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# Taupō Industrial Plan Change

## Preliminary Desktop Geotechnical Assessment

15 September 2022

CONFIDENTIAL



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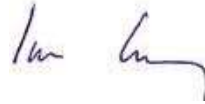
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## Document History and Status

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## Revision Details

Revision	Details
A	This report has been issued for client consideration prior to completion of site walkovers for the ground truth preliminary geotechnical assessment that will substantiate the desktop assessment for selected sites.
B	Updated land parcel extents, numbering and associated changes to desktop assessment, inclusion of Waikato Regional Council contaminated land information.
C	Updated total area for Site 4 and associated maps



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## Disclaimers and Limitations

This report (**'Report'**) has been prepared by WSP exclusively for Taupō District Council (**'Client'**) in relation to preliminary geotechnical assessment to inform the Taupō Industrial Plan Change (**'Purpose'**) and in accordance with the Consultancy Services Order dated 1 August 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

In preparing the Report, WSP has relied upon data, surveys, analyses, designs, plans and other information (**'Client Data'**) provided by or on behalf of the Client. Except as otherwise stated in the Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable in relation to incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

# 1 Introduction

WSP has been engaged by Taupō District Council to carry out a preliminary desktop based geotechnical assessment to inform the proposed Taupō Industrial Plan Change (TIPC). The TIPC proposes to rezone rural land to industrial land.

This geotechnical report will form part of a Section 32 and Planning Assessment in support of additional industrial land supply to enable business growth and development in Taupō.

This assessment is a limited desktop study to screen proposed plan change sites for significant geotechnical risks, areas of concern and to form the basis for more detailed assessment in the future.

## 1.1 Planning Context

The level of geotechnical assessment required to inform a Plan Change is set out in Earthquake Geotechnical Engineering Practice Module 2<sup>1</sup>. Module 2 provides minimum recommendations to support various land development scenarios. Minimum investigation requirements for a plan change involving land more than 10 hectares in size are as follows:

- 11 deep geotechnical investigation points for the first 10 hectares
- 1 deep geotechnical investigation point for every 4 hectares thereafter.

For context, two recent Private Plan Changes have occurred in the Taupō region, Whareroa (Plan Change 36 – rural to residential, 14.63 hectares) and Nukuhau (Plan Change 37 – rural to residential and medium density residential, 77.78 hectares).

Plan Change 36 was approved by a panel of independent commissioners without any deep geotechnical investigation being completed, on the basis that the Outline Development Plan (ODP) included a requirement for geotechnical investigation as a Preliminary Stage.

Geotechnical assessment and investigation consisting of 11 Cone Penetrometer Tests (CPTs), four rotary cored boreholes and four hand augered boreholes was carried out to inform Plan Change 37. Plan Change 37 was approved by a panel of independent commissioners.

This preliminary geotechnical desktop assessment contained herein is the first step in ensuring that high level theoretical geohazards are identified and can be managed so as not to create intolerable risk to future industrial development. Comprehensive site walkovers and deep geotechnical investigation will be required to further investigate geohazards that are identified through the desktop assessment process, either prior to the Plan Change or through an Outline Development Plan.

Geohazards will need to be evaluated based on the Waikato Regional Council Risk Management Framework (Section 13.1.1):

*Regional and district plans shall incorporate a risk-based approach into the management of subdivision, use and development in relation to natural hazards. This should be in accordance with relevant standards, strategies and plans, and ensure that:*

- a. new development is managed so that natural hazard risks do not exceed acceptable levels;*
- b. intolerable risk is reduced to tolerable or acceptable levels;*

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<sup>1</sup> MBIE & NZGS, Earthquake Geotechnical Engineering Practice Module 2: Geotechnical Investigations for Earthquake Engineering, Rev 1, November 2021

- c. the creation of new intolerable risk is avoided;
- d. any intolerable risk as a result of existing use and development is as low as reasonably achievable; and
- e. where intolerable risk remains, the risks will be managed until an acceptable level is achieved

## 2 Methodology

The scope of works is limited to a desktop-based assessment of geotechnical hazards, including review of the following information:

- Published geological maps;
- Historic aerial imagery (Google Earth and Retrolens);
- Investigation data available on the NZ Geotechnical Database;
- Data available on Taupō District Council's GIS mapping service 'Mapi';
- Waikato Regional Council's Online Hazards Portal;
- Existing geotechnical investigation data available for the sites and/or neighbouring sites provided by TDC;
- Publicly available LiDAR;
- Settlement monitoring information provided by Contact Energy.

An overview of geo-hazards present within the Taupō region are first presented and possible constraints these hazards pose to development are discussed generally. Each site is then assessed for susceptibility to these hazards.

Site maps, including LiDAR contour maps are included in Appendix A.

## 3 Site Description

At the time of reporting the proposed plan change covers six general land areas, identified as Sites 1 to 4, 6 and 7 as detailed in Table 1. Sites 5 and 8A were removed from the geotechnical desktop assessment scope prior to reporting due to land encumbrances but are included in the table for completeness. The location of the sites is shown in Figure 1. The sites are generally located to the north, east and south of the established Taupō industrial area.

Table 1: Site details

Site No.	Site Name	Address	Legal Description	Approx. Land Area (ha)
1	Centennial Northern Extension	Rakaunui Rd	Part of Section 6 SO 438783	110
2	Centennial Eastern Extension	40 Aratiatia Rd	Lot 1 DP 429009	10
3	Centennial Southern Extension	261 Broadlands Rd	Part of Lot 1 DP 445148	28
4	Broadlands Road West	63 Broadlands Rd	Part of Section 14 SO 438782	20
5	Broadlands Road East			
6	Rangatira E	Scoria Rd	Pt Rangatira E Block ML 20386	90
7	Napier Road	189 Napier Rd	Lot 2 DP 499406	4
8A	Aratiatia Road			



Figure 1: Approximate location of sites (ref: TDC Mapi Online), note site 5 and 8A not shown

## 4 Geological Setting

The GNS New Zealand 1:250k geological map of the Rotorua<sup>2</sup> area indicates that the area encompassed by the proposed plan change is underlain by the Taupō Pumice Formation (Q1v). The Taupō Pumice Formation is described as non-welded, loose to poorly consolidated to sintered, white to pale grey rhyolite ignimbrite with white to pale pink pumice clasts; commonly includes charcoal fragments and logs; fall deposits; minor alluvium.

Pumice deposits expected to be encountered across the sites originate from eruptions within the Taupō Volcanic Zone and are typically lightweight, highly crushable and hence compressible which differentiates them from hard grained sand deposits.

