Greig Metcalfe
07-Feb-2017

702 & 730A Horotiu Road, Te Kowhai

Structure Plan Geotechnical Suitability Assessment

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Executive Summary

Greig Metcalfe has engaged AECOM New Zealand Limited (AECOM) to undertake a desktop assessment of the geotechnical constraints associated with the potential development of two properties adjacent to Te Kowhai Village. The assessment is required to support rezoning of the land from rural zoned land, to allow for future rural residential or residential subdivision.

AECOM has undertaken a desk study investigation of the potential geohazards within the study area located 702 and 730a Horotiu Road. The Investigation area is approximately 68 Hectares of rural farmland.

The topography can be broadly grouped into the “Lowlands” and “Rolling Hills”. The lowlands are typically near level to gently undulating with river and stream gully systems incised across the surface. The soils of the lowlands are highly variable due to the alluvial deposition, and organic soils can also be present. Rolling hills up to 20 metres high protrude above the alluvial terraces of the lowlands. The rolling hills have a volcanic ash mantle covering, ancient alluvial deposits, and ignimbrite flows.

The key geohazards identified during the investigation are:

- Settlement of soft soils and peats has potential to damage structures and infrastructure within the lowlands.
- Slope instability has the potential to affect the rolling hills and gully slopes
- Soil liquefaction due to ground shaking is a geohazard applicable to the lowlands. Soil liquefaction can result in vertical settlement and horizontal displacement. This hazard has potential to do widespread damage to structures, roads and infrastructure.

A number of development practices have been identified as having potential to instigate, accelerate or make worse geohazards. Earthworks and track formation within the rolling hills could result in slips and erosion. Discharges to ground for managing stormwater and on-site effluent systems can reduce the stability of slopes and result in erosion.

AECOM has assessed the land within the study area against four development suitability categories. The suitability categories do not imply that a site is subject to natural hazard, but that the hazard is associated with that area and needs to be specifically assessed. The development suitability categories and the areas assessed as fitting the categories are:

Category A – Low risk – Top rolling hills with low slope angles.

Category B – Some risk - Rolling hills with low to moderate slope angles.

Category C – Moderate risk - Alluvial soils of the lowlands, rolling hills with evidence of shallow instability.

Category D – High risk – None was present in the mapping area.

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

The hazards identified are likely to be overcome during development of the area. 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.

The rolling hills will not be suitable for stormwater management using soakage due to the poor performance of the ash soils, and the suitability for soakage will need to be investigated in the alluvial parts of the site, however with the presence of water courses to discharge to it will be possible to design suitable stormwater management to service the development.

The geohazards will require investigation, assessment and mitigation design at resource consent stage.

1.0 Introduction

Greig Metcalfe has engaged AECOM New Zealand Limited (AECOM) to undertake a desktop assessment of the geotechnical constraints associated with the potential development of two properties adjacent to Te Kowhai Village. The assessment is required to support rezoning of the land from rural zoned land, to allow for future rural residential or residential subdivision.

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.

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.
- Discussion of the suitability for managing development generated stormwater and wastewater by discharge to ground

This assessment focuses on geohazards and therefore excludes other natural hazards such as flooding, surface ponding 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 boundary of the study area is directly north east of the area addressed in this report.

4.0 Study area description

4.1 General

The study area covers approximately 68 Hectares of predominately rural farmland located at 702 and 730A Horotiu Road, Te Kowhai. A map showing the site extent is presented on Sheet 2 in Appendix A.

The site is located directly to the south and west of Te Kowhai village on near level to gently undulating topography. A prominent gully runs east to west through, and along the northern side of the village.

Land use for the site is pastoral farmland with dairy farming the currently operating The site is bound by Horotiu Road to the south east, rural residential properties to the south, Woolrich Road to the west and Richards Road to the north.

Several structures have been constructed on the property associated with the farming operations. A milking shed and house is situated near the centre of the property. Several sheds and a house are situated near the southern boundary of the properties.

4.2 Geomorphology

The topography can be broadly grouped into the "Lowlands" and the "Rolling Hills".

The site is located approximately 14 Km west of the Waikato River and 2 km east of the Waipa River, the major river systems of the area. Incised tributary gully systems of the Waipa River traverse the site crossing the generally flat to gently undulating low lying portion of the site referred to as the Lowlands.

