Tonkin & Taylor

T&T Ref: 880360.00/LR001
04 April 2013

Queenstown Lake District Council
Private Bag 50072
Queenstown
9348

Attention: Ryan Clements

Dear Ryan

Queenstown Lakes District 2012 Liquefaction Hazard Assessment

Summary Report

1.0 Introduction

This letter report presents the results of a liquefaction risk assessment of the Queenstown Lakes District region. This assessment has been completed by Tonkin & Taylor Ltd (T&T) at the request of the Queenstown Lakes District Council (QLDC) and in accordance with the terms and conditions outlined in T&T proposal reference number 880360.00/LoE001. The work presented below was completed in October and November 2012.

2.0 Assessment Aim and Methodology

The aim of this assessment is to refine the current QLDC liquefaction hazard maps using existing available ground investigation data. In addition to refining the mapping, further information with respect to the expected liquefaction risk, and an appropriate level of ground investigation, has be determined for the mapped areas. It is understood this information will be used to guide planners, developers and regulatory bodies when determining an appropriate level of ground assessment required for a particular area.

3.0 Information Sources

The following sources of information have been used to complete this assessment;

- Published geological information;
- Data held on the T&T database e.g. test pit, borehole, cone penetrometer and field mapping, from detailed geotechnical assessments complete across the Queenstown Lakes District;
- Otago Regional Council well and groundwater data, and;
- Information from other geological or geotechnical consultants where appropriate.

4.0 Proposed Liquefaction Categories and Mapping

Liquefaction Investigation Categories (LIC) have been developed to provide guidelines on the liquefaction risk and recommended level of further investigation for a particular area. The categories range from LIC 1, for areas with an assessed low to nil risk of liquefaction, to LIC 3 (P), for areas which are assessed to have a 'possibly high' risk of liquefaction. The different categories reflect the level of information available for a particular area, and, where feasible, if liquefaction is expected to occur. Guidelines on the minimum requirements for ground investigation, and general comments/recommendations are also provided for each category.

Full details of the proposed liquefaction categories are provided on the attached table.

5.0 Department of Building and Housing Guidelines

This assessment correlates closely with work undertaken in Canterbury following the 2010 and 2011 earthquake events. In Canterbury a method to categorise the land based on the potential for vertical settlement and lateral spread (liquefaction deformation limits) has been developed. Department of Building and Housing (DBH) guidelines identify Technical Categories TC1, TC2 and TC3 with respect to ground movement in the Canterbury area, and also identify the minimum requirements for site investigation and appropriate methodologies for liquefaction analysis. (These 3 categories relate to the corresponding Liquefaction Investigation Categories.)

The engineering requirements outlined by the DBH are considered appropriate for use in the Queenstown Lakes District and reference should be made to the DBH document "Guidelines for the investigation and assessment of sub-divisions on the flat in Canterbury – Minimum requirements for geotechnical assessment for land development ('flatland areas' of Canterbury region).

6.0 Limitations

The information presented on the attached table and maps is limited by the availability of actual ground investigation data. It should be noted that the information used in this assessment was obtained in discrete locations and was not always obtained specifically for the purposes of completing liquefaction assessment work. A certain level of extrapolation was therefore required to determine the extent of the zones shown on the attached maps. It is therefore possible that areas at risk of liquefaction exist outside the mapped areas, and the mapped areas may be subject to a change of category if further ground investigation data becomes available.

The summary maps are provided to give a quick overview of the mapped areas only. It is recommended that the QLDC GIS mapping be consulted for actual assessments of any particular area.

7.0 Further Work

Specific geotechnical investigations would be required to further refine the mapping and extents of the categories as shown on the attached summary maps. All investigations should be completed in accordance with the DBH guidelines and are likely to comprise a combination of the following:

- Field mapping;
- Test pitting;
- SWS (Swedish Weight Sounding) testing
- Heavy Dynamic Cone Penetrometer testing
- Cone Penetrometer testing, and;
- Geotechnical drilling with standard penetration testing.