## 5 Geotechnical and Geo-Environmental Hazards

### 5.1 Earthquakes

#### 5.1.1 Faulting

There are many active faults within the Taupō District, mainly associated with the Taupō Rift. The GNS report titled 'Active fault hazards in the Taupō District'<sup>3</sup> provides the most up to date information relating to faulting hazards in the region.

<sup>2</sup> Leonard, G.S., Begg, J.G., Wilson, C.J.N. (compilers) 2010. Geology of the Rotorua area. Institute of Geological & Nuclear Sciences 1:250000 geological map 5. 1 sheet + 102p. Lower Hutt, New Zealand.

<sup>3</sup> GNS, Active fault hazards in the Taupō District, August 2020. GNS Science Consultancy Report 2020/31.



The GNS report references the Ministry for Environment 'Planning for Development of Land on or Close to Active Faults'<sup>4</sup> which provides guidance for zoning and developing land near active faults. Industrial buildings will typically be classified Importance Level (IL) 2b, and therefore when considering a greenfields development generally should not be built within a fault avoidance zone relating to a fault with an average recurrence interval of less than 5,000 years.

Several active faults and associated fault avoidance zones are identified through the sites. Fault avoidance zones have been created by setting a 20m buffer either side of a mapped fault line to define the likely rupture zone. The three faults that pass through the sites, Aratiatia, Rotokawa and Karapiti are all well-defined and have an average recurrence interval of less than 2,000 years.

It should be noted that there are discrepancies between the latest GNS fault line mapping (most recent work) and the location of the faults on Taupō District Council's planning maps (which remain operative, but which we assume will be updated). The best example of this is on Site 3 where we have included both sets of fault traces. Although it is almost certain that the planning maps will be modified to reflect the latest mapping work in time, consideration needs to be given to all identified faults until proven otherwise. *Should Council choose to defer to the latest GNS mapping, we would support that stance and modify our report accordingly.*

### 5.1.2 Liquefaction

Liquefaction refers to the sudden loss in shear stiffness and strength of soils associated with the reduction in effective stress due to pore water pressure generation during cyclic loading caused by earthquake shaking<sup>5</sup>. Consequently, vertical ground settlement and lateral spread can result in significant damage to buildings and infrastructure.

Determining liquefaction susceptibility of pumice sand deposits is more difficult than common sedimentary soil deposits. Current empirical methods for liquefaction analysis based on penetration testing are not applicable to pumiceous soils<sup>6</sup>.

Waikato Regional Council completed a Level A liquefaction vulnerability assessment in accordance with the MBIE document titled 'Planning and engineering guidance for potentially liquefaction-prone land'<sup>7</sup>. The assessment defines areas as being 'possibly prone to liquefaction', 'unlikely prone to liquefaction' or 'undetermined'. Most of the Taupō township is 'undetermined'.

Taupō District Council is in the process of carrying out a liquefaction susceptibility mapping exercise for the Taupō Town, however this information is not yet publicly available.

Without pre-empting the actual outcomes of the Taupō District Council regional assessment, in general, the sites would not traditionally be viewed as susceptible to liquefaction given their elevation above significant surface waters and the resulting high groundwater, which is one of the key determinates to liquefaction occurring under seismic cycling. Having said that, the boundary conditions for liquefaction and/or lateral spread to occur are problematic to define on a desktop study. For example, perched groundwater levels, which can be localised, may be close enough to the surface and coincide with loose surface sands or silts and could result in manifestation of liquefaction at ground surface under seismic cycling. There have been instances of this in the Taupō district.

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<sup>4</sup> Ministry for the Environment, Planning for Development of Land on or Close to Active Faults, July 2003

<sup>5</sup> MBIE/NZGS Earthquake Geotechnical Engineering Practice Module 3: Identification and Assessment of Liquefaction Hazards Rev 1, November 2021

<sup>6</sup> Orense et al., Evaluating Liquefaction Potential of Pumiceous Deposits Through Field Testing: Case Study of the 1987 Edgecumbe Earthquake, NZSEE, June 2020

<sup>7</sup> MBIE, Planning and engineering guidance for potentially liquefaction-prone land, Rev 0.1, September 2017

Deep geotechnical investigation and liquefaction analysis will be required to confirm the liquefaction susceptibility of the sites.

## 5.2 Land Instability

### 5.2.1 Landslides

There are no mapped landslides on or near the parcels of land identified for the proposed plan change. Most of the sites are flat and are more prone to land instability in the form of gully erosion, localised slope instability and tomo formation as described below.

### 5.2.2 Localised Instability and Gully Erosion

Many of the sites are scattered with naturally occurring, steeply incised gullies which have formed via erosion of the pumice deposits. The gullies can be seen on the LiDAR site maps included in Appendix A.

Slope stability is a common issue along the edges of the steep gully systems discussed above. Minimum set-back distances to slope crests are likely required to mitigate any affect slope instability may have on industrial development and associated infrastructure. Slope instability under earthquake loading will also need to be considered during development.

### 5.2.3 Tomo Formation

Tomos are commonly encountered throughout the pumice derived soils of the Taupō region. Tomos typically form due to some preferential flow of groundwater, which strips finer grains of the subsurface resulting in a void below the ground surface. Once the void grows to a size that can no longer be arched by the overlying soil there will be a collapse.

Tomos can be identified at surface only after collapse, and whilst underground voids can be intersected with deep investigation they are easily missed when using discrete investigation points.

Tomos that present at the surface after collapse are a significant hazard to the built environment. There are numerous examples in recent times of tomos affecting the local and state highway roading network as well as other network utilities.

Mitigation for commonly encountered tomos include excavation and replacement with compacted fill and diverting stormwater away from known tomo locations. Should deeper tomos ultimately be encountered, they are more difficult to manage and may only be able to be mitigated through development exclusion zones.

All sites identified in the proposed plan change are possibly affected by tomos.

## 5.3 Geothermal Hazards

### 5.3.1 Subsidence

Subsidence due to extraction of geothermal fluids for power generation and natural flows of geothermal fluids is a geohazard known to affect the Taupō township.

Waikato Regional Council have mapped the subsidence bowl associated with the Wairakei-Tauhara Geothermal Field, refer Figure 2. The subsidence bowl is indicated in yellow and areas where geothermal heat reaches the ground surface are shown in green. Several of the sites are located within the subsidence bowl.

Contact Energy actively monitors subsidence and have provided WSP with monitoring data for the period 2017 to 2021<sup>8</sup>. Most of the sites are located either wholly or partially within the area of subsidence.

The rate of future subsidence is entirely dependent on the rate of extraction and ability to counteract extraction effects with reinjection. Based on historic monitoring data, subsidence has the potential to result in differential settlement within the design life of a typical industrial building.

