

Queenstown Country Club

Appendix 5: Preliminary Geotechnical Report

Expression of Interest for a Special Housing Area
On behalf of Sanderson Group Ltd

April 2016





Preliminary Geotechnical Report

Queenstown Country Club,
Lower Shotover, Lake Hayes
Queenstown

Report prepared for:

Sanderson Group

Report prepared by:

GeoSolve Ltd

Distribution:

Sanderson Group

John Edmond & Associates

GeoSolve Limited (File)

April 2016

GeoSolve Ref: 160041



Table of Contents

1	Introduction	3
1.1	General	3
1.2	Development	3
2	Site Description	3
2.1	General	3
2.2	Topography and Surface Drainage	3
3	Expected Subsurface Conditions	4
3.1	Geological Setting	4
3.2	Stratigraphy and Geological Conditions	5
3.3	Groundwater	5
3.4	Natural Hazards	5
3.4.1	Seismic	5
3.4.2	Slope Stability	5
3.4.3	Liquefaction	6
3.4.4	Alluvial Fan	6
4	Preliminary Engineering Considerations	7
4.1	General	7
4.2	Excavations	7
4.3	Construction near Slope Crests	7
4.4	Foundations	7
4.5	Rock Fall	7
4.6	Groundwater issues	8
5	Neighbouring Structures/Hazards	8
6	Conclusions and Recommendations	9
7	Applicability	10

1 Introduction

1.1 General

This report presents the results of a preliminary geotechnical assessment undertaken by Geosolve Ltd to provide comment on the geological hazards, subsoil conditions and geotechnical issues expected to be present at the proposed Queenstown Country Club development, State Highway 6, Lower Shotover/Lake Hayes, Queenstown.

This report has been completed in accordance with the terms and conditions outlined in Geosolve proposal reference 160041, dated 15 March 2016.

The aim of this report is to provide a preliminary geotechnical assessment of the proposed development areas to support a Special Housing Area 'expression of interest.' The comments and recommendations provided should be confirmed by further investigations and engineering assessment during the detailed design stage of a future development.

1.2 Development

Plans provided to Geosolve indicate the proposed development will comprise residential retirement/residential housing, with associated larger accommodation, commercial and support buildings. Significant infrastructure (e.g. storm water) hardstand, pavement and landscaped areas will also be required. Building heights are expected to be predominantly single storey, occasionally 2 storey and with 1 building being a maximum of 3 storeys. The extent of the proposed development is shown on Figure 1b, Appendix A.

2 Site Description

2.1 General

The proposed development is located between the existing Lake Hayes Estate and Shotover Country sub-divisions, and is divided into two distinct areas, one in the north and one in the south. The northern area is located immediately south of State Highway 6 (Frankton Ladies Mile Highway), extending approximately 450m southward from the highway. The southern area is located a further 450m to the south. A third smaller area of the proposed development is located to the south east and is accessed from Onslow Road in Lake Hayes Estate.

Both northern and southern sites are primarily undeveloped farmland however an existing dwelling is present in the northern area. The location of the sites, and principle observations are shown on Figure 1b, Appendix A. General Views of the site development areas are shown on the Photographs provided in Appendix B.

2.2 Topography and Surface Drainage

Most of the development, with the exception of the Onslow road portions, is in an elevated position above the adjacent Lake Hayes Estate and Shotover Country Subdivisions. The sites are located on the highest historic river terrace of the Shotover River, being approximately 50-60m above the nearby Kawarau and Shotover Rivers which located 400m to the south and 1.2km to the west respectively.

Northern Area: The ground surface is sub-horizontal to gently sloping ($<5^\circ$) in a southern direction with an approximate RL of 360m. Surface water flows will be in a southerly direction. Along the southern boundary the ground falls 15m down a historic river terrace slope (see Photographs 3, Appendix B) which has typical slope of 25-35°.

Southern Area: This area of the development is located on the northern side of a low hill which falls at various grades in a north/north east direction towards Lake Hayes estate. Much of the site area is a gently sloping historic river terrace (approx. RL 360) however steep ground climbs immediately south of the property, with the summit of the low hill being 250m south and 80m higher than the terrace area. On the north eastern boundary of the property a historic river terrace slope is present which falls approximately 20m at 25-35° to Lake Hayes Estate. The portion of the development accessed from Onslow Road is at the base of this slope. The low hill is shown on Photograph 2 and the north eastern river terrace slope on Photograph 4, Appendix B.

