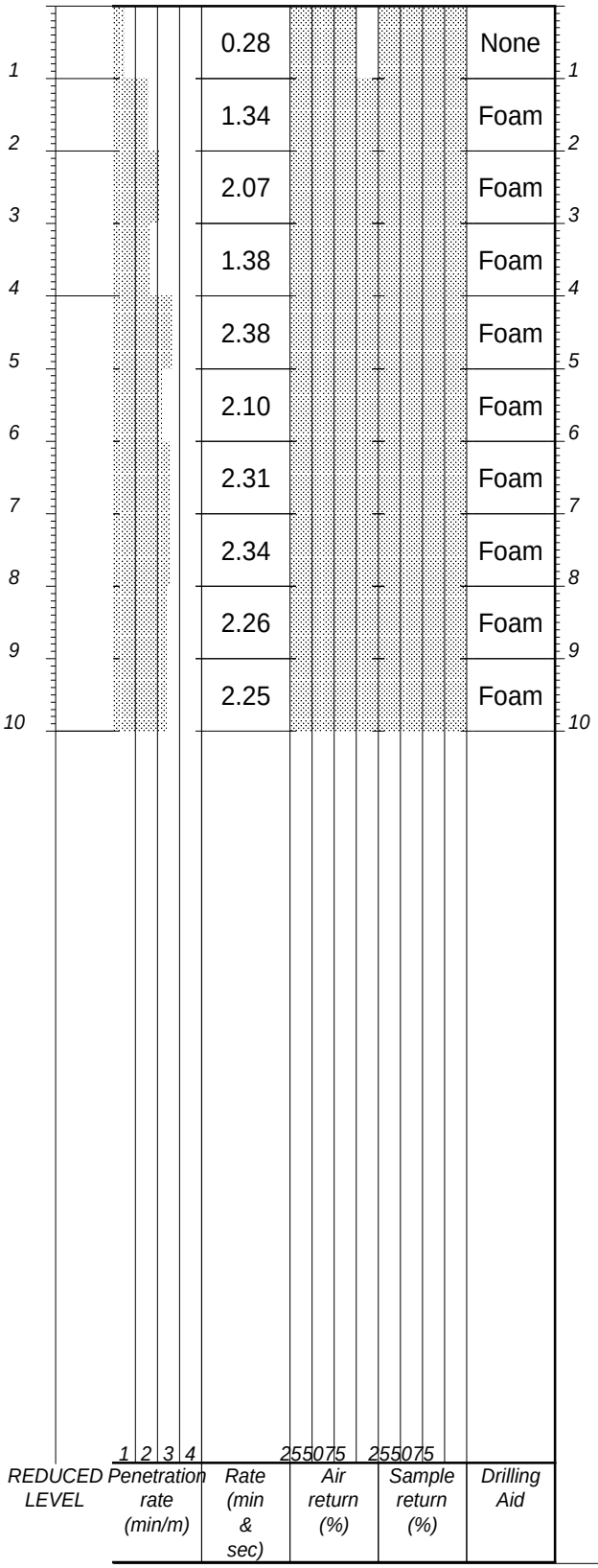
REVISION :
SETUP FILE : BGC_PERC.SET

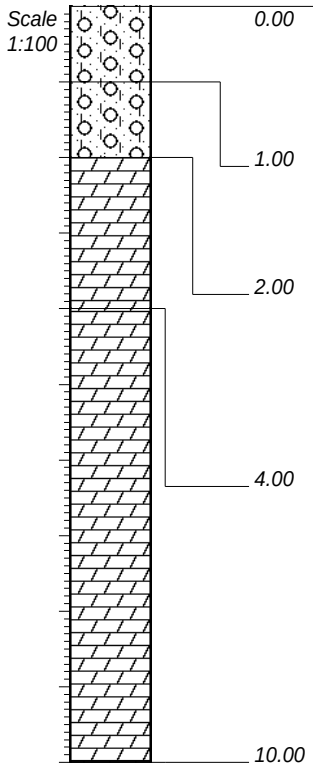
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH005
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with minor red brown, silty sand matrix. Transported.

As above but with traces of purple, slightly weathered, dolomite.

Purple and grey banded red, slightly weathered, DOLOMITE.
Minor gravel - possibly contaminated with material from above.

Purple and grey banded red, slightly weathered, hard rock, DOLOMITE.
Traces of gravel - possibly contaminated with material from above.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133500
Y-COORD : -6348

HOLE No: PH005

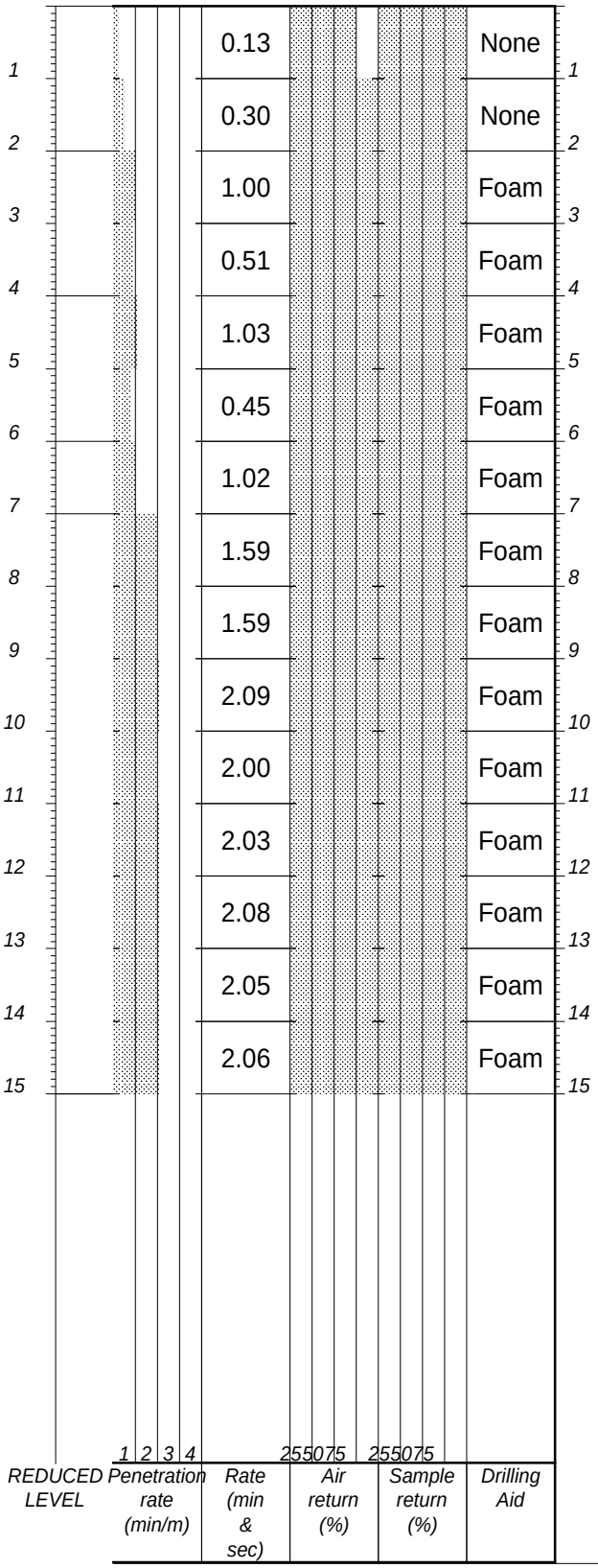
REVISION :
SETUP FILE : BGC_PERC.SET

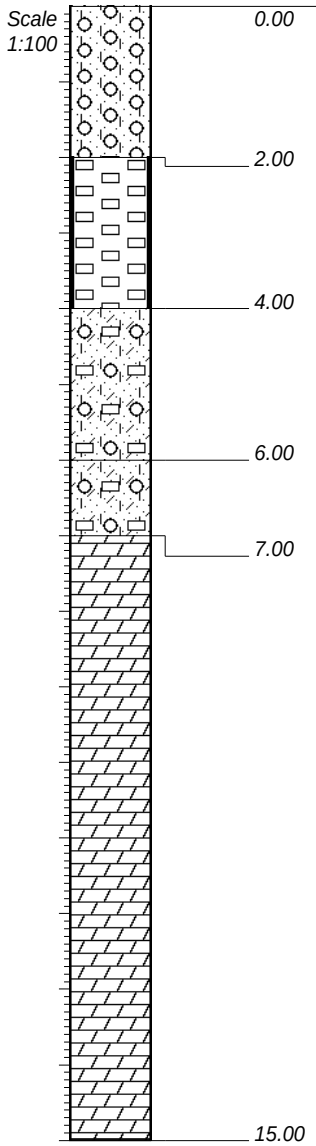
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH006
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix. Transported.

White and pink speckled and mottled grey, HARDPAN CALCRETE.

Brown, clayey silty SAND with abundant calcrete and minor gravel.

As above but with minor grey, slightly weathered, dolomite.

Grey light grey banded red, slightly weathered, hard rock, DOLOMITE.
Traces of gravel - possibly contaminated with material from above.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133115
Y-COORD : -6166

HOLE No: PH006

REVISION :
SETUP FILE : BGC_PERC.SET

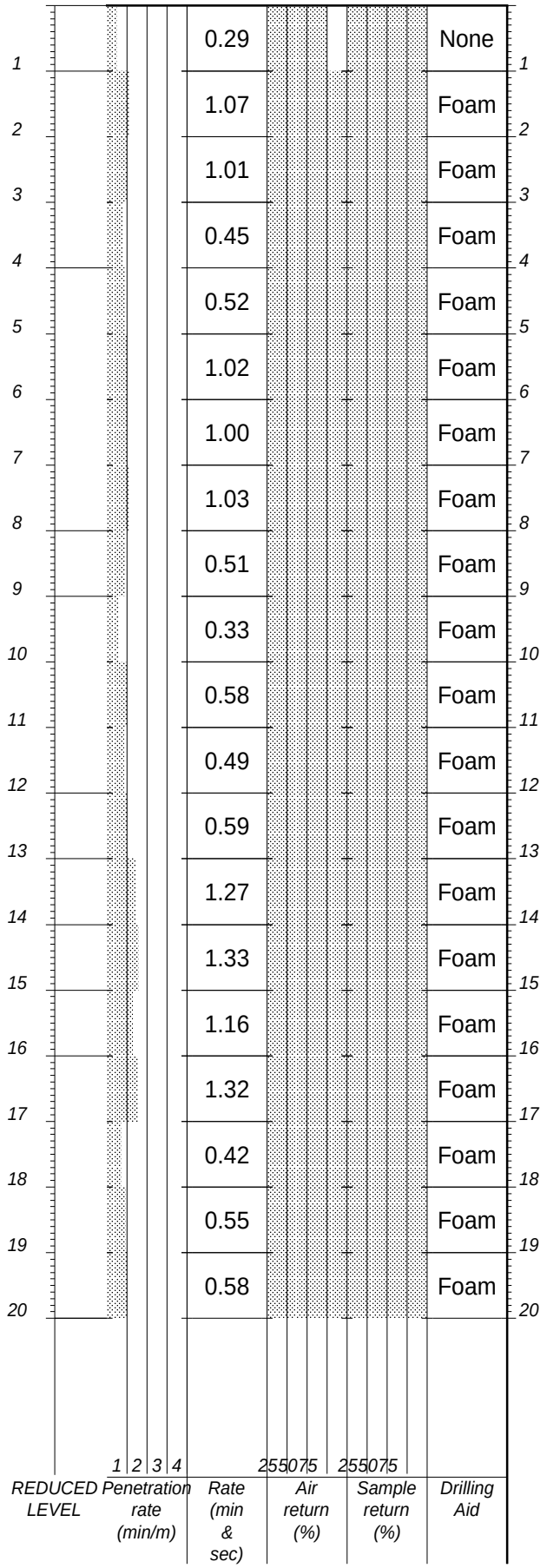
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

Bear GeoConsultants

TRANSNET
Postmasburg Housing Development

HOLE No: PH2056
Sheet 1 of 2

JOB NUMBER: J13-066



REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid	
	1 2 3 4		25 50 75	25 50 75		
1		0.29			None	1
2		1.07			Foam	2
3		1.01			Foam	3
4		0.45			Foam	4
5		0.52			Foam	5
6		1.02			Foam	6
7		1.00			Foam	7
8		1.03			Foam	8
9		0.51			Foam	9
10		0.33			Foam	10
11		0.58			Foam	11
12		0.49			Foam	12
13		0.59			Foam	13
14		1.27			Foam	14
15		1.33			Foam	15
16		1.16			Foam	16
17		1.32			Foam	17
18		0.42			Foam	18
19		0.55			Foam	19
20		0.58			Foam	20

0.00 – 1.00: GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix. Transported.

1.00 – 4.00: White and pink speckled and mottled grey, HARDPAN CALCRETE with traces of gravel.

4.00 – 8.00: Brown, silty SAND with abundant calcrete and traces of gravel.

8.00 – 9.00: Red brown sandy silty CLAY with abundant gravel and traces of calcrete.

9.00 – 12.00: As above but with abundant calcrete and traces of gravel.

12.00 – 13.00: Brown, clayey silty SAND with abundant moderately weathered dolomite.
Traces of calcrete and gravel.

13.00 – 14.00: Light grey banded purple, slightly weathered, DOLOMITE.

14.00 – 15.00: Light grey and red, slightly weathered, DOLOMITE.

15.00 – 16.00: Red, slightly weathered, DOLOMITE.
Traces of grey, slightly weathered, dolomite and gravel.

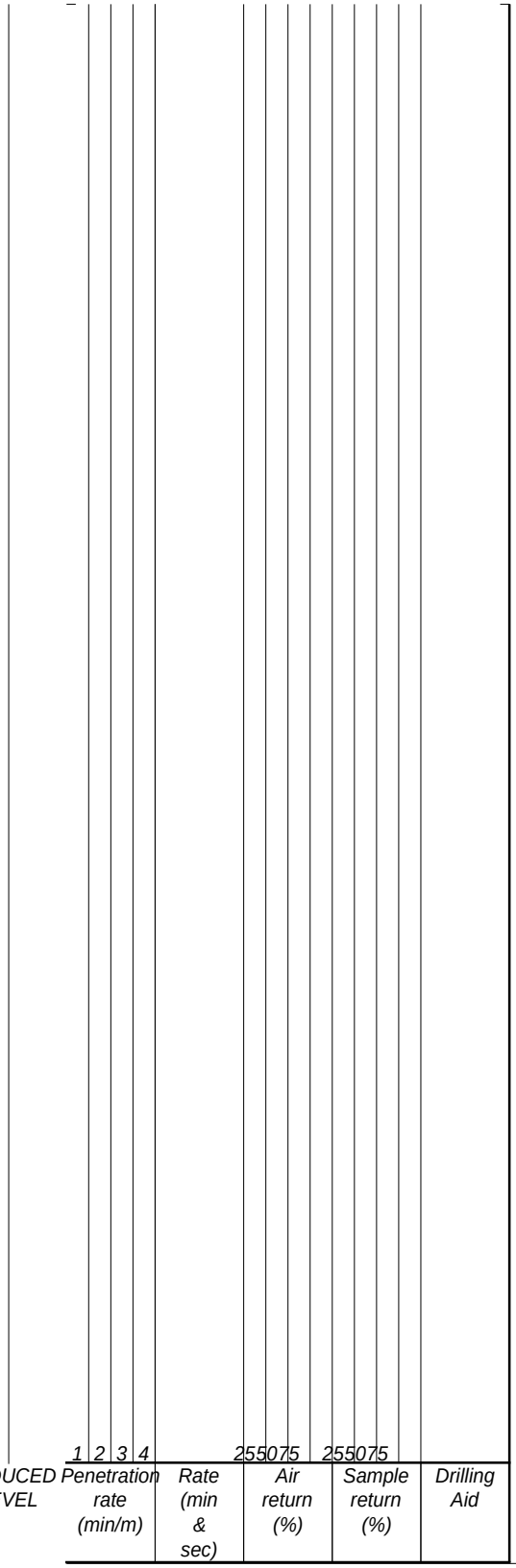
16.00 – 20.00: Brown, slightly clayey silty SAND with abundant calcrete, traces of slightly weathered dolomite and gravel.

