

**PROJECT: GFSH-2: CONSTRUCTION
COMPLETION REPORT:
IRENE EXTENSION 70 (CENTURY MANOR)**

VGI4063CR

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(CENTURY MANOR)**

SUMMARY

This report presents the results and observations of GFSH-2 Phase 2 geotechnical investigations (Construction Completion), undertaken for Irene Extension 70, also known at Century Manor.

VGIconsult is appointed by M&T Development to carry out the GFSH-2 Phase 2 geotechnical investigations and monitoring programme executed during the design of the township and installation of services. This process has involved ongoing liaison with M&T Development, civil engineers working on site and the Council for Geoscience on various matters, including:

- a) Geotechnical related issues.
- b) Interacting with the town planners, civil engineers and the developer concerning appropriate planning, design of infrastructure, etc.
- c) Establishing profiling procedures to ensure optimal utilisation of trenches for profiling purposes;
- d) Observing and recording soil profiles in exposed trenches wherever soil type changes are observed;
- e) Co-ordinating activities associated with the profiling procedures;
- f) Inspecting service trenches to verify the Phase 1 stability, soil zonation and to check for palaeo-karst structures;
- g) Undertaking supplementary Geotechnical Site Investigations where required;
- h) Recording representative soil profiles in the trenches.
- i) Compiling a Completion Report.

These GFSH-2, Phase 3 investigations have involved the following:

- ❑ Confirmation of the dolomite stability characterisation as contained in Intraconsult report IR523F and VGIconsult report VGI4063.
- ❑ Confirmation of the suitability of the proposed land usage type and density.
- ❑ Recommendations regarding the four proposed Residential 2 stands.
- ❑ Recommendations for foundation solutions.
- ❑ Proposition of appropriate precautionary measures.
- ❑ Presentation of the results of trench inspection and recommendations based thereon.
- ❑ Presentation of a Dolomite Risk Management Strategy.

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SUMMARY

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1. INTRODUCTION

This report presents the results and observations of GFSH-2 standard, Phase 2 investigations and monitoring programme undertaken on the township of Irene Extension 70 (also known as Century Manor).

This report documents, the terms of reference, location and description of the site, data used, geotechnical conditions reported on site during the GFSH-2, Phase 1 investigation and recommendations in order to develop this site in such a manner that an acceptable Development Risk is established and can be maintained in perpetuity. Dolomite Risk Management is a key element in maintaining an acceptable Development Risk. A site specific Risk Management Strategy is developed and presented.

2. TERMS OF REFERENCE

The terms of reference and scope of the work to be undertaken were discussed with Mr P.W. Kruger of M&T Development (Pty) Ltd. VGIconsult was appointed and instructed to proceed with the work in December 2007.

3. DESCRIPTION OF THE STUDY AREA

Irene Extension 70 is located immediately east of Pierre Van Ryneveld Extension 11, 13 and 14, south of the N1 Freeway and north of the proposed PWV6 road. The site incorporates approximately 21 ha of land.

The ground slopes from approximately 1495m AMSL in the south-easternmost corner to 1485 m AMSL along the northern boundary of the site.

4. AVAILABLE INFORMATION

Information sources include:

- **VGIconsult report**, VGI4063, dated 24 October 2007, entitled: "GFSH-2, PHASE 2: Infill Geotechnical Investigations: Irene Extension 70".
- **Intraconsult report**, IR523F, dated July 2003, "Geotechnical investigations for proclamation: approximately 417ha east of Irene".
- **Geological Map**, 1: 50 000 Scale Series: issued by the Geological Survey of South Africa (Council for Geoscience): Sheet 2528CC : Lyttelton, dated 1976.
- The Directorates Resource Directed Measures and Hydrological Information of the Department of Water Affairs and Forestry report: 'Intermediate groundwater reserve determination for quaternary catchments A21A and A21B', P.J. Hobbs, Project No 2002-316, 2004 (Draft 1).
- The Directorate of Geohydrology of the Department of Water Affairs report: '**Hydrogeology** of the Verwoerdburg Dolomite Aquifer', P.J. Hobbs, GH3502, July 1988.

- "Proposed **method for dolomite land hazard and risk assessment** in South Africa." by Buttrick, Van Schalkwyk, Kleywegt and Watermeyer 2001, Journal of the South African Institution of Civil Engineering, Volume 43, Number 2.
- **Generic Specification GFSH-2**, National Department of Housing Specification, "Geotechnical site investigations for housing development".
- **NHBRC Home Building Manual**, Parts 1 and 2, Revision 1, dated February 1999.
- **South African National Standard SANS 1936 Part 4** (in draft)

5. GEOLOGY AND GEOHYDROLOGY

Irene Extension 70 is located on chert-rich dolomite of the Eccles Formation of the Chuniespoort Group, of the Transvaal Supergroup.

Karoo transported Karoo materials or Post Eccles Formation (Leeuwenkloof Formation) deposits consisting of shale and chert occur in the east and central areas of the site. The destructive nature of the pneumatic percussion drilling method often results in uncertainty as to the Origin of a material e.g. distinguishing between the transported materials and chert residuum.

The karst development has led to a highly variable dolomite and chert bedrock topography. Cavernous conditions can be expected both within the bedrock and the overburden. Hard, unweathered dolomite bedrock is overlain by slightly weathered jointed bedrock and thereafter, through a sudden, dramatic transition, to highly weathered and typically low strength, insoluble residual material consisting of mainly manganese oxides (dolomite residuum), chert and iron oxides.

The various lithological units and their weathered derivatives, recorded on the site are as follows:

LITHOSTRATIGRAPHIC UNIT	LITHOLOGY
Karoo Supergroup or Transported/Reworked Karoo materials or Post Eccles Formation (Leeuwenkloof Formation) deposits	Shale and chert with soil derivatives
Monte Christo Formation, Chuniespoort Group, Transvaal Supergroup	Dolomite, chert and associated soil derivatives

The study area is mantled in many places by unconsolidated material deemed to be various Recent deposits (most likely 24 Ma [Miocene Epoch] and younger). The material varies in thickness, sedimentological- and geotechnical properties:

POST-GONDWANA DEPOSITS	
Pedocretes (cemented soils)	Ferricrete (cemented or replaced by iron oxides)/ Ferruginised soil (less than 50% cement or replacement material)
Colluvium: Talus (Course Colluvium) Hillwash Alluvium	Soils of clayey and silty composition

No groundwater was encountered in the boreholes drilled, although samples were, in instances, recorded as moist, particularly within layers of residual Karoo material, possibly suggesting the existence of perched ground water levels.

According to the report the site is located in the in the Fountains East Dolomite Groundwater Compartment and the groundwater level is anticipated at a depth of 114m (ground elevation 1404m AMSL) to 116m (ground elevation 1406m AMSL) or 1380m AMSL.

6. DOLOMITE STABILITY CHARACTERISATION

Irene Extension 70 is located in the Fountains East Dolomite Groundwater Compartment. Based on work by the Department of Water Affairs and Forestry, the OWL is anticipated at 1380m AMSL in the general site area i.e. approximately 114m to 116m below ground surface. Although the ground water level occurs at great depth and most likely within dolomite bedrock, it is essential that ground water management should form an integral part of the Dolomite Risk Management Strategy of the Local Authority.

The stability of the Century Development as a whole is characterised in five broad Dolomite Stability Zones, in terms of Intraconsult report number IR523F, dated 2003. According to this report, Irene Extension 70 is found to straddle Zone 1 and 4, described as follows:

Dolomite Stability Zone 1:	Area characterised as reflecting a medium risk of sinkhole and doline formation with respect to water ingress. Inherent Risk Class 4.
Dolomite Stability Zone 4:	Area characterised as reflecting a high risk of sinkhole and doline formation with respect to water ingress. Inherent Risk Class 8.

Phase 2 investigations were undertaken in Zone 4 permitting reclassification of this zone within Irene Extension 70 as follows:

Inherent Risk Class 4/1//1(4) Area

Area characterised as reflecting a medium (with sub-areas of low) Inherent Risk of sinkhole and doline formation (all sizes) with respect to ingress of water and a low with sub-areas of medium Inherent Risk with respect to groundwater level drawdown.

Based on the additional geotechnical data gathered during these investigations the stability of Irene Extension 70 as a whole is confirmed to be the same as described in report VGI4063R.

The results of the Phase 2 infill study is reproduced in Appendix 1 for ease of reference.