It should be noted that field mapping and test pitting can only assess the ground at shallow depths and are therefore only suitable in limited cases for the purposes of assessing liquefaction potential. In accordance with the DBH requirements, light penetrometer testing (Scala) is not considered appropriate to be the primary method to determine the liquefaction potential. Appropriate ground investigation techniques are outlined in the DBH document "Guidelines for the investigation and assessment of sub-divisions on the flat in Canterbury – Minimum requirements for geotechnical assessment for land development ('flatland areas' of Canterbury region).

Site investigations should extend to sufficient depth to identify potentially liquefiable formations that may lie beneath surficial deposits such as beach gravels and alluvium.

Refining the maps on an on-going basis may be feasible as ground investigations are periodically completed across the Lakes District area for private developments, however this approach is likely to take many years to address problem areas.

8.0 Applicability

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

TONKIN & TAYLOR LTD
Environmental & Engineering Consultants

Report Prepared By:

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Paul Faulkner
Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

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Graham Salt
Project Director, Dunedin Group Manager

Attachments: Table detailing the Categories for the Liquefaction Mapping
Summary Maps of the Queenstown, Wanaka, Glenorchy and Kingston areas

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Table showing the Categories for the Liquefaction Mapping, related to DBH requirements in response to Canterbury earthquakes

Liquefaction Investigation Category	Level of Data Available	Assessed Liquefaction Risk	Minimum requirements for geotechnical assessment for land development site investigations and reporting.	Comments	Probable Foundation Solution
LIC 1	Good knowledge of subsurface conditions from nearby sites in same geological terrain with no reported hazards.	Nil to Low	Additional geotechnical investigations are not mandatory (other than already prescribed in NZS 3604: Timber Framed Buildings to establish that the building platform is located entirely on ***good ground*** as defined in clause 3.1.3 of that standard). In the unlikely event that ***good ground*** is not confirmed or if saturated fine grained sediments (sands or silts) are present, then investigations shall proceed as for Zone LIC 2 (P).	Corresponds to DBH Technical Category 1 adopted for liquefaction following the Canterbury earthquakes. (LICC 1: Land damage from liquefaction is unlikely, and seismic ground deformations are expected to be within normally accepted tolerances.) Detailed investigations may still be required for non liquefaction related geotechnical aspects of the development, e.g. soft ground, deep cuts, fill placement, retaining wall design etc.	Use foundations as detailed in NZS 3604:2011 Timber Framed Buildings, as modified by B1/AS1 which requires ductile reinforcing in slabs (refer to the DBH's information sheet at http://www.dbh.govt.nz/seismicity-info)
LIC 1 Provisional LIC 1 (P)	Surrounding sites investigated with generally no reported hazards but there is limited ability to project stratigraphy because of variable geomorphology or distance from sites with subsurface investigations.	Probably Low. (Expected to be low but requires specific investigations for a definitive assessment of liquefaction).	Investigations shall be in accordance with NZS 3604: Timber Framed Buildings and with DBH Guidelines (see Note 1 below). In the event that ***good ground*** is not confirmed or if saturated fine grained sediments (sands or silts) are identified, then reporting shall proceed as for Zone LIC 2(P). Review required by an engineering Geologist or geotechnical engineer. Site investigations should extend to sufficient depth to identify potentially liquefiable formations that may lie beneath surficial deposits, such as beach gravels. If lake silts or sands, or other materials prone to liquefaction are identified then proceed to LIC2 (P).	LIC 1 is probable but uncertain. Depths of investigation may be reduced once stratigraphy is demonstrated to be consistent with surrounding sites.	If LIC 1 is confirmed, use foundations as detailed in NZS 3604:2011 Timber Framed Buildings, as modified by B1/AS1 which requires ductile reinforcing in slabs http://www.dbh.govt.nz/seismicity-info
LIC 2 (P)	Marginal to moderate liquefaction conditions identified elsewhere in the vicinity in similar terrain.	Possibly Moderate. (Nearest subsurface investigations are inadequate to establish a reliable category)	Deep geotechnical investigations and reporting in accordance with NZS 3604, DBH guidelines (see Note 1) and QLDC requirements, by a Certified Professional Engineer (CPEng).	LIC 2 is possible. (LIC 2: Minor to moderate land damage from liquefaction is possible in future large earthquakes.) Independent peer review recommended if any report recommends a solution without a recognised solution for liquefaction.	If LIC 2 is confirmed, use light- or medium-weight cladding, light-weight roofing with suspended timber floors and foundations in accordance with NZS 3604 Or Use foundation with enhanced slab (DBH Options 1 to 4, http://www.dbh.govt.nz/seismicity-info)
LIC 3 (P)	Severe liquefaction conditions identified elsewhere in similar terrain	Possibly High. (Nearest subsurface investigations are inadequate to establish a reliable category)	Deep geotechnical investigations and reporting in accordance with NZS 3604, DBH guidelines (see Note 1) and QLDC requirements, by a recognised geotechnical practitioner (CPEng).	LIC 3 is possible. (LIC 3 Moderate to significant land damage from liquefaction is possible in future large earthquakes) Independent peer review recommended.	If LIC 3 is confirmed, specific geotechnical engineering design required. Ground improvement or deep piles if suitable bearing layer <10 m. Slab support also required.