Differential settlement over a building footprint can cause significant serviceability issues, such as cracking of floor slabs and loss of access. Industrial activities that involve heavy machinery or activities such as high precision manufacturing can be highly sensitive to settlement related issues. Subsidence of this kind can typically only be mitigated through considered structural and foundation design that seeks to supply a solution for the design life of the structure, when balanced against the subsidence present at the time of that design.

Subsidence also has potential to affect the serviceability of infrastructure related to industrial development, such as roading, underground pipelines, drainage, and water supply. Effects can potentially be mitigated by incorporating flexible elements and resilient connection details.



Figure 2: Geothermal subsidence bowl (orange) and geothermal habitats (green), (ref: Waikato Regional Hazards Portal)

### 5.3.2 Hot Ground

A hot ground hazard area has been mapped by TDC to the east and north of the Taupō township.

Hot ground can be indicated at ground surface by sulphur patches, steam and/or poor vegetation growth. Aerial imagery suggests areas of geothermal heat reaching the ground surface are likely to be present on some of the sites proposed in the plan change. Site walkovers and temperature readings during intrusive investigation are required to confirm the presence of hot ground hazards.

<sup>8</sup> Contact Energy, Figure 9, Subsidence Contour Plan of the 2017 to 2021 Survey Period (Southern Part), Taupō-Wairakei-Tauhara Rates of Ground Level Change in mm/yr, ref 21/1, 30 November 2021

Hot ground and geothermal gases are problematic for development but also have human health implications. Geothermal gases within the soil must be considered during development, with appropriate mitigation measures put in place.

Hydrothermal eruptions are also possible within geothermally active areas and are known to have occurred in the Broadlands Road area, most recently in 1981. High pressure geothermal pressure features such as geysers are extremely hazardous to life and development.

## 5.4 Flooding

The Taupō township is predominantly underlain by free draining pumiceous soils and therefore surface flooding issues are atypical for the area. Stormwater generally soaks away quickly into the natural deposits. There are however certain conditions where the soils act in a hydrophobic nature, resulting in very high runoff factors. This is typically during summer months where soil moisture is very low and Taupō experiences very intensive and localised cloud burst events. Careful civil design will be required to ensure that overland flow paths and surcharging stormwater systems are carefully considered.

None of the sites have been identified as having specific flood hazards, however it is possible for flooding to occur within the gully systems that are present on many of the sites. The gullies will naturally convey stormwater which can lead to erosion and slope instability risks that are discussed above. Modification of the gully systems can also have significant implications on flooding vulnerability to downstream land.

Stormwater drainage design for industrial development must consider these gully networks and will ultimately be subject to carefully considered discharge consents.

## 5.5 Expansive, Compressible and Sensitive Soils

Expansive soils are those which exhibit significant shrinking or swelling due to changing water content, generally described as plastic clays. Clays encountered in the Central North Island typically do not exhibit expansive behaviour.

We are not aware of any mapped areas of compressible or sensitive soils within the sites. However, compressible and/or sensitive soils may be present in areas across the sites, either widespread or highly localised and will likely only be identified through physical investigation. If identified on the sites these soil types will require testing and careful integration into development designs. These soils typically create challenges when additional load is applied, for instance within large bulk fills or within the foundation influence zone of a structure. If present, the extent and depth of these soils will determine the level of mitigation required through the designs of earthworks and foundation systems of structures which could include elements such as specifically designed culvert foundations, monitoring of bulk fill settlements or compensated building foundation systems.

## 5.6 Uncertified Fill

No areas affected by uncertified fill have been identified during this desktop assessment. Uncertified fill is difficult to identify via desktop assessment, except for larger scale earthworks that can be picked up on historic aerials. Site walkovers and intrusive investigation will be required to confirm the absence of uncertified fill. It should be noted that most of the sites have been subject to pastoral or cropping farming activities over time, and which both almost certainly have had soils modification to a degree.

Construction of the East Taupō Arterial (ETA) in the early 2000s has modified ground levels near several of the sites. Although it is assumed that all filling activities associated with the ETA construction were controlled and certified appropriately, however this has not been checked as part of this assessment, and there may be areas that were used for bulk unsuitable soil disposal.

## 5.7 HAIL Sites

A site is considered to be contaminated when hazardous substances are found at significantly higher concentrations than their normal levels, and there is likely to be a risk to human health or the environment. Potentially contaminated land is land that has been used for an activity that is more likely than other activities to cause contamination<sup>9</sup>. The Hazardous Activities and Industries List (HAIL) prepared by the Ministry for the Environment is used to help identify potentially contaminated sites.

Identified HAIL sites require additional investigation and assessment to determine implications on industrial development. Site remediation may be required for contaminated sites.

The Waikato Regional Council (WRC) holds information relating to HAIL sites in the region. A request was submitted to WRC for information held on their Land Use Information Register. Parts of two of the sites appear on the Land Use Information Register, specific information is contained in the following site-specific sections.

One of the sites also appears on Taupō District Council's District Plan as a known contaminated site, due to the use of sewerage irrigation.

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<sup>9</sup> Waikato Regional Council, Contaminated Land, <https://www.waikatoregion.govt.nz/services/regional-services/waste-hazardous-substances-and-contaminated-sites/contaminated-sites/> [accessed 10.08.2022]

## 6 Centennial Northern Extension (Site 1)

The Centennial Northern Extension site is located at the northern end of Rakaunui Road and is bounded by the ETA (State Highway 1) to the west. Based on aerial photography, the site is currently open pasture with a farm track running through the middle. The site slopes downwards to the northwest. A large cow shed and effluent ponds are located towards the southern site boundary.

Table 2: Summary of Site 1

Hazard	Description
Faults	Two splays of the Aratiatia fault are mapped within the site with associated fault avoidance zones. The Aratiatia Fault has an estimated recurrence interval of less than 2000 years.
Liquefaction	Undetermined
Land Instability (including erosion)	Southwestern boundary of the site borders a steeply incised gully that flows to the Waikato River, localised slope instability and erosion risk.
Geothermal & Hot Ground	No geothermal features identified, not within the mapped hot ground zone
Subsidence	Partially within subsidence bowl, rate of subsidence for 2017-2021 measured at 0mm to 5mm per year.
Uncertified Fill	None identified. Certified fill associated with the ETA construction likely extends along the western site boundary.
Flooding	Flood risk not identified
Contaminated Land	The site is a 'Known Contaminated Site' (C13) as per the District Plan due to the use of sewerage irrigation and farming activities. Part of the site also appears on the WRC Land Use Information Register as LU12269, classified as unverified HAIL due to past land use for HAIL activity 'A8 livestock dip or spray race'. Contaminated land investigation and assessment required.
Existing Geotechnical Investigation Data	Multiple shallow CPTs, two deep boreholes and several test pits carried out along the western and eastern property boundary as part of the ETA design phase. Investigations show ground conditions consistent with regional geology - pumiceous SAND/Gravelly SAND with some Sandy SILT layers.