A network of rolling hills rise approximately 20 metres above the surrounding lowlands. The hills are situated in the south west of the property. These low hills are generally broad with rounded ridge crests and slope angles of between 6 and 20 degrees.

The hills are incised by spring feed stream systems which flow to the lowlands. Man-made shallow ponds are present across the site and are generally located along the routes of the water courses, likely to have been created by forming dams.

4.3 Geology

A geological map of the study area is shown on Sheet A3 in Appendix A. Many of the landforms at the site are as a result of the underlying geology. The geology is described below in terms of the dominant landforms (geomorphology). The landform units are Rolling Hills and the lowlands.

4.3.1 Rolling hills

The sinuous rolling hills of the area are mapped as the Walton Subgroup, which comprises the Puketoka and Karapiro Formations and dates from about 1 to 0.4 million years ago. These formations typically comprise silt, sand and clay of volcanic (rhyolitic) origin and were deposited by the proto-Waikato River. Peat, breccia and non-welded ignimbrite may also be present.

The Walton Subgroup is typically not a surface deposit in the Ngaruawahia area, as it is mantled by the Hamilton Ash Formation. The Walton Subgroup can be exposed in cuttings and or in areas where erosion or instability has occurred.

The Hamilton Ash is a series of completely weathered, clay-rich rhyolitic volcanic ash beds (airfall tephra). The ash beds were deposited between 80 and 380 thousand years ago. The ashes mantled the pre-existing landscape (eroded Walton Subgroup) and locally can be up to 6 metres in thickness, but are typically less than 2 metres on the flanks of slopes in the Ngaruawahia area. The Hamilton Ash is generally a stiff clay soil and does not undergo a significant strength loss when worked due to earthworks.

4.3.2 Alluvial soil of the lowlands

The rolling hills are surrounded by a gently north-westward sloping plain (Hinuera Surface) of 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.

In areas with poor drainage, peat swamps have formed. These swamps (and associated lakes) were formed by the Hinuera Formation sediments damming valleys in the rolling hills. Some of the valleys are broad, forming large areas of peat, for example the Driver Road valley (Kainui bog) to the east of Ngaruawahia. Smaller swamps are present in the Te Kowhai area.

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 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, gully bank erosion, seismicity and liquefaction, volcanic hazard and poor ground conditions (e.g. peat). These hazards are further discussed in the following sections.

5.1 Soil strength and characteristics

5.1.1 Overview

Soil strength is an important consideration when assessing the suitability of land for development, in particular the potential for unacceptable settlement and subsidence of buildings and infrastructure.

5.1.2 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.

5.1.3 Peat shrinkage

Peat is a difficult material with respect to land development. It is highly compressible and therefore settlements can be large under fill and structure loads unless mitigated or accommodated in design. In addition, where surface peat has been or is being drained, peat shrinkage is a significant issue due to the resulting potentially large ground settlements. Settlement due to peat shrinkage can be exacerbated due to applied loads.

Areas with undrained surface peat will generally have a water table close to or at the ground surface. In drained peat, as the peat shrinks over time, the water table depth decreases relative to the ground surface and surface ponding can recur. Land owners respond by deepening the drains which can lead to reactivation or acceleration of the shrinkage as the peat re-stabilises to the new hydrogeological conditions.

5.2 Slope instability

5.2.1 Gully slopes

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.

5.2.2 Rolling hills

The Rolling Hills of the subject area have slopes ranging from 5° to 25°.

Three types of instability are readily identifiable in this terrain.

- Soil creep
- Shallow slumping
- Deep-seated instability

Soil creep is common on slopes steeper than approximately 15°. Soil creep is the gradual downslope movement of the soil profile, which is generally limited to the zone about 1 m below the ground surface. Land owners typically refer to the visible manifestation of soil creep as sheep or cattle tracks.

Shallow instability that occurs in this terrain is generally rotational slumping that affects the uppermost 1 m to 2 m of the soil profile on the steeper slopes. Hummocky ground may be present where this has previously occurred.

Deep-seated instability in the form of rotational slumping is uncommon within low angle slopes of Hamilton Ash hills. Where deeper seated instability does occur slopes are generally steep and instability is usually caused by erosion of the toe of the slope by water courses or spring systems, or by modification to the slope by earthworks or farming.

5.3 Seismic hazard

5.3.1 Introduction

Earthquakes can result 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 5.4.