Notes

1) In view of the significance of the Alpine Fault to Queenstown, liquefaction considerations should now acknowledge procedures recently adopted in Canterbury. Engineering requirements should therefore be as in the Department of Building and Housing document "Guidelines for the investigation and assessment of subdivisions on the flat in Canterbury - minimum requirements for geotechnical assessment for land development ('flatland areas' of the Canterbury region)" http://www.dbh.govt.nz/subdivisions-assessment-guide
2) DBH requires that for each individual site, "visual assessment and reasonable enquiry does not suggest that the original classification (for liquefaction) is inappropriate and that normal geotechnical investigations are undertaken for the purposes of evaluating all other potential geotechnical issues". For areas not yet categorised for liquefaction, site specific investigations are required. Note that DBH considers: "Scala Penetrometer testing (refer NZS 4402:1998 Test 6.5.2) is often useful as a shallow investigation tool in conjunction with the methods outlined above. **However, Scala Penetrometer testing is not considered appropriate as the primary ground characterisation method for liquefaction purposes."**
3) Categories assigned in these maps assume founding within a metre of 2011 ground level or higher. For deeper excavations, site specific investigations are required.
4) Sections of the map that are not coloured have not yet been mapped for liquefaction in relation to current DBH criteria.

Key	Category	Assessed Liquefaction Risk	Minimum requirements for geotechnical assessment for land development site investigations and reporting.
