REPORT ON THE DOLOMITIC STABILITY INVESTIGATION OF PORTION 7 OF THE FARM RICKALETTA 387 JR AND PORTIONS 16, 64 AND 66 OF THE FARM KNOPJESLAAGTE 385 JR

1. INTRODUCTION

Louis Kruger Geotechnics cc was appointed by Nicholas & Jeanne Rose t/a Rosefield Farms to do an engineering geological investigation on Portions 1, 2 and 7 of the farm Rickaletta 387 JR and Portions 16, 64, 66 and 127 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doorrandje 386 JR. The investigation was undertaken according to the normal requirements for dolomitic stability investigations as defined in Technical guidelines Series No 1, Council for Geosciences, 1995 and the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004. The proposed use of the property is offices and retail. The following aspects are addressed in this report:

- Geology and soil profile
- Geohydrology
- Dolomitic stability

2. AVAILABLE INFORMATION

The following information was available:

- 1 : 50 000 Geological map 2528CC Lyttelton
- Colour aerial photographs, Tshwane Metropolitan Council
- Tshwane Internet Geographical information System
- "Report on the engineering geological investigation on Portions 16 and 18 of the farm Doornrandje 386-JR for Township Establishment", Louis Kruger Geotechnics, October 2006

3. TERMS OF REFERENCE

Louis Kruger Geotechnics cc was appointed by Nicholas & Jeanne Rose t/a Rosefield Farms to do an engineering geological investigation on Portions 1, 2 and 7 of the farm Rickaletta 387 JR and Portions 16, 64, 66 and 127 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doorrandje 386 JR. The investigation showed that granite is present on the southern boundary of Portion 64 of the farm Knopjeslaagte 385 JR and Portion 7 of the farm Rickaletta 387 JR. Since Portions 1 and 2 of the farm Rickaleta 387 JR and Portion 127 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doorrandje 386 JR is situated to the south of the granite-dolomite contact, these portions were not included in the dolomitic stability investigation. These portions will be addressed in the report on the shallow foundation investigation.

The aim of the investigation was to provide the client with an assessment of the dolomitic stability of the site and the implications that the dolomitic stability may have on the proposed development. The appointment included a gravity survey, percussion drilling, report compilation and liaison with The Council for Geosciences.

4. LOCALITY

The part of the proposed site that is underlain by dolomite covers approximately 210 hectares and is situated on Portion 7 of the farm Rickaletta 387 JR and Portions 16, 64 and 66 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doorrandje 386 JR. It is bounded by the Hartebeespoort Dam Road (R511) and undeveloped land in the west, by Gerhardsville Agricultural Holdings in the north, by undeveloped land and the M26 in the east, and by undeveloped land in the south. The locality of the site is shown on Figure 1.

5. PRESENT AND PROPOSED LAND USE

At present the site is undeveloped. The part of the proposed site underlain by dolomite covers approximately 130 hectares. The type of development on the dolomitic part of the site depends on the results of the dolomitic stability investigation.

6. TOPOGRAPHY AND DRAINAGE

The site had not been surveyed at the time of the investigation. The contours on the Tshwane Internet Geographical information System show that the site is relatively flat and slopes at approximately 3% towards the north-east. Surface water drains by means of sheetwash in the same direction. Based on the available information the site is not affected by flood lines.

7. GEOLOGY

The 1 : 50 000 geological map shows that the site is underlain by dolomite of the Transvaal Supergroup and that the dolomite- granite contact is present on the southern part of the site. Several syenite dykes and sills are shown on the geological map as well.

8. METHOD OF INVESTIGATION

The investigation consisted of a gravity survey on a thirty meter grid and the drilling of percussion boreholes.

8.1 Gravity survey

Fieldwork was carried out in mid May when 2310 gravity stations set thirty metres apart were laid out and occupied. Gravity was observed with a Scintrex Autograv whilst station elevations and positions were recorded with Leica GS20 GPS units. Data reduction followed the usual procedures associated with dolomite studies, the field data being reduced to relative Bouguer values using an elevation correction of 0,189 and a theoretical gravity gradient of 0,00065 mGals per metre. A plane was fitted by regression to the Bouguer data set and the calculated slope was taken to be the regional gravity trend. This plane was removed from the Bouguer data to generate a provisional residual gravity data set. On receipt of the drilling results the residual data were adjusted by constant so that the values fitted on average with bedrock depths.

8.2 Percussion drilling

After completion of the gravity survey, twenty-eight 76 mm diameter percussion boreholes were drilled to investigate gravity features.

8.3 Stability assessment

After completion of the drilling, the stability of each individual borehole and the entire site was assessed according to the standard method proposed by The Council for Geosciences (Technical guidelines Series No 1, 1995, amended 2001) and the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004.

9. GENERAL GEOLOGY

The regional geology of the site is shown on Figure 2. The geology of the site correlates well with the regional geology in the sense that the 1 : 50 000 scale geological map shows that the site is underlain by dolomite intersected by syenite sills and dykes. The syenite encountered during the investigation correlates well with the east-west trending syenite shown on the geological map to intersect the centre of the site.