The closest faults that are currently identified as active in the Geology of the Waikato area. Institute of Geological and Nucleur Sciences 1:250000 geological map 4 are the Turi Fault, Wairoa Fault and the Kerepehi Fault. The Turi Fault is located off the west coast of the Waikato, approximately 90 km south west of Te Kowhai, and is estimated to be capable of generating a M7.2 earthquake approximately every 1,600 years. The Wairoa Fault (60 km north of Te Kowhai) and the Kerepehi Fault (40 km west of Te Kowhai) are 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)

5.4 Soil liquefaction

5.4.1 Liquefaction mechanism

Parts of the site have been geologically mapped as Hinuera 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.

5.4.2 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 with 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.

5.4.3 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.

5.5 Subsidence

5.5.1 Rolling hill subsidence

From previous knowledge of the area it is known that subsurface conduits and voids (tomos) can occur within the rolling hills of the Waikato lowlands. While they are rare, tomos have been exposed or collapsed during development earthworks on the northern fringes of Hamilton. The mechanism for the formation of these voids is unclear and the distribution is not known. Given their rarity, specific exploration to detect these features is not warranted and they are best managed during project construction.

5.6 Non-engineered fill

The site has been used as farmland for an extended period of time, over time it is possible that non-engineered fill could have been placed to 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.

6.0 Development constraints

6.1 Low lands

Development of flat ground is likely to be straightforward. Aside from erosion of exposed soils and potential to alter land drainage paths, there is little risk of subdivision works contributing to natural hazards or environmental issues.

Given the nature of the soils across the lowlands combined with a high groundwater level in areas away from gullies, 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 easily mitigated by shallow ground improvement or by foundation design such as raft style foundations.

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. Significant peat swamps are not mapped within the subject area. However, outside of areas mapped as peat swamps, fine grained and organic materials are often encountered near the base of low hills or as thin beds within the Hinuera Formation. Excavation and replacement of these materials may be required if of significant thickness. If settlement proved to be an issue across the lowlands 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.

Further detail of the suitability of the lowlands for development is provided in section 7.0.

6.2 Rolling hills

On sloping ground or near gullies, certain activities have the potential to result in environmental damage or alter the stability of the natural ground. Earthworks are often required for access to lots and to form building platforms within the lots.

Cuttings associated with subdivision earthworks have the potential to destabilise land above the cutting and can increase the erosion potential of the site. Cuttings within stiff clay soil such as Hamilton Ash or soils such as those likely to be encountered on site can also stand steeply and unsupported when initially excavated. Filling has the potential to increase load on a slope, which can result in instability in the underlying in-situ soil. Side-casting over unprepared ground is inherently unstable increasing both the erosion and instability potential of the slope.

No evidence of large scale instability exists within the subject area. Shallow soil creep on steeper slopes near the crests of gullies or in the steepest area of the low hills is evident. Development within the rolling hill areas of the property are unlikely to be affected by existing instability, however slope stability would need to be considered during subdivision design.

Within the Walton Subgroup materials, soil type and strength can be highly variable depending on the degree of weathering. When highly to completely weathered, the Walton Subgroup materials can undergo significant strength loss when the in-situ structure is destroyed. Consideration is required during subdivision design to confirm the suitability of these materials for cut to fill and for building foundations.

Effluent discharges to ground continually add water to a slope. This can reduce soil strength and lead to slope destabilisation. Effluent discharge fields are defined as building work and are subject to the same requirements to avoid or mitigate natural hazards as the building itself.

Stormwater discharges to ground also have the potential to decrease the stability of nearby slopes. Poorly located dispersion systems can increase erosion potential and also result in instability. Where development is intensified, the cumulative effects of the discharges to ground need to be addressed. Tracks or driveways constructed through sloping terrain capture and concentrate stormwater runoff from both the track itself and also the land upslope of the track. Runoff volumes can far exceed what would be generated by the track alone. This concentration of stormwater can lead to soil erosion and instability.

Further detail of the suitability of the rolling hills for development is provided in section 7.0.

7.0 Development suitability recommendations

7.1 Development suitability categories

7.1.1 Overview

A map has been developed (provided in Appendix A) that classifies the development suitability of the study area based on landforms, geological and geotechnical constraints. The map provides a high level classification of the land and has been developed using the classification system presented in AECOM 2014.