## 7 Centennial Eastern Extension (Site 2)

The Centennial Eastern Extension site is accessed from Aratiatia Road and is bounded by the Off Road Highway to the south. The site is largely bare grassland, with a workshop/shed structure in the northwest corner of the site with a sealed accessway and small ancillary structures. A water tank is located on an elevated point in the centre of the property. A paper road with a high pressure gas pipeline cuts through the section of the site.

Table 3: Summary for Site 2

Hazard	Description
Faults	There are no mapped faults within the site.
Liquefaction	Unlikely
Land Instability (including erosion)	No gullies identified in aerial photography. Signs of instability identified on the southern hillside. Surface expression of tomos or other erosional feature possibly identified to the east of existing workshop.
Geothermal & Hot Ground	No geothermal features identified, not within the mapped hot ground zone.
Subsidence	Wholly within subsidence bowl, rate of subsidence for 2017-2021 measured at 5mm to 10mm per year.
Uncertified Fill	None identified
Flooding	Flood risk not identified
Contaminated Land	None identified
Existing Geotechnical Investigation Data	Closest investigation data is 500m west of the site (NZGD).

## 8 Centennial Southern Extension (Site 3)

The Centennial Southern Extension is a parcel of land between Broadlands Road and Centennial Drive, just south of the Te Huka Power Station. The site is just north of a geothermally active landform and a fault line cuts through the southern end of the site. The site is currently undeveloped, with a portion covered in pine trees and the rest of the site appears to be used for grazing.

Table 4: Summary for Site 3

Hazard	Description
Faults	There is an active fault line mapped along the southern boundary of the site, and fault avoidance zones are also mapped just east of the site, orientated in a northeast to southwest direction. The faults are traces of the Rotokawa Fault which has an estimated recurrence interval of less than 2000 years. Fault mapping along the southern boundary of the site is likely required.
Liquefaction	Part of the site is undetermined; part of the site is unlikely.
Land Instability (including erosion)	Multiple overland flow paths with potential for erosion issues identified throughout the site.
Geothermal & Hot Ground	The site is just south of the Te Huka Power Station which is owned and operated by Contact Energy. Expression of geothermal activity at ground surface identified just west of the site, possible that surface vents are located within the site. Hot ground hazard area mapped to the south of the land parcel.
Subsidence	Wholly within subsidence bowl, rate of subsidence for 2017-2021 measured at 0mm to 15mm per year.
Uncertified Fill	None identified. Certified fill associated with the ETA construction likely extends along the western site boundary.
Flooding	Flood risk not identified
Contaminated Land	None identified within the parcel proposed for plan change, however the property does appear on the WRC Land Use Information Register as LUI07784 related to the Te Huka Power Station/Tauhara One.
Existing Geotechnical Investigation Data	Several test pits, hand augers, CPTs and boreholes completed along the western property boundary as part of the ETA design phase. Investigations show ground conditions consistent with regional geology – pumiceous Sandy GRAVEL with some silt.



## 9 Broadlands Road West (Site 4)

Site 4 is located between State Highway (SH) 5 and Broadlands Road. The site is largely undeveloped, with one building located towards the Broadlands Road access. The site slopes downwards from east to west, towards a mapped geothermally active area.

A Preliminary Geotechnical Assessment Report was prepared by Cheal in 2018<sup>10</sup> to inform design of a commercial development over part of the site. The report concluded that the site is geotechnically suitable for the commercial development proposed subject to recommendations in the report. The Cheal assessment included a site walkover and shallow hand investigation.

Table 5: Summary for Site 4

Hazard	Description
Faults	There are no mapped faults within the site, however the Rotokawa Fault is mapped just north of the site and it is possible that traces of the fault could continue through the site. Fault mapping within the site may be required.
Liquefaction	Part of the site is undetermined; part of the site is unlikely.
Land Instability (including erosion)	Multiple overland flow paths with potential for erosion issues identified throughout the site. Cheal did not identify any active erosion within the portion of site they assessed. Cheal did identify 'isolated small sinkholes, one with dumped farming waste' within the portion of site they assessed.
Geothermal & Hot Ground	The western portion of the site is located within the Hot Ground Hazard Area and there are indications on aerial images that surface vents are present within the site.
Subsidence	Wholly within subsidence bowl, rate of subsidence for 2017-2021 measured at 5mm to 20mm per year.
Uncertified Fill	None identified
Flooding	Flood risk not identified
Contaminated Land	None formally identified. Farming activities evident on site, contaminated land investigation and assessment likely required. Cheal identified dumped farming/building waste on site.
Existing Geotechnical Investigation Data	<p>Several test pits, hand augers, CPTs and boreholes completed just west and south of the site as part of the ETA design phase. Investigations show ground conditions consistent with regional geology – pumiceous Sandy GRAVEL with some silt.</p> <p>Eight DCPs and one hand auger were carried out by Cheal on the site, with associated ground temperature readings.</p>

<sup>10</sup> Cheal, 63 Broadlands Road, Taupō, Preliminary Geotechnical Assessment Report for Mega Food Services Ltd. (ref: 17685), 22 March 2018

## 10 Rangatira E (Site 6)

The Rangatira E site is largely undeveloped pasture, with some residential housing and farm buildings located within the eastern extent of the land parcel. The site is just north of the Acacia Bay residential area and is most easily accessed from Poihipi Road. Gullies scar the surface of the site, and there are indications of prevalent erosion.

Table 6: Summary for Site 6

Hazard	Description
Faults	Active fault traces of the Karapiti Fault and associated fault avoidance zones cross the site. The Karapiti Fault, which has a recurrence interval of less than 2000 years.
Liquefaction	The site is partially undetermined, partially unlikely.
Land Instability (including erosion)	Multiple gullies identified on aerial imagery, tracking north to south through the land parcel. Indication of erosional issues and local instability along gully walls. Complex landforms.
Geothermal & Hot Ground	No geothermal features identified, not within the mapped hot ground zone.
Subsidence	Partially within subsidence bowl, rate of subsidence for 2017-2021 measured at 0mm to 5mm per year.
Uncertified Fill	None identified
Flooding	Flood risk not identified
Contaminated Land	None identified
Existing Geotechnical Investigation Data	The closest investigation data available on the NZGD is associated with the Nukuhau Private Plan Change, approximately 130m south and also just east of Poihipi Road. Investigations show ground conditions consistent with regional geology.