	LIC 1	Nil to Low	Additional geotechnical investigations are not mandatory (other than already prescribed in NZS 3604: Timber Framed Buildings to establish that the building platform is located entirely on 'good ground' as defined in clause 3.1.3 of the standard). In the unlikely event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are present, then investigations shall proceed as for Zone LIC 2 (P).
	LIC 1 (P) (Provisional)	Probably Low. (Expected to be low but requires specific investigations for a definitive assessment of liquefaction).	Preliminary geotechnical investigations shall be carried out to establish that the building platform is located entirely on 'good ground' as defined in NZS 3604:2011 Timber Framed Buildings (Section 3). The investigations should also be carried out in accordance with DBH Guidelines. In the event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are identified, then reporting shall proceed as for Zone LIC 2 (P). Review required by an engineering geologist or geotechnical engineer. Investigations should extend to sufficient depths to identify potentially liquefiable materials present beneath surficial deposits such as beach gravel and alluvium.
	LIC 2 (P) (Provisional)	Possibly Moderate. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	LIC 3 (P) (Provisional)	Possibly High. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
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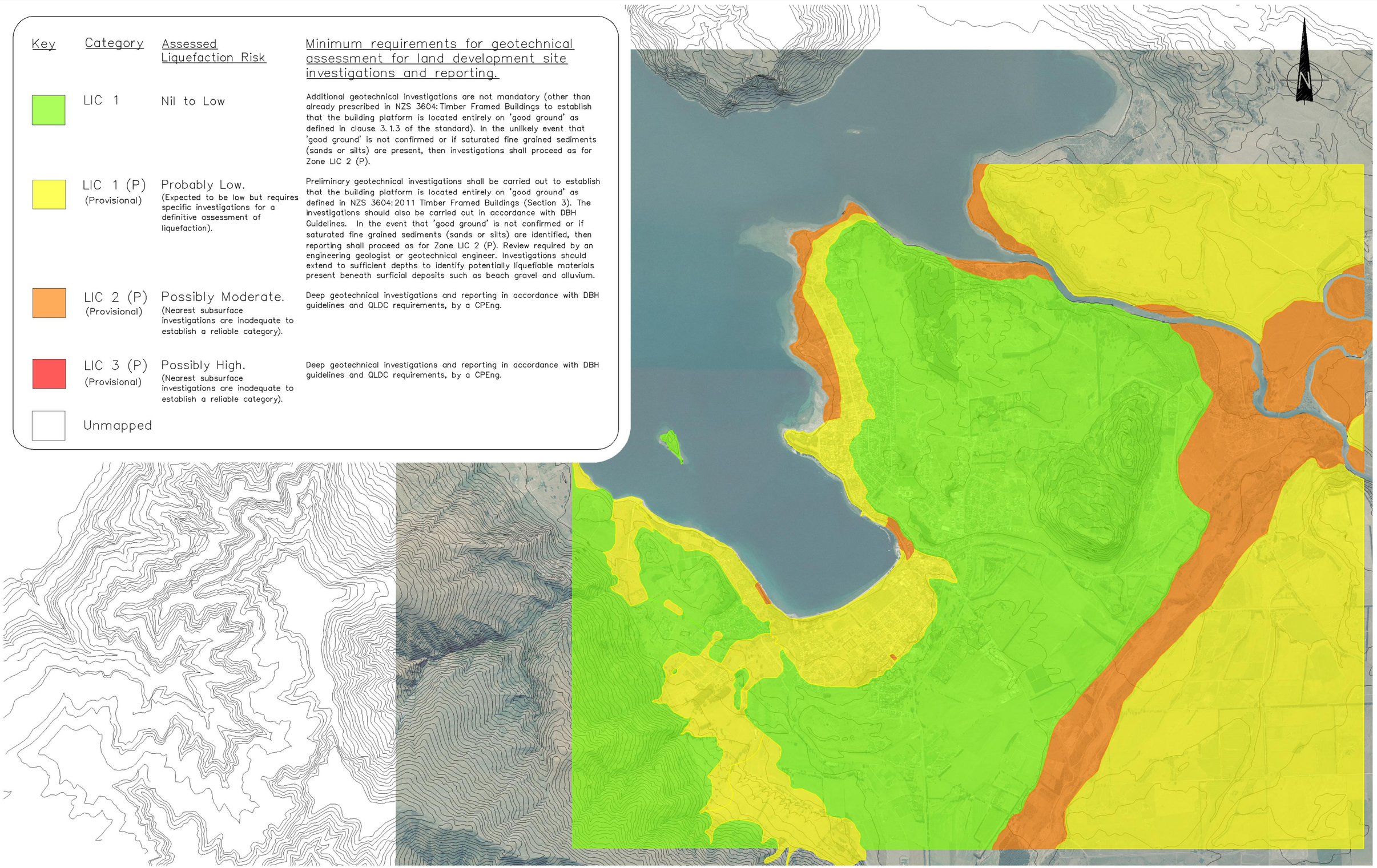

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QUEENSTOWN LAKES DISTRICT COUNCIL