7. SITE SOIL CLASSIFICATION

7.1 Soil classification methodology

The broad soil characteristics across the greater Century development are described in terms of several 'geotechnical category designations' defined below:

GEOTECHNICAL CATEGORY AND SITE CLASS DESIGNATION	GEOTECHNICAL CHARACTERISTICS
W	Wet areas, drainage line, seepage zone
Active soils (heave/shrink)	Expected range of total movement at surface:
H	<5mm
H1	5 – 15mm
H2	15-30mm
H3	>30mm
Collapsible soils	Expected range of total movement at surface:
C	<5mm
C1	5-10mm
C2	>10mm
Compressible soils	<5mm
S	5-15mm
S1	>15mm
S2	
E	Abandoned borrow areas, dump rock, waste pits and uncontrolled fill.
T	Steep Slope (>15 degrees)
P	Dolomitic Areas
R	Rock
R1	Rock outcrop
R2	Rock scattered outcrop
R3	Rock sub outcrop (surface to minus 1.5m)

(ii) Soils uncovered that could rapidly reduce in volume when loaded and wetted – potential ‘collapsible’ soils (i.e. NHBRC Site Classes C/C1/C2)

‘Medium dense’ hillwash materials have been uncovered in trial hole profiles across this site. Collapse potential (CP_{200}) tests have been carried out on selected samples and indicate ‘trouble’ to ‘severe trouble’ classes for this soil type.

For the purposes of this report a 1 percent collapse/reduction has been applied to profile thickness (i.e. from surface to minus 1.0m) in the assessment of these materials.

(iii) Very moist and fine grained soils uncovered that could (slowly) reduce in volume when loaded – potentially ‘compressible’ soils (i.e. NHBRC Site Classes S/S1/S2)

Small pockets of soil are occupied by varying thicknesses of very fine grained soils with a potentially low coefficient of permeability. Consolidometer tests on undisturbed samples taken from these materials provide characteristic values for analysing their compressibility for imposed loadings up to 50 kPa. Using the assumptions and processes outlined in Footnote ² below, the values used for assessing the profiles are summarised as follows:

MATERIAL	Cr.	Preconsolidate d stress kPa	e_0	bulk density, kg/m ³	Thickness of material, mm		
					S	S1	S2
RESIDUAL SYENITE	0.02	90	1.073	1460	1000	N/A(>1000)	-
GULLYWASH	0.02	480	0.757	1790	1000	N/A(>1000)	-

7.2 Site Soil classification

During the installation of services on Irene Extension 70, trench inspection procedures were established in accordance with the GFSH – 2 Phase 2 requirements. This trench inspection work included profiles of the exposed service trenches and laboratory testing of type soils encountered.

The soil profiles and are reported in Appendix 6, together with the soil profiles of the test pits excavated in 2003 on this site. The laboratory test results are included in Appendix 7.

Footnote ²: The consolidation settlement, dc , can be expressed as

$$dc = \frac{Cr}{(1 + e_0)} \times H \log_{10} \frac{Po' + Ap'}{Po'}$$

For the purposes of these analyses:

- Cr & e_0 estimated from lab. test results.
- Zone of influence taken to 1m below surface.
- Initial effective pressure, po' , at middle of this layer (i.e. bulk density $\times 9.81 \times 10^{-3} \times 0.5$).
- Additional effective pressure, Ap : owing to applied loading taken as 50kPa (NHBRC max. permitted).
- ‘H’, thickness of soil in profile, provided by substituting $dc = 10mm$ & $20mm$).

The additional observations and data has been used to assess and confirm Site Classes for the individual stands across the site. The classification is as follows:

PD3(H/C-C1/S): The site is underlain by dolomite materials at depth. Generally the profile comprises colluvial transported soils of varying thicknesses overlying chert residuum materials. Anticipate slight to moderate collapsible soils o this site.

The position of test pits and boreholes used in arriving at the classification is displayed on Drawing VGI4063CR/1. The Site Soil classification is displayed on Drawing VGI4063CR/2. The stand Site Class listing is provided in Appendix 8.

8. RECOMMENDATIONS

The precautionary measures given below apply to the Dolomite Stability Zones identified and delineated in Irene Extension 70, but exclude all proposed Residential 2 Stands.

8.1 Permissible land usage

The M&T Development township layout plan, referenced Irenex70/2, dated September 2007, exhibits Residential 1 stand sizes 550 m² and larger, four Residential 2 type stands, a Clubhouse and Gate house. The land usages are commensurate with the identified Inherent Risk classes prevalent on this site:

STAND NUMBERS	PERMISSIBLE LAND USAGE
3461	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3462-3499	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3500	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3501-3545	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3545	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3546-3594	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3595	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3596-3620	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3621	Clubhouse
3622-3624	Access Control
3625	Traffic circle
3626-3628	Servitude
3629	Traffic circle

No subdivisions or second dwellings should be considered on the Residential 1 stands.

8.2 **Single Storey Residential Foundation Recommendations**

Potentially problematic soils mantle the dolomite bedrock over the site area. The occupance of these soils and their anticipated in-service behaviour (under NHBRC 'light' foundations) has been assessed and broad Sub-Area classification provided on the Soil Map, Drawing VGI4063CR/2.

Inherent risk of doline and specified size sinkhole forming characterisation is reported in Section 7 report VGI4063R.

All structures should be placed on rationally designed concrete reinforced raft foundation. The foundation should have the following Performance Requirements:

- A sinkhole having a nominal diameter (typically no less than 5m) occurring anywhere beneath or adjacent to the building will not envelop the building or result in toppling or sliding failure of the building (or portion of the building) into such a sinkhole or collapse of the building into such a sinkhole.
- The design is such that in the event of catastrophic loss of support, there is sufficient time for occupants to safely escape after the occurrence of the sinkhole, and the level of expected damage associated with soil movements unrelated to sinkhole formation in near surface horizons is kept within reasonable limits.
- The reinforced concrete foundation should, when subjected to a loss of support due to a minimum diameter 5m sinkhole, carry the proposed loads within that section of the wall and have deflection limits not more severe than 1:250, permitting safe evacuation of people. It must be noted that these deflection limits will result in severe structural damage.

8.3 **Township Services Certificate**

The Township Services Certificate confirming areas of compliance and deviations from the standards and specifications of the NHBRC was prepared by the design engineer Mr Gelderblom on 4 December 2007 (Appendix 5).

Maintenance of services are the responsibility of the Local Authority and continued functioning of the services is dependent on the implementation of a suitable maintenance programme by the Local Authority.

8.4 **Comments and approval of the various statutory authorities**

8.4.1 The Council for Geoscience supported the development of Irene Extension 70 in letter of comment, referenced F3043, dated 15 November 2007, entitled: "GFSH-2, Phase 2, Infill Geotechnical investigation: Irene Extension 70: Including the Zone 2 Stands" (Appendix 2).

8.4.2 The Council for Geoscience countersigned the NHBRC B4 certificate on the dated 12 December 2007 (Appendix 4).

8.4.3 The NHBRC enrolled the development in principle on the 30 October 2003 (Appendix 3).

8.5 Water precautionary measures

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

Township services

- a. **Underground services** shall be designed and constructed so as to minimise maintenance requirements and any potential leakage points in wet services and shall, as far as possible, be designed to avoid possible disturbance of the underground environment.
- b. The relevant provision of SABS 1200 DB, L, LB, LC, LD and LE shall be observed in the **installation of all underground services**. No rocks in top layer.
- c. The **backfilling to service trenches** and other excavations shall, except in rock, not be more permeable than the surrounding material.
- d. Wherever feasible locate **water-bearing infrastructure** above ground. In such instances use appropriate designed steel pipe work. Above-ground designs should be the priority option in services design. Where services are buried, preferably use only HDPE piping for water (Class 12 and higher), sewer (Class 6 minimum) and storm water (8 kN) in high-risk areas or where services traverse high-risk areas. The design engineer should carefully and conservatively select the appropriate type and class of pipe.
- e. The **stormwater drainage and sewerage system** shall incorporate measures to ensure watertightness of conduits and other compartments. Whenever possible, storm water should be channelled in lined, surface canals. *Concrete non-pressure pipes should be of the spigot and socket type with rubber ring seals. Joints in box culverts, channels, etc. should be sealed.*
- f. **Stormwater drainage conduits** shall be constructed at gradients, which will not permit the deposition of silt, or sand, of the type present in the catchment area.
- g. **Water mains** shall be laid only in road reserves.
- h. All **stormwater, sewerage and water pipes and channels** must be watertight. All laid drainage and sanitary sewer pipes should be tested for leakage using the air test (see NBRI Info. Sheet X/BOU 2-34) on installation. The responsible local authority should have a system whereby follow up tests for leakage are carried out and the results monitored.
- i. Buried water, sewer and storm water piping should wherever possible not be placed parallel to buildings unless at least 10 meters away. Single direct connections to buildings are preferred. This precaution also applies to electricity and communication cables.
- j. The NHBRC recommends that **water piping materials** should be one or more of the following
 - pipes of 75mm and larger diameter:
 - high impact PVC pipes with vitaulic joints.

- steel pipes with internal and external corrosion protection or other flexible (as defined in SABS 0102 Part 1) water pipes with flexible, self anchoring connections.
- pipes having a diameter of less than 75mm:
 - HDPE type IV piping
 - polypropylene piping

The piping used in mains and communication pipes should be flexible, joints should be minimal in number and, be of the flexible, self anchoring type, i.e. not reliant on thrust blocks or friction for their anchorage.

