PRELIMINARY GEOTECHNICAL ASSESSMENT

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PREPARED FOR KIWIRAIL

October 2020

Stantec

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Preliminary Geotechnical Assessment

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1. Introduction

Stantec has been engaged by KiwiRail to undertake a preliminary geotechnical desktop assessment for the proposed Palmerston North Regional Freight Hub (Freight Hub).

1.1 Previous Work

The proposed freight hub site (Site) has been chosen following a detailed Multi Criteria Analysis (MCA) assessment process. Geotechnical considerations and natural hazards associated with site selection formed part of the MCA with the Site considered the preferred site overall from a technical perspective.

1.2 Scope of Work

The purpose of the assessment is to identify likely ground conditions in the area and provide a preliminary assessment of the likely geotechnical related hazards as well as the possible geotechnical constraints that may influence construction of the Freight Hub.

This assessment was carried out based on a desktop analysis in order to support the Notice of Requirement. The work comprised:

- An evaluation of the information obtained to identify the likely geotechnical risks and any constraints associated with development of the site
- Providing preliminary geotechnical risk mitigation options and recommendations for managing geotechnical risks

The following was not undertaken as part of this preliminary assessment:

- Ground investigations
- A geotechnical site walkover assessment
- Discussions with landowners or local contractors
- Contaminated land assessment (as this is undertaken as part of a separate, parallel study which is outlined in the Preliminary Site Investigation report.[1]

2. Project Description

The project involves the construction and operational of a rail freight yard and associated infrastructure. The Site is approximately 3km in length. The Freight Hub will include the following key components:

- Rail marshalling yard
- Maintenance facilities
- Network Services Depot
- Container terminal
- Freight forwarding facilities
- Log handling
- Bulk liquid storage
- Access roads
- New and upsized culverts
- Stormwater detention ponds (north and south)

[1] Stantec (September 2020), Preliminary Site Investigation, Palmerston North Regional Economic Hub Phase 2 – Notice of Requirement

In order to construct the Freight Hub, extensive earthworks will be required to create a level platform at RL50 (NZGD 2000)

