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Draft - Horotiu West Development

Desktop Preliminary Geotechnical Assessment

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Executive Summary

Perry Developments Limited has engaged AECOM New Zealand Limited (AECOM) to undertake a desktop assessment of the geotechnical constraints associated with the potential development of a parcel of land denoted as Horotiu West, located west of the Waikato River and immediately north of the Waikato Expressway. The assessment is required to support rezoning of the land from rural zoned land, to allow for future residential subdivision.

The proposed development will comprise a combination of low to high density residential lots that will be serviced from Horotiu via Great South Road and a new internal road network. Lot sizes are likely to range from around 197m^2 to around 502m^2. Prior to modification by quarrying and road construction, the property comprised of a broad and near flat upper level with a lower river terrace forming the northern portion of the property. The land has since been modified by sand mining and by the construction of the Waikato Expressway (directly east and within the north eastern extent).

Following a desktop review of geological maps, aerial photos and existing geotechnical assessment potential geotechnical constraints have been identified including soil liquefaction, static settlement, non-engineered fill and river bank slope stability.

Development of the land is possible providing mitigation of the constraints discussed in this report. Provided theses constraints are addressed, there is little risk of subdivision works contributing to natural hazards or environmental issues. The following sections further discuss potential constraints that would need to be addressed at subdivision consent design stage.

1.0 Introduction

Perry Developments Limited has engaged AECOM New Zealand Limited (AECOM) to undertake a desktop assessment of the geotechnical constraints associated with the potential development of a parcel of land located west of the Waikato River and immediately north of the Waikato Expressway.

The assessment is required to support rezoning of the land from Country Living to Residential Zone with the potential for a future mixed housing density subdivision. The proposed development will comprise a combination of low to high density residential lots that will be serviced from Horotiu via Great South Road and a new internal road network. Lot sizes are likely to range from around 197m^2 to around 502m^2.

The purpose of this assessment is to provide a document that can be used for discussion with the Waikato District Council and provide preliminary advice regarding the suitability of the land for development in relation to geotechnical constraints.

2.0 Scope of assessment

This assessment is a desk study and comprises:

- A review of natural hazard regulations related to development in the Waikato Region,
- A review of relevant geological maps and topographical maps,
- A review of aerial photography available in the public domain
- A site walkover by an engineering geologist
- Discussion of development issues within the study area based on the results of the desk study, mapping and AECOM experience with similar sites.

This assessment focuses on geohazards and therefore excludes other natural hazards such as flooding and wind.

3.0 Ngaruawahia Structure Plan

In August 2014, Waikato District Council (WDC) engaged AECOM New Zealand Limited (AECOM) to undertake an assessment of the geotechnical constraints within the study area of the Ngaruawahia Structure Plan. AECOM carried out a desk study of potential geotechnical constraints within the structure plan study area. Geotechnical constraints are natural hazards (geohazards) that can impact on development or be adversely affected by development.

Geotechnical suitability of land for development is concerned with the avoidance and mitigation of geohazards. The foundation framework is outlined in Legislation, District Plans, and New Zealand Standards. A brief outline of how these documents address the Natural Hazards is provided in the Ngaruawahia Structure Plan: Geotechnical Suitability Assessment provided in the 2014 report ‘Ngaruawahia Structure Plan: Geotechnical Suitability Assessment; 60316752’ by Trigger, M and Burns, D. The study area encompasses Ngaruawahia, Te Kowhai, Horotiu and up to Taupiri.

The Waikato Expressway forms the boundary of the study area directly east of the area addressed in this report.

4.0 Study area description

4.1 General

The site is located in Horotiu about 7 km south of Ngaruawahia at the northern boundary of Hamilton City. The legal description for the property is Lot 200 6 DP 12221 and has a land area of approximately 18ha.

The city boundary at the site location is delineated by the Waikato Expressway. The Horotiu West Development land area was formerly part of a larger 62 hectare block which was separated by the Waikato Expressway construction. The southern land block is now known as Te Awa Lakes and is planned to be developed as mixed use Tourism, commercial and residential.

This site is currently defined as Horotiu West pastoral farmland. Western parts of the site are original flat to gently rolling hills. The eastern edge of the site alongside the expressway features modified topography as a result of historic sand mining. The mined areas are flat bottomed depressions several meters lower than the original ground levels.

The site location is presented in Appendix A.

4.2 Geomorphology

Historic aerial photos of the site reveal that the land was previously generally flat pastoral farmland characterised by terraces and paleochannels of the Waikato River. Prior to modification by quarrying and road construction, the property comprised of a broad and near flat upper level with a lower river terrace forming the northern portion of the property. Shallow depressions or channels are typical in these areas and are often described as Maori borrow pits or shallow depressions associated with garden plots.