## 11 Napier Road (Site 7)

The Napier Road site is located to the southwest of the Napier/Taupō Highway Roundabout. The site is currently home to a commercial building, paved carparking areas and a large water storage pond. The area south of the building is undeveloped.

HD Geo Ltd completed a Preliminary Geotechnical Assessment<sup>11</sup> for this site in November 2021 that was informed by a site-specific geotechnical investigation. The report was prepared to support a Resource and Subdivision Consent application for a commercial development on the site. The report concluded the following:

*“The site has no major geotechnical hazards or considerations and is geotechnically suitable for the proposed subdivision. Further assessment will be needed to inform development and foundation design across the site, particularly in the areas of uncontrolled fill”.*

Table 7: Summary for Site 7

Hazard	Description
Faults	There are no mapped faults within the site.
Liquefaction	Insignificant – based on results of HD Geo’s Preliminary Geotechnical Assessment.
Land Instability (including erosion)	No evidence of erosion or instability identified on aerial photography, likely overland flow of stormwater in an east to west direction based on LiDAR. Historic gullies appear to have been infilled based on historic aerial imagery, possible erosion risk.
Geothermal & Hot Ground	No geothermal features identified. The southern extent of the site is within a Hot Ground Hazard Area.
Subsidence	Not located within subsidence bowl.
Uncertified Fill	Uncertified fill identified during investigation completed by HD Geo, in various locations between 0.1m and 2.7m below ground level. Certified fill associated with ETA construction likely extends along the eastern and northern site boundary.
Flooding	Flood risk not identified
Contaminated Land	None identified, uncertified fill may require testing.
Existing Geotechnical Investigation Data	Six test pits, 10 hand augers, six CPTs and one machine drilled borehole were completed on the site by HD Geo Ltd in 2021/2022. Investigations show ground conditions consistent with regional geology. Many of the investigation points identified hot ground.

<sup>11</sup> HD Geo Ltd, 189 Napier Road, Taupō, Preliminary Geotechnical Assessment, ref: HD2092, PGR-1, 1 November 2021

## 12 Summary & Conclusions

A preliminary desktop assessment has been carried out for six sites that form part of an Industrial Plan Change in Taupō. This preliminary assessment is intended to screen sites for geotechnical and geo-environmental hazards which have potential to create 'intolerable risk' to future industrial development.

The following conclusions can be made from the desktop assessment:

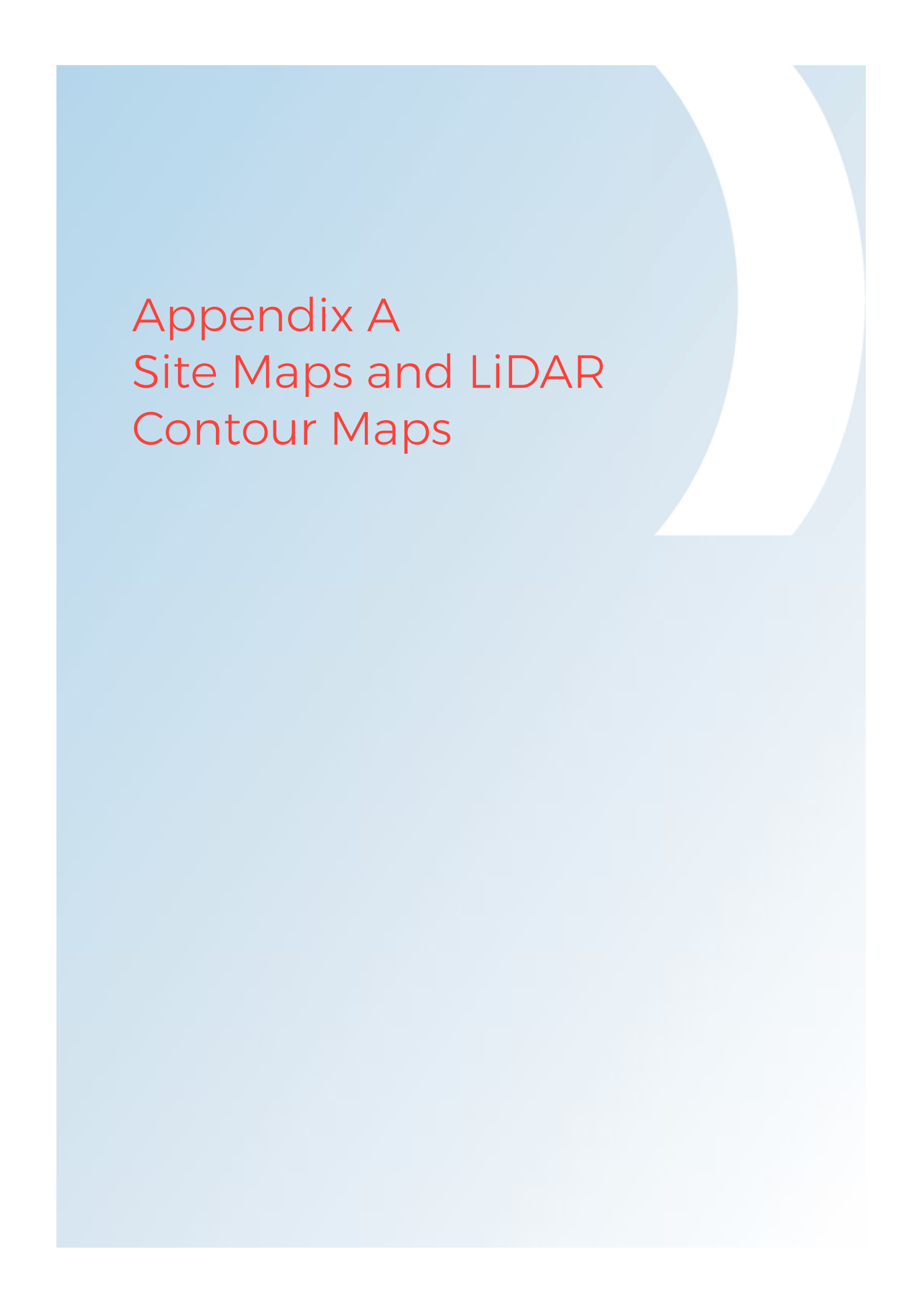
- Fault traces and fault avoidance zones are present on many of the sites. Detailed fault trace mapping is recommended for Sites 1, 3 and 6. Fault avoidance zones should be enacted for industrial development.
- Liquefaction susceptibility should be reviewed once the regional assessment is completed by TDC, as liquefaction hazard for most of the sites is undetermined. Site specific testing is required for all sites to assess susceptibility of the sites to liquefaction and the impact this may have on industrial development.
- Sites 1, 4 and 6 are affected by steeply incised gully systems which are likely prone to localised slope instability and ongoing erosion.
- All sites are potentially affected by tomo formation which can be a considerable risk to industrial development.
- Geothermal hazards are present on or very close to Sites 3, 4 and 5.
- Subsidence from extraction of geothermal fluids is known to affect Sites 1, 2, 3, 4 and 6. Future subsidence linked with geothermal activities is entirely dependent on extraction and reinjection rates, development of these sites will require careful consideration of the implications of both total and differential settlement.
- Site 1 is a known contaminated land site, whilst not expected to prohibit industrial development a contaminated land investigation and assessment will be required.