3 Expected Subsurface Conditions

3.1 Geological Setting

The site is located in the Wakatipu Basin, a feature formed predominantly by glacial advances, the last of which occurred approximately 10,000-20,000 years ago. The glaciation scoured the schist bedrock and left extensive deposits of till, outwash gravels and lake sediments. Post glacial times have been dominated by erosion of both the schist bedrock and overlying sediments and by localised deposition of alluvial deposits by rivers and streams.

The development sites are located on the historic Shotover Delta. This feature formed by the deposition of sediments during a period of high lake levels. Subsequent lowering of the lake, and down cutting by the Shotover and Lake Hayes River has resulted in a series of elevated historic river terraces across this area of Lower Shotover.

No active fault traces are known in the vicinity of the site, however, a significant seismic risk exists in the region from potentially strong ground shaking associated with rupture of the Alpine Fault located on the west coast of the south Island. There is a high probability that an earthquake with a magnitude of 7.5 to 8 will occur along the Alpine Fault within the next 50 years.

An excerpt from the regional geological map is provided on Figure 1a. The map indicates the development area is located on Q1a deposits described as 'Gravel and Sands in Alluvial Fans.' The low hill to the south of the southernmost development is shown as a Schist rock exposure.

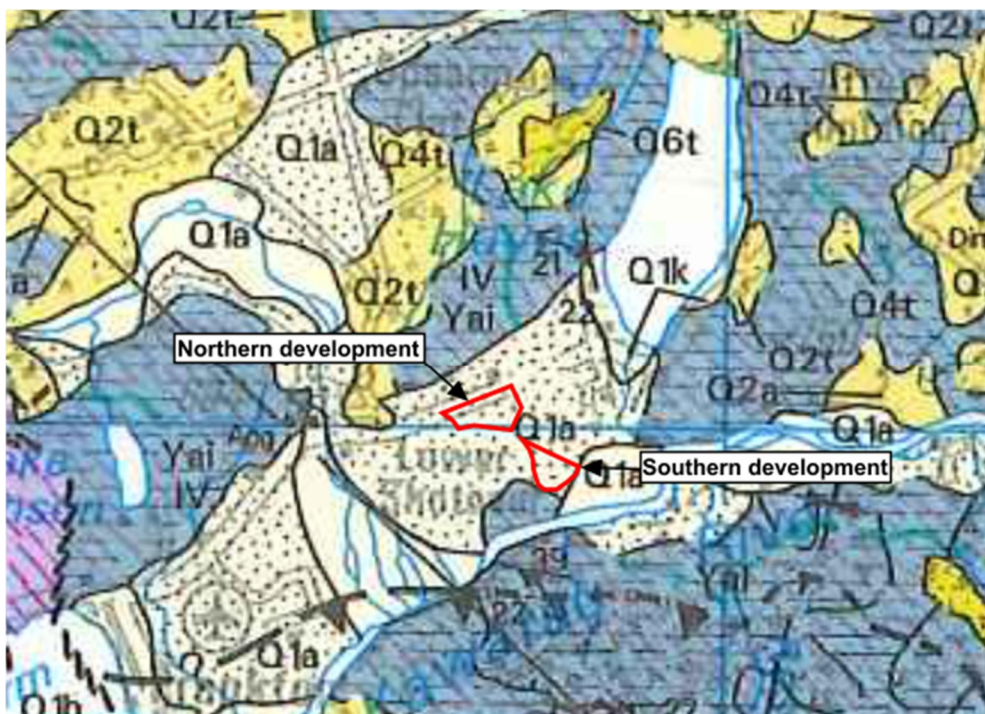


Figure 1a. Excerpt from the Institute of Geological and Nuclear Sciences 1:250,00 Scale Map, 18, Wakatipu.

3.2 Stratigraphy and Geological Conditions

A review of available data, published mapping together with site observations has been completed and the site stratigraphy over the gently sloping river terrace areas is expected to comprise.