The land has since been modified by sand mining and by the construction of the Waikato Expressway (directly east and within the north eastern extent). In general, the existing topography slopes gently towards the east with low points adjacent to the expressway embankment. Original ground levels at the site range from RL 16 m to RL 26 m. Excavated sand mine areas are as low as RL 13 m in some locations. Figure 1 below includes google earth images from 1941, 2002 and 2012 showing modification to landform by mining and expressway construction.

Figure 1 Historic aerial images

At the northern extent of the property, topography is gently sloping with the expressway situated some 4 to 5m above the surrounding land. The Waikato River Trail roughly follows the crest of the Waikato River bank.

Cut slopes have been formed as part of past sand mining operations approximately where Kernott Road meets the site boundary resulting in wetlands or areas where surface water collects and ponds. The southern extent of the site is 2 to 3 m higher than the expressway and generally flat.

An annotated aerial image is presented in Appendix A illustrating geomorphic features.

4.3 Geology

An extract of the geological map for the area is presented as Figure 1. The geology of the area is characterised by alluvial sediments deposited by the ancestral Waikato River. The alluvial sediments are mapped as the Hinuera Formation, and were deposited between 50 and 17 thousand years ago by the ancient braided river system. The bulk of the sediments were deposited following the voluminous Oruanui eruption 26 thousand years ago. Following cessation of rapid sedimentation, the river became entrenched in its current course and formed the modern Waikato River. As the Waikato River became more deeply entrenched so did the tributary gullies and streams.

The Hinuera Formation consists of variably pumiceous and rhyolitic gravel, sand and silt. Young surface and old subsurface peat and organic silt (lacustrine) deposits can be present. There is distinct cross-bedding throughout the formation, and soil conditions can be highly variable.

The Taupo Formation was deposited following the Taupo Ignimbrite eruption approximately two thousand years ago. The eruption blocked Lake Taupo (as did the earlier Oruanui eruption), raising its level. The eventual breakout flood resulted in rapid sedimentation that, in the Hamilton Basin, did not overtop the entrenched channel of Waikato River, but formed low terraces of pumiceous sand and silt within the channel. Undifferentiated alluvial and colluvial deposits have accumulated in the incised tributary gullies.

5.0 Existing information

A review of existing geotechnical information has been carried out as part of this assessment particularly geotechnical site investigation uploaded to the New Zealand Geotechnical Database. The following summarises publically available information that relates to the Waikato Expressway in close proximity to the site.

- Eight Cone Penetration Tests (CPT)
- Two machine drillholes
- Four machine excavated test pits

A plan showing investigation locations in relation to the site is presented in Appendix A.

5.1 Summary of ground conditions

As per the map description, ground conditions encountered adjacent to the site generally comprise alternating silt and sand with beds of peat or organic silt. Organic beds and decomposed wood fragments were encountered at the northern and southern extents of the site and are up to 1m thick. Up to 1.5m of uncontrolled fill material was encountered near the northern extent of the site.

Ground conditions are typically loose to medium dense within the upper 10 to 15m with drillhole SPT N values of between 4 and 14 and CPT cone resistance typically between 2 and 6 MPa. From approximately 15m SPT N values increase to 16 to 50 and CPT cone resistance from 8 to greater than 20 MPa.

Groundwater was encountered at a number of the investigation locations at depths of between 1.4 m and 2.2m below ground level.

6.0 Geohazards

Geotechnical constraints are constraints associated with geohazards that have the potential to impact on the development of land if the geohazard is not addressed. A geohazard is a broad term that refers to geological hazards caused by a combination of the structure, type, strength and topography of the land. Geohazards may be obvious such as a large land slide, or revealed only by thorough investigation like the settlement potential of buried soil. Often geohazards are unknown until they occur unexpectedly, such as an earthquake generated by an unknown fault.

The geological hazards (geohazards) considered relevant to the study area include slope instability, river bank erosion, seismicity and liquefaction, and poor ground conditions (e.g. peat). These hazards are further discussed in the following sections.

6.1 Static settlement

Static settlement results from compression of the ground underlying a structure or fill embankment due to the increased load. Generally, if uniform settlement occurs and it is of limited magnitude, structures typically do not sustain structural damage and the settlement can be undetectable without reference levels. When settlement occurs it is common for the land adjacent to the structure to also be affected as a depression is created towards the loaded area.

Differential settlement occurs when there is non-uniform settlement across a structure. This can be due to lateral variability in applied loads or differences in the thickness and/or compressibility of the materials underlying the loaded area. When differential settlement occurs, the walls and cladding of buildings are susceptible to cracking, floors become uneven, and doors and windows become tight and prone to jamming. The integrity and function of onsite services can also be compromised when settlement affects auxiliary structures such as water tanks. Connections between buried services and buildings can also be adversely affected.