7.1.2 Category A – Low Risk

Category A represents land that is likely to be suitable for development with minimal geotechnical input. There is little risk to buildings and infrastructure. Residential buildings are likely to be able to be developed using foundation details from NZS3604. There is also little environmental risk from developments within the Category A land; however the cumulative effects of stormwater discharges onto or into the land should be addressed as it may affect land beyond this zone.

Category A land has been identified in the south west corner of the property and across the ridge to the south of the cow shed. This area is categorised by ash covered hills with low angle slopes (less than 7 degrees).

7.1.3 Category B – Some Risk

Category B represents land that is likely to be suitable for development with some geotechnical input. Although pockets of land that are unsuitable for development may occur, most land is suitable for residential buildings developed using foundation details from NZS3604 but with shallow ground improvement (e.g. undercut and replacement or foundations that are deepened to more competent materials).There is some environmental risk from developments within the Category B land, which will typically be related to sediment run off due to earthworks for building sites and access ways. Consideration to the management of development induced water discharges and the cumulative effects of increased runoff volumes or soakage to ground volumes is required.

Land that is categorised as Category B is located on the rolling hill where the slope angle exceeds 7 degrees but there is no shallow instability features identified. The angle of these slopes is typically between 7 and 13 degrees.

7.1.4 Category C – Moderate Risk

Category C land has a moderate development risk. There are likely to be development constraints that will need specific and detailed geotechnical assessment to identify how the potential hazards could impact on the development. These hazards include the effects of liquefaction and settlement. Development within Category C land is likely to be possible, however site investigation and assessment of liquefaction and settlement is required in order to develop cost effective mitigation options.

There can be significant environmental risk from developments within the Category C land, which will typically be related to sediment run off due to earthworks for building sites and access ways. Assessment of the cumulative effects of development induced water discharges, in particular increased runoff or soakage to ground volumes and how these may affect the geohazards is required.

Areas categorised as Category C are located:

- At the base of the foothills where soft colluvium may have accumulated.
- Areas in the rolling hills where slopes exceed 7 degrees and there is shallow instability present, this usually occurs on slopes exceeding 13 degrees.
- On the alluvial plains which have potentially liquefiable soils.

7.1.5 Category D – High Risk

Land within Category D is assessed as having a high risk of being subject to a significant geohazard within the zone. Where such hazards are present, mitigation is unlikely to be possible in a safe and economically viable manner and avoidance should be the expectation. Development is not recommended without extensive engineering assessment and design. Hazards may be due to geological conditions beyond the property boundary, and assessment of the wider area is recommended in Category D areas near slopes.

There can be significant environmental risk from developments within the Category D land, which will typically be related to earthworks for building sites and accesses, and development induced water discharges. Assessment of the cumulative effects of development induced water discharges, in particular increased runoff volumes or the volume discharged to ground, and how these may affect the geohazards is required.

No land has been allocated Category D in the investigation area.

7.2 Geomorphological sub -categories

7.2.1 Alluvial Terraces of the Lowlands

The alluvial terraces of the lowlands can generally be considered suitable for urban development or country living zoning, subject to a detailed assessment during the consenting process. Due to variability of soil type and strength, the potential for soil liquefaction and settlement and compression and settlement of soft and/or peaty soils will need to be assessed on a case by case basis. Assessment will need to address risks to both building and infrastructure. It is likely that engineering solutions to mitigate hazards will be required. The alluvial terraces are therefore generally considered to be Category C.

It should be recognised that there are cost effective mitigation measures for managing minor to moderate settlement and liquefaction and therefore would not be a development constraint unless the effects were high or severe.

7.2.2 Rolling Hills

The rolling hills that protrude above the alluvial terrace have a mantle of Hamilton Ash which is typically stiff and has a negligible risk of soil liquefaction. Earthworks may expose lower strength soil which can likely be mitigated during the building consent process.

Slope instability can be present on the steeper flanks of the rolling hills; however it is typically shallow and regressive. Deep-seated failures and debris flows are not typical of the hills.

The rolling hills are predominantly mapped into Category A and B. Category C land occurs on the flanks of the rolling hills where slope instability is present.

8.0 On-site stormwater management

The soils on the rolling hills in the Waikato Basin are typically clayey silt and silty clay derived from volcanic ashes and have low permeability characteristics. These soils are not generally suitable for stormwater management systems that utilise soakage to ground.