10. GRAVITY RESULTS

The gravity report is attached as Appendix D and the residual gravity is shown on Figure 3. According to the 1:50 000 scale geology map covering the area (2528CC Lyttelton) the Chuniespoort Group-Archaean basement contact lies close to the southern boundary of the site, whilst the site itself is underlain by dolomite intruded by syenite. The east-north-east banding in the geology is reproduced in the residual gravity map, pointing not unexpectedly to a link between geology and the weathering pattern or bedrock depth. Drilling indicated that a gradient separating a high along the southern boundary of the site from an adjacent low probably marks the dolomite-granite contact and additionally demonstrated that residual gravity values do largely reflect bedrock depths. Gravity anomalies are also related to the occurrence of syenite, for example the narrow rectilinear low explored by boreholes 1656, 2760 and 3562 marks a thick intrusion whilst immediately to the north of the low on a gravity high syenite is absent and dolomite rock is shallow. It is also notable that the occurrence of syenite increases towards the east, along with the complexity of the gravity pattern.

11. PERCUSSION BOREHOLE RESULTS

The percussion borehole profiles are attached as Appendix A and the driller's logs are attached as Appendix B. The borehole positions are shown on Figure 3. The percussion borehole results are summarized in the following table:

BH	COLLUVIUM	DOLOMITIC RESIDUUM	RESIDUAL SYENITE	DOLOMITIC RESIDUUM	DOLOMITE	RESIDUAL SYENITE	SYENITE	SLATE	GRANITE
1656			0-28				28-34		
1662		0-3			3-10				
1950		0-11	11-23	23-41	41-48				
2135		0-21			21-27				
2531	0-2								2-44
2544		0-21			21-27				
2625	0-1								1-9
2760	0-1		1-17				17-23		
2955		0-11			16-22			11-16	
3041	0-1	1-7			7-13				
3367					0-10				
3562	0-1		1-16				16-22		
3640	0-1	1-15	15-27	27-36	36-42				

BH	COLLUVIUM	DOLOMITIC RESIDUUM	RESIDUAL SYENITE	DOLOMITIC RESIDUUM	DOLOMITE	RESIDUAL SYENITE	SYENITE	SLATE	GRANITE
3749	0-1	1-9			9-15				
3858	0-1		1-8	8-17	17-23				
4538			0-17	17-23	23-29				
4746	0-1		1-5	5-11	11-17				
4864	0-1	1-3	3-9	9-12	12-18				
4954			0-5	5-26	26-32				
5570		0-9			9-15				
5642	0-1	1-9	9-16	16-29		29-33	33-39		
5657		0-5	5-20	20-24	24-30				
5849	0-1	1-13	13-27		27-32				
5935									0-15
6065	0-1	9-13			13-22			1-9	
6549			0-16				16-22		
6965	0-1		1-15		23-29			15-23	
7061	0-1	1-3			3-10				

- Deep dolomite bedrock was encountered in the gravity low on the south-western part of the site.

- Shallow dolomite bedrock was encountered over most of the site.

- Syenite bedrock was encountered was encountered in four boreholes on the east-west striking gravity high on the northern part of the site and in three boreholes on south-eastern part of the site. These features correspond well with the syenite shown on the 1 : 50 000 scale geological map.

- Residual syenite, covering dolomitic residuum was present in several boreholes. In the centre of the site the residual material is however thin with an average thickness of 6 meters.

- Granite was encountered in three boreholes on the southern part of the site. This corresponds well with the granite-dolomite contact shown on the 1 : 50 000 scale geological map.

12. <u>ENGINEERING GEOLOGICAL ZONING</u>

The site was divided into seven engineering geological zones:

- Engineering Geological Zone 1: Dolomitic residuum (wad and chert) underlain by dolomite bedrock or residual syenite at less than 15 meters below surface.

- Engineering Geological Zone 2: Dolomitic residuum (wad and chert) underlain by deep dolomite bedrock.

- Engineering Geological Zone 3: Residual syenite underlain by dolomitic residuum (wad and chert) at depths exceeding 15 meters below surface.

- Engineering Geological Zone 4: Residual syenite underlain by dolomitic residuum (wad and chert) at depths less than 15 meters below surface.

- Engineering Geological Zone 5: Residual syenite underlain by syenite bedrock.

- Engineering Geological Zone 6: Granite

- Engineering Geological Zone 7: Carbonaceous shale (slate) underlain by dolomitic residuum and dolomite bedrock.

The zoning is shown on Figure 4 and the generalized profile for the different zones is summarized in the following table:

ZONE	GENERAL PROFILE
1	0-1 m: Transported 1-8 m: Dolomitic residuum + 8 m: Dolomite/syenite
2	0-21 m: Dolomitic residuum +21 m: Dolomite
3	0-1 m: Transported 1-16 m: Residual syenite 16-23 m: Dolomitic residuum +23 m: Dolomite
4	0-1 m: Transported 1-6 m: Residual syenite 6-18 m: Dolomitic residuum +18 m: Dolomite
5	0-1 m: Transported 1-19 m: Residual syenite +19 m: Syenite
6	0-22 m: Residual granite and granite
7	0-1 m: Transported 1-9 m: Carbonaceous shale 9-13 m: Dolomitic residuum +13 m: Dolomite

13. GEOHYDROLOGY

The water rest levels are shown in the following table:

BH	WATER LEVEL (meters below surface)
1656	24.1
1662	Dry
1950	23.52
2135	Dry
2531	14.5
2544	Dry
2625	4.9
2760	Dry
2955	18.4
3041	12.6
3367	Dry
3562	Dry
3640	16.5
3749	14.5
3858	19.8
4538	6.8

BH	WATER LEVEL (meters below surface)
4746	7.9
4864	Dry
4954	Dry
5570	Dry
5642	9.6
5657	7
5849	10.5
5935	Dry
6065	Dry
6549	13
6965	9.2
7061	Dry

In the boreholes where syenite is absent, the ground water level is clearly situated within the dolomite bedrock. In the boreholes where residual syenite and syenite was encountered, the water level is situated above- or within the syenite, possibly reflecting a perched water table.