20.00: End of hole.

TRANSNET
Postmasburg Housing Development

HOLE No: PH2056
Sheet 2 of 2

JOB NUMBER: J13-066



REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133045
Y-COORD : -5971

HOLE No: PH2056

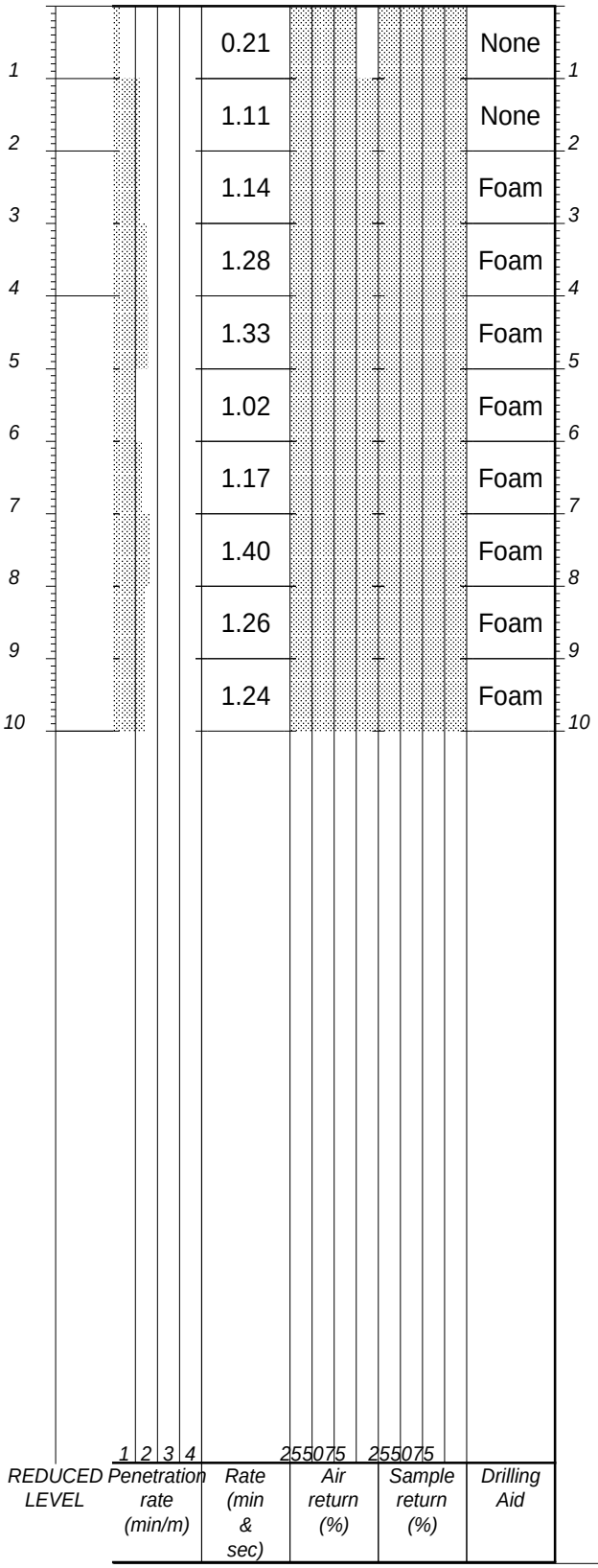
REVISION :
SETUP FILE : BGC_PERC.SET

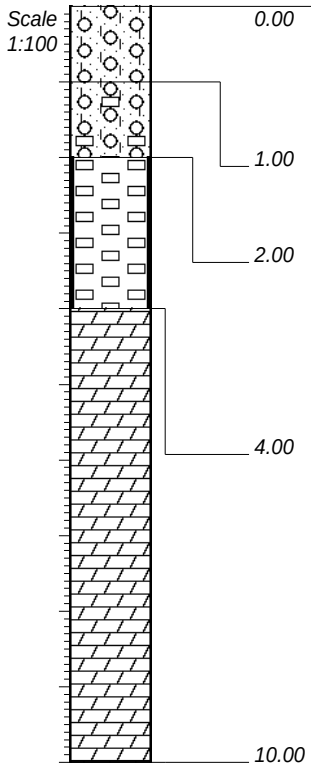
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2066
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with minor red brown, silty sand matrix. Transported.

As above but with traces of calcrete.

White and pink mottled and speckled grey, HARDPAN CALCRETE with abundant gravel - possibly contaminated with material from above.

Light grey and red, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.
Minor to traces of gravel and traces of green mineral - possibly contaminated with material from above.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133118
Y-COORD : -5899

HOLE No: PH2066

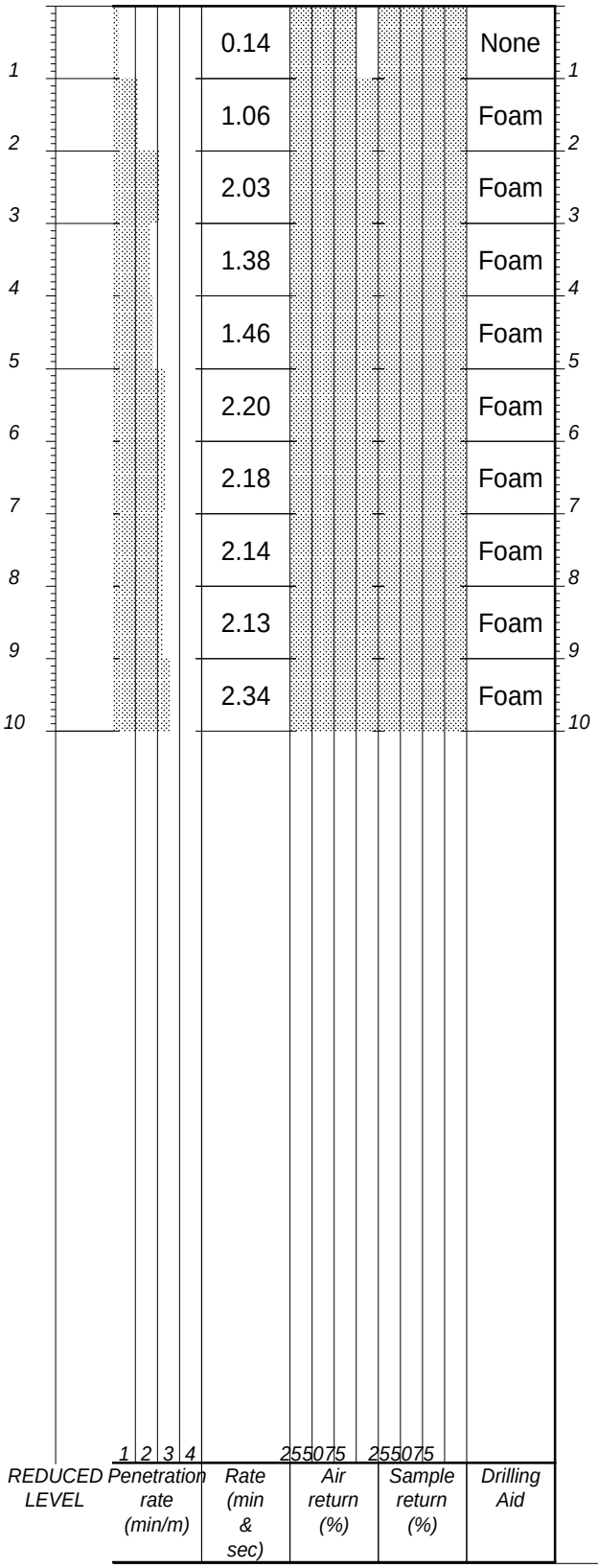
REVISION :
SETUP FILE : BGC_PERC.SET

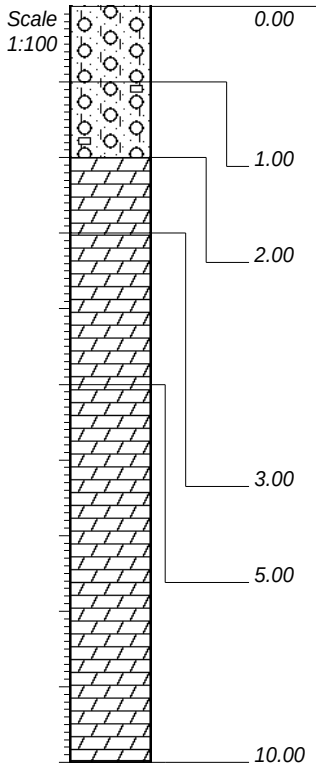
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2108
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix. Transported.

As above but with minor white and pink calcrete.

Light grey, slightly weathered, DOLOMITE.
Minor gravel and traces of calcrete - possibly contaminated with material from above.

Light grey, slightly weathered, DOLOMITE.

Grey and light grey banded red, slightly weathered, hard rock DOLOMITE.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133041
Y-COORD : -5855

HOLE No: PH2108

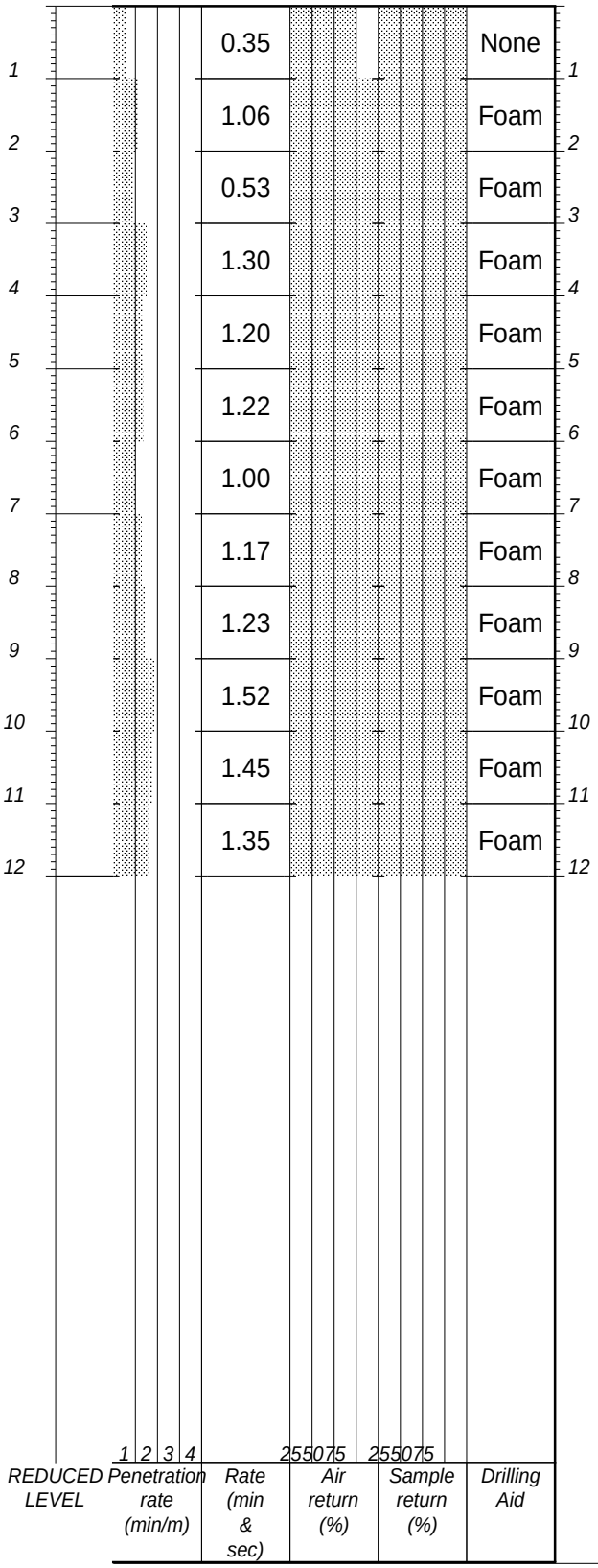
REVISION :
SETUP FILE : BGC_PERC.SET

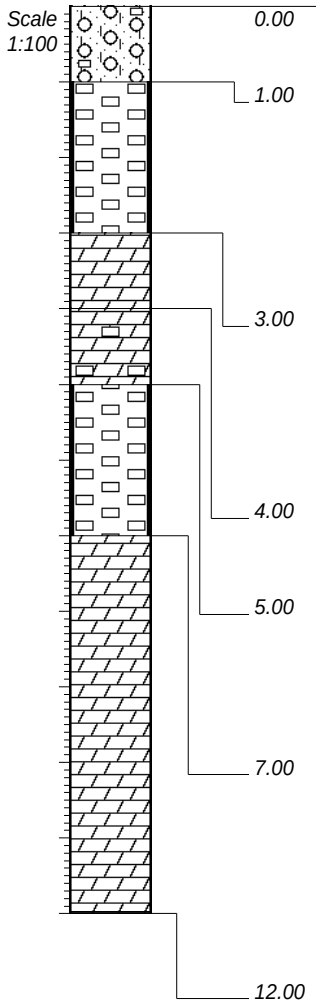
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2131
Sheet 1 of 1

JOB NUMBER: J13-066





0.00 – 1.00	Red brown, silty SAND with abundant gravel and calcrete.
1.00 – 3.00	Black white and pink mottled black, HARDPAN CALCRETE. Traces of gravel and brown silty sand - possibly contaminated with material from above.
3.00 – 4.00	Light grey banded red, slightly weathered, DOLOMITE. Traces of gravel - possibly contaminated with material from above.
4.00 – 5.00	As above but with abundant calcrete.
5.00 – 7.00	Pink speckled and mottled grey, HARDPAN CALCRETE with minor, slightly weathered, dolomite.
7.00 – 12.00	Light grey, slightly weathered, DOLOMITE. Some evidence of joint faces. Traces of gravel - possibly contaminated with material from above.
12.00	End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3132966
Y-COORD : -5853