The Hinuera Formation is a variable alluvial deposit that is characterised by interbedded layers of sandy soils, silts and clays. Based on our experience the suitability for soakage depends on the presence sandy soils of suitable thickness in the upper two metres of the soil profile. Groundwater levels and lot / road levels will need to be established as part of future works.

The cumulative effects of multiple discharges to ground and /or large point source discharges to ground will need to be considered with respect to gully stability and erosion.

On the basis of the site walk over soakage to ground can be considered a possible method of managing stormwater where Hinuera Formation is present, subject to specific suitability assessment that considers permeability, groundwater levels, design levels and possible effects on gully slopes.

The site has several small gullies and streams that would be suitable receiving environments for attenuated stormwater discharges. Where soakage is not possible then attenuation in tanks, pipes or ponds can be utilised to reduce runoff rates prior to discharge to the natural drainage network.

9.0 On-site wastewater management

AECOM understands that there is limited capacity in the Te Kowhai wastewater treatment facility and for development to proceed at this site it may be necessary to establish onsite wastewater treatment systems.

On-site wastewater treatment would likely require either individual lots to treat and discharge the wastewater within each property or a community based system. Both are briefly discussed below and will need further evaluation.

9.1 Individual systems

If individual systems are used the specific requirements are deferred to building consent, however at the time of the subdivision consent it will be necessary to demonstrate that each lot has an area that is suitable. The most common form of on-site wastewater management is a secondary treatment that discharges to a drip irrigation field. These systems utilise evapotranspiration and infiltration through the topsoil and underlying soil.

Silty clay soils (ash soils) are likely to underlie the topsoil throughout the elevated part of the study area. In areas were Hinuera Formation is present there can also be clayey soils below the topsoil. Appropriate discharge rates may vary from 2 to 4mm/m2 per day. For a typical design flow of 1400 litres per day (4 bedroom house, 7 person occupancy, 200L/day) the drainage field requirements on each lot could be between 350 to 700 m2 per lot with an additional 50% reserve area required.

During the subdivision consent process there will be opportunity to revisit the discharge rates and the likely area requirements and suitability of locations in relation the proposed lot layout.

9.2 Community systems

The other option is a community wastewater treatment plant. The land area required will depend on the number of dwellings being served, however for preliminary guidance the range provided above can be considered reasonable for each lot being serviced by the system. If sand soils are present it may be possible to significantly reduce the drainage field requirements by using drainage beds with discharge rates between 10 and 40mm per day depending on subsoil evaluation (35 to 140m2 per dwelling). It should also be noted that for a community system several discrete drainage fields may be possible, rather than identifying a single large area.

9.3 Constraints

Several constraints were identified in the site walkover and will need to be considered during subdivision design.

- Steep slopes with soil creep will not be suitable for effluent discharge
- Effluent discharges will need to adequately separated from watercourses as per the requirements of the Waikato Regional Plan
- Proximity to steep gully slopes will need to be evaluated
- Groundwater depth will need evaluation

Despite the constraints above a large proportion of the site will be suitable for on-site effluent management, although it should be recognised that this will need to be a consideration that is taken into account when determining the lot sizes and layouts.

10.0 Summary

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

The rolling hills will not be suitable for stormwater management using soakage, and the suitability for soakage will need to be investigated in the alluvial parts of the site, however with the presence of water courses to discharge to it will be possible to design suitable stormwater management to service the development.

Some parts of the rolling hills and areas near water courses and gullies may not be suitable for discharge of wastewater. Lots can be designed to have suitable areas to manage the discharge individually or a community system can be used to increase the density of the lots. This can be evaluated during subdivision consenting.

11.0 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 District Council, 2013, Ngaruawahia Structure Plan Preliminary Assessment Scoping Report.