14. DOLOMITIC STABILITY ANALYSES

The dolomitic stability of the site was evaluated according to the standard method proposed by the Council for Geosciences (Technical guidelines Series No 1, 1995).

The parameters assessed to evaluate the stability were the following:

- Receptacles
- Mobilization media
- The characteristics of the blanketing layer
- The mobilization potential of the blanketing layer
- The potential development space

14.1 Receptacles

Although limited air losses occurred during the drilling, it is assumed that cavities and disseminated receptacles, large enough to accommodate all the mobilized material can be expected in the dolomite bedrock and the blanketing layer.

14.2 Mobilization media

Since the results of the investigation shows that the ground water level in is situated within the dolomite bedrock, only surface water ingress was considered as mobilization media.

14.3 Blanketing layer

14.3.1 Engineering Geological Zone 1

The blanketing layer consists of dolomitic residuum (wad and chert) underlain by residual syenite or dolomite bedrock at depths shallower than 15 meters below surface.

14.3.2 Engineering Geological Zone 2

The blanketing layer consists of dolomitic residuum (wad and chert) underlain by bedrock at depths exceeding 20 meters below surface.

14.3.3 Engineering Geological Zone 3

The blanketing layer consists of residual syenite underlain by dolomitic residuum (wad and chert). The average thickness of the residual syenite is 16 meters. Dolomite bedrock is present at an average depth of 23 meters below surface.

14.3.4 Engineering Geological Zone 4

The blanketing layer consists of residual syenite underlain by dolomitic residuum (wad and chert). The average thickness of the residual syenite is 6 meters and the thickness varies between five meters and eight meters. Dolomite bedrock is present at an average depth of 16 meters below surface.

14.3.5 Engineering Geological Zone 5

The blanketing layer consists of residual syenite underlain by syenite or dolomite bedrock. The average thickness of the residual syenite is 16 meters and syenite bedrock was encountered in all the boreholes

14.3.6 Engineering Geological Zone 6

Granite was encountered in this zone, no dolomite is present.

14.3.7 Engineering Geological Zone 7

The blanketing layer consists of carbonaceous shale (slate) underlain by dolomitic residuum and dolomite bedrock.

14.4 Mobilization potential

14.4.1 Engineering Geological Zone 1

Due to the presence of shallow dolomitic residuum and the presence of wad in the blanketing layer, the risk for mobilization of the material in the blanketing layer is considered to be High.

14.4.2 Engineering Geological Zone 2

Due to the presence of thick dolomitic residuum and the presence of wad in the blanketing layer, the risk for mobilization of the material in the blanketing layer is considered to be Medium to High

14.4.3 Engineering Geological Zone 3

The blanketing layer consists of residual syenite with an average thickness of sixteen meters underlain by dolomitic residuum and dolomite bedrock. Due to the thickness of the syenite, the risk for mobilization of the material in the blanketing layer is considered to be Low.

14.4.4 Engineering Geological Zone 4

Although residual syenite covers the dolomitic residuum it is localized and thin. Due to the presence of dolomitic residuum below the residual syenite and the presence of wad in the blanketing layer, the risk for mobilization of the material in the blanketing layer is considered to be Medium to High.

14.4.5 Engineering Geological Zone 5

The blanketing layer consists of residual syenite with an average thickness of thirteen meters underlain by syenite bedrock. The risk for mobilization of the material in the blanketing layer is considered to be Low

14.4.6 Engineering Geological Zone 6

The risk for mobilization of the material in the blanketing layer is considered to be Low due to the absence of dolomite.

14.4.7 Engineering Geological Zone 7

The blanketing layer consists of shale (slate) with an average thickness of ten meters underlain by dolomite bedrock. The risk for mobilization of the material in the blanketing layer is considered to be Low.

14.5 Potential development space

The potential development space was calculated by application of the standard method and by using the angles of draw mentioned by Buttrick and Van Schalkwyk (1995).

- The average depth to bedrock in Engineering Geological Zone 1 is 8 meters, therefore the potential development space in this zone is considered to be small.
- The depth to bedrock in Engineering Geological Zone 2 is in the order of 21 meters, therefore the potential development space in this zone is considered to be medium to large.
- The average depth to bedrock in Engineering Geological Zone 4 is 16 meters, therefore the potential development space in this zone is considered to be small.
- The potential development space is not relevant in Engineering Geological Zone 3, 5, 6 and 7.

14.6 Risk assessment for sinkholes

According to Buttrick et al (2002) and the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004, the risk assessment is as follows:

- Engineering geological zone 1: High risk for a small sinkhole.
- Engineering geological zone 2: High risk for a medium to large sinkhole.
- Engineering geological zone 3: Low risk for sinkhole formation.
- Engineering geological zone 4: Medium to High risk for a small sinkhole.
- Engineering geological zone 5: Low risk for sinkhole formation.
- Engineering geological zone 6: Low risk for sinkhole formation.
- Engineering geological zone 6: Low risk for sinkhole formation.