- k. Where feasible provision for **future connections** shall be made in order to minimise the cutting into pipes to provide such connections.
- l. Provision shall be made in **all water bearing pipelines** to accommodate any potential differential movements without causing the pipeline or joints to leak. Also use flexible coupling either side of **manholes**.
- m. **Road surfaces** shall be located sufficiently low so as to permit the drainage of even onto them.
- n. **Roadways**, which have a gradient of less than 1:80, shall be surfaced/sealed.
- o. During **construction excavations** should be opened and closed as rapidly as possible. Avoid leaving trenches open over weekends or holidays.
- p. Berms should be constructed on either side of the **trenches** to prevent the inflow of water during storms.
- q. **Construction site camp services** should also be subject to the precautionary measures as above and below.
- r. The backfilling to **service trenches and other excavations** shall, except in rock, not be more permeable than the surrounding material. (General minimum compaction standard of 93 % Mod AASHTO). The use of non-cohesive single size graded sand or crusher sand for bedding, surround blankets and backfill should not be permitted. The backfilling to service trenches and other excavations shall, except in rock, not be more permeable than the surrounding material.
- s. Blasting during construction and service installation:

Experience elsewhere on dolomite indicates that blasting may lead to severe disturbance of the metastable dolomite environment giving rise to sinkhole formation. Consequently, if blasting proves essential the following recommendation is made: Emphasis should be placed on minimal disturbance of the environment in order to reduce the likelihood of triggering events. It is essential that appropriately experienced blasters or companies are approached to determine the particular method specification for blasting, regarded as appropriate in the context of the geological conditions.

Plumbing

- a. All sewer and water pipes and fittings shall be provided with flexible, self-anchoring joints.

- b. **The use of surface mounted water pipes from the roof downward or on external walls is preferred. The chasing of water piping into walls should be kept to a minimum.**
- c. No plumbing and drainage pipes shall be placed under floor slabs, as far as is practicable.
- d. The fall of the trenches shall be away from the buildings.
- e. Pipes through walls shall be sleeved to permit relative movement.
- f. WC pans shall be provided with a flexible connection at the junction with the outlet pipe.
- g. Water pipes shall have a minimum cover of 500mm.
- h. Wherever practical, the fall of trenches shall be away from buildings and shall not be excavated along the length of housing units within the first 3,0m beyond the perimeter of such units.
- i. The selection of piping material shall take cognisance of corrosion (both external and internal), should preferably be welded HDPE or alternatively PVC with vitaulic joints.

Stormwater

- a. Natural ponds and watercourses located within 30 m of any structure shall be rendered impervious up to a point at least 60 m away from the building. (Design criteria: 1 in 5 year flood capacity minimum).
- b. Use aprons of large (2,0 m min width) impervious paved areas around structures to enhance drainage.
- c. Storm water drainage around buildings should preferably be kept on the surface or in open canals at slopes of not less than 1:50 for surfaced areas and canals, and 1:20 minimum for unsurfaced areas. All surfaces shall slope away from buildings. Drainage in passages or between buildings needs to slope away from structures and drain along the centre of open space. No drainage toward a structure is to be allowed. Preferably use 1m or wider, V-shaped concrete drains.
- d. The storm water drainage system shall incorporate measures to ensure water tightness of conduits, canals and other compartments. All pipes should be tested for leakage using standard air or water tests. All pipes and structures to be tested to show zero percent leakage.
- e. Open drains to be preferably shallow 1000 mm (min) wide in-situ cast V - shaped drains with sealed key type construction and expansion joints and steel reinforcement (if applicable) continuous over joints to disallow horizontal displacement.
- f. Storm water drainage conduits should be constructed at gradients, which will not permit the deposition of silt, or sand, of the type present in the catchment area. In order to deal with rain water run off from the roofs of structures the following is recommended:
 - If guttering is used, then the down pipes should discharge into a lined, watertight stormwater canal or precast furrow. This canal should discharge the water at least 5m away from the structure, where it should drain freely, without ponding to the stormwater system and off the site.

- If no guttering is to be utilised then it is recommended that at least 3 to 4m sealed surface be cast along those walls of the structure where water will be discharged from the roof. Water will cascade off the sloping roof onto the slab and be distributed away from the foundations and should drain freely, without ponding, into the stormwater system.
- g. Concrete apron slabs or brick paving should have a minimum of 1:20 fall away from buildings.
- h. Drainage canals traversing walkways should not be piper under walkways. Use impervious canals and grids.
- i. Brick and precast concrete courtyard walls, etc. must be so designed as to provide drainage ports at ground level to permit the passage of water.

Sewer

- a. Sanitation systems should not incorporate soakaways. Use conservancy tanks with low flush volumes where sewer connections are not available. Sewer works or maturation ponds should be located well away from the development (>200m).
- b. Subsurface sewer pipe materials should be as follows:
 - HDPE: Within 15 m of building.
SABS 533 Type 4 Part II - Class 6 Use electro fusion or butt-welded joints to improve water tightness. Preferably use a manhole when linking different pipe material types. The use of pre-manufactured HDPE manholes is advised.
 - PVC: Only to be used beyond 15 m from structures.
SABS 791 Heavy duty - Class 34 (solid wall).
- c. All connections to manholes should be flexible.
- d. All sewerage pipes must be watertight. All laid drainage and sanitary sewer pipes should be tested for leakage using water test on installation. Welded HDPE pipe systems to be pressure tested.
- e. All sewers and structures to be tested to zero percent leakage for water tests.
- f. Avoid using rodding and cleaning eyes and rather use small HDPE manholes (multi directional collecting pots), which are pre-manufactured small size (300, 500 and 700 mm diameter) manholes with factory fitted HDPE benching and covers. Piping from the manhole to surface level shall consist of HDPE pipes and long radius bends with electro fusion/butt welded connections.

Water

- a. The piping used in mains and communication pipes should be flexible, joints should be minimal in number and of the flexible, self anchoring type, i.e. not reliant on thrust blocks or friction for their anchorage.
- b. Subsurface water pipe materials should be one or more of the following, depending on existing service on the site:
 - Pipes of 75mm and larger diameter:
 - * Preferred: HDPE piping 9SABS 533 Type 4, Class 12) with butt-welded joints for pipes and fittings.
 - * Alternative: high impact PVC pipes 9SABS 966, class 12) with victaulic joints.

- Pipes having a diameter of less than 75mm.
 - * HDPE pipe (SABS 533 type 4, Class 16) with butt-welded joints. Piping from main reticulation to the buildings should be unjointed HDPE Class 16.
- c. Underground valves to be placed in watertight manholes.
- d. No high-pressure compression connections to be allowed below ground level. All connections to be placed in watertight manholes.
- e. Shut-off valves and water meter shall be supplied at main supply with permanently fixed pressure gauge on the building side of the main shut-off valve (for regular systems testing).

Swimming Pools

- a. Swimming pools should be designed as self contained, rigid structures capable of bridging local ground settlement.
- b. Backwash and other water from swimming pools, shall be discharged via HDPE piping into either the stormwater or drainage systems as required by the local authority. Discharge point to be closer than 20m from pool or any other structure.
- c. The area surrounding the swimming pools shall be totally impervious (concrete paving) for a distance of at least 5 meters with provision of a drainage canal to collect splashed water.
- d. The pool shall not have an automatic replenishment system.
- e. Dolomite risk specialist to advise on placing of pool (not closer than 5m to buildings).

Electricity and Communication

- a. The sleeve and draw box systems for electrical and communication cables shall also be water tight, flexible and constructed to avoid water entering the system. HDPE piping and small diameter manholes as described for sewers above are ideally suited for this purpose.
- b. Trenching, backfilling and compaction of trenches to be similar as for wet services.
- c. The use of non-cohesive single size graded sand or crusher sand for bedding and surround blankets and backfilling of trenches shall not be allowed. Construction detail to be similar as for water and sewer pipes.

8.6 Dolomite Risk Management Strategy

Dolomite Risk Management is a key element in maintaining an acceptable development risk. Consequently a site specific Risk Management Strategy is developed and presented in Appendix 9.