HOLE No: PH2131

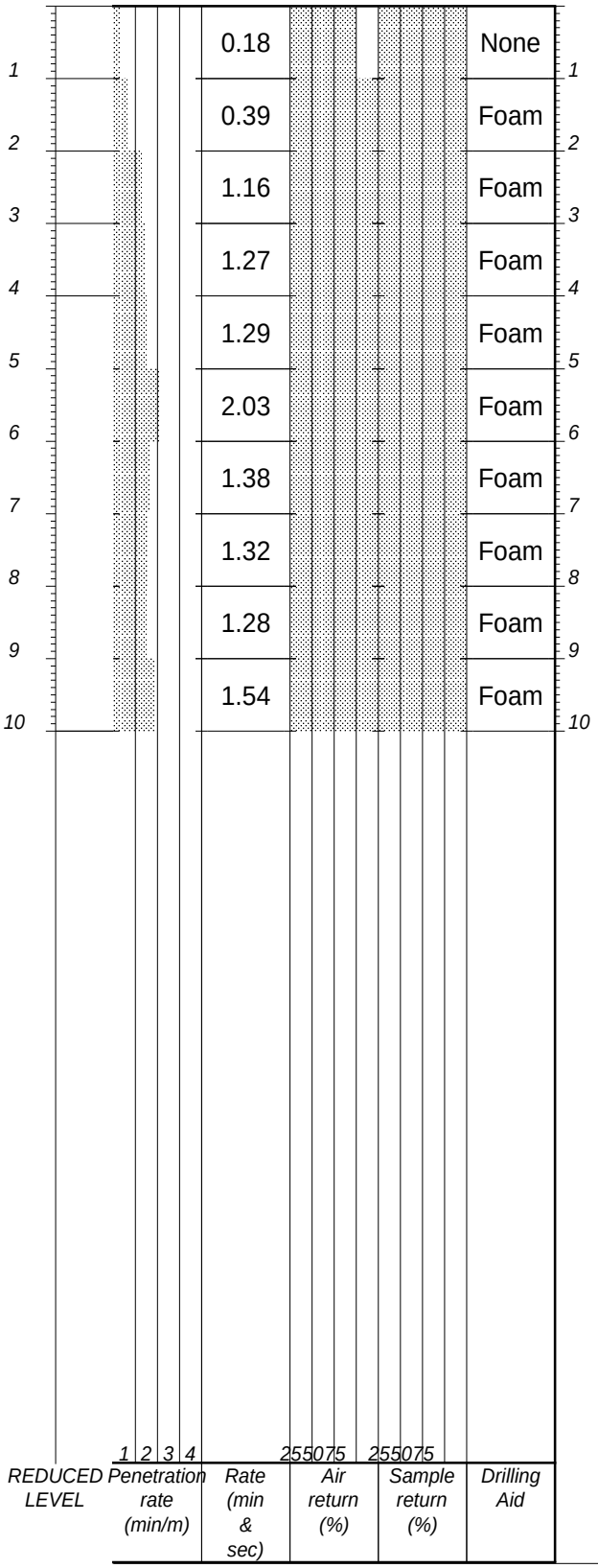
REVISION :
SETUP FILE : BGC_PERC.SET

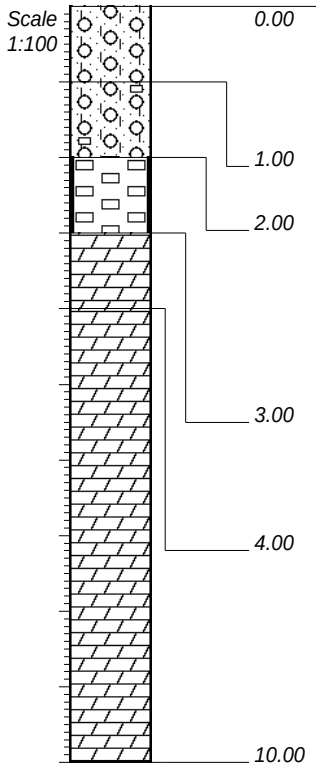
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2147
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

As above but with minor calcrete.

Pink speckled and mottled black, HARDPAN CALCRETE with minor gravel - possibly contaminated with material from above.

Purple and light grey, slightly weathered, DOLOMITE with minor calcrete.

Light grey and purple, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133013
Y-COORD : -5776

HOLE No: PH2147

REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

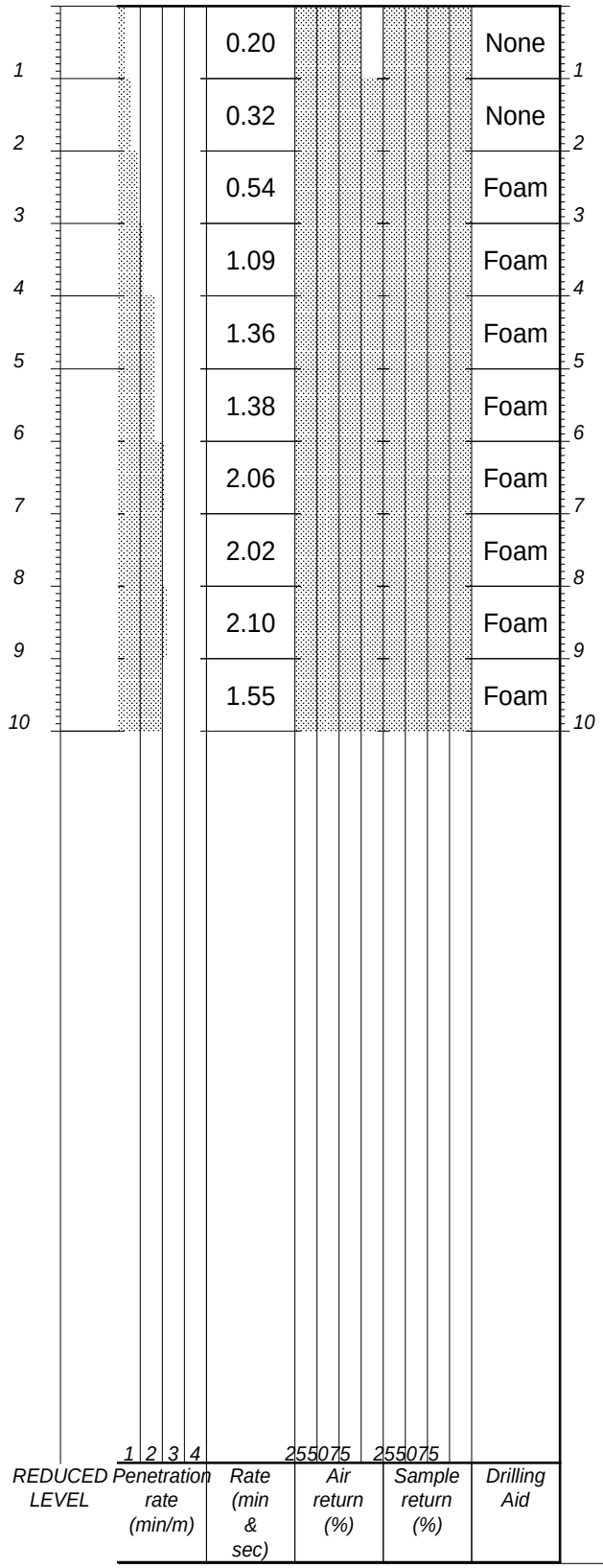
TRANSNET

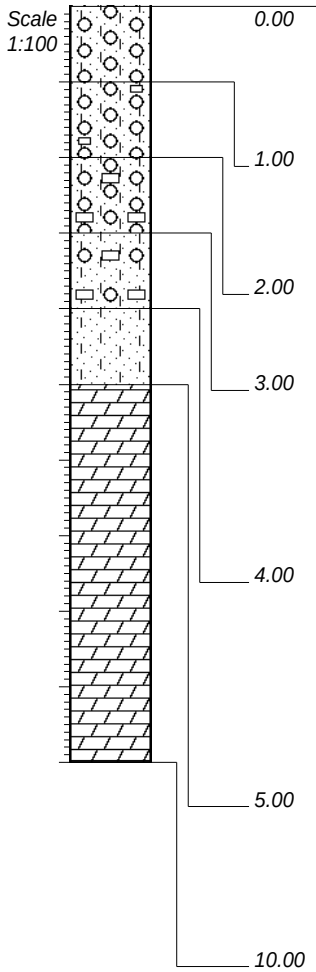
Postmasburg Housing Development

HOLE No: PH2165

Sheet 1 of 1

JOB NUMBER: J13-066





0.00	GRAVEL (quartz, chert and banded ironstone) with minor red brown, silty sand matrix. Transported.
1.00	As above but with minor black speckled white, calcrete. Transported.
2.00	Brown, silty SAND with abundant gravel and calcrete.
3.00	Brown, silty SAND with abundant red calcrete, traces of gravel, and traces of grey slightly weathered and highly weathered dolomite.
4.00	Brown, silty SAND with abundant moderately weathered and slightly weathered dolomite. Traces of gravel - possibly contaminated with material from above.
5.00	Grey and light grey banded red, slightly weathered, DOLOMITE. Abundant evidence of joint faces.
10.00	End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3132924
Y-COORD : -5787

HOLE No: PH2165

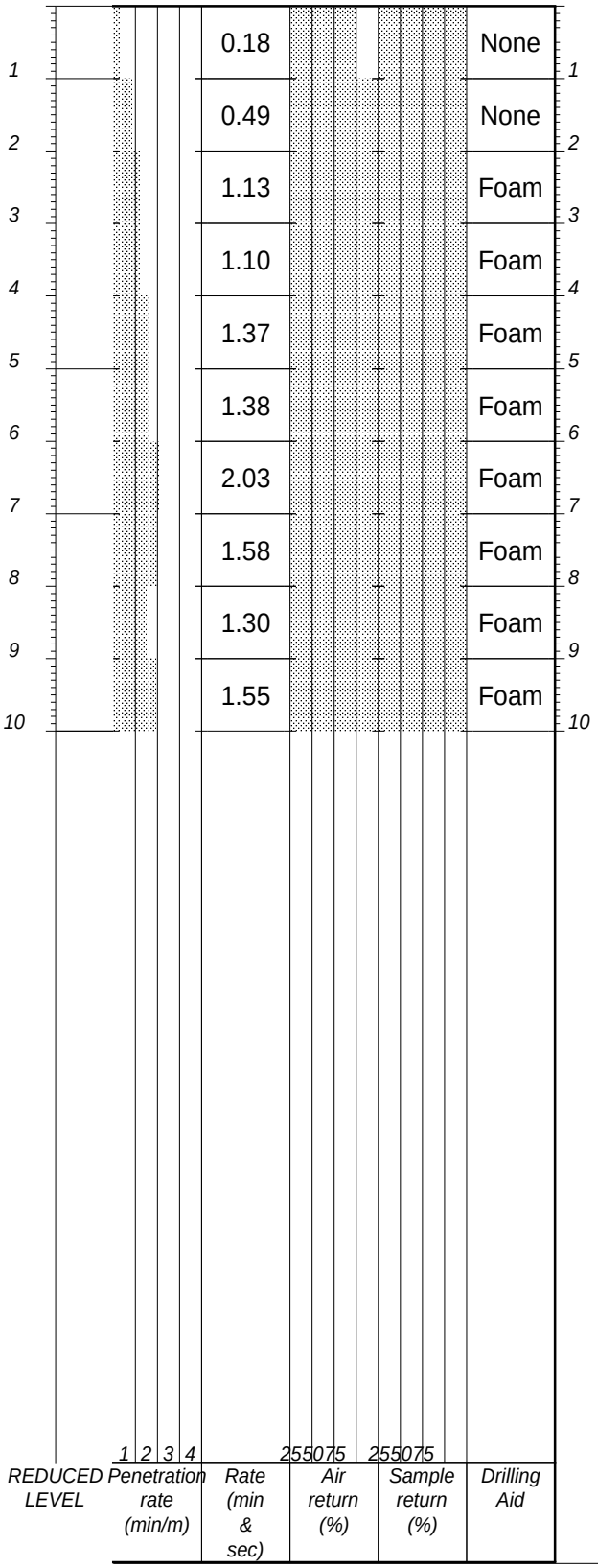
REVISION :
SETUP FILE : BGC_PERC.SET

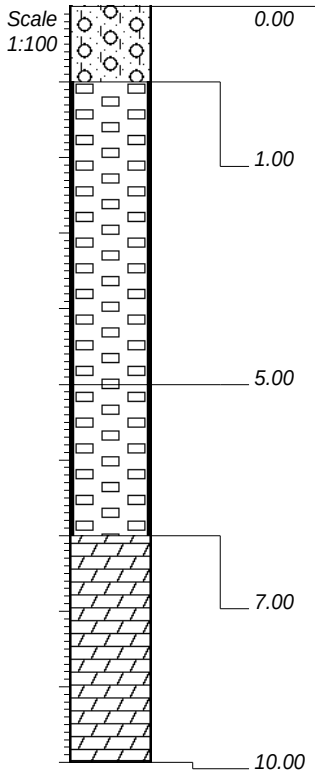
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2201
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

White pink grey and dark red, HARDPAN CALCRETE with abundant gravel - possibly contaminated with material from above.

Grey brown, HARDPAN CALCRETE with abundant gravel - possibly contaminated with material from above.
Traces of highly weathered dolomite towards base.

Grey brown speckled red, highly weathered, DOLOMITE.
Abundant calcrete and traces of gravel.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3132940
Y-COORD : -5632

HOLE No: PH2201

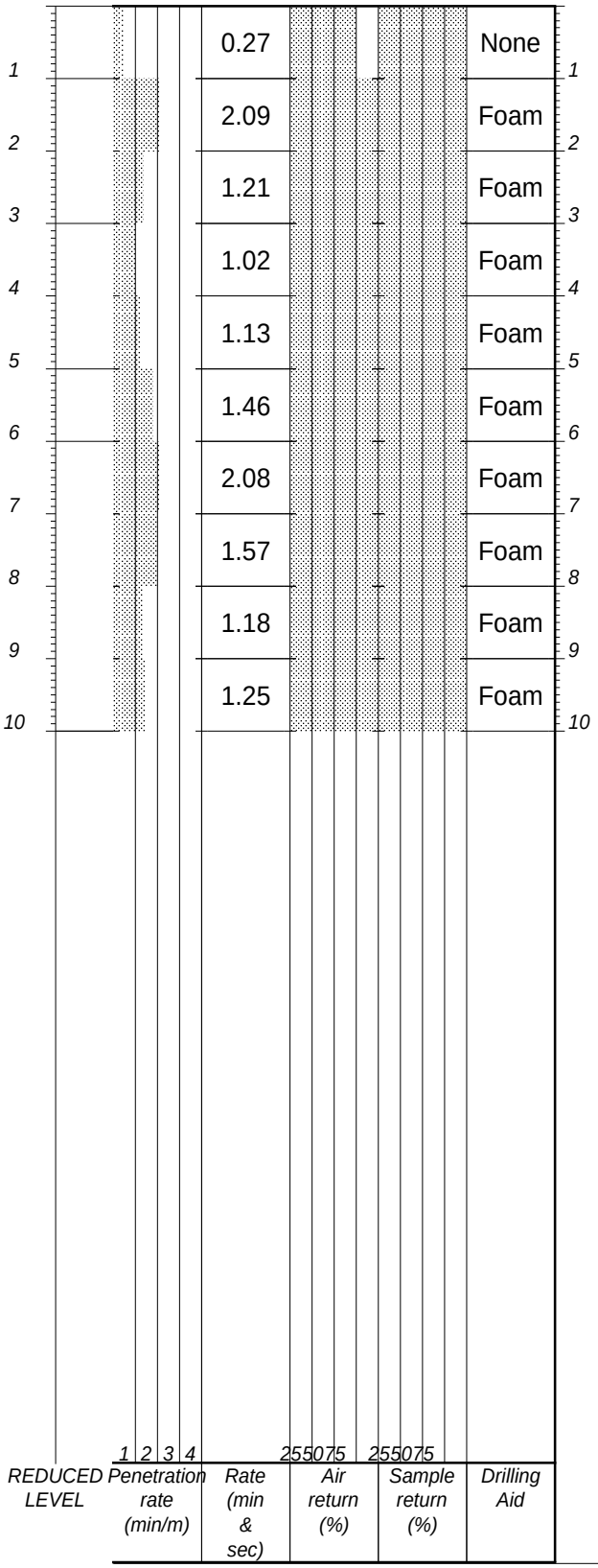
REVISION :
SETUP FILE : BGC_PERC.SET

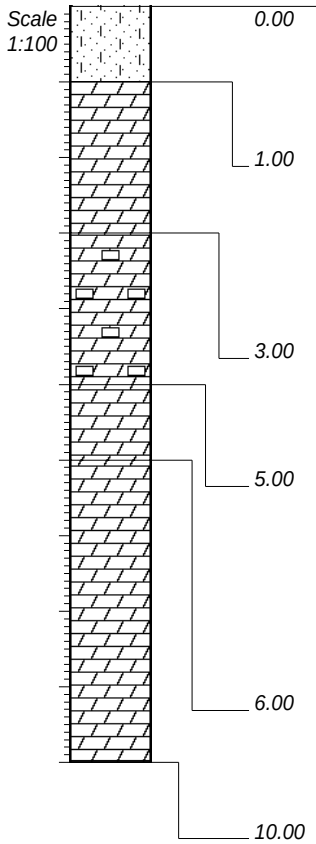
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2206
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

Grey, slightly weathered, DOLOMITE.
Traces of gravel - possibly contaminated with material from above.