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

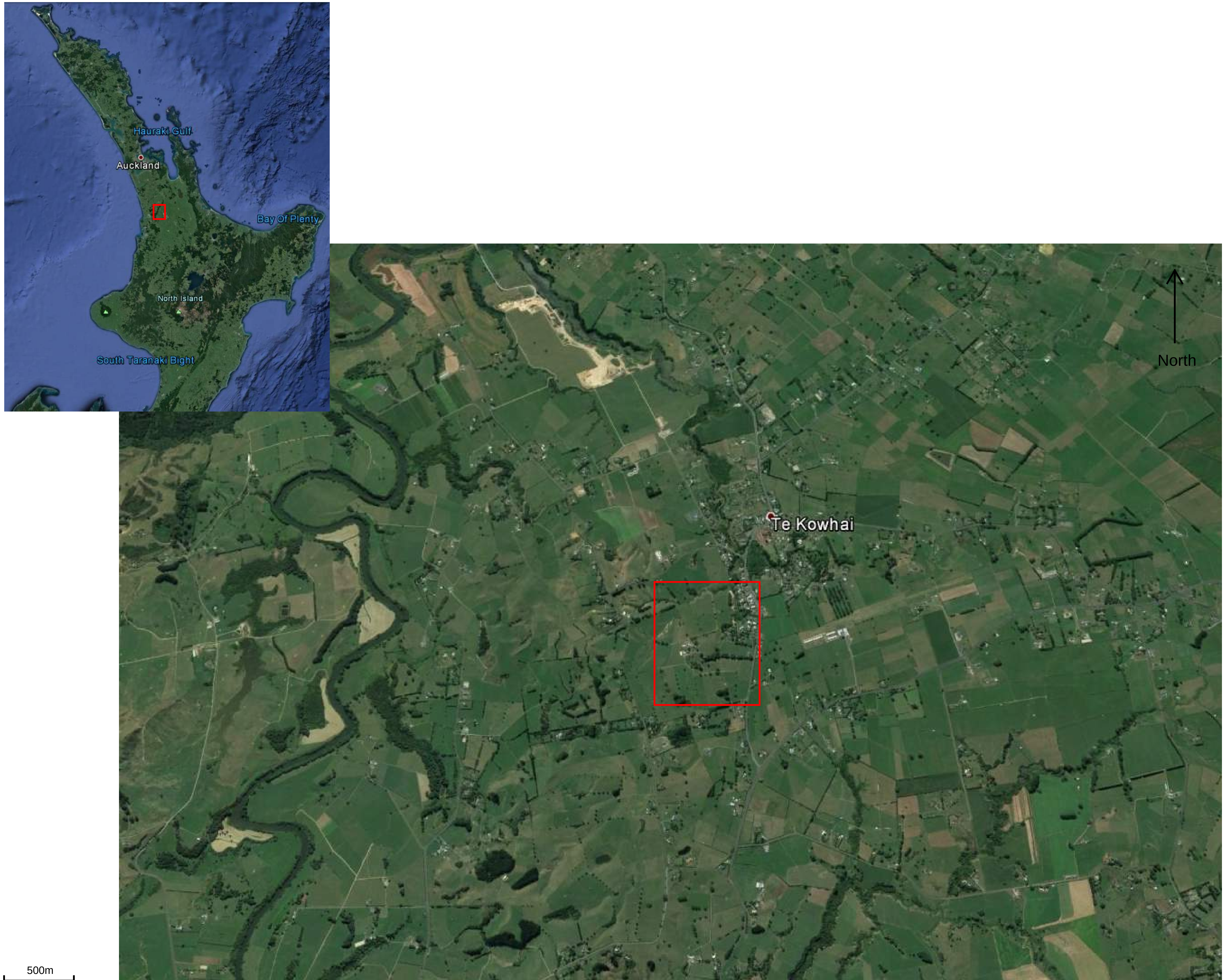
12.0 Limitations

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



500m

Image sourced from Google Earth Pro

ISO A1 594mm x 841mm

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ISSUE/REVISION

I/R	DATE	DESCRIPTION

KEY PLAN

Site location

PROJECT NUMBER

60533162

SHEET TITLE

Site location Plan

SHEET NUMBER

Figure 1

17 Jan 2017 13:17

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Designed		Checked	
Drawn			