Roads and buried services are generally at low risk of issues related to static settlement, unless the works include embankments or structures as part of the works or in close proximity to the infrastructure.

6.2 Slope instability

The slopes that define the gullies and banks associated with the tributaries of the Waikato River are generally steep to very steep. There is typically a sharp slope break at the crest of gullies. Slope materials tend to consist of sub-horizontally bedded layers of silt and sand. Full slope saturation is unusual, as percolating rainfall tends to be impeded by the less permeable layers (e.g. silt) and track horizontally to the slope face.

Slope failures tend to be of the shallow regressive type, and commonly associated with rainfall or slope modification. Stream and river bank erosion can remove toe support, which destabilises the slope above. Deeper-seated failures can occur but they tend to exit at the base of the slope and not extend below the toe level. Debris from slips generally accumulates at the toe of the slope forming a protective ramp; subsequent stream erosion however can progressively remove the debris leading to further slope failures.

Stormwater soakage is currently encouraged as the preferable method for managing stormwater. This increases the percentage of rainfall entering the ground containing the soakage facility compared to what would have naturally infiltrated from the surface, as rainfall is collected from a larger area and concentrated in the soakage field. This can alter the hydrogeological conditions near gullies and reduce stability.

6.3 Seismic hazard

6.3.1 Introduction

Earthquakes can result in widespread damage to land and buildings. Land damage has traditionally been considered in this context as destabilisation of slopes and ground surface movement associated with shaking and fault rupture.

Building codes and standards such as NZS3604 Timber Framed Buildings have generally ensured that buildings are structurally designed to withstand earthquake shaking.

Since the occurrence of the Canterbury Earthquake Sequence and the Kaikoura and Seddon Earthquakes there has been heightened awareness of the effects of soil liquefaction and shaking damage on both buildings and infrastructure. Soil liquefaction is addressed in greater detail in Section 6.4.

The closest fault currently identified as active in the Geology of the Waikato area Institute of Geological and Nuclear Sciences 1:250000 geological map 4, is the Kerepehi Fault. The Kerepehi Fault (40 km west of Horotiu) is estimated to be capable of generating M6.6 earthquakes, with return periods of 22,000 and 2,500 years respectively. (Ref. GNS active fault database, www.gns.cri.nz)

6.4 Soil liquefaction

6.4.1 Liquefaction mechanism

The site has been geologically mapped as Hinuera Formation and Taupo Formation which is alluvial sand, silt and gravel. The cyclic ground motion induced by earthquakes can cause a build-up of excess pore pressure within these soils. If the excess pore pressure exceeds overburden pressure, liquefaction can occur, which causes a loss of strength and commonly ejection of material at the

surface (e.g. sand boils). As the excess pore pressure dissipates following cessation of shaking, densification of the soil can occur that, together with the loss of ejected material, causes settlement that may damage structures.

Such liquefaction and densification typically occurs in geologically young, loose, saturated, fine to medium grained, non-cohesive and low plasticity soils.

6.4.2 Potential effects of soil liquefaction

When soil liquefaction occurs there is a significant decrease in the soil strength. While this is a temporary situation, foundation bearing capacity failure can occur if the liquefied soil is sufficiently close to the foundations.

Liquefied material adjacent to a free face, such as a terrace, gully or river, can allow un-liquefied material above it to move towards the free face (lateral spreading). Lateral spreading can result in ground displacement and cracks developing several hundred metres from the slope. Lateral spreading is particularly damaging to buildings, roads and services within the zone of displacement.

Services such as buried pipelines, manholes and tanks can become buoyant resulting in damage to infrastructure. This can also be worsened by ground surface settlement. Roads can be damaged by ground settlement and lateral spreading.

6.4.3 Soil liquefaction potential

Within the study area, the alluvial soils of the lowlands (e.g. Hinuera Formation) can contain significant beds of loose sand and silt which are commonly saturated close to the surface, particularly at locations distant from incised gullies. As these soils are also relatively young, and have limited clay content and cohesion, there is a potential liquefaction hazard throughout the Hamilton lowlands.

7.0 Development constraints and recommendations

Development of the land is possible providing mitigation of the constraints discussed in the following sections. Provided theses constraints are addressed, there is little risk of subdivision works contributing to natural hazards or environmental issues. The following sections further discuss potential constraints that would need to be addressed at subdivision consent design stage.