A site walkover is recommended to identify geomorphological features that are not easily identified from aerial imagery. For example, expression of tomos at ground surface would indicate a higher risk of tomo formation underground. A walkover will also aid in identification of geothermal features by observing sulphur patches, steam, and/or poor vegetation growth.

Several geotechnical investigation data points are available for Site 7, however investigation data is extremely limited for all other sites. Whilst a desktop assessment is appropriate to screen sites for potential hazards, a ground investigation is required to further define the risk that those geohazards pose to industrial development. Development of a comprehensive geotechnical investigation plan is recommended once site walkovers have been completed. It needs to be noted that site specific information (invasive testing, modelling and assessment) provided here may well be superseded once detailed work has been completed.

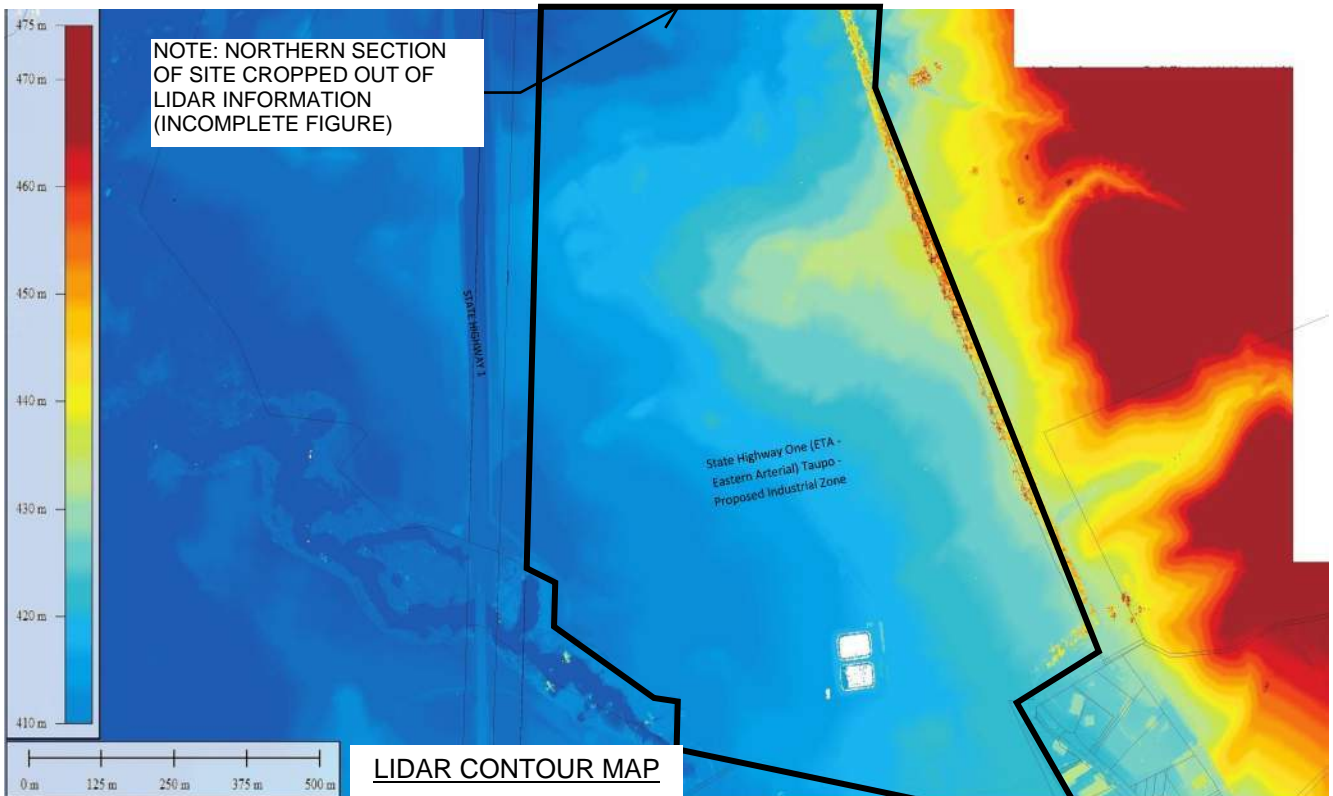
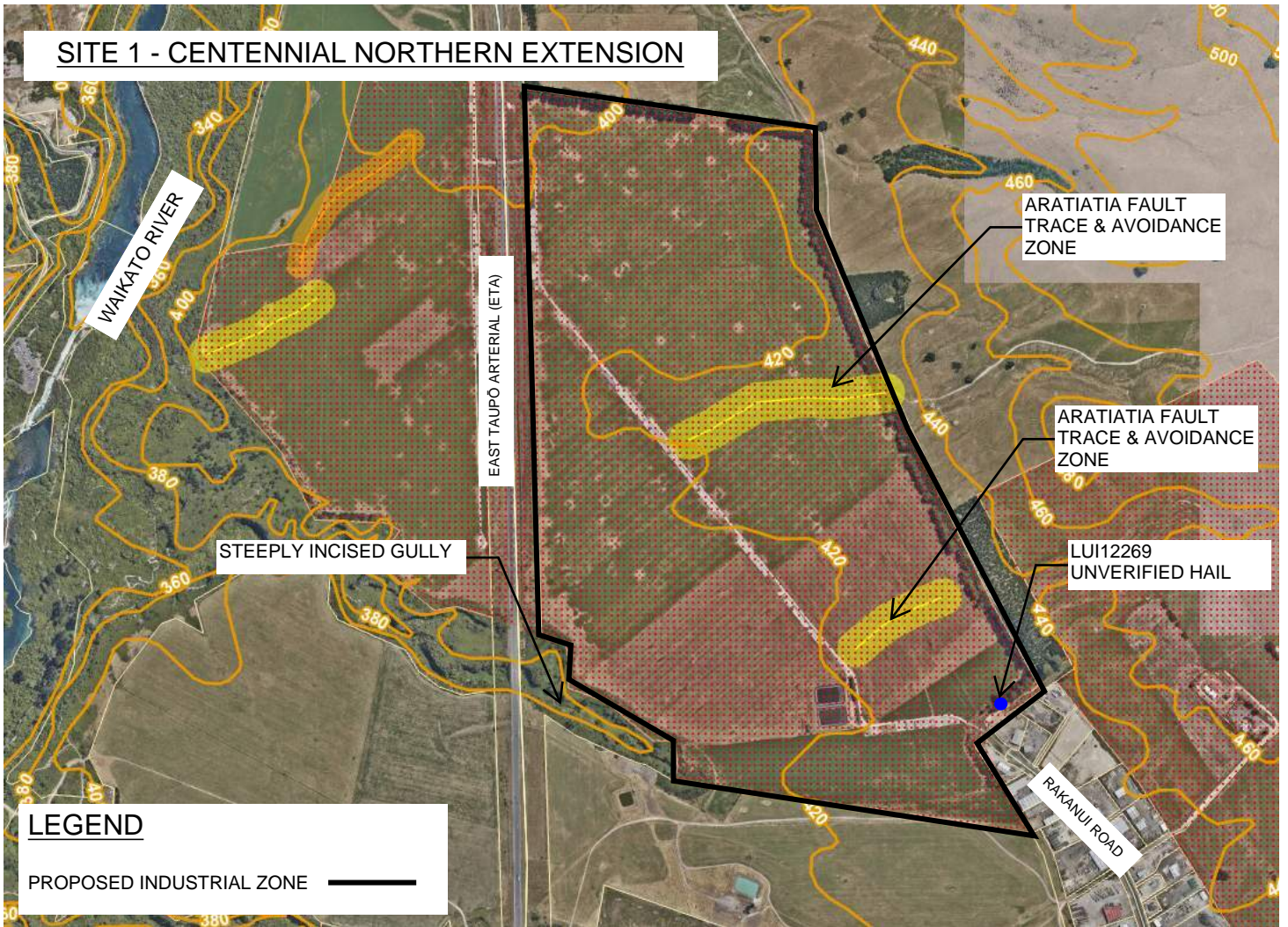
It is recommended that geotechnical investigation, including fault trace mapping and liquefaction analysis are completed either prior to re-zoning of the land parcels or as a requirement within an Outline Development Plan (ODP).