As above but with abundant grey, pink and white calcrete and brown, silty sand.

Light grey and grey, slightly weathered, DOLOMITE with traces of chert.
Minor calcrete and traces of gravel - possibly contaminated with material from above.

Dark grey light grey speckled red, slightly weathered, DOLOMITE.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3132856
Y-COORD : -5686

HOLE No: PH2206

REVISION :
SETUP FILE : BGC_PERC.SET

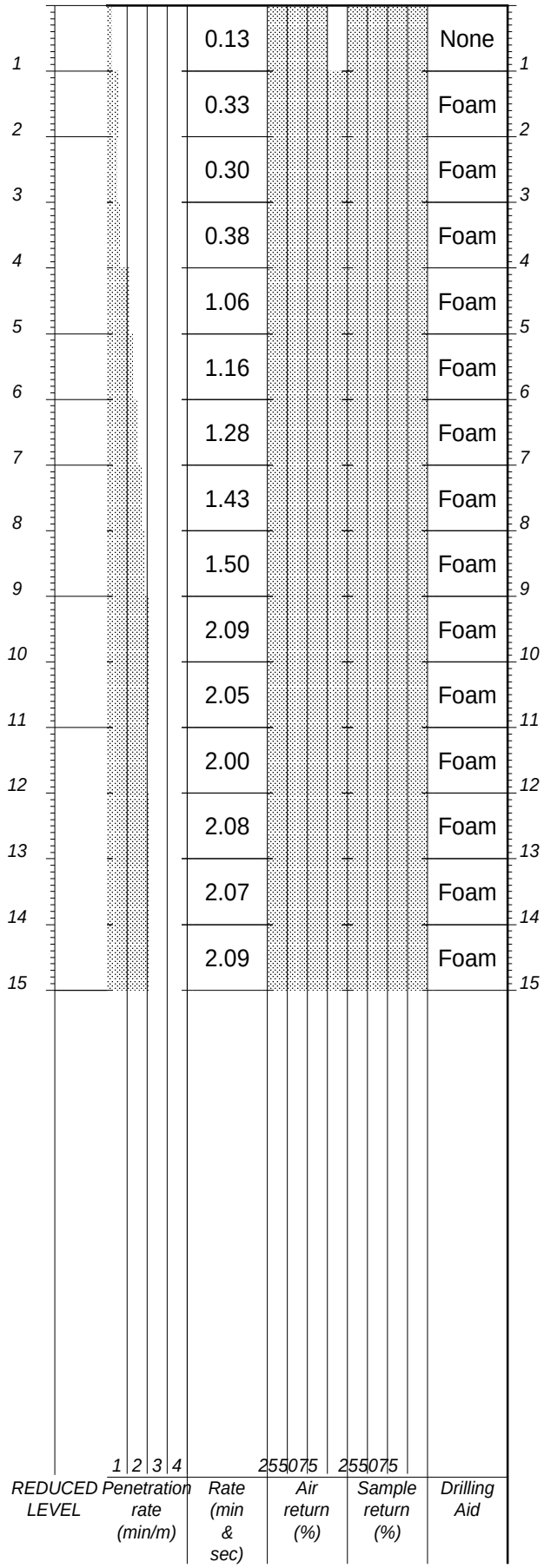
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

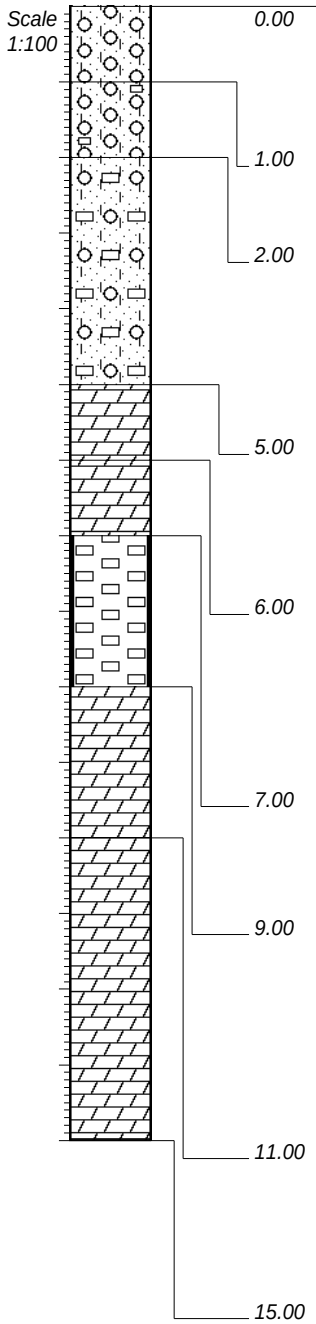
Bear GeoConsultants

TRANSNET
Postmasburg Housing Development

HOLE No: PH2241
Sheet 1 of 2

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix. Transported.

As above but with traces of calcrete.

Dark brown, silty SAND with abundant white and pink speckled and mottled black, hardpan calcrete and minor gravel.

Grey and light grey banded red, slightly weathered to moderately weathered, DOLOMITE with traces of gravel.

Red, slightly weathered to moderately weathered, DOLOMITE.
Traces of slightly weathered, dolomite and calcrete.

Grey brown white and pink, HARDPAN CALCRETE with traces of dolomite towards base.

Grey brown banded red, slightly and moderately weathered, DOLOMITE.
Abundant evidence of joint faces.
Traces of calcrete and gravel.

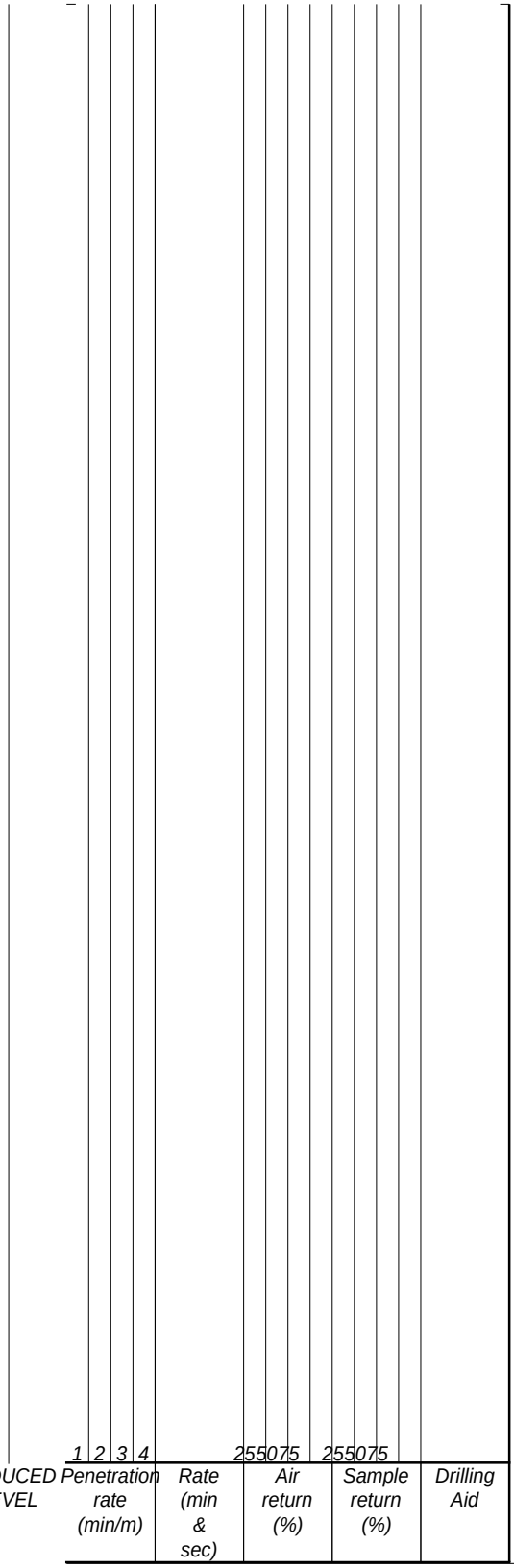
Grey brown banded red, slightly weathered, hard rock DOLOMITE.
Some evidence of joint faces.

End of hole.

TRANSNET
Postmasburg Housing Development

HOLE No: PH2241
Sheet 2 of 2

JOB NUMBER: J13-066



REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3132990
Y-COORD : -5672

HOLE No: PH2241

REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

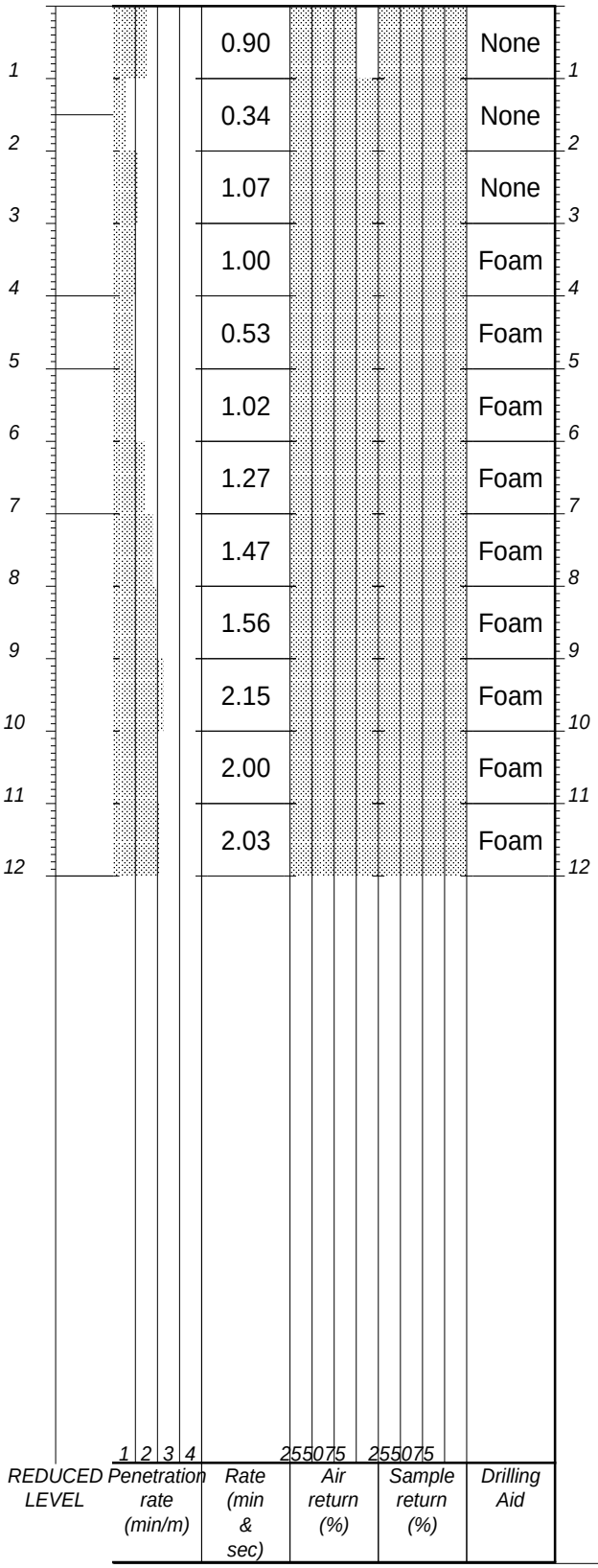
TRANSNET

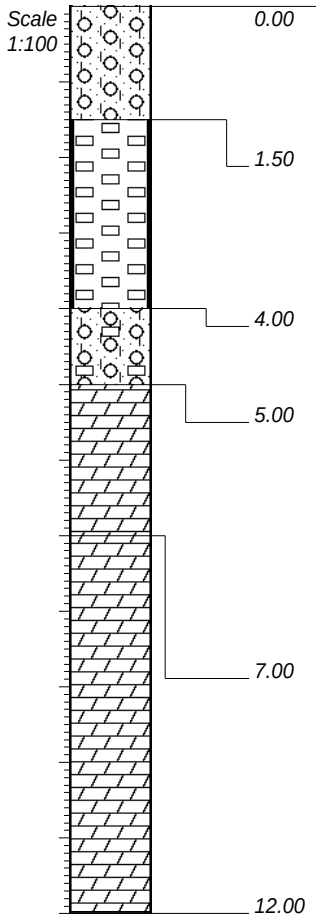
Postmasburg Housing Development

HOLE No: PH2261

Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

Pink and white speckled and mottled black, HARDPAN CALCRETE.
Traces of gravel.

Brown, silty SAND with abundant gravel and calcrete.

Dark grey and red, moderately weathered, DOLOMITE with abundant gravel, traces of calcrete and traces of brown, silty sand.
Possibly contaminated with material from above.

Grey, light grey and red, slightly weathered, hard rock DOLOMITE.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133125
Y-COORD : -6085

HOLE No: PH2261

REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

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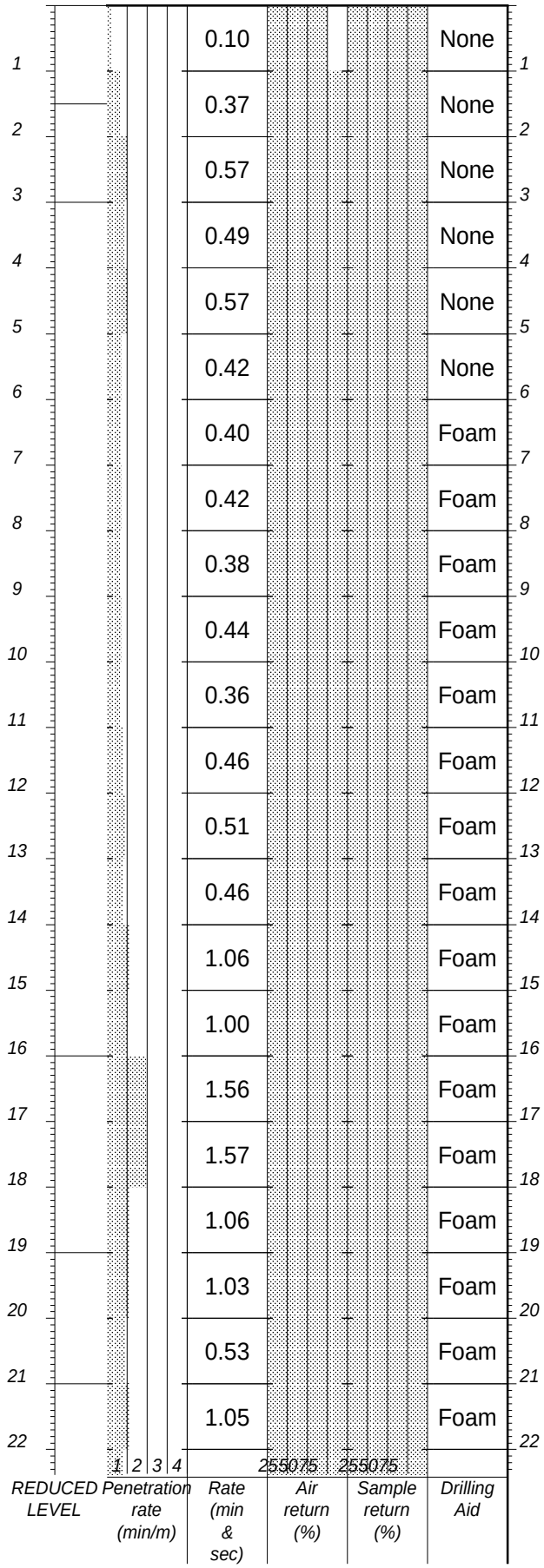
TRANSNET
Postmasburg Housing Development

HOLE No: PH2286
Sheet 1 of 2

JOB NUMBER: J13-066



REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid
	1 2 3 4		255075	255075	
1		0.10			None
2		0.37			None
3		0.57			None
4		0.49			None
5		0.57			None
6		0.42			None
7		0.40			Foam
8		0.42			Foam
9		0.38			Foam
10		0.44			Foam
11		0.36			Foam
12		0.46			Foam
13		0.51			Foam
14		0.46			Foam
15		1.06			Foam
16		1.00			Foam
17		1.56			Foam
18		1.57			Foam
19		1.06			Foam
20		1.03			Foam
21		0.53			Foam
22		1.05			Foam

0.00 – 1.50: GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

1.50 – 3.00: Pink and white speckled and mottled grey, HARDPAN CALCRETE with abundant gravel - possibly contaminated with material from above.