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DRAWINGS

DRAWING VGI4063CR/1

BOREHOLES, TEST PITS AND TRENCH LOG POSITIONS : IRENE EXTENSION 70

DRAWING VGI4063CR/2

SOILS SITE CLASS : IRENE EXTENSION 70

APPENDICES

Appendix 1

REPORT: GFSH-2, PHASE 2: INFILL GEOTECHNICAL INVESTIGATIONS: IRENE
EXTENSION 70

Appendix 2

COUNCIL FOR GEOSCIENCE COMMENT FOR INFILL INVESTIGATION

Appendix 3

B4 CERTIFICATE

Appendix 4

NHBRC LETTER

Appendix 5

TOWNSHIP SERVICES CERTIFICATE

Appendix 6

TRIAL HOLE PROFILES

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LABORATORY TEST RESULTS

Appendix 8

SOIL CLASS DESIGNATION LIST

Appendix 9

RISK MANAGEMENT STRATEGY

Appendix 1

REPORT: GFSH-2, PHASE 2: INFILL GEOTECHNICAL INVESTIGATIONS: IRENE
EXTENSION 70

Appendix 2

COUNCIL FOR GEOSCIENCE COMMENT FOR INFILL INVESTIGATION

Appendix 3

B4 CERTIFICATE

Appendix 4

NHBRC LETTER

Appendix 5

TOWNSHIP SERVICES CERTIFICATE

Appendix 6

TRIAL HOLE PROFILES

Appendix 7

LABORATORY TEST RESULTS

Appendix 8

SOIL CLASS DESIGNATION LIST

STAND NO	CONFIRMED NHBRC SITE CLASS
3461	TO BE DETERMINED
3462	PD3(H/C-C1/S)
2463	PD3(H/C-C1/S)
3464	PD3(H/C-C1/S)
3465	PD3(H/C-C1/S)
3466	PD3(H/C-C1/S)
3467	PD3(H/C-C1/S)
3468	PD3(H/C-C1/S)
3469	PD3(H/C-C1/S)
3470	PD3(H/C-C1/S)
3471	PD3(H/C-C1/S)
3472	PD3(H/C-C1/S)
3473	PD3(H/C-C1/S)
3474	PD3(H/C-C1/S)
3475	PD3(H/C-C1/S)
3476	PD3(H/C-C1/S)
3478	PD3(H/C-C1/S)
3479	PD3(H/C-C1/S)
3480	PD3(H/C-C1/S)
3481	PD3(H/C-C1/S)
3482	PD3(H/C-C1/S)
3483	PD3(H/C-C1/S)
3484	PD3(H/C-C1/S)
3485	PD3(H/C-C1/S)
3486	PD3(H/C-C1/S)
3487	PD3(H/C-C1/S)
3488	PD3(H/C-C1/S)
3489	PD3(H/C-C1/S)
3490	PD3(H/C-C1/S)
3491	PD3(H/C-C1/S)
3492	PD3(H/C-C1/S)
3493	PD3(H/C-C1/S)
3494	PD3(H/C-C1/S)
3495	PD3(H/C-C1/S)
3496	PD3(H/C-C1/S)
3497	PD3(H/C-C1/S)
3498	PD3(H/C-C1/S)
3499	PD3(H/C-C1/S)
3500	TO BE DETERMINED
3501	PD3(H/C-C1/S)
3502	PD3(H/C-C1/S)
3503	PD3(H/C-C1/S)
3504	PD3(H/C-C1/S)
3505	PD3(H/C-C1/S)
3506	PD3(H/C-C1/S)
3507	PD3(H/C-C1/S)
3508	PD3(H/C-C1/S)
3509	PD3(H/C-C1/S)
3510	PD3(H/C-C1/S)

STAND NO	CONFIRMED NHBRC SITE CLASS
3511	PD3(H/C-C1/S)
3512	PD3(H/C-C1/S)
3513	PD3(H/C-C1/S)
3514	PD3(H/C-C1/S)
3515	PD3(H/C-C1/S)
3516	PD3(H/C-C1/S)
3517	PD3(H/C-C1/S)
3518	PD3(H/C-C1/S)
3519	PD3(H/C-C1/S)
3520	PD3(H/C-C1/S)
3521	PD3(H/C-C1/S)
3522	PD3(H/C-C1/S)
3523	PD3(H/C-C1/S)
3524	PD3(H/C-C1/S)
3525	PD3(H/C-C1/S)
3526	PD3(H/C-C1/S)
3527	PD3(H/C-C1/S)
3528	PD3(H/C-C1/S)
3529	PD3(H/C-C1/S)
3530	PD3(H/C-C1/S)
3531	PD3(H/C-C1/S)
3532	PD3(H/C-C1/S)
3533	PD3(H/C-C1/S)
3534	PD3(H/C-C1/S)
3535	PD3(H/C-C1/S)
3536	PD3(H/C-C1/S)
3537	PD3(H/C-C1/S)
3538	PD3(H/C-C1/S)
3539	PD3(H/C-C1/S)
3540	PD3(H/C-C1/S)
3541	PD3(H/C-C1/S)
3542	PD3(H/C-C1/S)
3543	PD3(H/C-C1/S)
3544	PD3(H/C-C1/S)
3545	TO BE DETERMINED
3546	PD3(H/C-C1/S)
3547	PD3(H/C-C1/S)
3548	PD3(H/C-C1/S)
3549	PD3(H/C-C1/S)
3550	PD3(H/C-C1/S)
3551	PD3(H/C-C1/S)
3552	PD3(H/C-C1/S)
3553	PD3(H/C-C1/S)
3554	PD3(H/C-C1/S)
3555	PD3(H/C-C1/S)
3556	PD3(H/C-C1/S)
3557	PD3(H/C-C1/S)
3558	PD3(H/C-C1/S)
3559	PD3(H/C-C1/S)
3560	PD3(H/C-C1/S)

STAND NO	CONFIRMED NHBRC SITE CLASS
3561	PD3(H/C-C1/S)
3562	PD3(H/C-C1/S)
3563	PD3(H/C-C1/S)
3564	PD3(H/C-C1/S)
3565	PD3(H/C-C1/S)
3566	PD3(H/C-C1/S)
3567	PD3(H/C-C1/S)
3568	PD3(H/C-C1/S)
3569	PD3(H/C-C1/S)
3570	PD3(H/C-C1/S)
3571	PD3(H/C-C1/S)
3572	PD3(H/C-C1/S)
3573	PD3(H/C-C1/S)
3574	PD3(H/C-C1/S)
3575	PD3(H/C-C1/S)
3576	PD3(H/C-C1/S)
3578	PD3(H/C-C1/S)
3579	PD3(H/C-C1/S)
3580	PD3(H/C-C1/S)
3581	PD3(H/C-C1/S)
3582	PD3(H/C-C1/S)
3583	PD3(H/C-C1/S)
3584	PD3(H/C-C1/S)
3585	PD3(H/C-C1/S)
3586	PD3(H/C-C1/S)
3587	PD3(H/C-C1/S)
3588	PD3(H/C-C1/S)
3589	PD3(H/C-C1/S)
3590	PD3(H/C-C1/S)
3591	PD3(H/C-C1/S)
3592	PD3(H/C-C1/S)
3593	PD3(H/C-C1/S)
3594	PD3(H/C-C1/S)
3595	TO BE DETERMINED
3596	PD3(H/C-C1/S)
3597	PD3(H/C-C1/S)
3598	PD3(H/C-C1/S)
3599	PD3(H/C-C1/S)
3600	PD3(H/C-C1/S)
3601	PD3(H/C-C1/S)
3602	PD3(H/C-C1/S)
3603	PD3(H/C-C1/S)
3604	PD3(H/C-C1/S)
3605	PD3(H/C-C1/S)
3606	PD3(H/C-C1/S)
3607	PD3(H/C-C1/S)
3608	PD3(H/C-C1/S)
3609	PD3(H/C-C1/S)
3610	PD3(H/C-C1/S)
3611	PD3(H/C-C1/S)

STAND NO	CONFIRMED NHBRC SITE CLASS
3612	PD3(H/C-C1/S)
3613	PD3(H/C-C1/S)
3614	PD3(H/C-C1/S)
2615	PD3(H/C-C1/S)
3616	PD3(H/C-C1/S)
3617	PD3(H/C-C1/S)
3618	PD3(H/C-C1/S)
3619	PD3(H/C-C1/S)
3620	PD3(H/C-C1/S)
3621	PD3(H/C-C1/S) Clubhouse
3622	PD3(H/C-C1/S) Access control
3623	PD3(H/C-C1/S) Access control
3624	PD3(H/C-C1/S) Access control
3625	PD3(H/C-C1/S) Traffic circle
3626	PD3(H/C-C1/S) Servitude
3627	PD3(H/C-C1/S) Servitude
3628	PD3(H/C-C1/S) Servitude
3629	PD3(H/C-C1/S) Traffic circle

Appendix 9

RISK MANAGEMENT STRATEGY

**RISK MANAGEMENT STRATEGY
IRENE EXTENSION 70
CENTURY MANOR**

1. INTRODUCTION

This document serves to set out the requirements for the management of Irene Extension 70 from a dolomite risk perspective.

2. TERMS OF REFERENCE AND SCOPE OF WORK

This information is collated as part of the construction report undertaken for M&T Development in compliance of the requirements set out by the NHBRC.

3. EXISTING INFORMATION

The following information has been used in the investigation and assessment of the site:

- **VGIconsult report**, dated 24 October 2007, entitled: "GFSH-2, PHASE 2: Infill Geotechnical Investigations: Irene Extension 70".
- **Intraconsult report**, IR523F, dated July 2003, "Geotechnical investigations for proclamation: approximately 417ha east of Irene".
- **Geological Map**, 1: 50 000 Scale Series: issued by the Geological Survey of South Africa (Council for Geoscience): Sheet 2528CC : Lyttelton, dated 1976.
- The Directorates Resource Directed Measures and Hydrological Information of the Department of Water Affairs and Forestry report: '**Intermediate groundwater reserve determination for quaternary catchments A21A and A21B**', P.J. Hobbs, Project No 2002-316, 2004 (Draft 1).
- The Directorate of Geohydrology of the Department of Water Affairs report: '**Hydrogeology** of the Verwoerdburg Dolomite Aquifer', P.J. Hobbs, GH3502, July 1988.
- **Generic Specification GFSH-2**, National Department of Housing Specification, "Geotechnical site investigations for housing development".
- **NHBRC Home Building Manual**, Parts 1 and 2, Revision 1, dated February 1999.
- **South African National Standard SANS 1936 Part 4** (in draft).