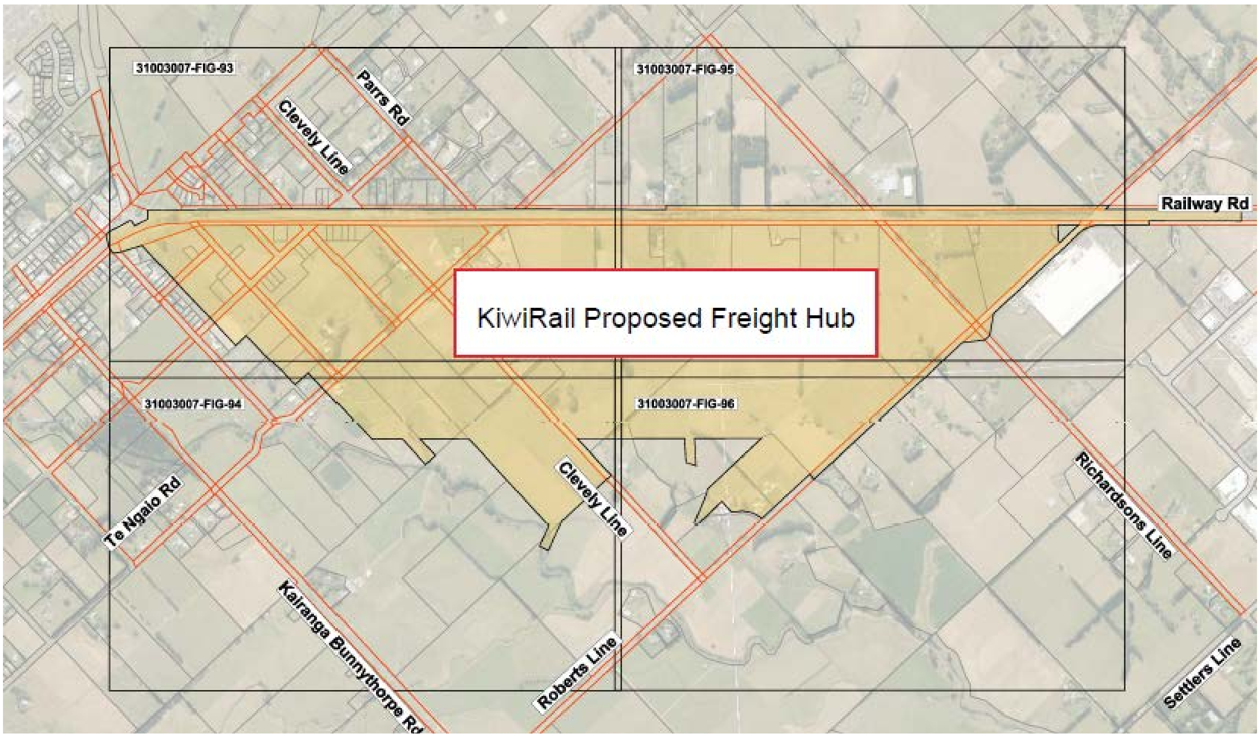

Figure 2-1: Designation Extent

3. Assessment Methodology

A desktop study has been carried out to collate existing information for the area under study. This includes a review of the following:

- Published geological mapping including Geological and Nuclear Sciences (GNS) QMap Sheet 11 Wairarapa.
- Geotechnical logs available on the New Zealand Geotechnical Database (NZGD).
- Geological and Nuclear Sciences (GNS) Active Faults Database.
- Historical aerial photographs available from Retrolens, Google Earth and other publicly available database.
- Palmerston North City Council Hazard Overlays / District Plan Section 22.
- Beetham D., Barker P., Beetham J., Begg J., Levick S. July 2011. Assessment of liquefaction and related ground failure hazards in Palmerston North, New Zealand. GNS Science Consultancy Report 2011/108.
- Google Earth and Google Street View assessment of the Site.
- Site lidar contours and scheme plans viewed as overlays in Google Earth.

No geotechnical walkover of the Site was undertaken as part of this ground investigation.

4. Site Description

As site walkover was not undertaken as part of this assessment, the following Site description is based on Google Earth and Google Street View imagery.

The proposed Site is located between Bunnythorpe and Palmerston North airport with the existing North Island Main Trunk (NIMT) line forming the eastern boundary. Bunnythorpe is to the north while an industrial estate and Palmerston Airport are to the south.

The Site is approximately 3km long along the eastern boundary becoming narrower towards the west. There are several formed and unformed roads currently crossing the Site including Railway Road, Te Ngaio Road, Clevely Line, Roberts Line and Richardson's Line.

Current land use is a mixture of lifestyle blocks and pasture agriculture.

The Site is largely undulating with two significant drainage features crossing the Site, including two tributaries of the Mangaone Stream with a smaller stream cutting east-west through the site and crossing Railway Rd near the centre of the Freight Hub.

4.1 Geomorphology

The Site is predominantly located on an alluvial terrace which is dissected by two unnamed streams and several smaller watercourses as shown in the contour overlay in Figure 4-1. Contour information is shown at 0.5m intervals and comes from the NZGD2000.

The larger watercourses drain from east to west and between RL42 and RL45, while the terraces rise to RL53 (yellow colour in Figure 4-1). The base of the two largest watercourses are in broad, flat gullies between approximately 100m and 400m in width and extend under the NIMT. The two large gullies are highlighted in Figure 4-1as Q1a (off white colour) crossing the site and where contours are closer together). South facing gully slopes are generally steeper than north facing slopes at up to approximately 15 degrees.

The existing NIMT at the eastern edge of the Site has a low point of approximately RL46 where the southern gully crosses the Site with the remainder of the line at approximately RL49 to RL53. The western boundary of the Site opens out to the gully floodplain with the Mangaone Stream flowing in a south westerly direction adjacent to part of the western boundary.

Former stream courses and areas of shallow ponding were noted from Google Earth imagery in the base of the two large gullies indicating shallow groundwater and possibly variable soft/loose soils in these areas.