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Rev	Date	Description

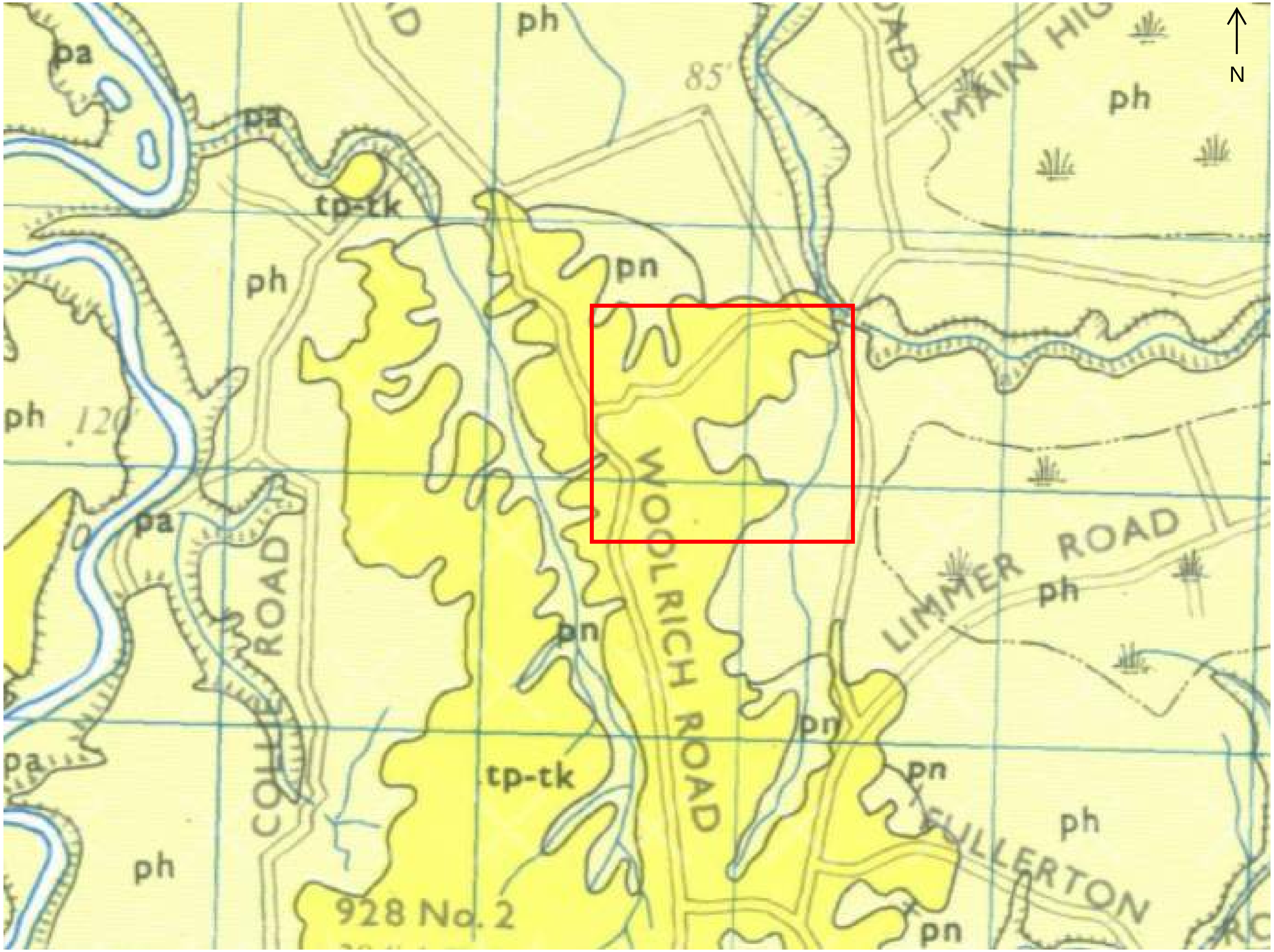
Scale: 1:2,000 (A1 size)

KEY PLAN

PROJECT NUMBER

SHEET TITLE

MAP NUMBER



ph	**Hinuera Formation** Current bedded pumiceous sands, silts and gravels interbedded with peat.
tk	**Karapiro Formation** (tk) Sands like Hinuera but usually highly weathered.
tp	**Puketoka Formation** (tp) Predominantly highly pumiceous silts and sands interbedded with peat.

750m

Image sourced from Geological Map of New Zealand, Sheet N56 - Ngaruawahia. New Zealand geological Survey