Further conversations with Contact Energy are also required to better understand future subsidence predications and constraints this may pose to industrial development.

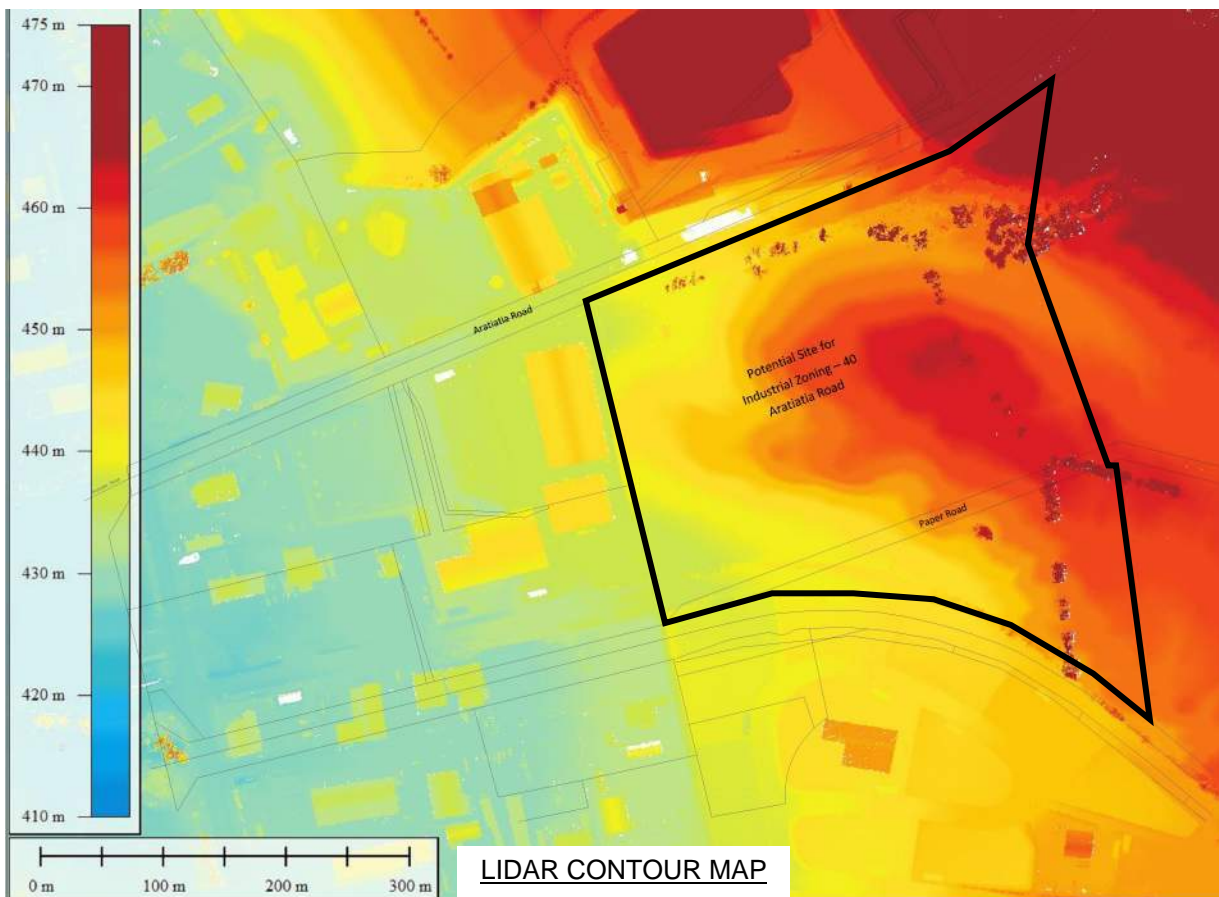