3.00 – 16.00: Dark brown, silty SAND with abundant calcrete and traces of gravel.
From 6 - 7 m: Traces of banded ironstone.
Traces of dolomite towards base.

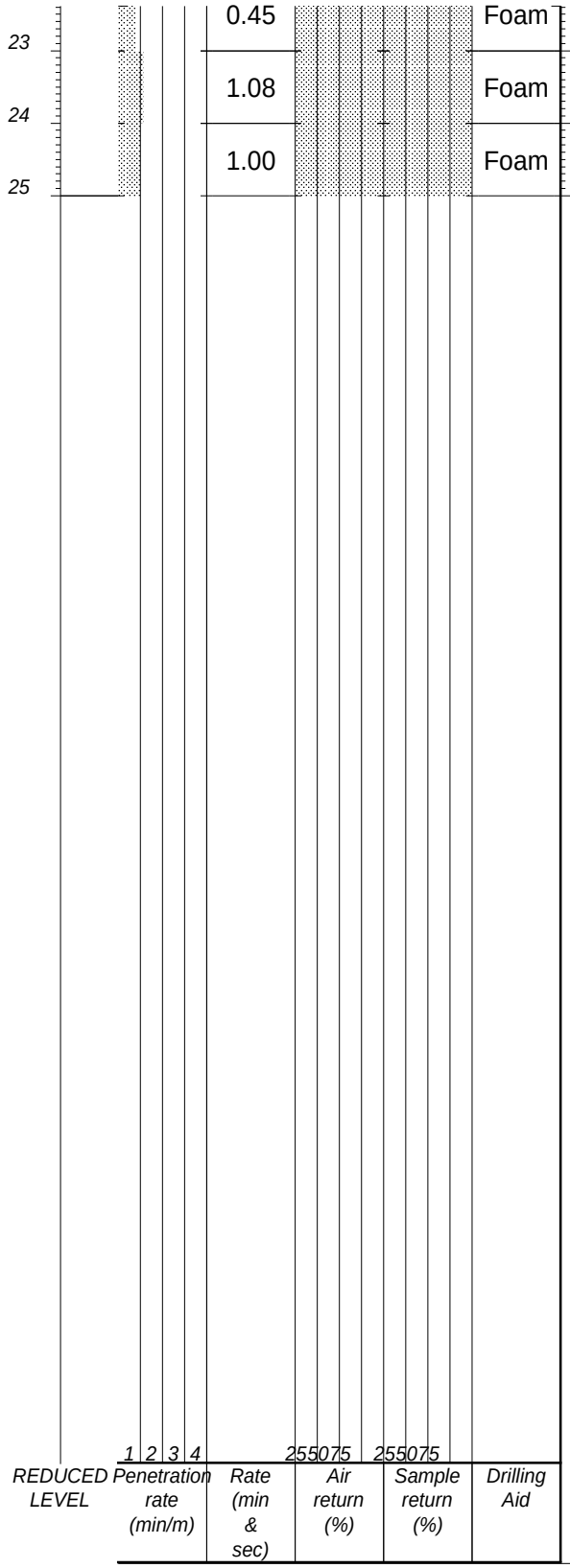
16.00 – 19.00: Grey light grey banded red, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.
Minor gravel and calcrete - possibly contaminated with material from above.

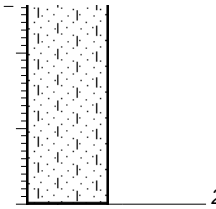
19.00 – 21.00: Brown, silty SAND with minor grey brown, moderately weathered, dolomite, traces of gravel and calcrete.

TRANSNET
Postmasburg Housing Development

HOLE No: PH2286
Sheet 2 of 2

JOB NUMBER: J13-066





Brown, silty SAND with abundant slightly and moderately weathered, dolomite, minor calcrete and gravel.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133107
Y-COORD : -6170

HOLE No: PH2286

REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET

Postmasburg Housing Development

HOLE No: PH2294

Sheet 1 of 1

JOB NUMBER: J13-066

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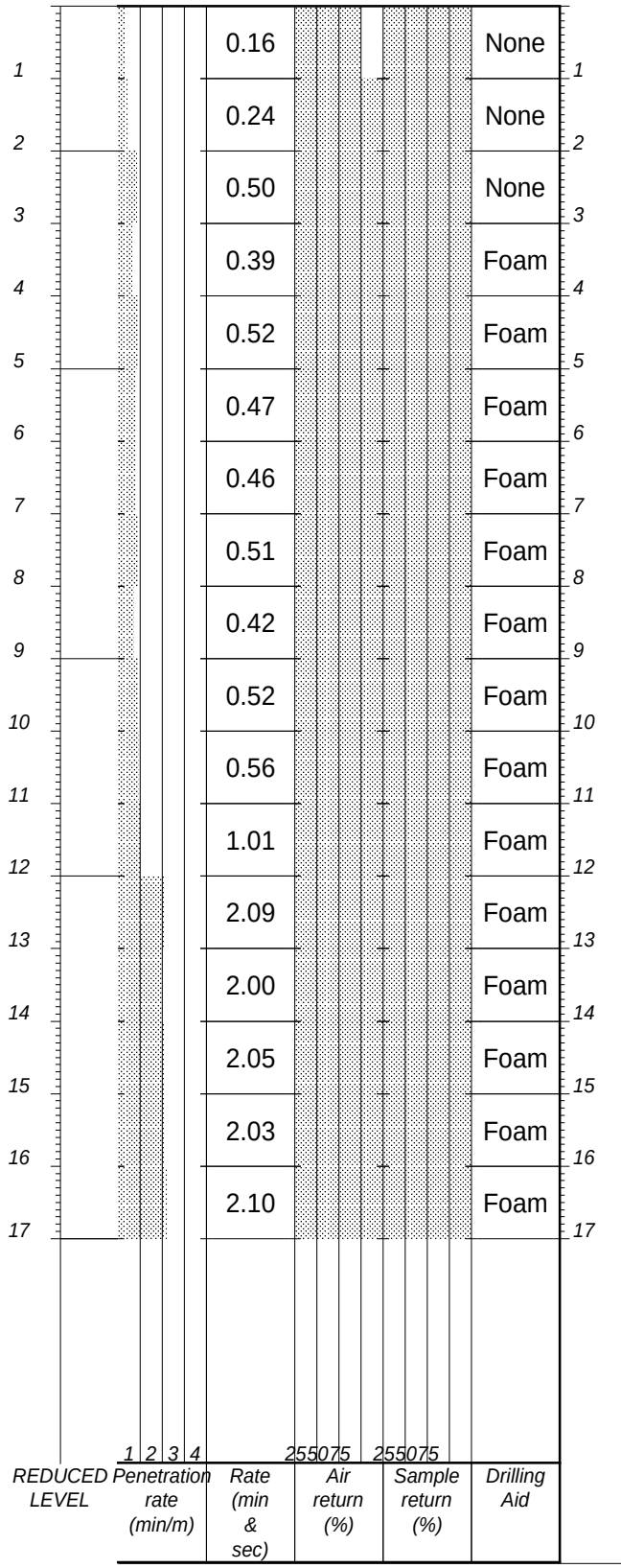

GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

White and pink speckled and mottled grey, HARDPAN CALCRETE with minor gravel - possibly contaminated with material from above.

Brown, sandy silty CLAY with abundant calcrete and gravel.

Grey brown, sandy silty CLAY with abundant gravel and calcrete.

Purple grey and light grey banded red, slightly weathered, hard rock, DOLOMITE.
Some evidence of joint faces.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133238
Y-COORD : -6082

HOLE No: PH2294

REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

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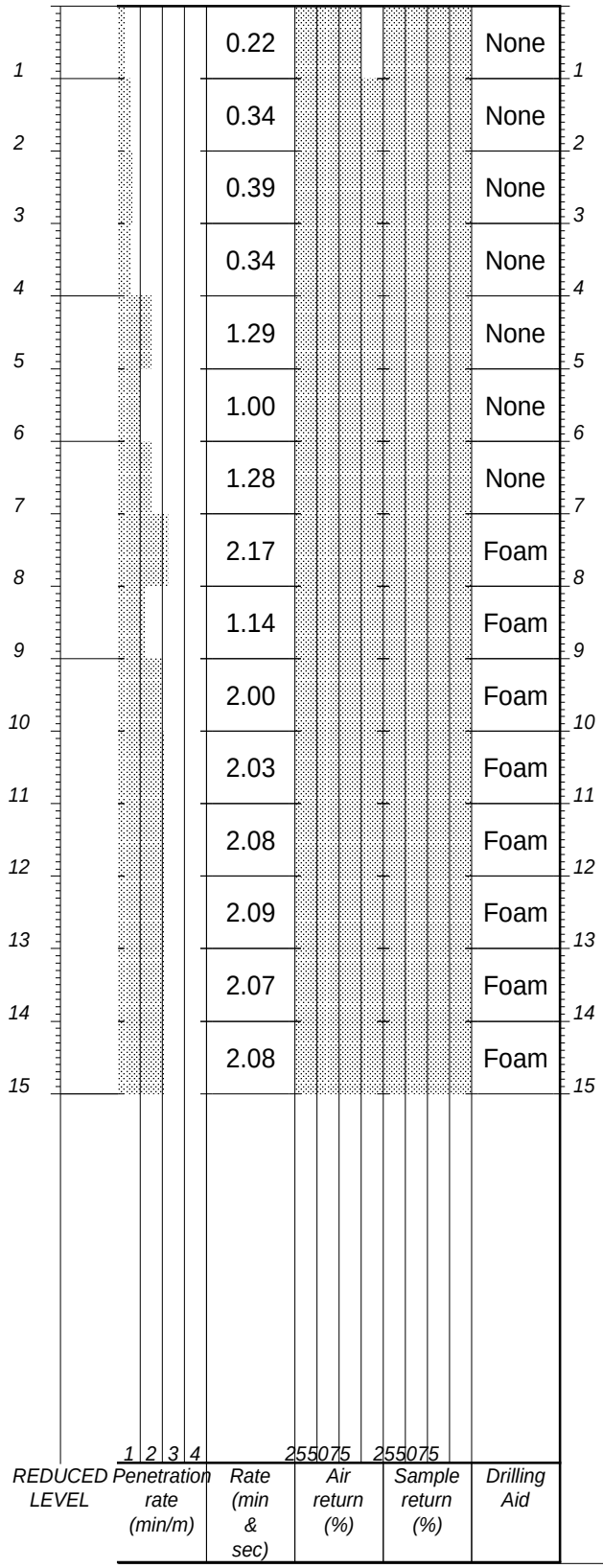
TRANSNET
Postmasburg Housing Development

HOLE No: PH2307
Sheet 1 of 1

JOB NUMBER: J13-066



REDUCED LEVEL	Penetration rate (min/m)	Rate (min & sec)	Air return (%)	Sample return (%)	Drilling Aid
	1 2 3 4	0.22	255075	255075	None
		0.34			None
		0.39			None
		0.34			None
		1.29			None
		1.00			None
		1.28			None
		2.17			Foam
		1.14			Foam
		2.00			Foam
		2.03			Foam
		2.08			Foam
		2.09			Foam
		2.07			Foam
		2.08			Foam

GRAVEL (quartz, chert and banded ironstone) with red brown, silty sand matrix and traces of calcrete. Transported.

White and pink speckled and mottled grey, HARDPAN CALCRETE with traces of gravel.

As above but with traces to minor grey, slightly weathered, dolomite.

Grey light grey banded red, slightly weathered, DOLOMITE.
Some evidence of joint faces.

Grey light grey banded red, slightly weathered, hard rock DOLOMITE.
Some evidence of joint faces.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133150
Y-COORD : -6162

HOLE No: PH2307

REVISION :
SETUP FILE : BGC_PERC.SET

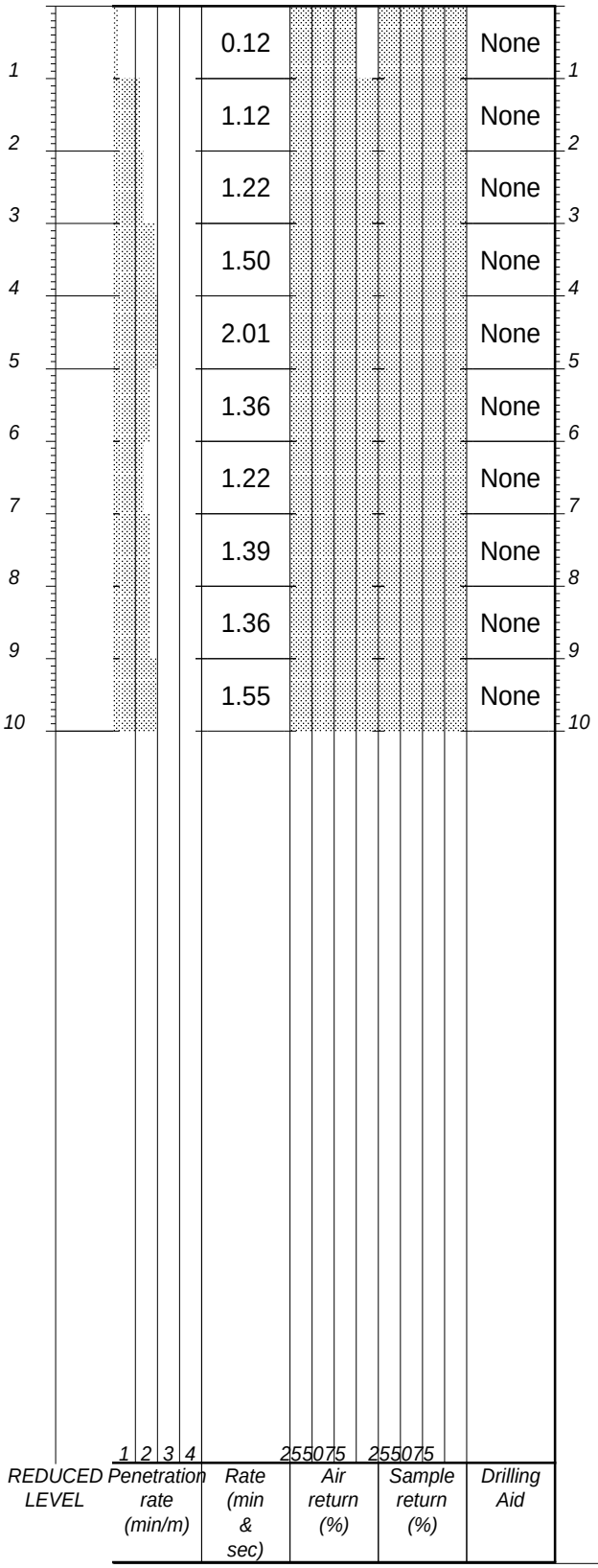
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

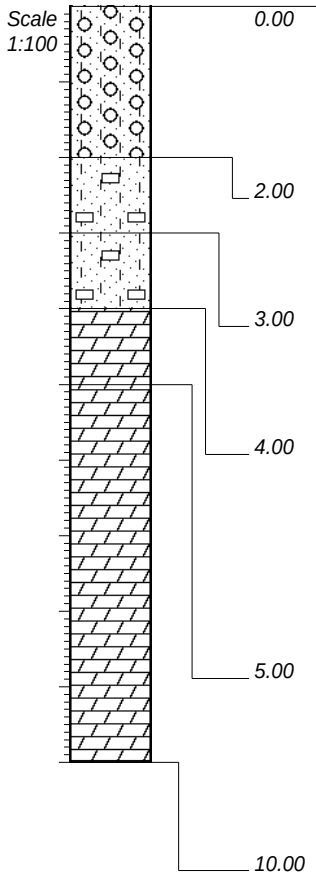
TRANSNET

Postmasburg Housing Development

HOLE No: PH2335
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix and calcrete towards bottom. Transported.