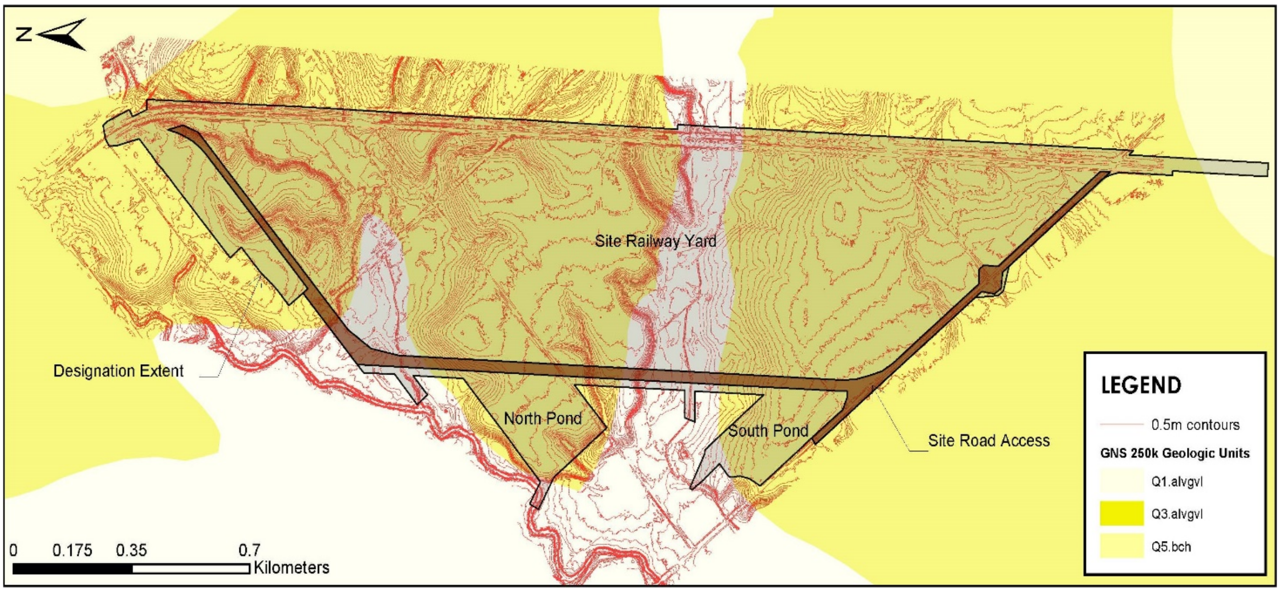

Figure 4-1: Geological and Topographical Map

4.2 Published Geology

The geology of the Site in the context of the regional geology is presented on the GNS Geology of the Wairarapa area (Map 11). An extract of the electronic geological map for the study area is presented in Figure 4-2 and summarised in Table 4-1.