4. GENERAL LOCATION AND DESCRIPTION OF THE SITE

Irene Extension 70 is located immediately east of Pierre Van Ryneveld Extension 11, 13 and 14, south of the N1 Freeway and north of the proposed PWV6 road. The site incorporates approximately 21 ha of land.

The ground slopes from approximately 1495m AMSL in the south-easternmost corner to 1485 m AMSL along the northern boundary of the site.

5. GEOLOGY AND GEOHYDROLOGY

Irene Extension 70 is located on chert-rich dolomite of the Eccles Formation of the Chuniespoort Group, of the Transvaal Supergroup. The various lithological units and their weathered derivatives, recorded on the site are as follows:

LITHOSTRATIGRAPHIC UNIT	LITHOLOGY
Karoo Supergroup or Transported/Reworked Karoo materials or Post Eccles Formation (Leeuwenkloof Formation) deposits.	Shale and chert with soil derivatives.
Monte Christo Formation, Chuniespoort Group, Transvaal Supergroup.	Dolomite, chert and associated soil derivatives.

The study area is mantled in many places by unconsolidated material deemed to be Recent deposits (24 Ma and younger). The material varies in thickness, sedimentological- and geotechnical properties:

POST-GONDWANA DEPOSITS	
Pedocretes (cemented soils)	Ferricrete (cemented or replaced by iron oxides)/ Ferruginised soil (less than 50% cement or replacement material)
Colluvium: Talus (Course Colluvium) Hillwash Alluvium	Soils of clayey and silty composition

No groundwater was encountered in the boreholes drilled, although samples were, in instances, recorded as moist, particularly within layers of residual Karoo material, possibly suggesting the existence of perched ground water levels.

According to the report the site is located in the in the Fountains East Dolomite Groundwater Compartment and the groundwater level is anticipated at a depth of 114m (ground elevation 1404m AMSL) to 116m (ground elevation 1406m AMSL) or 1380m AMSL.

6. STABILITY CHARACTERISATION

Irene Extension 70 is located in the Fountains East Dolomite Groundwater Compartment. Based on work by the Department of Water Affairs and Forestry, the OWL is anticipated at 1380m AMSL in the general site area i.e. approximately 114m to 116m below ground surface. Although the ground water level occurs at great depth and most likely within dolomite bedrock, it is essential that ground water management should form an integral part of the Dolomite Risk Management Strategy of the Local Authority.

Based on the gathered geological, geophysical, geohydrological and historical data, the stability of Irene Extension 70 and the identified stands are characterised as reflecting a medium (with sub-areas of low) Inherent Risk of sinkhole and doline formation (all sizes) with respect to ingress of water and a low with sub-areas of medium Inherent Risk with respect to ground water level draw down i.e. ***Inherent Risk Class 4/1//1(4) Area***. The stability conditions are therefore similar to those described for the remainder of Irene Extension 70 in Intraconsult report IR523F.

7. DOLOMITE RISK MANAGEMENT STRATEGY

7.1 Principles

The Risk Management Strategy incorporates steps to mitigate risk before, during and after construction.

Ongoing water precautionary measures and the monitoring and maintenance of buildings and infrastructure form an integral part of any dolomite risk management programme aimed at the mitigation of the negative impacts of urban development on the metastable conditions prevalent in dolomite land.

The mitigation measures include:

- a) the placing of restrictions on land use and development densities;
- b) the establishing of requirements for the management of surface drainage;
- c) the establishing of requirements for the management and monitoring of groundwater levels;
- e) the establishing of requirements for the maintenance of water bearing structures and services;
- a) the identification of all the risks that are to be managed for the life time of the development; and
- g) establish suitable risk management controls, processes, procedures and measures to manage the identified risks.

The developer shall remain responsible for the implementation of the dolomite risk management plan until such time as such responsibility can be transferred to and accepted in writing by the owner of the development or the accounting

authority and, in the case of municipal services, to the local authority (or both).

7.2 Risk Management Strategy Irene Extension 70

Names, professional registration numbers and contact particulars of competent persons appointed:

Name	Capacity	Professional registration	Contact details
Dave Buttrick	Engineering geologist: VGIconsult (geotechnical investigations)	SACNSP	011 469 0854
Nicole Trollip	Engineering geologist: VGIconsult (dolomite risk management)	SACNSP	011 469 0854
Hendri Gelderblom	Engineer: Dekker & Gelderblom (township services design)	ECSA	012 369 6720

Foundation- and services design for individual stands are undertaken by property owner appointed engineers.

It is recommended that the Section 21 Company keep record of the engineers for future reference.

7.2.1 Inherent Risk Zonation

STAND NUMBERS	INHERENT RISK ZONATION
3461	TO BE DETERMINED
3462	Inherent Risk Class 4/1//1(4)
2463	Inherent Risk Class 4/1//1(4)
3464	Inherent Risk Class 4/1//1(4)
3465	Inherent Risk Class 4/1//1(4)
3466	Inherent Risk Class 4/1//1(4)
3467	Inherent Risk Class 4/1//1(4)
3468	Inherent Risk Class 4/1//1(4)
3469	Inherent Risk Class 4/1//1(4)
3470	Inherent Risk Class 4/1//1(4)
3471	Inherent Risk Class 4/1//1(4)
3472	Inherent Risk Class 4/1//1(4)
3473	Inherent Risk Class 4/1//1(4)
3474	Inherent Risk Class 4/1//1(4)
3475	Inherent Risk Class 4/1//1(4)
3476	Inherent Risk Class 4/1//1(4)
3478	Inherent Risk Class 4/1//1(4)
3479	Inherent Risk Class 4/1//1(4)
3480	Inherent Risk Class 4/1//1(4)
3481	Inherent Risk Class 4/1//1(4)
3482	Inherent Risk Class 4/1//1(4)
3483	Inherent Risk Class 4/1//1(4)
3484	Inherent Risk Class 4/1//1(4)
3485	Inherent Risk Class 4/1//1(4)

STAND NUMBERS	INHERENT RISK ZONATION
3486	Inherent Risk Class 4/1//1(4)
3487	Inherent Risk Class 4/1//1(4)
3488	Inherent Risk Class 4/1//1(4)
3489	Inherent Risk Class 4/1//1(4)
3490	Inherent Risk Class 4/1//1(4)
3491	Inherent Risk Class 4/1//1(4)
3492	Inherent Risk Class 4/1//1(4)
3493	Inherent Risk Class 4/1//1(4)
3494	Inherent Risk Class 4/1//1(4)
3495	Inherent Risk Class 4/1//1(4)
3496	Inherent Risk Class 4/1//1(4)
3497	Inherent Risk Class 4/1//1(4)
3498	Inherent Risk Class 4/1//1(4)
3499	Inherent Risk Class 4/1//1(4)
3500	TO BE DETERMINED
3501	Inherent Risk Class 4/1//1(4)
3502	Inherent Risk Class 4/1//1(4)
3503	Inherent Risk Class 4/1//1(4)
3504	Inherent Risk Class 4/1//1(4)
3505	Inherent Risk Class 4/1//1(4)
3506	Inherent Risk Class 4/1//1(4)
3507	Inherent Risk Class 4/1//1(4)
3508	Inherent Risk Class 4/1//1(4)
3509	Inherent Risk Class 4/1//1(4)
3510	Inherent Risk Class 4/1//1(4)
3511	Inherent Risk Class 4/1//1(4)
3512	Inherent Risk Class 4/1//1(4)
3513	Inherent Risk Class 4/1//1(4)
3514	Inherent Risk Class 4/1//1(4)
3515	Inherent Risk Class 4/1//1(4)
3516	Inherent Risk Class 4/1//1(4)
3517	Inherent Risk Class 4/1//1(4)
3518	Inherent Risk Class 4/1//1(4)
3519	Inherent Risk Class 4/1//1(4)
3520	Inherent Risk Class 4/1//1(4)
3521	Inherent Risk Class 4/1//1(4)
3522	Inherent Risk Class 4/1//1(4)
3523	Inherent Risk Class 4/1//1(4)
3524	Inherent Risk Class 4/1//1(4)
3525	Inherent Risk Class 4/1//1(4)
3526	Inherent Risk Class 4/1//1(4)
3527	Inherent Risk Class 4/1//1(4)
3528	Inherent Risk Class 4/1//1(4)
3529	Inherent Risk Class 4/1//1(4)
3530	Inherent Risk Class 4/1//1(4)
3531	Inherent Risk Class 4/1//1(4)
3532	Inherent Risk Class 4/1//1(4)
3533	Inherent Risk Class 4/1//1(4)
3534	Inherent Risk Class 4/1//1(4)
3535	Inherent Risk Class 4/1//1(4)
3536	Inherent Risk Class 4/1//1(4)
3537	Inherent Risk Class 4/1//1(4)
3538	Inherent Risk Class 4/1//1(4)
3539	Inherent Risk Class 4/1//1(4)
3540	Inherent Risk Class 4/1//1(4)