14.7 Risk assessment for doline formation

Since the ground level is situated within the dolomite bedrock, the risk for doline formation is considered to be low.

14.8 Classification

According to Buttrick et al (2002) and The Approach to Residential Development on Dolomite, Council for Geosciences, October 2004, Engineering Geological Zones 1 and 4 are classified as Stability Class 3(b), Engineering Geological Zone 2 is zoned as Stability Class 6(7) and Engineering Geological Zone 3, 5 and 7 is classified as Stability Class 2 and Engineering Geological Zone 6 is classified as stability Class 1. The zoning is shown on Figure 5.

15. CRITICAL FACTORS

The following critical factors were identified:

- The results of the investigations show that most of the site is zoned as stability class 3(b).
- Although stability class 2 conditions are present on the north eastern, eastern and southern parts of the site, the density of information is not sufficient to delineate these zones accurately. These zones are therefore included in Stability Class 3(b).
- The positions of the proposed structures are not known, and the conditions below the proposed structures are expected to vary considerably.

16. <u>CONCLUSIONS AND RECOMMENDATIONS</u>

The dolomitic stability assessment, the zoning of the site, critical factors and recommendations were discussed with Me N Trollip and Mr I.S Venter of The Council for Geosciences and he provisionally agreed with the findings of the report. *It is important to note that the recommendations are based on percussion borehole results and the interpolation of information. It is therefore possible that variations from the expected conditions can occur.*

Based on the results of the investigation and the discussions with The Council for Geosciences, the site is considered suitable for development, ***subject to the following:***

- No residential development is recommended in Engineering Geological Zone 2 (Stability Zone 6(7)). Special types of commercial or light industrial (dry) development only (e.g. Storage facilities, all surfaces must be sealed) can however be considered. Suitable for parkland.

- The dolomite – granite contact should be defined more accurately. Me N Trollip and Mr I.S Venter of The Council for Geosciences agreed that this investigation can be done as part of the shallow foundation investigation.

- The part of the site underlain by granite (Engineering Geological Zone 6) is considered suitable for high density development subject to the delineation of the dolomite-granite contact.

- The parts of the site underlain by syenite and shale (Engineering Geological Zones 5 and 7) are considered suitable for high density development subject to the verification of the thickness of these materials and subject to the accurate delineation of the boundaries of these zones.

- The remainder of the site is considered suitable for the following types of development:

    - Residential development with a maximum density of 10 units per hectare. According to the Approach to Residential Development on Dolomite, Council for Geosciences (October 2004) the maximum number of stands per representative borehole is two stands. Since the density of boreholes that was drilled during the current investigation is low, this type of development will result in an extensive drilling program.

    - Residential development consisting of large stands (e.g. 1 hectare stands or larger). According to the Approach to Residential Development on Dolomite, Council for Geosciences (October 2004) this type of development is subject to identification of a suitable footprint with a Risk Class of 4 or better or Risk Class 5(3).

- Due to the risk for sinkhole formation and the variability of the founding conditions the structures should be placed on an earth mattress and an impermeable layer should be included in the mattress to prevent the ingress of water. The parts of the site underlain by syenite can be delineated more accurately during the construction investigation; appropriate founding measures can be formulated after inspection of the trenches.

- **French drains are *unacceptable***. Although it is accepted that no waterborne sewerage is available on or near the site, french drains or septic tanks are not acceptable. It is recommended that sealed water purification units and tanks be installed from where purified water can be sprayed/irrigated evenly over an area of at least 1 000 m2 per stand.

- The developer should take note of the risk if water is at anytime allowed to penetrate the soil profile. Exceptionally stringent water precautionary measures should be implemented.

- The final layout, showing stand sizes and densities, should be submitted to the Council for Geosciences before the final approval of the development.

- If ownership, the layout, density and/or land use change, the influence of the dolomitic stability on the development should be re-assessed and all the relevant documentation has to be resubmitted to the Council for Geosciences for comment.

- The local council must have strict monitoring and control over the ground water table.

- The percussion boreholes should be protected during construction. If the construction includes excavations, it vital that the boreholes be sealed at the final level of excavation since it could act as points of water ingress resulting in instability.

- All the precautionary measures listed in Appendix C should be strictly adhered to. **It is recommended that the water precautionary measures are implemented across the entire site.**

- A construction report for the development must be compiled to ensure that adverse conditions are identified and re-evaluated timeously. If the construction of the structures is phased, individual construction reports for individual structures should be compiled and once the development is complete, a construction report for the entire development should be compiled.

- Water features, water bearing canals and swimming pools should not be allowed, unless structure specific investigations are done.

- A *specific* Risk Management Strategy must be drawn up for the development and managed by the developer or owner of the development (whichever is applicable) on behalf of the local authority. Doline and sinkhole formation can be minimized by establishing a **Dolomite Risk Management Plan**[1] for the development and adhering to the recommendations at all times. As a crucial part of the Risk Management Plan, attention must be given to;

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a. [1]A comprehensive strategy to be implemented by a responsible group, who have a direct interest in the sustainability of a specific development which addresses all aspects of good governance on dolomitic land (stormwater management, pro-active maintenance, monitoring, emergency reaction planning, comprehensive database, vigilance etc.)