ISO A1 594mm x 841mm

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Site location

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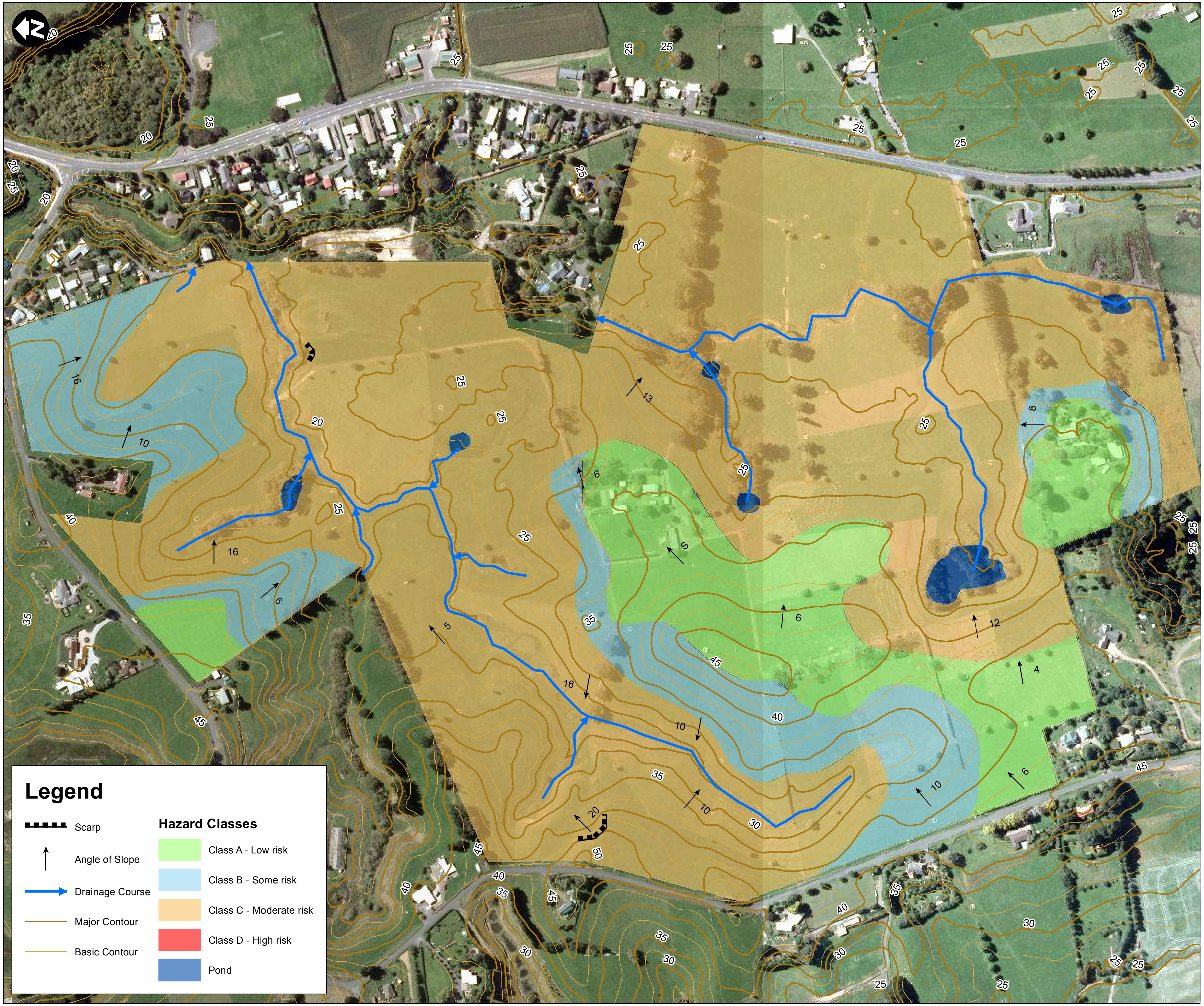
SHEET TITLE

Geology Plan

SHEET NUMBER

Figure 3



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SPATIAL REFERENCE

Scale: 1:4,000 (A3 size)

40 20 0 40 80 120 Meters

Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

PROJECT MANAGEMENT

Approved	DMM	Date	31.01.17
Checked	DMM	Date	31.01.17
Designed	RJS	Date	31.01.17
Drawn	RJS	Date	31.01.17

ISSUE/REVISION

Rev	Date	Description
A	31.01.17	For information

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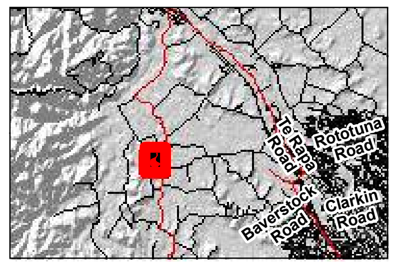

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SHEET TITLE

Hazard class map

MAP NUMBER

Figure 4

ISO A3 297mm x 420mm
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