STAND NUMBERS	INHERENT RISK ZONATION
3541	Inherent Risk Class 4/1//1(4)
3542	Inherent Risk Class 4/1//1(4)
3543	Inherent Risk Class 4/1//1(4)
3544	Inherent Risk Class 4/1//1(4)
3545	TO BE DETERMINED
3546	Inherent Risk Class 4/1//1(4)
3547	Inherent Risk Class 4/1//1(4)
3548	Inherent Risk Class 4/1//1(4)
3549	Inherent Risk Class 4/1//1(4)
3550	Inherent Risk Class 4/1//1(4)
3551	Inherent Risk Class 4/1//1(4)
3552	Inherent Risk Class 4/1//1(4)
3553	Inherent Risk Class 4/1//1(4)
3554	Inherent Risk Class 4/1//1(4)
3555	Inherent Risk Class 4/1//1(4)
3556	Inherent Risk Class 4/1//1(4)
3557	Inherent Risk Class 4/1//1(4)
3558	Inherent Risk Class 4/1//1(4)
3559	Inherent Risk Class 4/1//1(4)
3560	Inherent Risk Class 4/1//1(4)
3561	Inherent Risk Class 4/1//1(4)
3562	Inherent Risk Class 4/1//1(4)
3563	Inherent Risk Class 4/1//1(4)
3564	Inherent Risk Class 4/1//1(4)
3565	Inherent Risk Class 4/1//1(4)
3566	Inherent Risk Class 4/1//1(4)
3567	Inherent Risk Class 4/1//1(4)
3568	Inherent Risk Class 4/1//1(4)
3569	Inherent Risk Class 4/1//1(4)
3570	Inherent Risk Class 4/1//1(4)
3571	Inherent Risk Class 4/1//1(4)
3572	Inherent Risk Class 4/1//1(4)
3573	Inherent Risk Class 4/1//1(4)
3574	Inherent Risk Class 4/1//1(4)
3575	Inherent Risk Class 4/1//1(4)
3576	Inherent Risk Class 4/1//1(4)
3578	Inherent Risk Class 4/1//1(4)
3579	Inherent Risk Class 4/1//1(4)
3580	Inherent Risk Class 4/1//1(4)
3581	Inherent Risk Class 4/1//1(4)
3582	Inherent Risk Class 4/1//1(4)
3583	Inherent Risk Class 4/1//1(4)
3584	Inherent Risk Class 4/1//1(4)
3585	Inherent Risk Class 4/1//1(4)
3586	Inherent Risk Class 4/1//1(4)
3587	Inherent Risk Class 4/1//1(4)
3588	Inherent Risk Class 4/1//1(4)
3589	Inherent Risk Class 4/1//1(4)
3590	Inherent Risk Class 4/1//1(4)
3591	Inherent Risk Class 4/1//1(4)
3592	Inherent Risk Class 4/1//1(4)
3593	Inherent Risk Class 4/1//1(4)
3594	Inherent Risk Class 4/1//1(4)
3595	TO BE DETERMINED
3596	Inherent Risk Class 4/1//1(4)

STAND NUMBERS	INHERENT RISK ZONATION
3597	Inherent Risk Class 4/1//1(4)
3598	Inherent Risk Class 4/1//1(4)
3599	Inherent Risk Class 4/1//1(4)
3600	Inherent Risk Class 4/1//1(4)
3601	Inherent Risk Class 4/1//1(4)
3602	Inherent Risk Class 4/1//1(4)
3603	Inherent Risk Class 4/1//1(4)
3604	Inherent Risk Class 4/1//1(4)
3605	Inherent Risk Class 4/1//1(4)
3606	Inherent Risk Class 4/1//1(4)
3607	Inherent Risk Class 4/1//1(4)
3608	Inherent Risk Class 4/1//1(4)
3609	Inherent Risk Class 4/1//1(4)
3610	Inherent Risk Class 4/1//1(4)
3611	Inherent Risk Class 4/1//1(4)
3612	Inherent Risk Class 4/1//1(4)
3613	Inherent Risk Class 4/1//1(4)
3614	Inherent Risk Class 4/1//1(4)
2615	Inherent Risk Class 4/1//1(4)
3616	Inherent Risk Class 4/1//1(4)
3617	Inherent Risk Class 4/1//1(4)
3618	Inherent Risk Class 4/1//1(4)
3619	Inherent Risk Class 4/1//1(4)
3620	Inherent Risk Class 4/1//1(4)
3621	Inherent Risk Class 4/1//1(4) (Clubhouse)
3622	Inherent Risk Class 4/1//1(4) (Access control)
3623	Inherent Risk Class 4/1//1(4) (Access control)
3624	Inherent Risk Class 4/1//1(4) (Access control)
3625	Inherent Risk Class 4/1//1(4) (Traffic circle)
3626	Inherent Risk Class 4/1//1(4) (Servitude)
3627	Inherent Risk Class 4/1//1(4) (Servitude)
3628	Inherent Risk Class 4/1//1(4) (Servitude)
3629	Inherent Risk Class 4/1//1(4) (Traffic circle)

7.2.2 Permissible land usages

STAND NUMBERS	PERMISSIBLE LAND USAGE
3461	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3462-3499	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3500	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3501-3545	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3545	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3546-3594	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3595	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3596-3620	RESIDENTIAL 1 : Stand Sizes $\geq 500 \text{ m}^2$
3621	Clubhouse

STAND NUMBERS	PERMISSIBLE LAND USAGE
3622-3624	Access Control
3625	Traffic circle
3626-3628	Servitude
3629	Traffic circle

7.2.3 **Restrictions for reasons of dolomite risk management**

No subdivisions or second dwellings should be considered on the Residential 1 stands.

Land usage for stands 3461, 3500, 3545 and 3595 are to be determined subsequent to further investigations.

7.2.4 **Dolomite Area Designation**

STAND NUMBERS	DOLOMITE AREA DESIGNATION
3461	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3462-3499	D3
3500	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3501-3545	D3
3545	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3546-3594	D3
3595	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3596-3620	D3
3621	TO BE DETERMINED SUBSEQUENT TO INVESTIGATIONS
3622-3624	D3
3625	D3
3626-3628	D3
3629	D3

7.2.5 Monitoring

7.2.5.1 Monitoring Principles

Monitoring Designations are assigned to the site. The type of monitoring activities and frequencies thereof are indicated below.

Monitoring Designations are identified and delineated according to Inherent Risk characterisation of the site and knowledge of problems in areas impacting on the infrastructure on site.

The Monitoring Activities are:

Annotation	Activity
A	Visual inspections of ground, structures and above ground infrastructure (e.g. roads, storm water canals, ditches). Any evidence of cracking or ground settlement should immediately be reported and investigated.
B	Visual inspection of stormwater systems crossing the site for blockages. Any evidence of blockages should be reported and cleared immediately.
C	Testing of wet-services for leaks. Any leaks to be reported and repaired immediately.
D	Monitoring of structures and ground levels. Any evidence of movement must be reported and investigated.
E	Monitoring of the groundwater level. Evidence of lowering must be reported to the Department of Water Affairs and Forestry.

Activities A to C are intended to monitor, control and therefore prevent concentrated ingress of water.

Activity D aims to monitor the potential effects of triggering mechanisms (i.e. water ingress or groundwater level drawdown) by means of, for example, precision levelling.

Activity E is intended to monitor groundwater level drawdown.

The Frequency with which each Activity is to be performed is selected from the following categories:

Annotation	Frequency
() ^{DAILY}	Activities to be undertaken daily.
() ^{WEEKLY}	Activities to be undertaken weekly.
() ¹	Activities to be undertaken once a month.
() ³	Activities to be undertaken quarterly.
() ⁶	Activities to be undertaken bi-annually.
() ¹²	Activities to be undertaken annually.
() ²⁴	Activities to be undertaken once every two years.
() ⁰	No action required.
() ^{tbd}	To be determined.

Areas of '**no Inherent Risk**' require no monitoring at all from a dolomite risk management perspective. For example, a site on granite rock or Witwatersrand Supergroup rocks may be designated as (ABCDE)⁰ indicating that no action is required to lower the risk of dolomite related instability.

Areas of '**low Inherent Risk**' are assigned a low priority and require basic monitoring and maintenance activities at long intervals. For example, where a site is located on thick Karoo Supergroup rocks (in excess of 30 metres) the section may be designated as (ABC)²⁴(DE)⁰ indicating that all identified activities which control ingress water need only be undertaken once every two years with precision structure and ground levelling and groundwater monitoring not being required. However, where such rocks overlie dolomite residuum below the original groundwater level a designation of (ABC)²⁴E¹ may apply, indicating that activities which control the ingress of concentrated water remain necessary once every two years but groundwater level monitoring is critical and should be undertaken once a month.