- the surface drainage for the entire development i.e. **Stormwater management Plan**[2], the plan must also be integrated with a **Regional Stormwater Management Plan** which pertains to the area outside the boundaries of the site.

- as well as monitoring and maintenance of all wet services i.e. **Wet Services Plan**[3].

The risk management system must be endorsed by the CGS. The system must report on the location of drilled boreholes as potential problematic points.

L.J Kruger Pr. Sci. Nat.

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b. [2]A formalized plan whereby consideration is given to the flow direction and volume of stormwater, and the capacity of the storm water system so that all surface water can drain off the structures, off the property and directly into the regional stormwater system.

c. [3]A formalized plan whereby all wet services (mains and stand specific) can be monitored (i.e. must know where they are located, what piping was utilized) according the priority areas assigned by the consultant and maintained (replaced if punctured or old).

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AND
PORTIONS 16, 64 AND 66
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THE FARM KNOPJESLAAGTE 385 JR
FOR
TOWNSHIP ESTABLISHMENT

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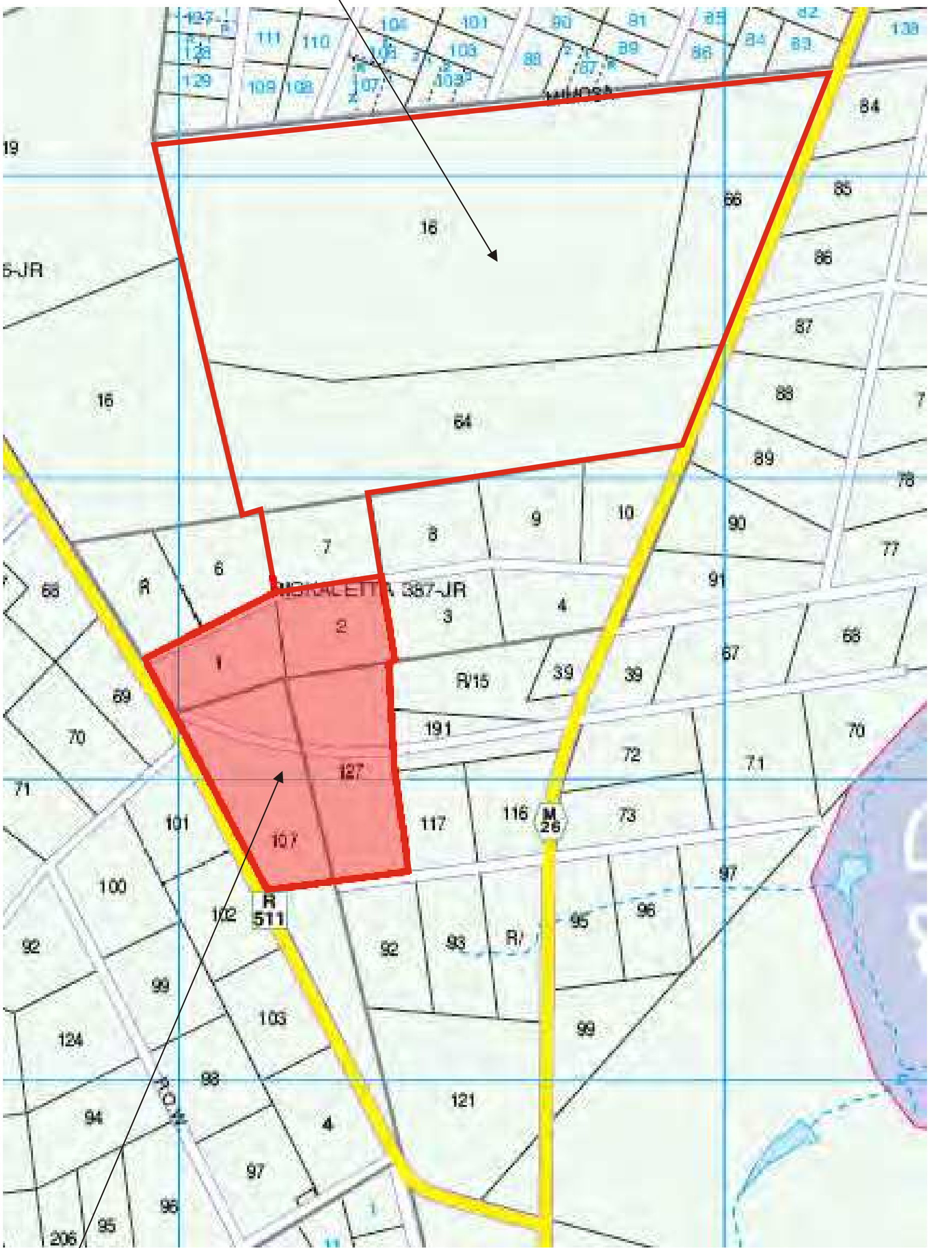
SEPTEMBER 2007