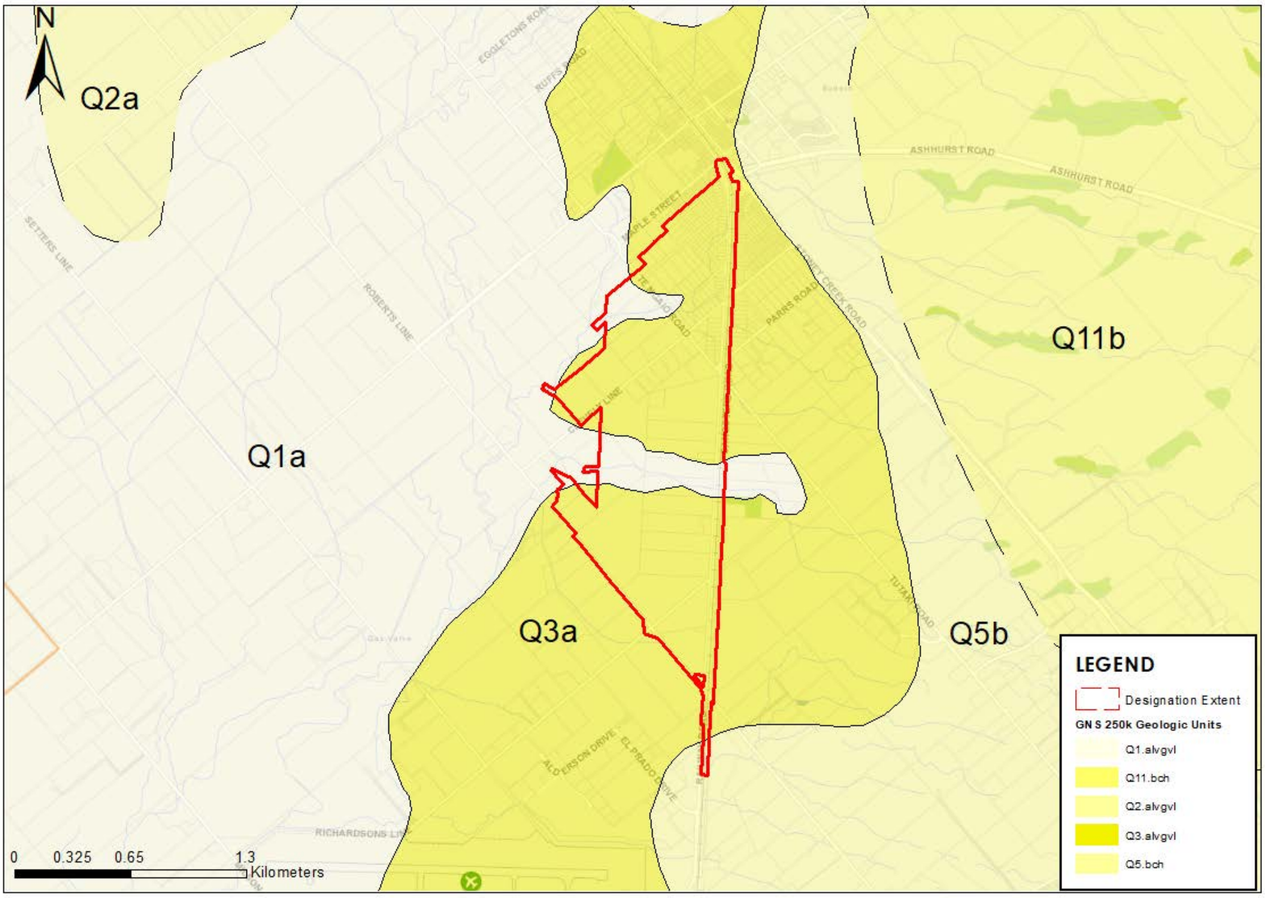

Figure 4-2: Geology Plan

Table 4-1: Geologic Unit Summary

Geological Unit	Text Code	Description	Age
Unweathered Holocene alluvium	Q1a	Alluvial gravel, sand, silt mud and clay with local peat, includes modern riverbeds	Holocene
Middle Quaternary alluvial terraces	Q3a	Weathered poorly to moderately sorted gravel with loess, sand and silt.	Pleistocene

The Site is predominately mapped as Q3a alluvium forming elevated river terrace deposits between 24,000 and 59,000 years old.

Gully floor materials consist of Q1a geologically very recent alluvium.

4.2.1 Faults and Seismicity

Strong ground shaking from earthquakes is a hazard to buildings, occupants, and lifelines (utilities) and occur from Modified Mercalli (MM) 7 levels. Damage becomes more severe at higher level Modified Mercalli events.

While no known active faults underlie the Site, several are within 15km of the Site including the Wellington Fault to the south of the Site which has a high recurrence interval and high slip (movement) rate. Active faults could be present under the Site but be obscured by alluvial deposits. Table 4-2 summarises the seismic characteristics of the active faults closest to the site as they appear on the GNS Active Faults database.