WANAKA REGION LIQUEFACTION MAPPING
Overview

FIG. No. Figure 1

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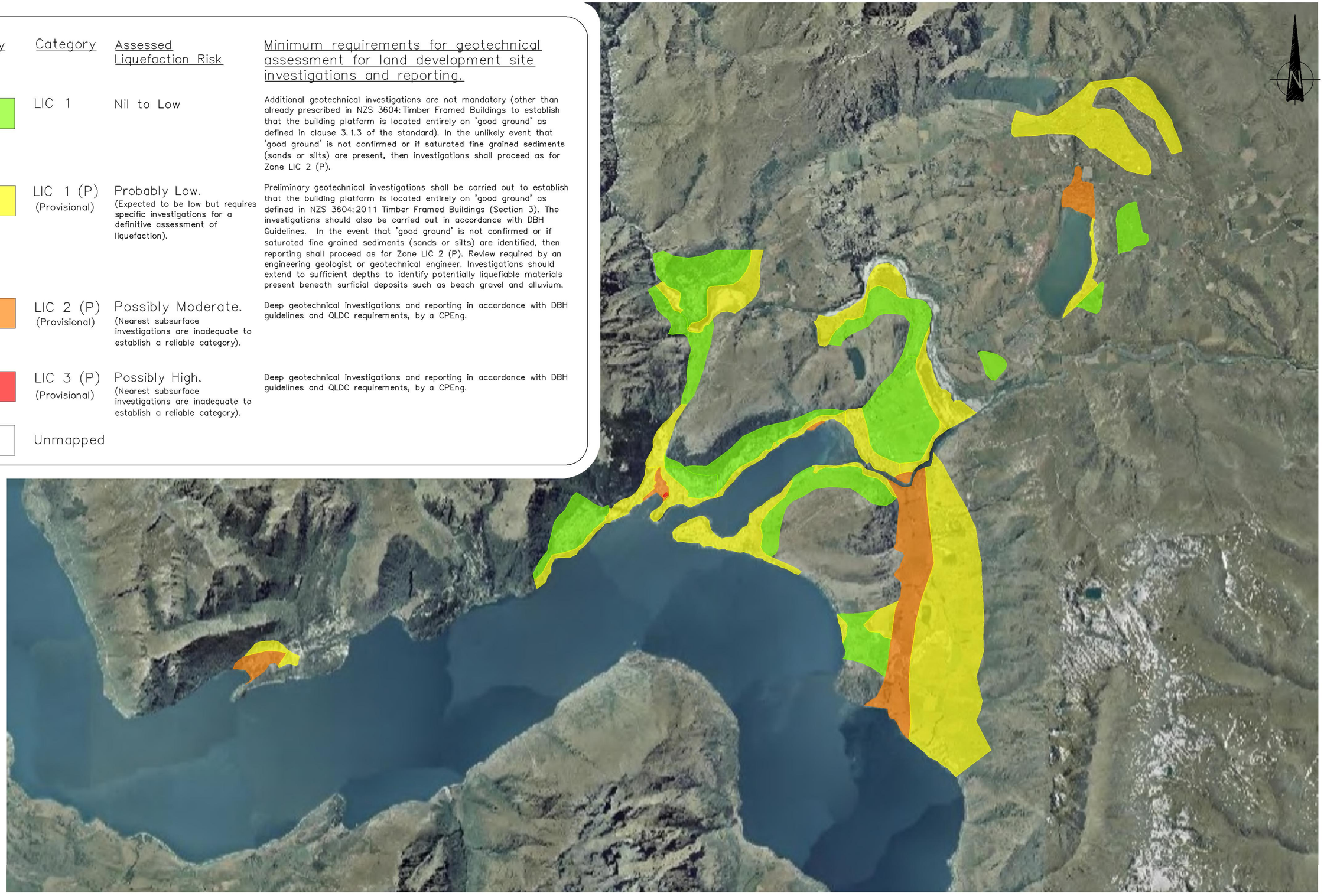
Key	Category	Assessed Liquefaction Risk	Minimum requirements for geotechnical assessment for land development site investigations and reporting.
	LIC 1	Nil to Low	Additional geotechnical investigations are not mandatory (other than already prescribed in NZS 3604: Timber Framed Buildings to establish that the building platform is located entirely on 'good ground' as defined in clause 3.1.3 of the standard). In the unlikely event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are present, then investigations shall proceed as for Zone LIC 2 (P).
	LIC 1 (P) (Provisional)	Probably Low. (Expected to be low but requires specific investigations for a definitive assessment of liquefaction).	Preliminary geotechnical investigations shall be carried out to establish that the building platform is located entirely on 'good ground' as defined in NZS 3604: 2011 Timber Framed Buildings (Section 3). The investigations should also be carried out in accordance with DBH Guidelines. In the event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are identified, then reporting shall proceed as for Zone LIC 2 (P). Review required by an engineering geologist or geotechnical engineer. Investigations should extend to sufficient depths to identify potentially liquefiable materials present beneath surficial deposits such as beach gravel and alluvium.
	LIC 2 (P) (Provisional)	Possibly Moderate. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	LIC 3 (P) (Provisional)	Possibly High. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	Unmapped		