Client

NICHOLAS & JEANNE ROSE T/A ROSEFIELD FARMS

The part of the site underlain by dolomite

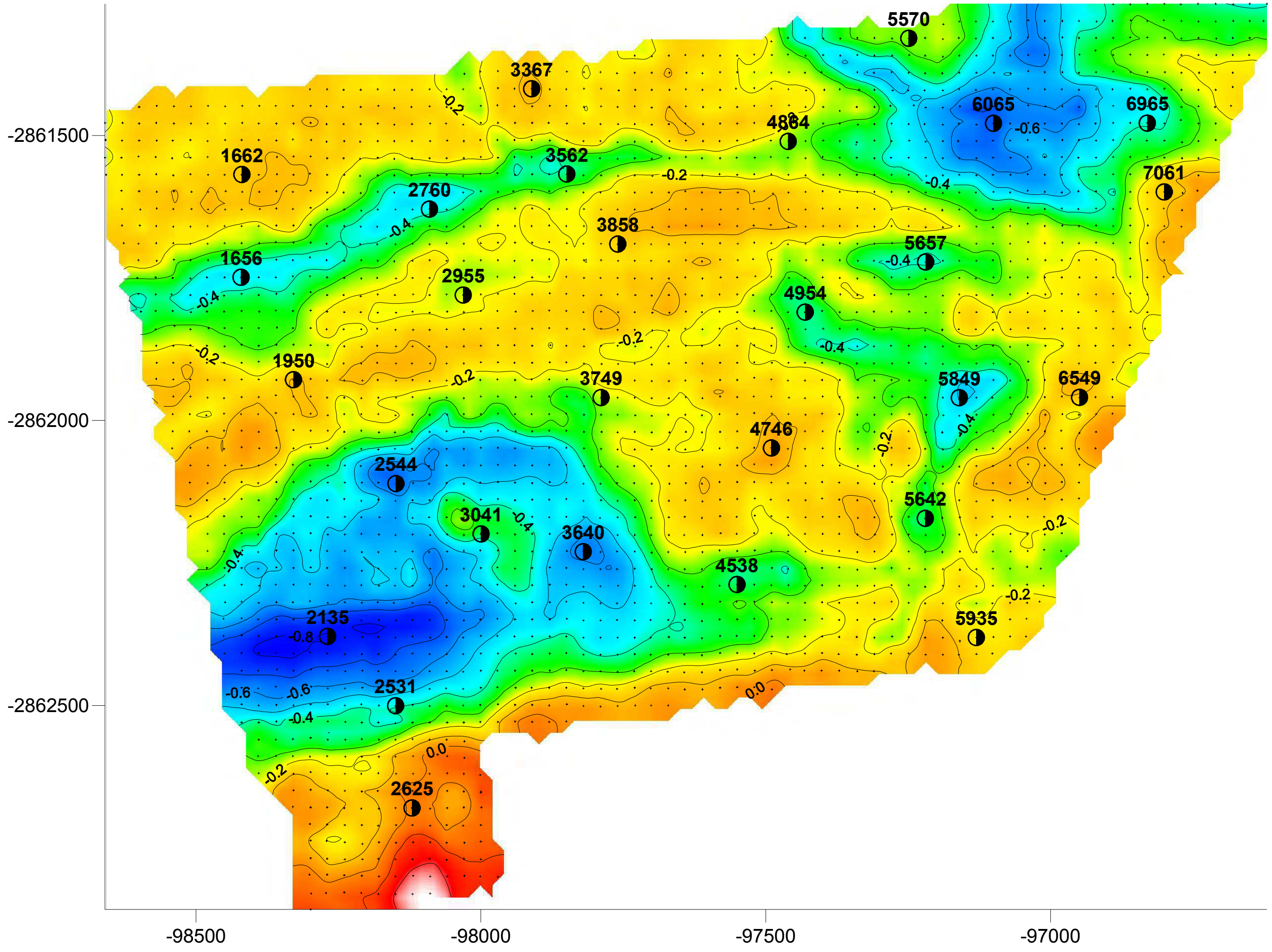


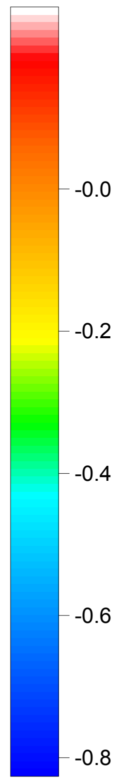
Part of the site excluded from the dolomitic stability investigation due to the presence of granite