Brown, silty SAND with abundant grey brown, white and pink, calcrete.

As above but with traces of red and grey highly weathered dolomite.

Predominantly red slightly weathered DOLOMITE and traces of grey moderately weathered dolomite.
Abundant evidence of joint faces.

Grey and red, slightly weathered, DOLOMITE.
Abundant evidence of joint faces.
From 8 - 9 m: traces of chert.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133311
Y-COORD : -6155

HOLE No: PH2335

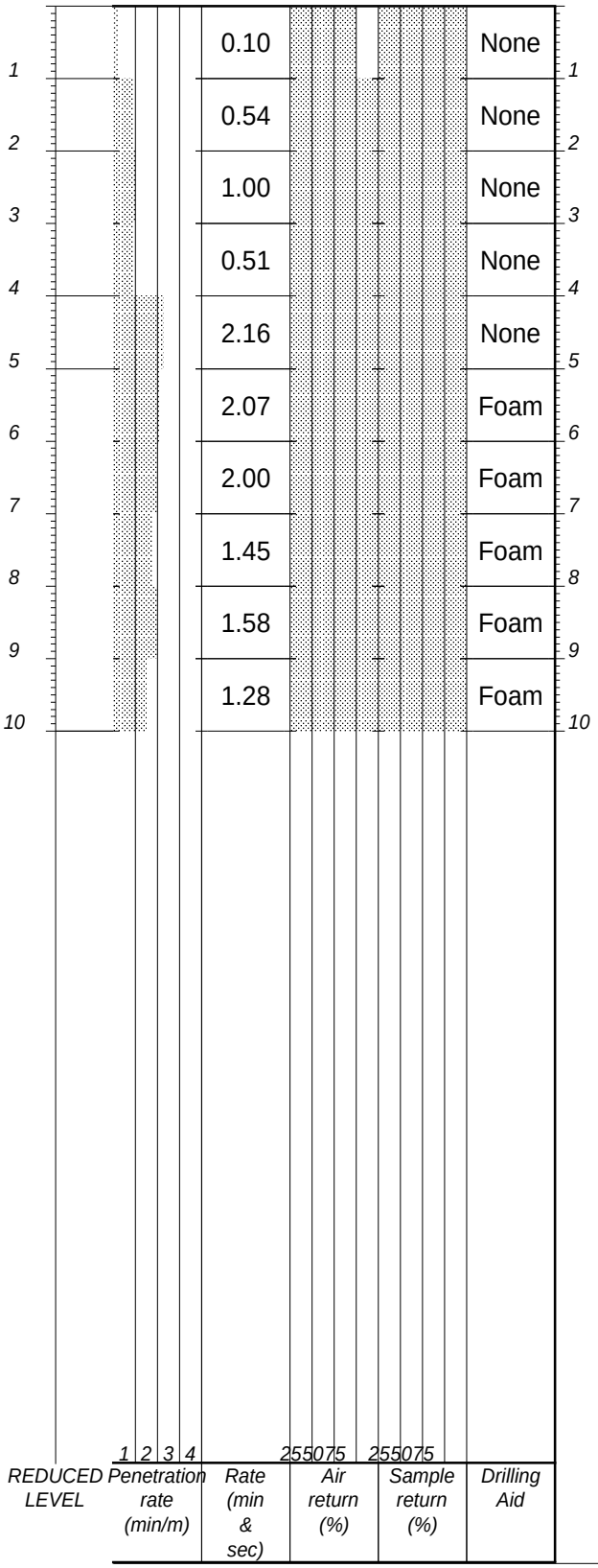
REVISION :
SETUP FILE : BGC_PERC.SET

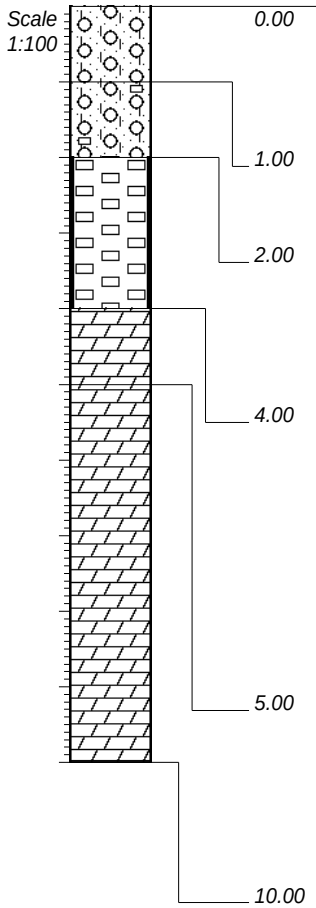
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

TRANSNET
Postmasburg Housing Development

HOLE No: PH2338
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

As above but with minor pink and white speckled black, calcrete.

Black red brown speckled white grey, HARDPAN CALCRETE with traces of gravel and minor brown, silty sand.

Grey brown and grey banded red, moderately weathered, DOLOMITE.
Traces of gravel and calcrete - possibly contaminated with material from above.
Abundant evidence of joint faces.

Light grey and red, slightly weathered, hard rock, DOLOMITE.
Abundant evidence of joint faces.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133260
Y-COORD : -6188

REVISION :
SETUP FILE : BGC_PERC.SET

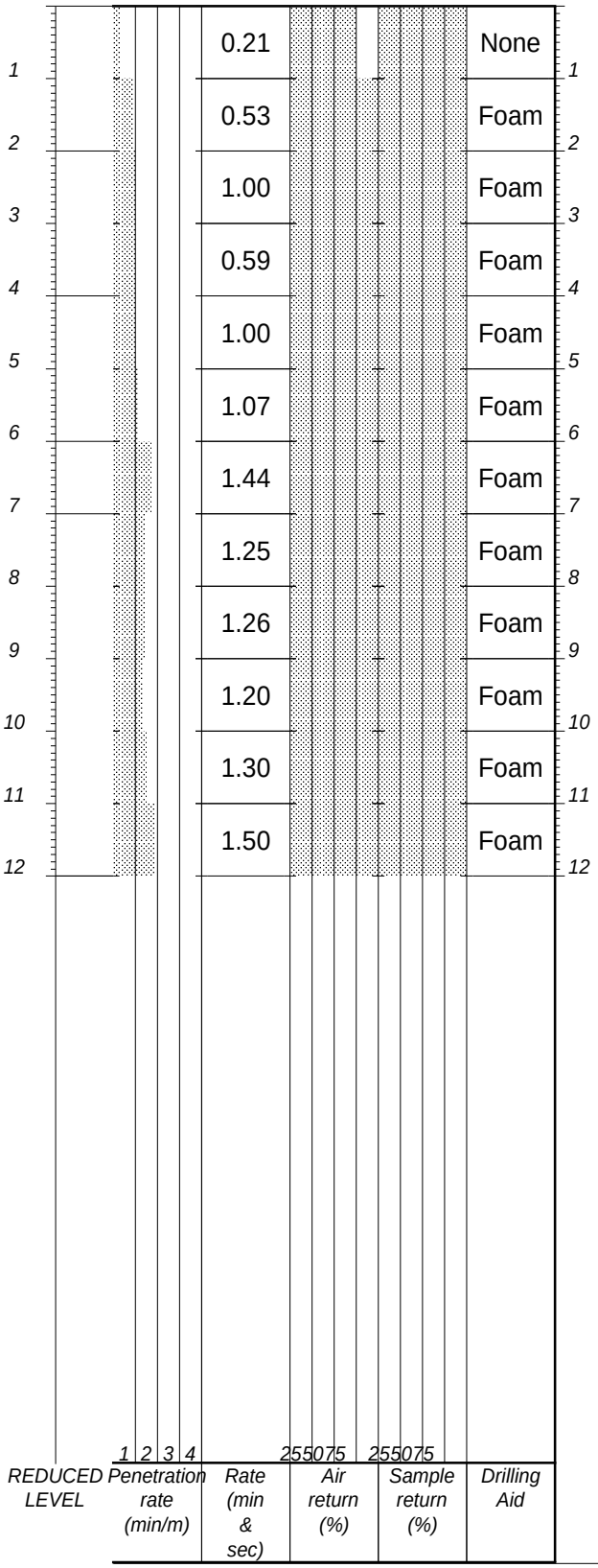
DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

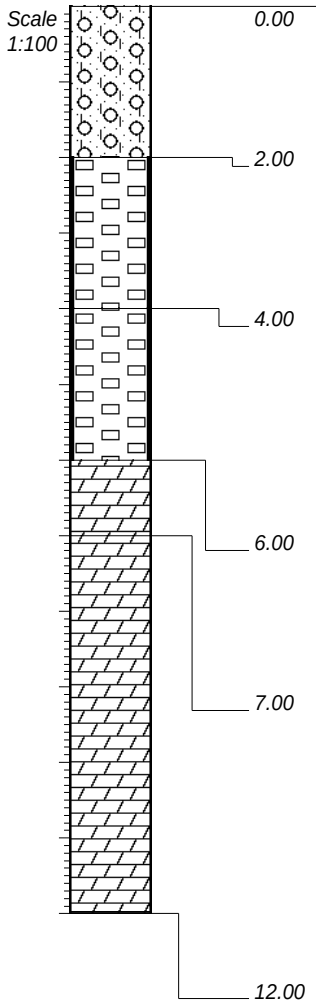
HOLE No: PH2338

TRANSNET
Postmasburg Housing Development

HOLE No: PH2505
Sheet 1 of 1

JOB NUMBER: J13-066





GRAVEL (quartz, chert and banded ironstone) with traces of red brown, silty sand matrix. Transported.

Pink grey and green, HARDPAN CALCRETE with abundant gravel - possibly contaminated with material from above.

Red brown speckled white mottled grey, HARDPAN CALCRETE with abundant gravel and brown silty sand.
Traces of dolomite towards base.

Grey brown and light grey, moderately to highly weathered, DOLOMITE.
Abundant brown, silty sand.

Light grey and red, slightly weathered, hard rock, DOLOMITE.
Abundant evidence of joint faces.
Traces of gravel.
From 7 - 8 m: minor highly weathered dolomite.

End of hole.

NOTES

1) No water strikes noticed.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : DJ ROUX BOORWERKE
MACHINE : 750 cfm 18bar
OPERATOR : Johannes
PROFILED BY : KMZ

INCLINATION :
DIAM : 165 mm
DATE DRILLED : 16/09/2013
DATE PROFILED : 23/09/2013

ELEVATION :
X-COORD : 3133322
Y-COORD : -6242

HOLE No: PH2505

REVISION :
SETUP FILE : BGC_PERC.SET

DATE : 08/10/13 15:37
TEXT : ..C:\PROFILES\PROFIL~1.TXT

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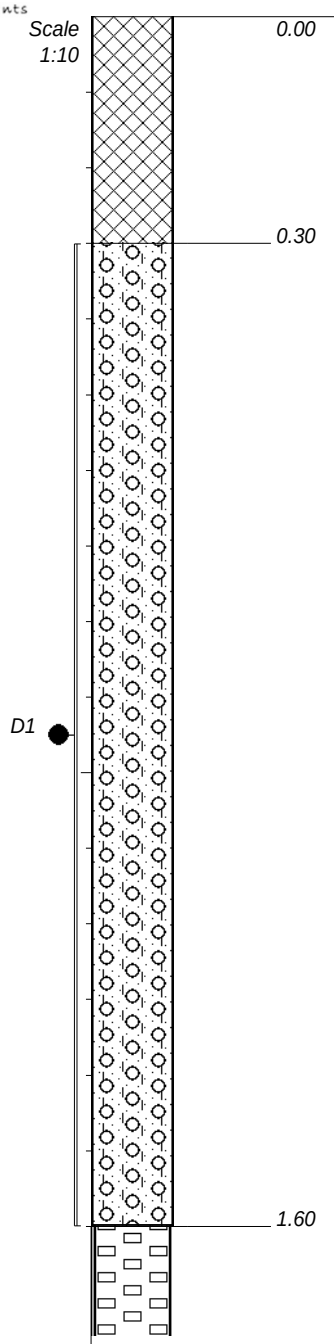
Transnet
Postmasburg Housing Development

HOLE No: TP001
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



FILL - predominantly rounded gravel in a silty sand matrix with builders rubble and general waste.

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Bulk disturbed sample D1 taken from 0.30--1.60 m.

3) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

ELEVATION : 1335 m
X-COORD : 3133234
Y-COORD : -6378

HOLE No: TP001

REVISION :
SETUP FILE : BGC_TP.SET

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

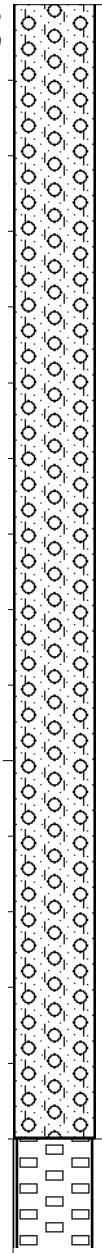
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP002
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense. Roots to 0.2 m.

1.50

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1334 m
X-COORD : 3133106
Y-COORD : -6161

HOLE No: TP002

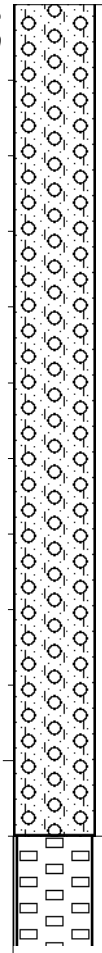
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP003
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.
With scattered boulders of calcrete up to 500 mm in diameter.

1.10

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

ELEVATION : 1324 m
X-COORD : 3133163
Y-COORD : -6153

HOLE No: TP003

REVISION :
SETUP FILE : BGC_TP.SET

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

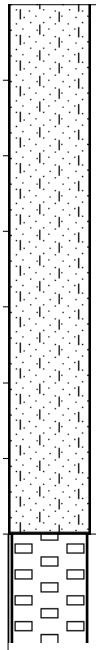
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP004
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00 Slightly moist, reddish brown, loose, intact, silty SAND with minor coarse medium and fine gravel. Hillwash. Roots.