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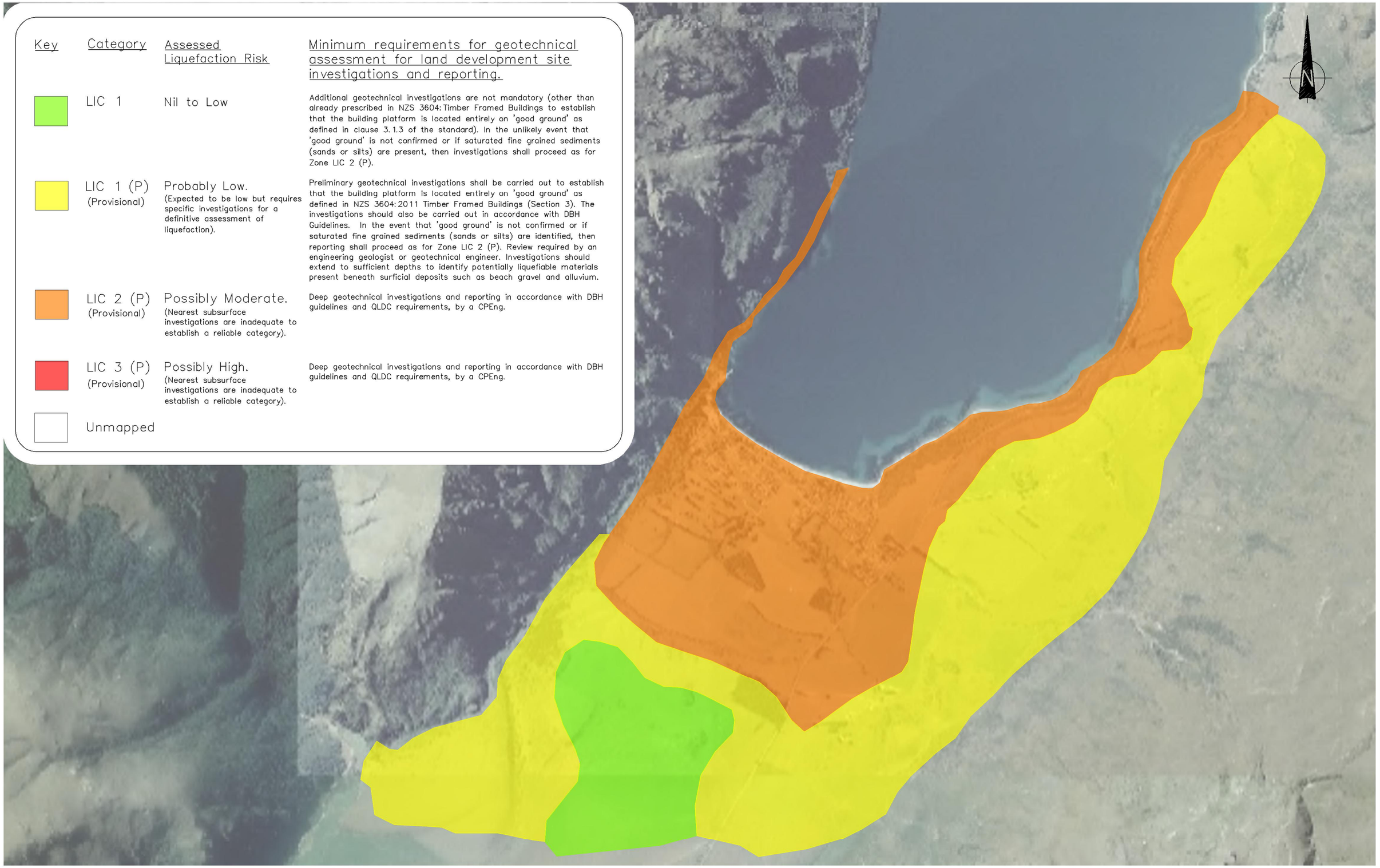
QUEENSTOWN REGION LIQUEFACTION MAPPING
Overview – Queenstown