Variations in geology can give rise to amplification effects, i.e. the intensity of an earthquake may be amplified depending upon ground conditions. The ground Shaking Hazard Map (Map 22.6.1) within the Palmerston North District Plan indicates that the higher alluvial terrace deposits (Q3a) are not expected to have significant amplification of ground shaking. The low-lying ground (Q1a) to the west of the Site is indicated to be of moderate amplification. This means that higher shaking events may be encountered more frequently within the Q1a material, particularly to the west of the Site.

Table 4-2: Active Faults

Fault Name	Approximate distance to the Freight Hub	Slip rate	Last event	Recurrence interval (years)
Tokomaru Fault	13km	Low	Holocene	5000-10,000
Pohangina Fault	7km	Moderate	Unknown	5000-10,000
Forest Hill Road Fault	9km	Unknown	Unknown	Unknown
Northern Ohariu Fault	18km	Moderate	Holocene	2000-3500
Wellington Fault	15km	High	Millenium	Under 2000
Mount Stuart-Halcomb Fault	11km	Moderate	Unknown	Unknown
Ruahine Fault	15km	Moderate	Millenium	2000-3500

4.3 New Zealand Geotechnical Database (NZGD)

There are twenty-eight (28) Cone Penetration Test (CPT) logs available on the NZGD which have been undertaken within southern part of the site. All CPT's were undertaken on the Q3a terrace material at the southern end of the site. CPT summary details including depth and groundwater where recorded are presented in Table 4-3.

CPT tests do not generally retrieve core but instead infer soil types using empirical equations from the electronic cone at the tip of the CPT which is pushed into the ground at a constant rate using the weight of the CPT rig or screwed in ground anchors. Inferred soil types indicate generally granular material to between 1.1m to 4m depth overlying predominantly silts and clays.

Table 4-3: Historical Site Specific Ground Investigations

NZGD ID	Reference	Date	E (NZTM)	N (NZTM)	mRL (NZVD)	Total depth (m)	GW depth
72314	CPT37	25/02/2014	1823500	5534732	48.902	7.26	1.6
72315	CPT38	25/02/2014	1823591	5534606	49.474	6.94	-
72316	CPT39	25/02/2014	1823628	5534773	50.812	7.48	-
72317	CPT40	25/02/2014	1823552	5534788	50.461	7.4	-
72318	CPT41	25/02/2014	1823417	5534801	48.28	7.88	2.2
72319	CPT42	25/02/2014	1823517	5534901	49.527	6.94	-
72320	CPT43	25/02/2014	1823622	5534993	50.406	7.18	-
72321	CPT44	26/02/2014	1823383	5534929	48.379	7.62	4
72322	CPT45	26/02/2014	1823271	5535053	48.106	7.1	5.3
72323	CPT46	26/02/2014	1823586	5535080	50.847	7.1	3.7

NZGD ID	Reference	Date	E (NZTM)	N (NZTM)	mRL (NZVD)	Total depth (m)	GW depth
72324	CPT47	26/02/2014	1823450	5535163	49.441	7.58	5.3
72325	CPT48	26/02/2014	1823359	5535304	49.339	9.58	2.6
72326	CPT49	26/02/2014	1823599	5535248	49.524	6.32	6.2
72327	CPT50	28/02/2014	1823457	5535409	47.867	6.16	-
72328	CPT51	28/02/2014	1823588	5535408	44.342	9.1	2
72329	CPT52	28/02/2014	1823361	5535503	45.897	7.08	1.7
72330	CPT53	28/02/2014	1823482	5535500	44.701	4.06	2
72331	CPT54	28/02/2014	1823631	5535512	43.315	7.44	1.9
72332	CPT55	4/03/2014	1823287	5535606	44.023	4.4	2.4
72333	CPT56	4/03/2014	1823167	5535494	45.619	16	-
72334	CPT57	4/03/2014	1822994	5535351	47.39	8.64	3.1
72335	CPT58	4/03/2014	1823110	5535233	47.361	7.58	4.5
72336	CPT59	4/03/2014	1823261	5535384	48.85	7.1	-
72337	CPT61	5/03/2014	1823174	5535488	Not avail.	4.74	-
72338	CPT62	5/03/2014	1823176	5535501	45.6	5.4	1.5
72339	CPT63	5/03/2014	1823161	5535490	45.6	13.44	4.7
72340	CPT64	5/03/2014	1823158	5535500	45.6	16.14	2.2
72341	CPT 24	1/04/2014	1823185	5535147	47.427	6.56	-