0.70 Refusal on pink mottled white and black, soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1331 m
X-COORD : 3133124
Y-COORD : -6099

HOLE No: TP004

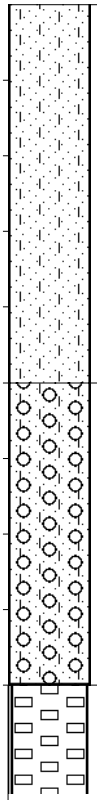
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP005
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00 Slightly moist, reddish brown, loose, intact, silty SANDY with minor coarse medium and fine gravel. Hillwash. Roots.

0.50 Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.
Abundant calcrete boulders at base.

0.90 Refusal on pink mottled white and black, soft rock to medium hard rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1331 m
X-COORD : 3133003
Y-COORD : -5960

HOLE No: TP005

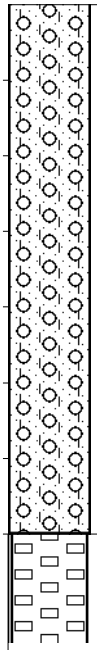
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP006
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is medium dense.

0.70

Refusal on pink mottled white and black, soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1327 m
X-COORD : 3132925
Y-COORD : -5809

HOLE No: TP006

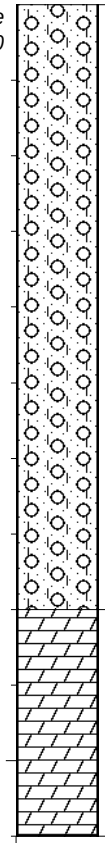
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP007
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

0.80

Grey, slightly to moderately weathered, very closely jointed, medium hard rock to hard rock, DOLOMITE with thin bands of chert.

1.10

Refusal in above.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1329 m
X-COORD : 3132836
Y-COORD : -5651

HOLE No: TP007

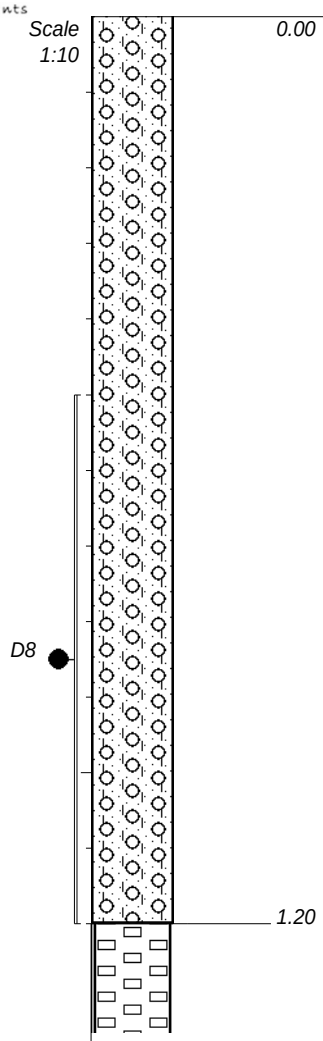
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP008
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is medium dense.
Roots to 0.5 m.

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Bulk disturbed sample D8 taken from 0.50--1.20 m.

3) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1323 m
X-COORD : 3132941
Y-COORD : -5585

HOLE No: TP008

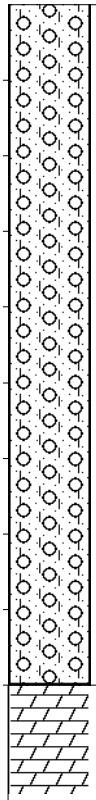
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP009
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

0.90

Refusal on grey, slightly weathered, hard rock, DOLOMITE.
Depth varies from 0.6 - 1.2 m.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1325 m
X-COORD : 3132947
Y-COORD : -5707

HOLE No: TP009

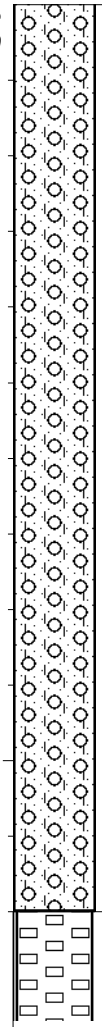
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP010
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is medium dense.
Abundant manganiferrous concretions at base.

1.20

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1326 m
X-COORD : 3133060
Y-COORD : -5764

HOLE No: TP010

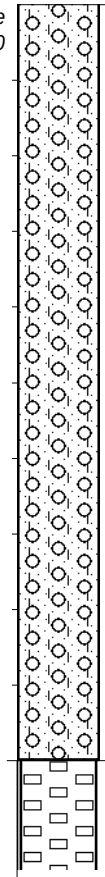
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP011
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.
Abundant manganiferrous concretions at base.

1.00

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1329 m
X-COORD : 3133019
Y-COORD : -5822

HOLE No: TP011

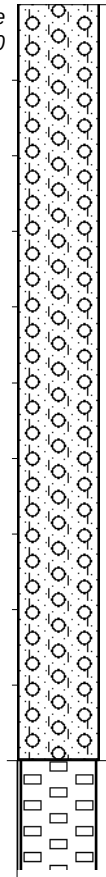
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP012
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

1.00

Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.
Depth varies from 0.8 - 1.2 m.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1322 m
X-COORD : 3133140
Y-COORD : -5872

HOLE No: TP012

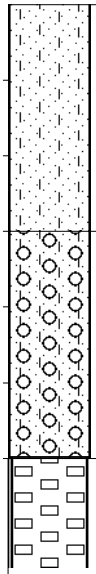
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP013
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00	Slightly moist, reddish brown, loose, intact, silty SAND with minor coarse medium and fine gravel. Hillwash. Roots.
0.30	Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.
0.60	Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete. Depth varies from 0 .8 - 1.2 m.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

ELEVATION : 1325 m
X-COORD : 3133203
Y-COORD : -6004

HOLE No: TP013

REVISION :
SETUP FILE : BGC_TP.SET

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

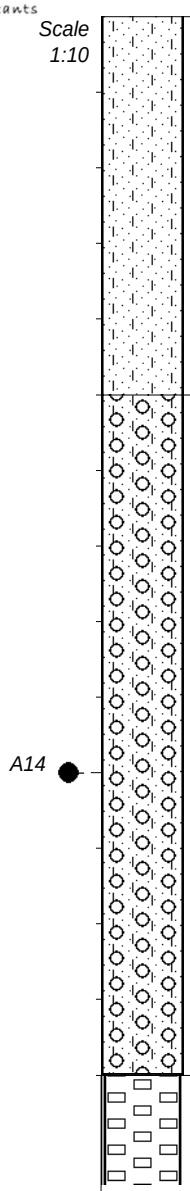
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP014
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00 Slightly moist, reddish brown, loose, intact, silty SAND with minor coarse medium and fine gravel. Hillwash. Roots.

0.50 Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

1.40 Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Disturbed sample A14 taken from 1.00 m.

3) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1328 m
X-COORD : 3133215
Y-COORD : -6097

HOLE No: TP014

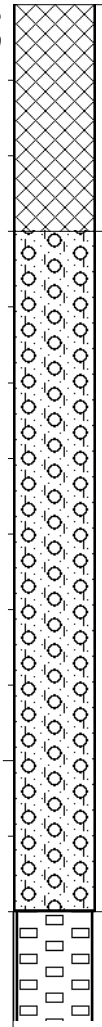
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP015
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00 FILL - ash and gravel.

0.30 Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

1.20 Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1329 m
X-COORD : 3133291
Y-COORD : -6191

HOLE No: TP015

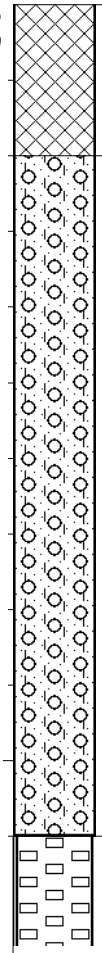
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP016
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00 FILL - gravel and silty sand and general refuse.

0.20 Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

1.10 Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1321 m
X-COORD : 3133279
Y-COORD : -6261

HOLE No: TP016

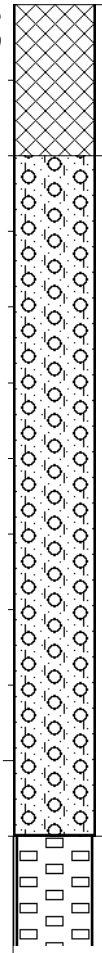
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP017
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00 FILL - gravel and silty sand and general refuse.

0.20 Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

1.10 Refusal on pink mottled white and black, very soft rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1330 m
X-COORD : 3133342
Y-COORD : -6233

HOLE No: TP017

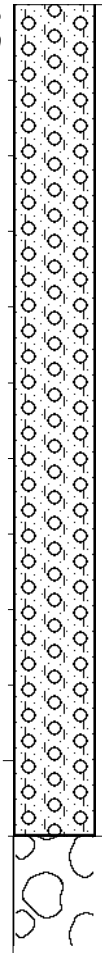
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP018
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.
Large dolomite boulders.

1.10

Refusal on boulders.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB

REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013

DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1321 m
X-COORD : 3133429
Y-COORD : -6226

HOLE No: TP018

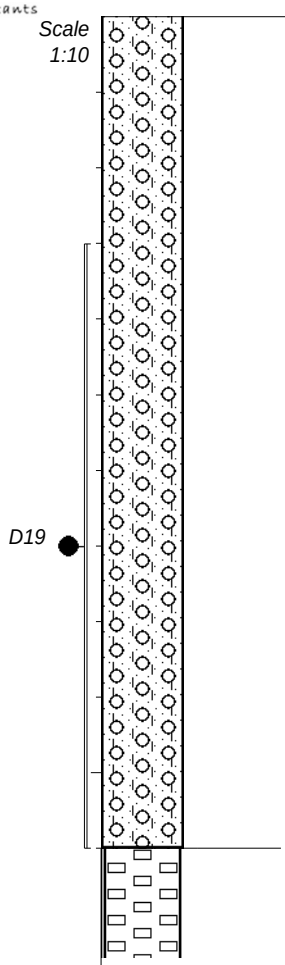
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP019
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

Refusal on pink mottled white and black, soft rock to medium hard rock, CALCRETE with gravel sized fragments of manganocrete.

NOTES

1) No water encountered.

2) Bulk disturbed sample D19 taken from 0.30--1.10 m.

3) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1324 m
X-COORD : 3133471
Y-COORD : -6312

HOLE No: TP019

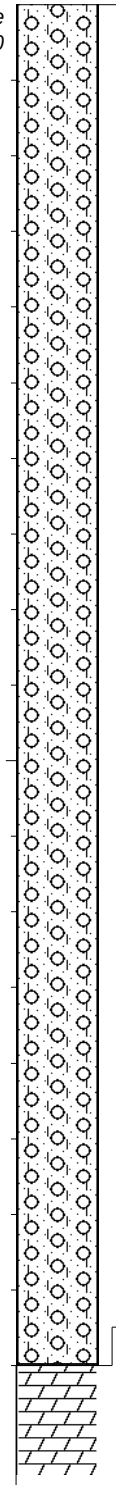
Bear GeoConsultants

Transnet
Postmasburg Housing Development

HOLE No: TP020
Sheet 1 of 1

JOB NUMBER: J13-066

Scale 1:10



0.00

Clast supported, subrounded and subangular, GRAVEL and COBBLES in a matrix of moist, reddish brown, silty sand. Alluvium. Overall consistency is dense.

1.80

Refusal on grey, slightly weathered, hard rock, DOLOMITE.
Depth varies from 0.5 - 3.0 m.

NOTES

1) No water encountered.

2) Coordinates and elevations were recorded using a hand held GPS. Map datum is WGS84 Lo23.

CONTRACTOR : Burma Plant Hire
MACHINE : CAT 422E
OPERATOR : Alfred
PROFILED BY : LRR and TAB
REVISION :
SETUP FILE : BGC_TP.SET

INCLINATION :
DIAM :
DATE DRILLED : 12/09/2013
DATE PROFILED : 12/09/2013
DATE : 18/09/13 11:37
TEXT : ..C:\PROFILES\PROFILES.TXT

ELEVATION : 1328 m
X-COORD : 3133497
Y-COORD : -6383

HOLE No: TP020

APPENDIX B

LABORATORY TEST RESULTS

APPENDIX C

REPORT ON GRAVITY SURVEY

APPENDIX D

METHODOLOGY USED IN ANALYSING DOLOMITIC SITES

Analytical methodology

The method used follows present day standards (Ref.8) but has been adopted to take into account modifications currently being considered by the South African Bureau of Standards (SABS) in the construction of their standards concerning development on dolomitic land. This document is expected to be released by the end of 2011 and consists of four parts. The reference number will be SANS 1936.

The following factors are used to evaluate the degree of hazard associated with sinkhole and subsidence (formally called doline)development:

- The presence of cavities and the depth to them;
- Mobilising agencies, most importantly ingress water from leaking services or ponding of water on surface;
- Potential sinkhole development space;
- Nature of the blanketing layer, including its potential to erode into underlying cavities and it's potential to absorb or reduce the velocity of water flowing vertically through it;
- The depth to the present groundwater level and its position relative to bedrock and overburden; and
- Bedrock morphology. This is largely determined by relating boreholes to the gravity survey contours.

It should be noted that cavities include voids in the dolomite bedrock ***or*** in the overburden, which are capable of receiving overburden. Cavities are assumed to be present within the bedrock or within selected overburden horizons as no reliable geophysical tool exists which allows for their detection. The mobilising agencies considered in this analysis are ingress water, major groundwater level fluctuations (>6m), ground vibrations and gravity.

The potential sinkhole development space, where used, is the maximum size sinkhole that can develop assuming that the agency mobilising the overburden continues to operate unchecked. This is expected to be a conservative estimate. The sinkhole development space is related to the nature of the overburden and the depth of the cavity into which material will flow.

The potential for the overburden material to mobilise is related both to its strength and its permeability. However, low strength, relatively homogenous soils, such as residual intrusive or shale, can significantly enhance the stability of the overburden by acting as aquitards.

While the above describes the factors that must be considered when assessing the impact of ingress water into the soil above dolomitic terrain, other factors must be considered should the groundwater level drop significantly (>6 m) or for that matter rise significantly. The position of the original groundwater level provides a strong indicator as to what will happen should major fluctuations occur. Other factors which will be taken into account should the water table fluctuate dramatically are the presence of porous and compressible material through which the water level will move and the presence of cavities which will be emptied or filled by the fluctuating water table.

Classification of Dolomite Sites for Urban Development

The level of hazard associated with sinkhole development is categorised as being of low, medium or high. ***Table A*** below (Ref.8) gives guidelines, used in conjunction with the factors listed above, which give a reasonable indication of the degree of hazard associated with different profiles. Note especially the comments concerning the depth to the water table and the presence of materials with a low potential for mobilisation in the blanketing layer.