- Topsoil, overlying;
- 0.1m to 1.0m thickness of Loess, overlying
- 0.0-1.0m of localised Alluvial Silt, overlying;
- A significant thickness (10-70m+) of interbedded Deltaic sand and gravel deposits with varying fractions of each constituent material.

In close proximity to the low hill present immediately south of the southern development, steep slope areas are expected to be underlain by:

- Topsoil, overlying;
- Slope Colluvium, overlying;
- Glacial soils (till and outwash) deposits, overlying;
- Schist bedrock present at shallow depths and exposed at the surface in elevated locations.

A review of available Otago Regional Council (ORC) bore data for the northern area of the development indicates the depth of the Deltaic deposits is in excess of 66m. The location of the ORC boreholes (reference F41/0134 and F41/0239) are shown on Figure 1b, Appendix A.

3.3 Groundwater

The regional groundwater is expected to lie well below typical foundation and excavation levels. Groundwater levels are expected to rise gently from the Kawarau and Shotover Rivers beneath the development areas. This observation is confirmed by available ORC well data in the northern development area which indicates groundwater to be 51m and 40m below ground level in wells F41/0104 and F41/0134. The location of these wells is shown on Figure 1b, Appendix A.

Perched seepages may be encountered at shallow depths in the Hillside area to the south, and near the Onslow Road development.

3.4 Natural Hazards

3.4.1 Seismic

A significant seismic risk is present across the region, as discussed in Section 3.1 above.

3.4.2 Slope Stability

The following comments are provided with respect to slope instability:

- No deep seated, recent or active slope instability of the soils slopes was observed during the site walkover, and no known risks are present on the Queenstown Lakes District Council (QLDC) GIS system.
- Historic shallow movement of the river terrace slopes has occurred in some localised areas, with small fan features and crest deformation present in some areas.
- Small scale rock fall associated with localised weathering and gradual fretting of the rock was observed from the bluffs present in the southern area of the development.

3.4.3 Liquefaction

The QLDC GIS mapping system indicates both northern and southern development areas are in an area designated as 'possibly susceptible' to liquefaction. This assessment is based on a regional study completed by Opus Consultants in 2002, see Figure 1c, Appendix A.

The depth to groundwater (40m+), and subsequent studies completed in adjacent areas, indicate liquefaction is nil to low in the development area. This area is considered, by Geosolve, to be the equivalent of LIC1 with respect to liquefaction investigation category.

3.4.4 Alluvial Fan

No alluvial fan hazard has been identified at the site, and none are indicated on the QLDC GIS mapping system, see Figure 1c, Appendix A.

4 Preliminary Engineering Considerations

4.1 General

The proposed development is expected to be achievable from a geotechnical perspective. Ground conditions will largely be similar to the adjacent Frankton Flats, Lake Hayes Estate and Shotover Country Developments, however, further investigation and assessment will be required during the detailed design phase and recommendations are provided in the sections below.

The preliminary recommendations and opinions contained in this report are based upon ground investigation data obtained at discrete locations and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

Site specific intrusive investigations should be completed at the detailed design phase of the project to confirm all recommendations provided in this report.

4.2 Excavations

Excavations can be readily achieved across the site area. If deep excavations are required, geotechnical investigation should be completed to confirm the near surface soil profile and appropriate temporary and permanent batter angles and any retaining issues.

4.3 Construction near Slope Crests

Development plans indicate buildings will be located close to slope crests. During the detailed design phase slope stability analysis for static and seismic (serviceability and ultimate limit state) cases should be completed. The analysis should determine the factors of safety against failure, and the location and magnitude of any surface displacement expected. Building set-back distances and/or specific foundation design requirements can then be incorporated into the detailed design.

4.4 Foundations

Shallow foundations can be constructed across the site, however reduced foundation bearing capacities are likely if bearing on surface silt deposits. Increased foundation bearing is expected to be available at depth on sand and gravel materials.

Specific foundation design, or deeper foundations may be required where construction close to slope crests is indicated. Investigation and analysis will be required to determine foundation and/or building set-back requirements in these areas (see Section 4.3).

Specific investigation and assessment should be completed to determine a cost effective foundation solution for the proposed buildings.