7.1 Liquefaction

Given the nature of the soils across the site combined with a high groundwater level, liquefaction is a risk and could affect development if not assessed and addressed during subdivision design and development. The effects of liquefaction can generally be mitigated by shallow ground improvement or by foundation design such as raft style foundations.

Instability and lateral spreading due to liquefaction is a potential constraint that would require consideration during future assessment. The discontinuous nature of Hinuera Formation materials and the typical limited continuity of liquefiable layers mean that the conditions required for lateral spreading occur are unlikely to be present on the site. While lateral spreading as a mechanism is considered unlikely, future building foundation design may need to take lateral spread into account.

7.2 Settlement

As the geology of the area is mapped as the Hinuera Formation comprising of alluvial sediments and peat, there is a risk of static settlement associated with soft organic materials. Fine grained and organic materials were encountered as t beds up to 1.5m thick within the Hinuera Formation as part of the site investigation carried out for the Waikato Expressway. Excavation and replacement of these materials may be required if of significant thickness, although groundwater control may be required during such works. If settlement proved to be an issue during subdivision design, the effects of settlement can be mitigated by pre-loading or by deepened foundations such as piles that will transfer building loads to more competent underlying soils.

7.3 Ponding areas

Areas adjacent to the expressway where water is currently ponding are likely to be attributed to modifications to drainage paths or lowering of ground level during sand mining. Flood level assessment is not included in this scope of work, however earthworks may be required to elevate development in these areas. Alternatively these areas would be retained as stormwater ponds or wetlands. Where groundwater lowering or filling is proposed, geotechnical input is necessary to evaluate settlement effects. The effects of high groundwater will need to be taken into consideration during subsequent stages of assessment, particularly with regard to the stability of excavations for foundations and underground utilities.

7.4 Non-engineered fill

Given the past history and following review of aerial photos and ground conditions adjacent to the site, non-engineered fill is likely to be encountered across the property. The site has been used as farmland and for sand mining for an extended period of time, over time it is possible that non-engineered fill could have been placed to level the land, create access ways, pond dams and to cover rubbish holes. Non-engineered fill can be prone to settlement and instability. It is likely that there are more instances of non-engineered fill throughout the study area. It is appropriate to deal with any non-engineered fill during subdivision planning and construction.

7.5 River bank slope stability

River bank slopes at this location are of variable gradient, steep and approximately 5 m high. The existing property boundary is setback approximately 5 m from the slope crest with the Waikato River Trail following the slope crest. In the north east corner of the property the slope has been modified by construction of the Waikato Expressway bridge abutment.

Due to the potential for instability of Waikato River slopes building restriction zones are typically defined at the crest of the slopes.

Any part of a building located within the restriction zone would require engineer designed foundations and so it is recommended that development within this zone is avoided.

Based on experience in the area, it is considered that an extended period of wet weather, and hence saturated soils, would be the primary cause of any potential instability. It is therefore important that water generated from development activities is controlled and directed away from steep slopes. Soakage systems should not be placed close to the riverbank slopes and any systems within 20m of the slopes should have geotechnical review.

8.0 Summary

Despite the constraints illustrated in the above sections, it is believed that the area of interest is suitable for residential development.

The geohazards identified are likely to be mitigated by assessment and appropriate engineering design. Density and layout of the development will be determined during the subdivision design and consenting stage and these constraints would need to be taken into account throughout the subdivision design process.

Additional geotechnical investigation comprising of CPT, machine boreholes, machine excavated test pit and hand auger will be required to inform subdivision suitability assessment for landuse consent and subdivision design. The site investigation results will be used to further assess and refine the above constraints and make recommendations for development.

9.0 References

Edbrooke, S.W. (compiler) 2005. Geology of the Waikato Area. Institute of Geological and Nuclear Sciences 1:250:0000 Geological map 4. 1 sheet + 68p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Limited.

Kear, D. and Petty, D. R. 1976, Waikato Coalfiields: Glen Massey Coalfield, 1:15 840, New Zealand Geological Survey Miscellaneous Series Maps 7 (Geology) & 8 (Mining) and notes (14p), New Zealand Department of Scientific and Industrial Research, Wellington.

Waikato Regional Council, 2003, Waikato Region Earthquake Hazard Map.

10.0 Limitations

The recommendations and opinions contained in this report are based upon topography, geological maps and engineering experience of the issues within the areas considered. Inferences about the nature and continuity of geohazards are made using geological principles and engineering judgement. However it is possible that ground conditions over the site may vary and therefore it is not possible to guarantee that all hazards have been identified and appropriately zoned.

This report has been prepared for the particular project described in the owner's brief to us and no responsibility is accepted for the use of any part of this report in other contexts or for any other purposes.

Appendix A

Figures

Appendix B

NZGD Site Investigation Data