Table A: Guidelines for assessing the potential for mobilisation of the blanketing layer (Inherent Hazard for Sinkholes)

Inherent Hazard	Typical site conditions
Low	The profile displays no voids. No air loss or sample loss is recorded during drilling operations. Either a very shallow water table or a substantial horizon of materials with a low potential susceptibility to mobilisation may be present within the blanketing layer (e.g. continuous intrusive features or shale material). Depth to potential receptacle is typically great and the nature of the blanketing layer is not conducive to mobilisation.
Medium	This type of profile is characterised by an absence of substantial 'protective' horizon and has a blanketing layer of materials potentially susceptible to mobilisation by extraneous mobilisation agents. The water table is below the blanketing layer. Typically chert rich profiles of intermediate to very great thicknesses without voids.
High	The blanketing layer of the high risk profile reflects a great susceptibility to mobilisation. A void may be present and is interpreted to be very likely, within the potential development space, indicating that the process of sinkhole formation has already started. Boreholes may register large cavities, sample loss, air loss, etc. Convincing evidence exists of cavernous subsurface conditions which will act as receptacles. The water table is below the blanketing layer. In a dewatering situation, the lowering of a shallow groundwater level would obviously increase the risk of mobilisation.

Sinkholes are divided into the following class sizes:

Small – <2 m diameter

Medium	–	2 - 5 m diameter
Large	–	5 - 15 m diameter
Very Large	–	>15 m diameter

Table B below (Ref.8) is used to provide an indication of how many incidences of subsidence could be expected in a zone categorised as described in the previous table. It is important to note that these figures are largely derived from developments not effectively and appropriately designed or maintained.

Table B: Subsidence Events Related to Hazard Characterisation

Inherent Hazard	Anticipated events per hectare over time (magnitude of problem)*
LOW	Typically 0 up to and including 0.1 events per hectare anticipated but occurrence of events cannot be excluded. Return Period is greater than 200 years.
MEDIUM	Typically greater than 0.1 and less than and equal to 1.0 events per hectare. Return period is between 200 and 20 years.
HIGH	Typically greater than 1.0 events anticipated per hectare. Return period is less than 20 years.

* that have occurred per hectare in a 20 year period in the "type" areas (statistics based on poor service design and maintenance)

Eight standard Inherent HazardClasses have been defined (Ref.8 and forthcoming SANS standards) and apply to a non-dewatering scenario as shown in ***Table C*** below:

Table C: Description of Hazard Classes

Inherent Hazard Class(IH Class)	Characterisation of area
1	Areas characterised as reflecting a low inherent susceptibility of all sizes of events occurring.
2	Areas characterised as reflecting a medium inherent susceptibility of small-size events occurring.
3	Areas characterised as reflecting a medium inherent susceptibility of medium-size events occurring.
4	Areas characterised as reflecting a medium inherent susceptibility of large-size events occurring.
5	Areas characterised as reflecting a high inherent susceptibility of small-size events occurring.
6	Areas characterised as reflecting a high inherent susceptibility of medium-size events occurring.
7	Areas characterised as reflecting a high inherent susceptibility of large-size events occurring.
8	Areas characterised as reflecting a high inherent susceptibility of very large-size events occurring.

APPENDIX E

GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT
after Partridge, Wood and Brink, 1993

CONSTRAINT		Most Favourable (1)	Intermediate (2)	Least favourable (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750mm in thickness.*	Any collapsible horizon or consecutive horizons with a depth of more than 750mm in thickness.	A least favourable situation for this constraint does not occur.
B	Seepage	Permanent or perched water table more than 1,5m below ground surface	Permanent or perched water table less than 1,5m below ground surface.	Swamps and marshes
C	Active Soil	Low soil-heave potential predicted*	Moderate soil heave potential predicted.	High soil heave potential predicted.
D	Highly compressible soil	Low soil compressibility expected *	Moderate soil compressibility expected	High soil compressibility expected
E	Erodability of soil	Low.	Intermediate	High
F	Difficulty of excavation to 1,5m depth	Scattered or occasional boulders less than 10% of the total volume	Rock or hardpan pedocretes between 10 and 40% of the total volume.	Rock or hardpan pedocretes more than 40% of the total volume.
G	Undermined ground	Undermining at a depth greater than 100m below surface (except where total extraction mining has not occurred).	Old undermined areas to a depth of 100m below surface where stope closure has ceased	Mining within less than 100m of surface or where total extraction mining has taken place.
H	Instability in areas of soluble rock	Possibly unstable	Probably unstable	Known sinkholes and dolines
I	Steep slopes	Between 2 and 6 degrees (all regions)	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape). Slopes between 6 and 12 degrees and less than 2 degrees (all other regions)	More than 18 degrees (Natal and Western Cape) More than 12 degrees (all other regions)
J	Areas of unstable natural slopes	Low risk	Intermediate risk	High risk (especially in areas subject to seismic activity)
K	Areas subject to seismic activity	10% probability of an event less than 100 cm/s^2 within 50 years	Mining-induced seismic activity more than 100 cm/s^2	Natural seismic activity more than 100 cm/s^2
L	Areas subject to flooding	A “most favourable” situation for this constraint does not occur.	Areas adjacent to a known drainage channel or floodplain with slope less than 1%.	Areas within a known drainage channel or floodplain.

*These areas are designated as 1A, 1C, 1D or 1F where localised occurrence of the constraint may arise.

APPENDIX F

RESIDENTIAL SITE CLASS DESIGNATIONS NHBRCHomeBuilding Manual, Revision 1, February 1999

RESIDENTIAL SITE CLASS DESIGNATIONS

TYPICAL FOUNDING MATERIAL	CHARACTER OF FOUNDING MATERIAL	EXPECTED RANGE OF TOTAL SOIL MOVEMENTS (mm)	ASSUMED DIFFERENTIAL MOVEMENT (% OF TOTAL)	SITE CLASS
Rock (excluding mudrocks which may exhibit swelling to some depth)	STABLE	NEGLIGIBLE	-	R
Fine grained soils with moderate to very high plasticity (clays silts and sandy clays)	EXPANSIVE SOILS	<7,5 7,5 - 15 15 - 30 >30	50% 50% 50% 50%	H H1 H2 H3
Silty sand, sands, sandy and gravely soils	COMPRESSIBLE AND POTENTIALLY COLLAPSIBLE SOILS	<5 5 - 10 >10	75% 75% 75%	C C1 C2
Fine grained soils, (clayey silts and clayey sands of low plasticity), sands, sandy and gravely soils	COMPRESSIBLE SOIL	<10 10 - 20 >20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Landslip Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	VARIABLE	VARIABLE		P

Notes :

1. The classifications, C, H, R and S are not intended for dolomitic areas sites unless specific investigations are carried out to access the stability (hazard of sinkholes and doline formation) of the dolomites. Where the hazard is found to be acceptable, the site shall be designated as class P (dolomitic areas).

2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as percentage of the total soil movements are approximately equal to 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the soil movements must be adjusted so that the resultant differential movement implied by the table is equal to that which is expected in the field.

3. In some instances, it may be more appropriate to use a composite description to describe a site more fully, e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement, e.g. a Class R/S1 may be described as a Class S2 site. Alternatively, a further site investigation may be necessary as the final design solution may depend of the location of the building on a particular site.

4. Where it is not possible to provide a single site designation and a composite designation is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions, e.g. H-H1-H2 OR C1-C2.

5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as Class S1 or S2, as relevant and appropriate.

6. Sites containing contaminated soils include those associated with reclaimed mine land, land down of mine tailings and old land fills.

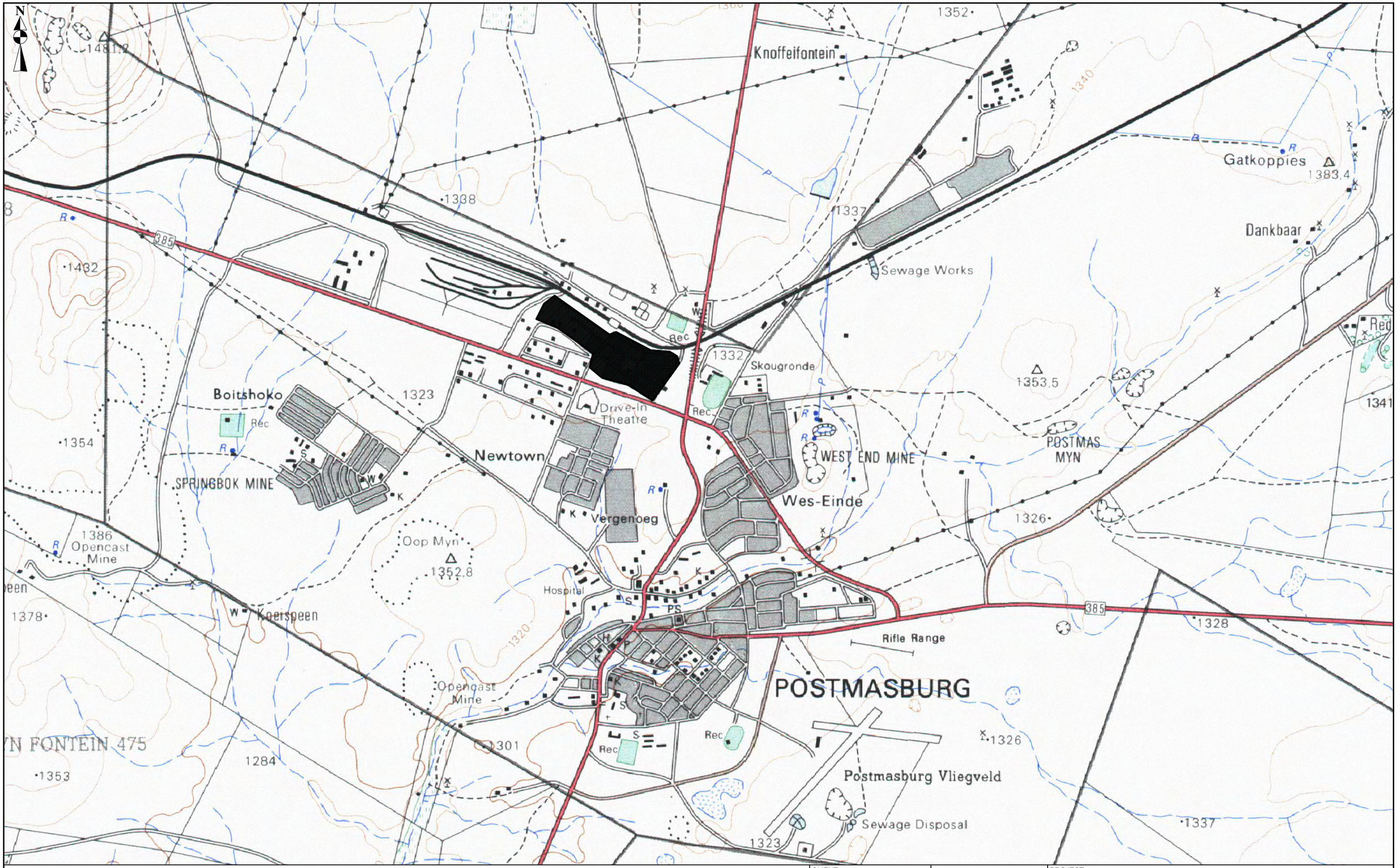
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.

8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix, i.e. P (contaminated soils). Under certain circumstances, composite descriptions may be more appropriate, e.g. P (dolomitic areas) - C1.

9. Certain fills may contain contaminants which present a health risk. The nature of such fills should be evaluated and should be clearly demarcated as such.

APPENDIX G

DRAWINGS



LEGEND

Site

Scale 1:25000

0 0.15 0.3 0.6 0.9 1.2 1.5 km

CLIENT

TRANSNET

Bear GeoConsultants

PROJECT

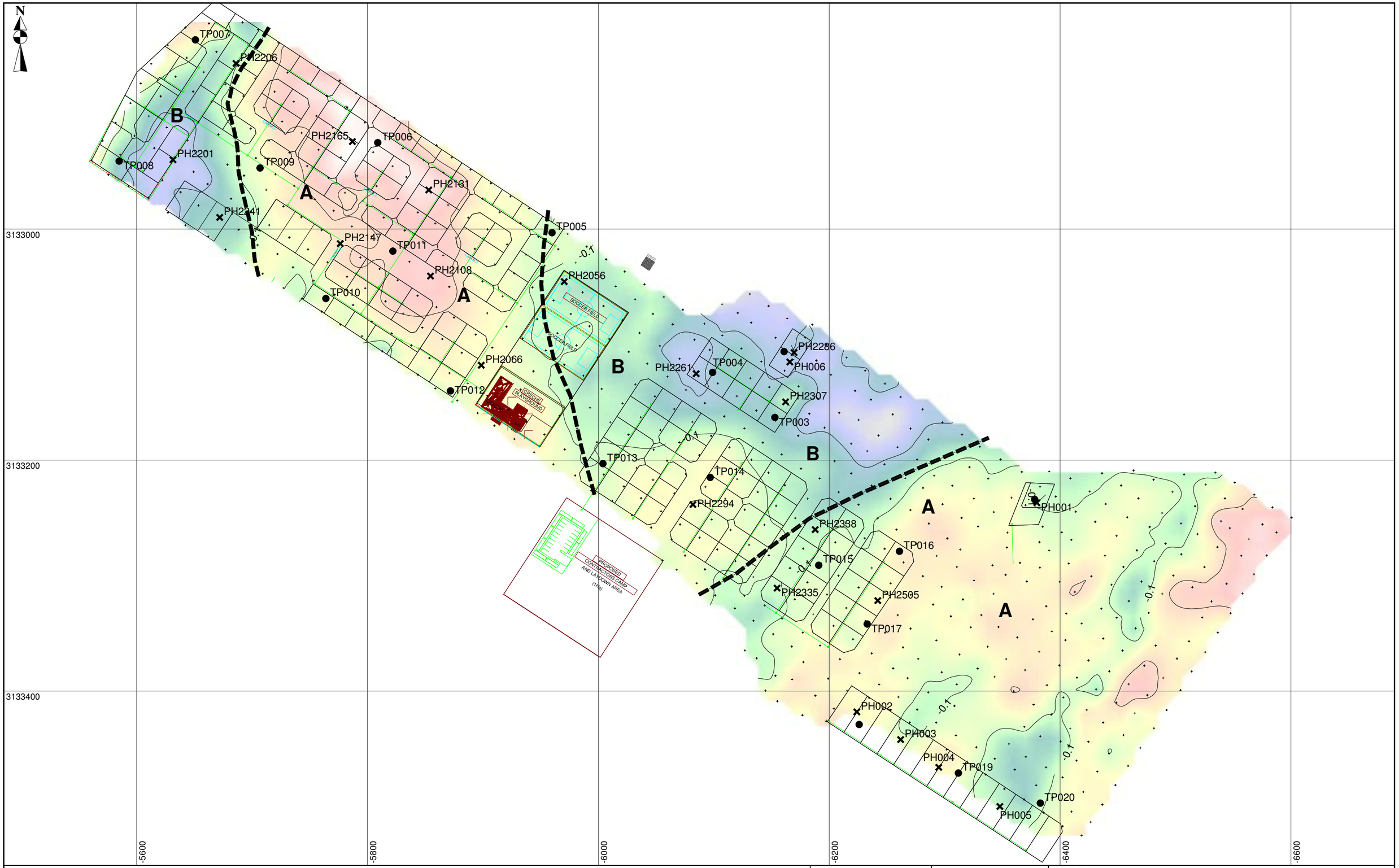
POSTMASBURG HOUSING DEVELOPMENT

GEOTECHNICAL INVESTIGATION

LOCALITY PLAN

DWG No.

J13-066/1



LEGEND

- Stands Investigated
- Test Pits
- Boreholes
- Geotechnical Zone Boundary

Scale 1:3000

0 15 30 60 90 120 150 m

Map Datum: WGS84 Lo23

CLIENT

TRANSNET

Bear GeoConsultants

PROJECT

POSTMASBURG HOUSING DEVELOPMENT

GEOTECHNICAL INVESTIGATION

GEOTECHNICAL PLAN

DWG No.

J13-066/2