Recorded groundwater level was variable and reflects short term conditions in the terrace deposits during the CPT investigation. The ground investigation was undertaken between February and March 2014 (CPT 24 was undertaken on 1 April) and groundwater levels may vary seasonally in response to rainfall rising in winter. Groundwater may also increase following investigation (i.e. recharge) due to changes in soil porewater pressures. Groundwater in the low-lying areas is likely to be higher than recorded in the CPT investigation and may show a greater seasonal variation.

4.4 Aerial Photo Review

We have reviewed historical aerial photographs from Retrolens, and Google Earth dating from 1952 to 2019. The photographs were viewed under the context of identifying general changes to the Site's landforms and use. The Site has not changed significantly, stream courses have moved in places and become more defined.

A stream at the southern end of Sangsters Road which crossed into the Site near the end of the road has been diverted so that it now flows south parallel to Railway Road and into another stream before crossing into the Site.

4.5 Liquefaction hazards

In 2011, PNCC commissioned GNS to undertake a liquefaction hazard assessment of the city as it was at that time. The resulting GNS report[2] divided the city into liquefaction zones based on soil type and age.

While the Designation Extent is marginally outside the then city boundary, geological units underlying parts of the city and those on the Site are the same and the Site is shown in the GNS report liquefaction mapping. Liquefaction ground potential damage from the GNS report will apply to the Site as follows:

- Q1a low lying recent alluvial soils – Moderate to high liquefaction damage potential

[2] Assessment of liquefaction and related ground failure hazards in Palmerston North, New Zealand. GNS Science Consultancy Report 2011/108

- Q3a alluvial terrace – Negligible liquefaction damage potential

Noting the above comments, further site-specific ground investigation and assessment may modify the site's liquefaction potential.

5. Ground Conditions

5.1 General

Desktop study data collated from Section 3 references has been assessed in order to determine the anticipated ground conditions underlying the Site.

5.2 Generalised Ground Conditions

The engineering properties of soils likely to underlie the Designation Extent has been generalised and is discussed below.

5.2.1 Fill

Based on Google Street View images and Lidar contours, fill (possibly several metres thick) is likely to be present on the Site underlying Railway Road and the NIMT where it crosses the two large gullies. Fill may also be present elsewhere on site due to historic agricultural activities. Localised farm rubbish pits may also be present. Fill is likely to have relatively good engineering properties and low settlement potential under the NIMT and Railway Road due to age and position. Some liquefiable Q1a material may remain below the fill unless it has been excavated and replaced.

5.2.2 Alluvial Deposits

5.2.2.1 Q1a Recent Alluvium

Geologically very recent and currently deposited alluvium in the base of gullies and on low lying ground west of the Site is likely to consist of sand, silt and clay possibly with peat. Groundwater is likely to be within 1m of the ground surface, although varying seasonally. Based on published geology, the 2011 GNS study and experience with similar materials elsewhere, generally soft/loose ground conditions prone to liquefaction and settlement are anticipated over at least part of this geological unit.

5.2.2.2 Q3a Alluvial terrace deposits

A mix of granular and cohesive soils including sand, silt and clay is likely to cover most of the Site and form terraces above the low lying Q1a material. Groundwater is generally lower than 2m BGL. Based on published geology, the 2011 GNS study, site specific CPT's and experience with similar materials elsewhere, low liquefaction potential and moderate bearing capacity / strength is anticipated.

5.2.3 Solid Geology

Due to the extent of alluvial soils covering the region and published geological mapping, rock is not likely to be encountered within at least 20m of the ground surface.

5.2.4 Groundwater

While groundwater in the alluvial terrace CPT investigation was noted to be elevated and around 2m BGL in several holes, this may represent "perched" or elevated pockets of groundwater and may not represent the main groundwater table which is expected to be below this depth.