4.5 Rock Fall

Bluffs are present in the southern area of the proposed development. Preliminary assessment indicates the risk of rock fall is low, however some weathering and minor fretting of the rock face was observed in some areas. Detailed inspection and assessment of these areas should be completed. If adverse instability is identified measures such as fences, scaling, removal, rock fall mesh, spot bolts and anchoring will be appropriate to address any identified stability concerns.

4.6 Groundwater issues

No significant ground water issues are expected, however minor seepages may be encountered if excavation close to the hill in southern areas of the site is undertaken as is typical of hillside developments in the Wakatipu area.

5 Neighbouring Structures/Hazards

Distances to adjoining structures: The site is situated close to developed residential areas with the neighbouring buildings in close proximity. The existing developments are not expected to be adversely effected provided geotechnical input to the project is provided at the detailed design and construction phase.

Aquifers: No aquifer resource will be adversely affected by the development. If ground source heating, water abstraction, or other deep drilling activity is undertaken, consenting may be required with respect to groundwater and confirmation should be sought from the local and regional councils.

Hazards: A regional seismic hazard is present in the Wakatipu area. No specific investigation and assessment is considered necessary with respect to alluvial fan and liquefaction hazards. Slope stability and rock fall hazards are discussed above in Sections 4.3 and 4.5.

6 Conclusions and Recommendations

- From a geotechnical perspective construction of the development is considered technically feasible. Developments have been readily achieved in similar ground conditions across the Shotover, Lake Hayes and Frankton Areas.
- Preliminary assessment indicates standard engineering solutions will be available to address any likely geotechnical issues that may arise.
- There is a region wide seismic risk at the site which should be addressed in all future engineering design. Further assessment with respect to liquefaction and alluvial fan hazards is not considered necessary.
- Further investigation and assessment will be required at the detailed design phase of the project. The assessment should confirm the preliminary recommendations in this report, provide detailed engineering recommendations as appropriate. The principle geotechnical issues to be addressed include:
 - Confirmation of the near surface soil stratigraphy and foundation bearing capacities;
 - Stability/ set back and foundation options for buildings located close to river terrace slope crests;
 - An inspection of rock fall/bluff instability and any requirements in the southern area of the site.
 - Other geotechnical inputs as required for detailed design e.g. Pavement CBR values for roadway construction, safe temporary and permanent batter angles.

7 Applicability

This report has been prepared for the benefit of the Sanderson Group with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Report prepared by:

A handwritten signature in blue ink, appearing to read "Paul Faulkner".




.....
Paul Faulkner

Senior Engineering Geologist

Appendix A



Key

-  = Bore Hole location
-  = Well location
-  = Slope angle and direction

Scale 1:8000

0 100 200 300 400(m)