FIG. No. Figure 2

REV. 6

Key	Category	Assessed Liquefaction Risk	Minimum requirements for geotechnical assessment for land development site investigations and reporting.
	LIC 1	Nil to Low	Additional geotechnical investigations are not mandatory (other than already prescribed in NZS 3604: Timber Framed Buildings to establish that the building platform is located entirely on 'good ground' as defined in clause 3.1.3 of the standard). In the unlikely event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are present, then investigations shall proceed as for Zone LIC 2 (P).
	LIC 1 (P) (Provisional)	Probably Low. (Expected to be low but requires specific investigations for a definitive assessment of liquefaction).	Preliminary geotechnical investigations shall be carried out to establish that the building platform is located entirely on 'good ground' as defined in NZS 3604: 2011 Timber Framed Buildings (Section 3). The investigations should also be carried out in accordance with DBH Guidelines. In the event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are identified, then reporting shall proceed as for Zone LIC 2 (P). Review required by an engineering geologist or geotechnical engineer. Investigations should extend to sufficient depths to identify potentially liquefiable materials present beneath surficial deposits such as beach gravel and alluvium.
	LIC 2 (P) (Provisional)	Possibly Moderate. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	LIC 3 (P) (Provisional)	Possibly High. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	Unmapped		



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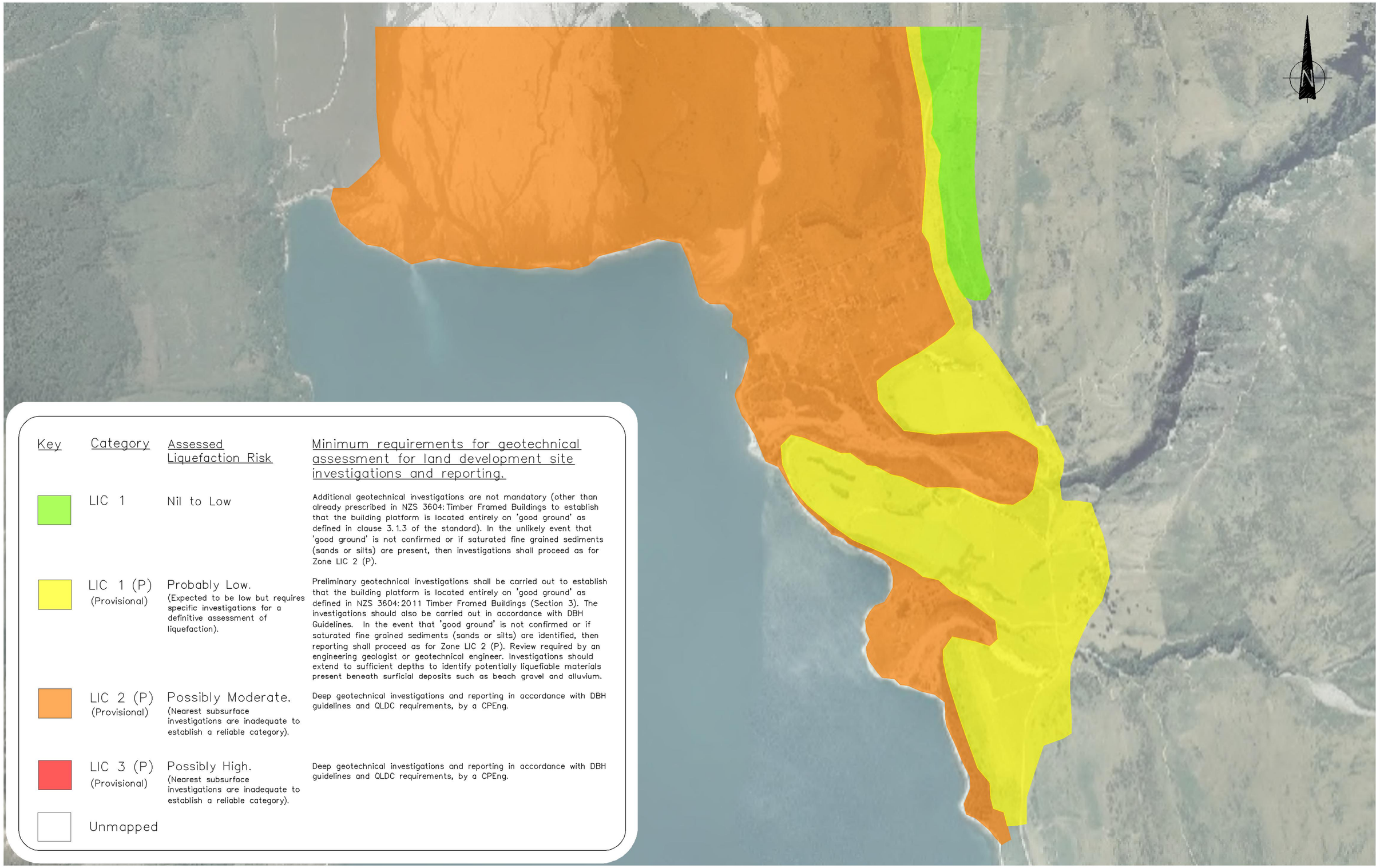
QUEENSTOWN REGION LIQUEFACTION MAPPING
Overview – Kingston

FIG. No. Figure 3 REV. 2



Key	Category	Assessed Liquefaction Risk	Minimum requirements for geotechnical assessment for land development site investigations and reporting.