LOCALITY	FIGURE 1 NTS

Prepared for Geotechnics

by E&EGS cc September 2007



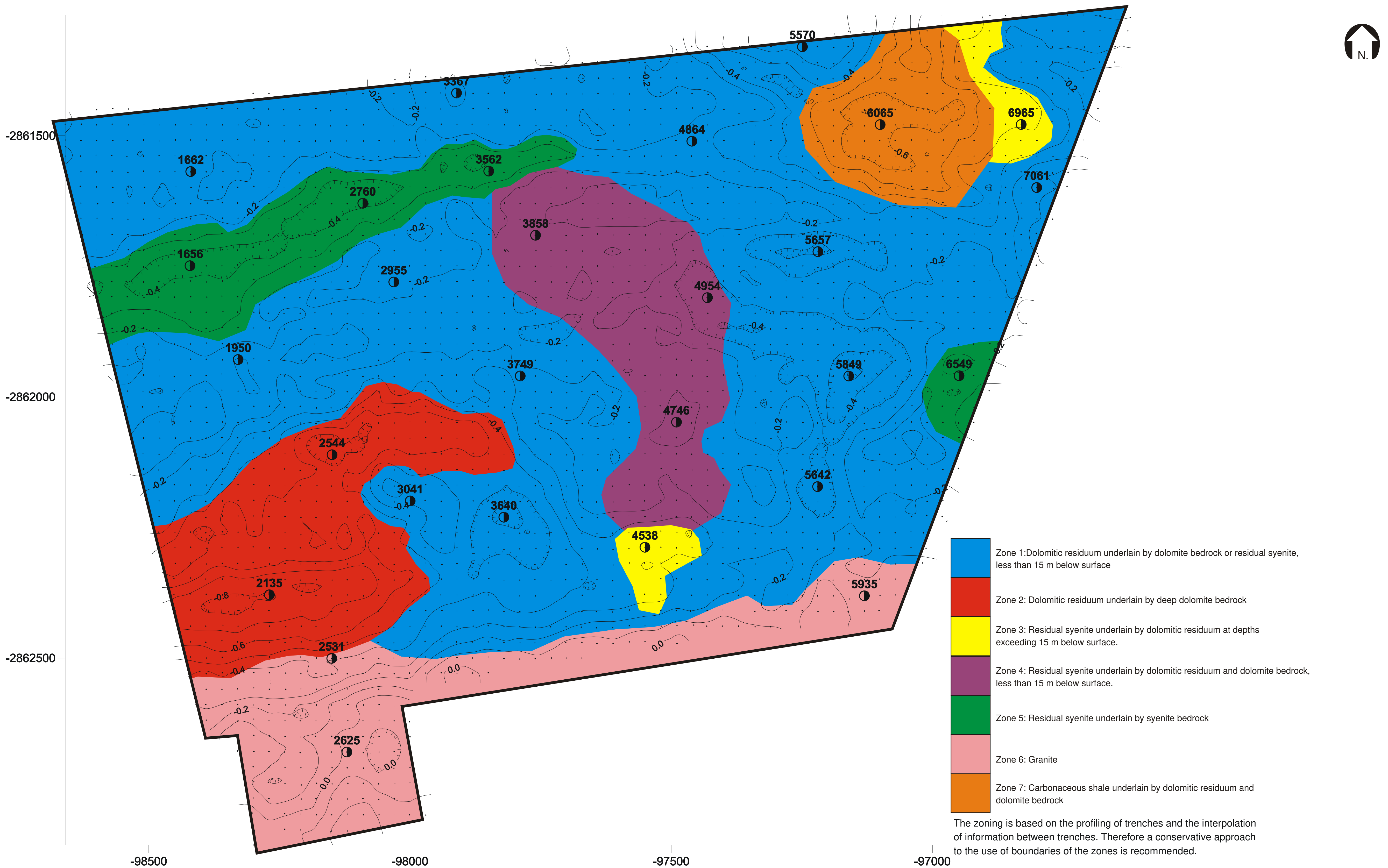


Contour interval 0,1 mGals

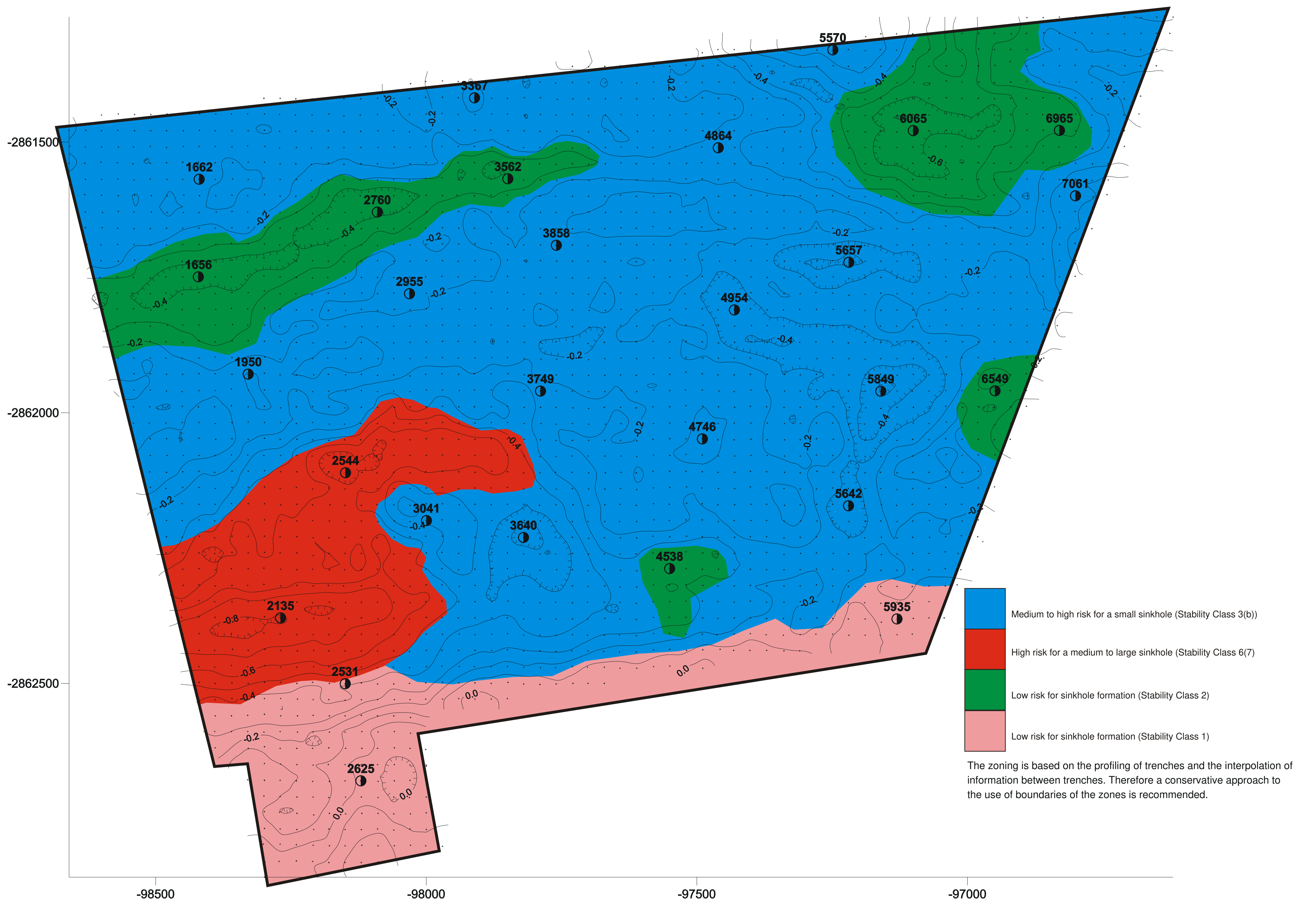
Borehole ◐

-WG29

Figure 3: Residual gravity



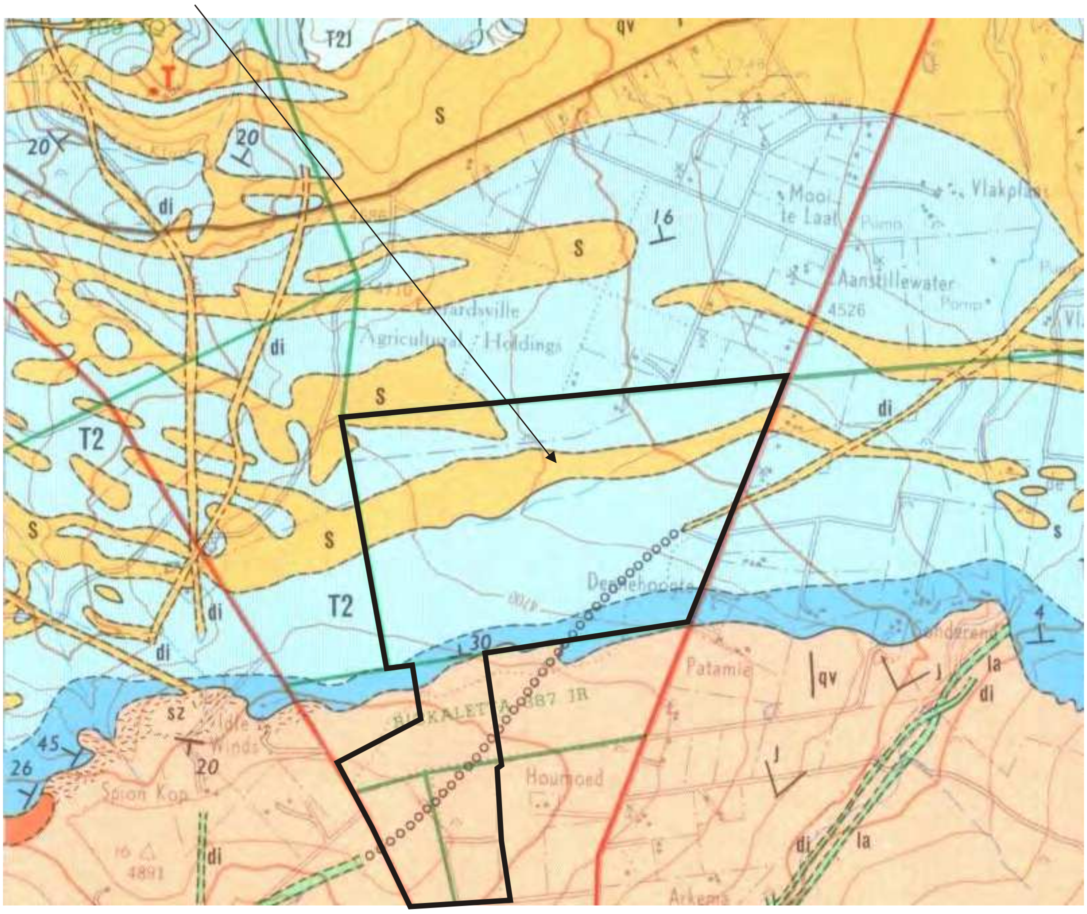
ENGINEERING GEOLOGICAL ZONING	SCALE 1 : 7 500	FIGURE 4



DOLOMITIC STABILITY ZONING	SCALE 1 : 7 500	FIGURE 5

N.

THE SITE



From the 1 : 50 000 Geological Series 2528 CC Lyttelton (Council for Geoscience)

Chert, chert breccia, chert rubble

Dolomite locally with shale band near base

Syenite

REGIONAL GEOLOGY

FIGURE 2

NTS