GEO SOLVE

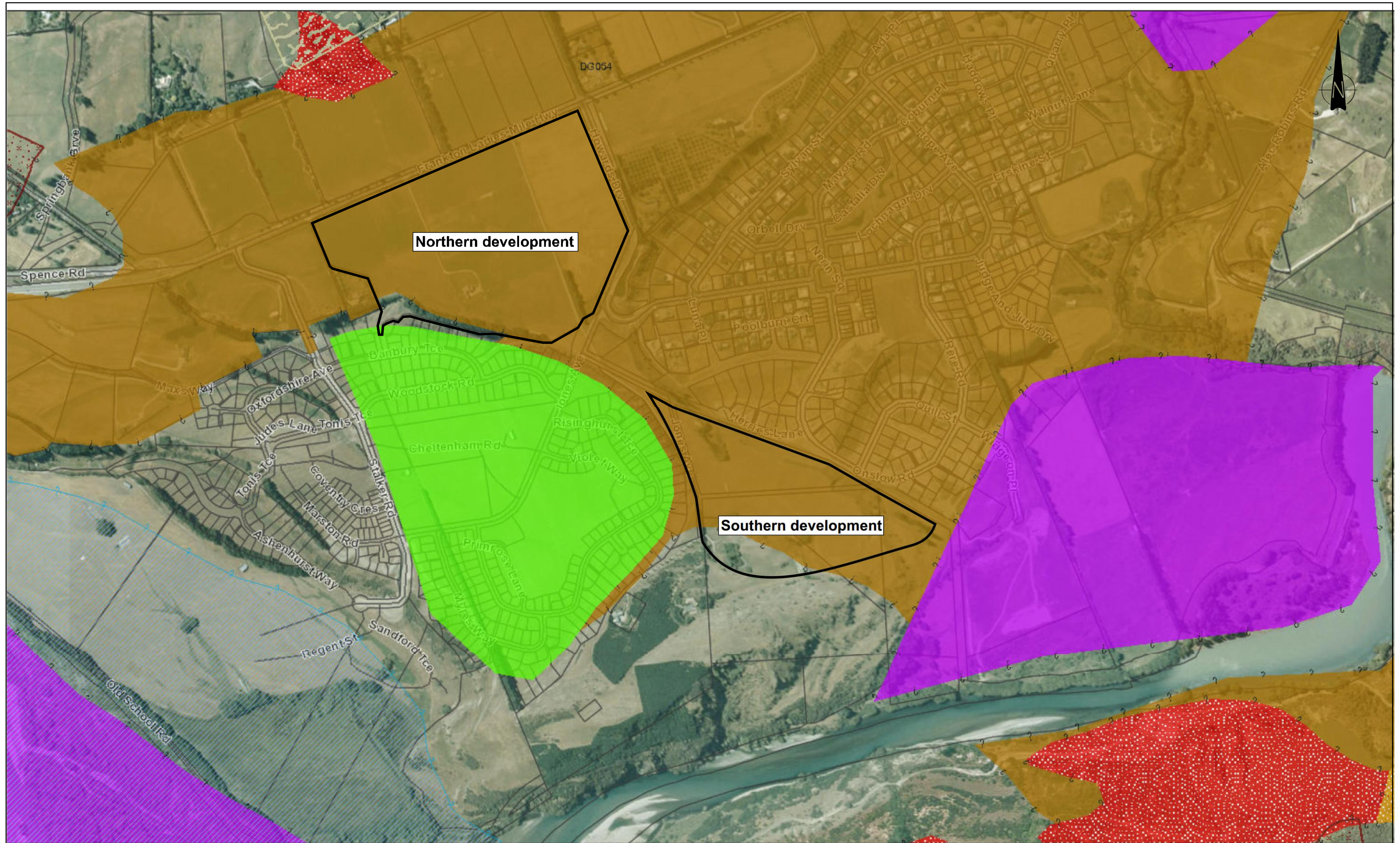
GEOTECHNICAL ENGINEERING • GEOHYDROLOGY & HYDROLOGY
ENGINEERING GEOLOGY • PAVEMENT STRUCTURAL TESTING

DRAWN	GXS	03/16
DRAFTING CHECKED	PCF	03/16
APPROVED	PGF	03/16
FILE : PDF		
SCALE: (AT A3 SIZE) 1:8000		
PROJECT No. 160041		

SANDERSON GROUP
Preliminary Geotechnical Assessment
Queenstown Country Club
Site Plan

FIG No. Appendix A - Figure 1b

REV: 0



Key

- = Liquefaction Risk: Nil to Low (T&T 2012)
- = Liquefaction Risk: Possibly Susceptible (Opus 2002)
- = Liquefaction Risk: Susceptible (Opus 2002)
- = Flooding due to Rainfall
- = Alluvial Fan (Regional scale) Active, Debris-dominated

Scale 1:8000
 0 100 200 300 400(m)



DRAWN	GXS	03/16
DRAFTING CHECKED		
APPROVED		
FILE : PDF		
SCALE: (AT A3 SIZE) 1:8000		
PROJECT No. 160041		

SANDERSON GROUP
 Preliminary Geotechnical Assessment
 Queenstown Country Club
 QLDC Hazard Map

FIG No. Appendix A - Figure 1c

REV: 0

Appendix B



Photograph 1. General view looking south west across the gently sloping farmland of the northern development area.



Photograph 2. General view looking south across the southern development area. Steep ground and rock bluffs are present in the distance, the gently sloping areas in the foreground and river terrace slope on the left.



Photograph 3. River terrace slope on the south western boundary of the northern development (to be located at the crest), with the Shotover Country sub-division at the slope toe.



Photograph 4. The river terrace slope along the northern eastern boundary of the southern development, with Lake Hayes Estate and Herries Lane at the slope toe.