	LIC 1	Nil to Low	Additional geotechnical investigations are not mandatory (other than already prescribed in NZS 3604: Timber Framed Buildings to establish that the building platform is located entirely on 'good ground' as defined in clause 3.1.3 of the standard). In the unlikely event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are present, then investigations shall proceed as for Zone LIC 2 (P).
	LIC 1 (P) (Provisional)	Probably Low. (Expected to be low but requires specific investigations for a definitive assessment of liquefaction).	Preliminary geotechnical investigations shall be carried out to establish that the building platform is located entirely on 'good ground' as defined in NZS 3604:2011 Timber Framed Buildings (Section 3). The investigations should also be carried out in accordance with DBH Guidelines. In the event that 'good ground' is not confirmed or if saturated fine grained sediments (sands or silts) are identified, then reporting shall proceed as for Zone LIC 2 (P). Review required by an engineering geologist or geotechnical engineer. Investigations should extend to sufficient depths to identify potentially liquefiable materials present beneath surficial deposits such as beach gravel and alluvium.
	LIC 2 (P) (Provisional)	Possibly Moderate. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	LIC 3 (P) (Provisional)	Possibly High. (Nearest subsurface investigations are inadequate to establish a reliable category).	Deep geotechnical investigations and reporting in accordance with DBH guidelines and QLDC requirements, by a CPEng.
	Unmapped		

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QUEENSTOWN LAKES DISTRICT COUNCIL

QUEENSTOWN REGION LIQUEFACTION MAPPING
Overview – Glenorchy

FIG. No. Figure 4 REV. 2