Areas of ‘**high Inherent Risk**’ and therefore high priority in terms of monitoring and maintenance should receive attention more frequently. Such areas are typically characterised by:

- i. Metastable subsurface conditions or latent sinkhole formation.
- ii. High risk conditions.
- iii. Poor subsurface conditions e.g. cavitation, sample or air loss.
- iv. Previous sinkhole or doline formation.
- v. Palaeo-sinkhole or palaeo-doline structures.
- vi. Geological contact areas.
- vii. Fault zones.
- viii. Anticipated ground settlement or
- ix. Ponding of water, etc.

For example, an area in which various sinkholes have already been reported and where the area is designated as high risk or even medium to high risk from an ingress of water perspective a $(ABCD)^3(E)^0$ or even $(AB)^{\text{daily}}(D)^3(E)^0$ designation may apply, indicating the need to undertake activities controlling ingress of water quarterly, or even daily, with no action required to monitor the groundwater level.

In areas where it was not possible to assign an Inherent Risk characterisation a difficulty presents itself in terms of the determination of monitoring and frequency thereof. In such a case a designation $(ABCDE)^{\text{tbd}}$ is assigned, indicating that insufficient data exists, the monitoring activities are yet to be determined.

7.2.5.2 **Monitoring Designation for Irene Extension 70**

The designation is follows:

Inherent Risk Class	Monitoring Designation
4/1//1(4)	$A^6(BC)^{12}D^0E^6$

7.2.5.3 Infrastructure monitoring programme (A,B,C)

7.2.5.3.1 The following infrastructure monitoring should be undertaken on a **seasonal interval/three monthly basis** by **Tshwane Metropolitan Municipality (TMM) or the Section 21 Company on behalf of TMM:**

- visual checks for debris in stormwater channels at the start of the rainy season (preferably also after heavy storms);
- visual checks for water flowing out of stormwater manholes; and
- the examination of buildings for cracks.

7.2.5.3.2 The following infrastructure monitoring should be undertaken on a **three monthly interval basis** by **stand owners:**

- visual checks for outside dripping taps and pressure valves;
- visual checks for damp or moss grown areas;
- visual checks for debris in open storm water channels;
- visual checks for water flowing out of sewer- and storm water manholes;
- the examination of buildings, paving, walls, etc for cracks;
- visual check for over-wetting of gardens; and
- visual check for blocked drainage ports in garden walls.

7.2.5.3.3 The following infrastructure monitoring should be undertaken on **an annual interval basis** by **Tshwane Metropolitan Municipality or the Section 21 Company on behalf of TMM:**

- Sewer mains should be checked for water tightness by means of an air test and repairs undertaken where necessary.
- All bulk water pipes must be tested for water tightness or blockages and cleared or repaired (or both) where required.

Repair of leaks in the sewer and water reticulation:

The response time for a repair team to reach the repair site and commence with the repair of any leak detected, measured from the time that a leak is reported, shall be not more than:

- a) one hour in the case of pipes having a diameter of 75mm and greater; and**
- b) one and a half hours where the pipe has a diameter less than 75mm.**

7.2.5.4 Groundsurface monitoring programme

Visual groundsurface monitoring should be undertaken by stand owners on a regular basis (at least annually). This should be done by inspecting paved areas after rainstorms (ponding water indicates an area of differential settlement). Search for ground cracks and cracks in lined and unlined channels.

It may be necessary to undertake precision groundsurface levelling, particularly in areas that have been rehabilitated after a sinkhole. Such levelling should be undertaken by a surveyor, recorded and stored in the databank and appropriate actions taken when excessive settlement continues.

7.2.5.3 Groundwater level monitoring

Irene Extension 70 is located in the Fountains East Dolomite Groundwater Compartment and the groundwater level is anticipated at a depth of 114m (ground elevation 1404m AMSL) to 116m (ground elevation 1406m AMSL) or 1380m AMSL.

Any substantial lowering of the groundwater level may induce ground subsidence events in the general area. The groundwater level should be monitored and maintained within natural seasonal fluctuation limits, i.e. dewatering resulting from the artificial drawdown of the groundwater level cannot be permitted.

Groundwater monitoring is the responsibility of the Department of Water Affairs and Forestry (DWAF).

DWAF should be notified of the requisite monitoring by the Tshwane Metropolitan Municipality.

As the infrastructure on this site could be negatively impacted on in the event of groundwater lowering it is recommended that DWAF be approached by the Local Authority to set up a reporting system whereby it is regularly informed of the results of DWAF monitoring activities. DWAF should immediately disclose any groundwater level drawdown beyond that which represents natural seasonal fluctuations. Action should immediately be taken by DWAF to investigate the cause and every effort made to cease further lowering of the groundwater level.

Recommended frequency of groundwater levelling is as follows:

GROUNDWATER COMPARTMENT	ORIGINAL WATER LEVEL (m AMSL)	Depth	Frequency of groundwater levelling
Fountains East Sub-Compartment	1380	114-116	6 MONTHLY

7.2.6 Precautionary measures required to support development for designated land uses

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

Township services

- a. **Underground services** shall be designed and constructed so as to minimise maintenance requirements and any potential leakage points in wet services and shall, as far as possible, be designed to avoid possible disturbance of the underground environment.
- b. The relevant provision of SABS 1200 DB, L, LB, LC, LD and LE shall be observed in the **installation of all underground services**. No rocks in top layer.

- c. The **backfilling to service trenches** and other excavations shall, except in rock, not be more permeable than the surrounding material.
- d. Wherever feasible locate **water-bearing infrastructure** above ground. In such instances use appropriate designed steel pipe work. Above-ground designs should be the priority option in services design. Where services are buried, preferably use only HDPE piping for water (Class 12 and higher), sewer (Class 6 minimum) and storm water (8 kN) in high-risk areas or where services traverse high-risk areas. The design engineer should carefully and conservatively select the appropriate type and class of pipe.
- e. The **stormwater drainage and sewerage system** shall incorporate measures to ensure watertightness of conduits and other compartments. Whenever possible, storm water should be channelled in lined, surface canals. *Concrete non-pressure pipes should be of the spigot and socket type with rubber ring seals. Joints in box culverts, channels, etc. should be sealed.*
- f. **Stormwater drainage conduits** shall be constructed at gradients, which will not permit the deposition of silt, or sand, of the type present in the catchment area.
- g. **Water mains** shall be laid only in road reserves.
- h. All **stormwater, sewerage and water pipes and channels** must be watertight. All laid drainage and sanitary sewer pipes should be tested for leakage using the air test (see NBRI Info. Sheet X/BOU 2-34) on installation. The responsible local authority should have a system whereby follow up tests for leakage are carried out and the results monitored.
- i. Buried water, sewer and storm water piping should wherever possible not be placed parallel to buildings unless at least 10 meters away. Single direct connections to buildings are preferred. This precaution also applies to electricity and communication cables.
- j. The NHBRC recommends that **water piping materials** should be one or more of the following:
 - pipes of 75mm and larger diameter:
 - high impact PVC pipes with vitaulic joints.
 - steel pipes with internal and external corrosion protection or other flexible (as defined in SABS 0102 Part 1) water pipes with flexible, self anchoring connections.
 - pipes having a diameter of less than 75mm:
 - HDPE type IV piping
 - polypropylene piping

The piping used in mains and communication pipes should be flexible, joints should be minimal in number and, be of the flexible, self anchoring type, i.e. not reliant on thrust blocks or friction for their anchorage.

- k. Where feasible provision for **future connections** shall be made in order to minimise the cutting into pipes to provide such connections.
- l. Provision shall be made in **all water bearing pipelines** to accommodate any potential differential movements without causing the pipeline or joints to leak. Also use flexible coupling either side of **manholes**.
- m. **Road surfaces** shall be located sufficiently low so as to permit the drainage of erven onto them.
- n. **Roadways**, which have a gradient of less than 1:80, shall be surfaced/sealed.
- o. During **construction excavations** should be opened and closed as rapidly as possible. Avoid leaving trenches open over weekends or holidays.
- p. Berms should be constructed on either side of the **trenches** to prevent the inflow of water during storms.
- q. **Construction site camp services** should also be subject to the precautionary measures as above and below.
- r. The backfilling to **service trenches and other excavations** shall, except in rock, not be more permeable than the surrounding material. (General minimum compaction standard of 93 % Mod AASHTO). The use of non-cohesive single size graded sand or crusher sand for bedding, surround blankets and backfill should not be permitted. The backfilling to service trenches and other excavations shall, except in rock, not be more permeable than the surrounding material.
- s. Blasting during construction and service installation:
Experience elsewhere on dolomite indicates that blasting may lead to severe disturbance of the metastable dolomite environment giving rise to sinkhole formation. Consequently, if blasting proves essential the following recommendation is made:
Emphasis should be placed on minimal disturbance of the environment in order to reduce the likelihood of triggering events. It is essential that appropriately experienced blasters or companies are approached to determine the particular method specification for blasting, regarded as appropriate in the context of the geological conditions.