6. Potential Geotechnical Considerations

The main geotechnical hazard likely to impact development of the Site are described and discussed below.

6.1 Seismic Hazards

The Site is located in a highly active seismic area with several significant faults with high recurrence intervals close by (for example the Wellington, Ruahine and Northern Ohariu Faults). While the majority of the Site appears to be in a zone of no significant amplification of ground shaking, a significant earthquake could still generate damaging shaking for infrastructure and slopes due to the Site's proximity to significant active faults.

The closest known active fault is the Pohangina Fault, which is approximately 7km to the east of the Site. However, concealed active faults under the Site obscured by relatively recent alluvial deposits cannot be ruled out.

6.2 Liquefaction and Lateral Spreading

The potential for liquefaction depends on the level of earthquake shaking, groundwater level, presence of sandy or silty soils and soil strength. Weak soils are typically present in geologically recent alluvial soils (for example Q1a floodplain material) while older soils tend to be stronger and more resistant to liquefaction.

The 2011 GNS report indicates that the elevated alluvial terrace deposits (Q3a) covering most of the Site are likely to have negligible liquefaction induced damaging potential while the low lying geologically recent (Q1a) alluvial material will have a moderate to high liquefaction damage potential. Liquefaction has the potential to result in differential settlement, particularly where there are strong contrasts in materials.

Lateral spreading can occur where slopes have high groundwater levels or are adjacent to watercourses. While gullies will be infilled to create a platform for rail and associated infrastructure, lateral spreading could still occur at the perimeter of the Site, particularly where it crosses existing gullies, or where watercourses flow adjacent to the Site.

6.3 Soft Ground

Soft ground is likely in the Q1a material in the base of gullies. Loading of soft ground with fill (i.e. earthworks), structures or heavy live loads (e.g. locomotives) may cause settlement.

Settlement effects can be more significant where differential settlement occurs. For example, a large structure such as a warehouse straddling two soil types of differing strengths. If one of these soil types settles very little while the other has significant settlement, then differential settlement can occur at the junction between the different material, affecting floor slabs and structural integrity of buildings (e.g. warehouses or maintenance sheds).

6.4 Earthworks (Cut & Fill)

The proposed KiwiRail Site is up to approximately 3km in length and requires a flat surface at a similar level to the NIMT. The level at which the Site is set, and the suitability of site excavated material for reuse is an important geotechnical project consideration.

Based on concept design, the Site yard and infrastructure is proposed to be at an elevation of RL50m. Gullies on the Site are as low as RL42m and as high as RL53m, which will result in significant cut and fill earthworks requirements for the Site.

Granular soils (e.g. graded sands and gravels) are generally more suitable for use as engineered fill. Cohesive soils (i.e. silts and clays) tend to be more moisture sensitive and may require treatment to make them suitable for use, for example drying or addition of additives such as lime or cement. Ideally all the soils on Site would be suitable for reuse as engineered fill and there would be a cut-fill balance (i.e. all cut material is reused as fill).

Published geological mapping shows the Q3a alluvial terrace materials are expected to be a mixture of granular and cohesive material. CPT testing from the southern area of the Site indicates a significant proportion of cohesive soils (i.e. fine grained). These materials appear to be highly layered which may make reuse challenging, particularly if soils vary significantly horizontally.

6.5 Slope stability

Google Street View assessment indicates that natural slopes are low angle and associated with terrace margins, particularly gullies crossing the Site in an east-west direction. These natural slopes are a maximum of approximately 15 degrees, while cut slopes associated with Railway Road are approximately 25 degrees or locally steeper up to a height of approximately 3m. There were no signs of slope instability from the Street View imagery.

Gullies crossing the Site will be infilled as part of the development. As a result, the only slopes are likely to be:

- Around the perimeter of the Site, particularly on the downstream (western) and eastern (upstream) side of the Site at the location of infilled gullies.
- Where open water courses flow through or adjacent to the Site.
- Detention ponds located at the edge of the Q3a terrace are likely to require specific geotechnical design.