Plumbing

- a. All sewer and water pipes and fittings shall be provided with flexible, self-anchoring joints.
- b. The use of surface mounted water pipes from the roof downward or on external walls is preferred. The chasing of water piping into walls should be kept to a minimum.
- c. No plumbing and drainage pipes shall be placed under floor slabs, as far as is practicable.
- d. The fall of the trenches shall be away from the buildings.
- e. Pipes through walls shall be sleeved to permit relative movement.
- f. WC pans shall be provided with a flexible connection at the junction with the outlet pipe.
- g. Water pipes shall have a minimum cover of 500mm.
- h. Wherever practical, the fall of trenches shall be away from buildings and shall not be excavated along the length of housing units within the first 3,0m beyond the perimeter of such units.
- i. The selection of piping material shall take cognisance of corrosion (both external and internal), should preferably be welded HDPE or alternatively PVC with victualic joints.

Stormwater

- a. Natural ponds and watercourses located within 30 m of any structure shall be rendered impervious up to a point at least 60 m away from the building. (Design criteria: 1 in 5 year flood capacity minimum).
- b. Use aprons of large (2,0 m min width) impervious paved areas around structures to enhance drainage.
- c. Storm water drainage around buildings should preferably be kept on the surface or in open canals at slopes of not less than 1:50 for surfaced areas and canals, and 1:20 minimum for unsurfaced areas. All surfaces shall slope away from buildings. Drainage in passages or between buildings needs to slope away from structures and drain along the centre of open space. No drainage toward a structure is to be allowed. Preferably use 1m or wider, V-shaped concrete drains.
- d. The storm water drainage system shall incorporate measures to ensure water tightness of conduits, canals and other compartments. All pipes should be tested for leakage using standard air or water tests. All pipes and structures to be tested to show zero percent leakage.

- e. Open drains to be preferably shallow 1000 mm (min) wide in-situ cast V - shaped drains with sealed key type construction and expansion joints and steel reinforcement (if applicable) continuous over joints to disallow horizontal displacement.
- f. Storm water drainage conduits should be constructed at gradients, which will not permit the deposition of silt, or sand, of the type present in the catchment area. In order to deal with rain water run off from the roofs of structures the following is recommended:
 - If guttering is used, then the down pipes should discharge into a lined, watertight stormwater canal or precast furrow. This canal should discharge the water at least 5m away from the structure, where it should drain freely, without ponding to the stormwater system and off the site.
 - If no guttering is to be utilised then it is recommended that at least 3 to 4m sealed surface be cast along those walls of the structure where water will be discharged from the roof. Water will cascade off the sloping roof onto the slab and be distributed away from the foundations and should drain freely, without ponding, into the stormwater system.
- g. Concrete apron slabs or brick paving should have a minimum of 1:20 fall away from buildings.
- h. Drainage canals traversing walkways should not be piper under walkways. Use impervious canals and grids.
- i. Brick and precast concrete courtyard walls, etc. must be so designed as to provide drainage ports at ground level to permit the passage of water.

Sewer

- a. Sanitation systems should not incorporate soakaways. Use conservancy tanks with low flush volumes where sewer connections are not available. Sewer works or maturation ponds should be located well away from the development (>200m).

Subsurface sewer pipe materials should be as follows:

- HDPE: Within 15 m of building.
SABS 533 Type 4 Part II - Class 6
Use electro fusion or butt-welded joints to improve water tightness.
Preferably use a manhole when linking different pipe material types.
The use of pre-manufactured HDPE manholes is advised.
 - PVC: Only to be used beyond 15 m from structures.
SABS 791 Heavy duty - Class 34 (solid wall).
- b. All connections to manholes should be flexible.
 - c. All sewerage pipes must be watertight. All laid drainage and sanitary sewer pipes should be tested for leakage using water test on installation. Welded HDPE pipe systems to be pressure tested.
 - d. All sewers and structures to be tested to zero percent leakage for water tests.
 - e. Avoid using rodding and cleaning eyes and rather use small HDPE manholes (multi directional collecting pots), which are pre-manufactured small size (300, 500 and 700 mm diameter) manholes with factory fitted HDPE benching and covers. Piping from the manhole to surface level shall consist of HDPE pipes and long radius bends with electro fusion/butt welded connections.

Water

- a. The piping used in mains and communication pipes should be flexible, joints should be minimal in number and of the flexible, self anchoring type, i.e. not reliant on thrust blocks or friction for their anchorage.
- b.
- c. Subsurface water pipe materials should be one or more of the following, depending on existing service on the site:
 - Pipes of 75mm and larger diameter
 - * Preferred – HDPE piping 9SABS 533 Type 4, Class 12) with butt-welded joints for pipes and fittings.
 - * Alternative- high impact PVC pipes 9SABS 966, class 12) with victualic joints.

- Pipes having a diameter of less than 75mm
 - * HDPE pipe (SABS 533 type 4, Class 16) with butt-welded joints. Piping from main reticulation to the buildings should be unjointed HDPE Class 16.
- d. Underground valves to be placed in watertight manholes.
- e. No high-pressure compression connections to be allowed below ground level. All connections to be placed in watertight manholes.
- f. Shut-off valves and water meter shall be supplied at main supply with permanently fixed pressure gauge on the building side of the main shut-off valve (for regular systems testing).

Swimming Pools

- a. Swimming pools should be designed as self contained, rigid structures capable of bridging local ground settlement.
- b. Backwash and other water from swimming pools, shall be discharged via HDPE piping into either the stormwater or drainage systems as required by the local authority. Discharge point to be closer than 20m from pool or any other structure.
- c. The area surrounding the swimming pools shall be totally impervious (concrete paving) for a distance of at least 5 meters with provision of a drainage canal to collect splashed water.
- d. The pool shall not have an automatic replenishment system.
- e. Dolomite risk specialist to advise on placing of pool (not closer than 5m to buildings).

Electricity and Communication

- a. The sleeve and draw box systems for electrical and communication cables shall also be water tight, flexible and constructed to avoid water entering the system. HDPE piping and small diameter manholes as described for sewers above are ideally suited for this purpose.
- b. Trenching, backfilling and compaction of trenches to be similar as for wet services.
- c. The use of non-cohesive single size graded sand or crusher sand for bedding and surround blankets and backfilling of trenches shall not be allowed. Construction detail to be similar as for water and sewer pipes.

7.2.7 Areas of restricted movement

No areas of restricted movement are identified.

7.2.8 **Maintenance programme**

This programme must take account of short, medium and long term maintenance requirements in relation to the nature, age and type of services and structures, prioritises maintenance tasks according to monitoring area designations and establishes the work and procedures associated with the following:

- 1) routine service replacement;
- 2) repair of service after damage;
- 3) repair of service after instability;
- 4) responsibilities for undertaking repairs and the like.

7.2.9 **Emergency reaction programme**

Despite man's best effort to minimise the occurrence of instability, the occurrence of sinkholes, dolines and severe cracking of structures or of the ground surface cannot be totally precluded. Treatment of dolomite related instability consists of five components:

- a) emergency reaction;
- b) timeous reporting;
- c) investigation of incident;
- d) rehabilitation; and
- e) ongoing monitoring

As the development consists mainly of full-title Residential 1 type stands the responsibility of emergency reaction in the event of sinkhole formation and the handling thereof (investigation, rehabilitation and monitoring thereof) rests with the Local Authority.

Property owners should be advised to contact the Local Authority in the event of sinkhole formation at 012 310 6300 or 012 310 6400, which is Tshwane Metropolitan Municipality's one Stop Emergency Number, or 012 358 2111 in the event of non-threatening sinkholes (i.e. a sinkhole in the veld some distance away from development).

In the event that a sinkhole has ruptured water-bearing pipes on a private property the water supply must immediately be turned off at the municipal connection to the property.

7.2.10 Recording of incidents sinkhole or doline formation, damage and actions taken

As the development consists mainly of full-title Residential 1 type stands this responsibility rests with the Local Authority.

7.2.11 Dolomite risk awareness programme

As the development consists mainly of full-title Residential 1 type stands this responsibility for dolomite risk awareness rests with the Local Authority.

It is advisable that the Section 21 company be informed of the risks involved in residing on dolomite and how to manage these risks. In the interest of good risk management every owner, as well as new owners, should be issued with the Risk Management Strategy.

7.2.12 Lodging of reports, records relating to routine service replacement and the repair of service after damage or instability, ground subsidence events and structural damage in an accessible databank

As the development consists mainly of full-title Residential 1 type stands this responsibility rests with the Local Authority. In the interest of owner risk management the Section 21 Company:

- should store a copy of the Intraconsult and VGIconsult reports referenced in Section 3
- should store a copy of the township services layout and Site Development Plan.
- should, upon completion of the investigations scheduled for the Residential 2 stands, add the information to the Companies database for future reference.

7.2.13 Registered servitudes of wet services which traverse the property and are not maintained by the Local Authority

There are no such registered servitudes in this development.