It is likely that all slopes on the Site will require a long-term static (i.e. none seismic) Factor of Safety (FOS) against failing of FOS=1.5 which is an industry design standard for slopes supporting structures. Numerical slope stability assessment and FOS selection will be undertaken following ground investigation and as part of the design process. Seismically induced instability and lateral spreading should also be assessed where appropriate. Foundation soils in the base of gullies around the Site perimeter may require treatment or excavation and replacement to reach this design standard.

6.6 Pavement

New roads are proposed as part of the development. Poor subgrades may be encountered where roads cross soft Q1a material and special design may be required e.g. light weight fill, stabilisation, geosynthetics.

7. Preliminary Geotechnical Risk Appraisal

A qualitative preliminary geotechnical risk appraisal has been undertaken and is presented in Table 7-1 below. The risk assessment is appropriate for the available information at this concept design stage.

Qualitative risks have been assigned to geotechnical hazards based on:

- the significance of the geotechnical hazards and
- the level on information currently available and commented upon in preceding sections of this report.

It is recommended that the risk table be reviewed and updated as geotechnical investigations and design progresses.

Table 7-1: Preliminary Risk Table

Geotechnical Related Hazard		Risk Type	Qualitative Risk	Risk Management Options
5.1	Seismic hazard	Financial	Medium	• Ground investigation and design • Site specific seismic assessment to inform detailed design
5.2 and 5.3	Liquefaction / lateral spreading and soft ground	Financial Time	High	• Ground investigation and design • Define extent of soft ground vertically and horizontally (ground model) • Risk assessment updated once structure size and locations are confirmed • Localised ground improvement where required • Excavate and replace liquefiable material
5.4	Earthworks suitability	Financial Environmental	High	• Ground investigation and laboratory testing • Develop ground model for site • Define earthworks compaction criteria/requirements, quantities, and zones

Geotechnical Related Hazard		Risk Type	Qualitative Risk	Risk Management Options
5.5	Slope stability	Financial	Medium	• Ground investigation and design • Risk assessment updated once structure size and locations are confirmed • Slope stabilisation works and pond lining where required.
5.6	Pavement failure	Financial	Medium	• Ground investigation and design

8. Conclusions and Recommendations

A geotechnical desk study assessment has been undertaken of the Freight Hub using the documents outlined in Section 2 of this report.

Although there are several geotechnical risks for the Site outlined in Section 6, based on this desktop study, we do not consider that these risks are likely to make the project unfeasible.

The most significant geotechnical risks related to this study at this stage of the project include:

- Earthworks cut to fill balance, material suitability and availability. This is the most significant risk and has a potentially large impact on the overall project cost.
- Potential soft and liquefiable ground, particularly associate with low lying / gully deposits, their extent and thickness. This is both a time and cost risk.

The extent of geotechnical risks will be better understood following a targeted and staged ground investigation addressing each of the risks outlined in Section 6, together with planned on Site infrastructure prior to the detailed design process. The ground investigation would likely consist of boreholes, CPT's test pits, hand augers and laboratory testing.

Geotechnical risks outlined above should be included in a project risk register and updated as more information becomes available.

9. Limitations

This report has been prepared for KiwiRail in accordance with the generally accepted practices and standards in use at the time it was prepared. Stantec accepts no liability to any third party who relies on this report.

The information contained in this report is accurate to the best of our knowledge at the time of issue. Stantec has made no independent verification of this information beyond the agreed scope set out in the report.

The interpretations as to the likely subsurface conditions contained in this report are based on the information obtained from desk study, as described in this report. Stantec accepts no liability for any unknown or adverse ground conditions that would have been identified had ground investigations, sampling, and testing been undertaken.

Actual ground conditions encountered may vary from the predicted subsurface conditions. For example, subsurface groundwater conditions often change seasonally and over time. No warranty is expressed or implied that the actual conditions encountered will conform to the conditions described herein.

Where conditions encountered at the site differ from those inferred in this report Stantec should be notified of such changes and should be given an opportunity to review the report recommendations made in this report in light of any further information.

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