# Appendix A Site Maps and LiDAR Contour Maps

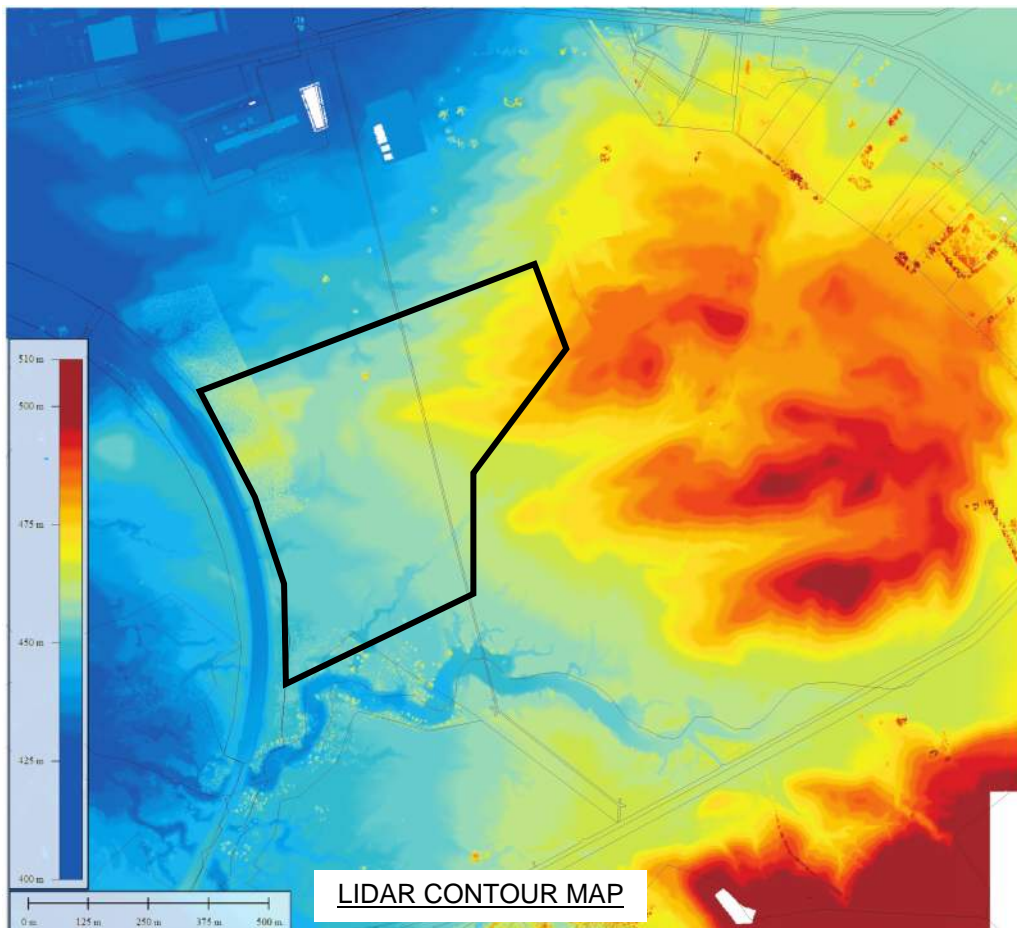
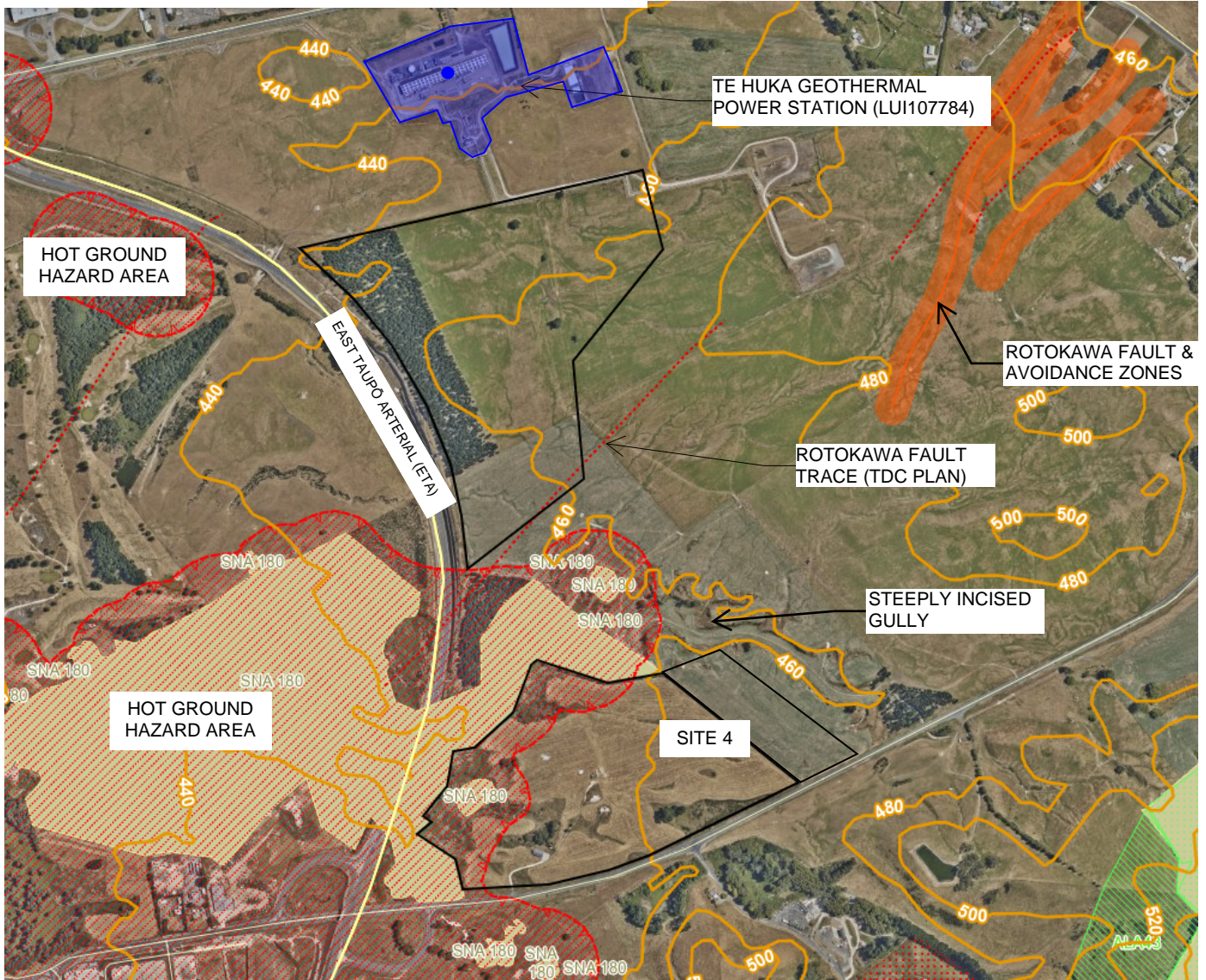
# SITE 1 - CENTENNIAL NORTHERN EXTENSION



# SITE 2 - CENTENNIAL EASTERN EXTENSION

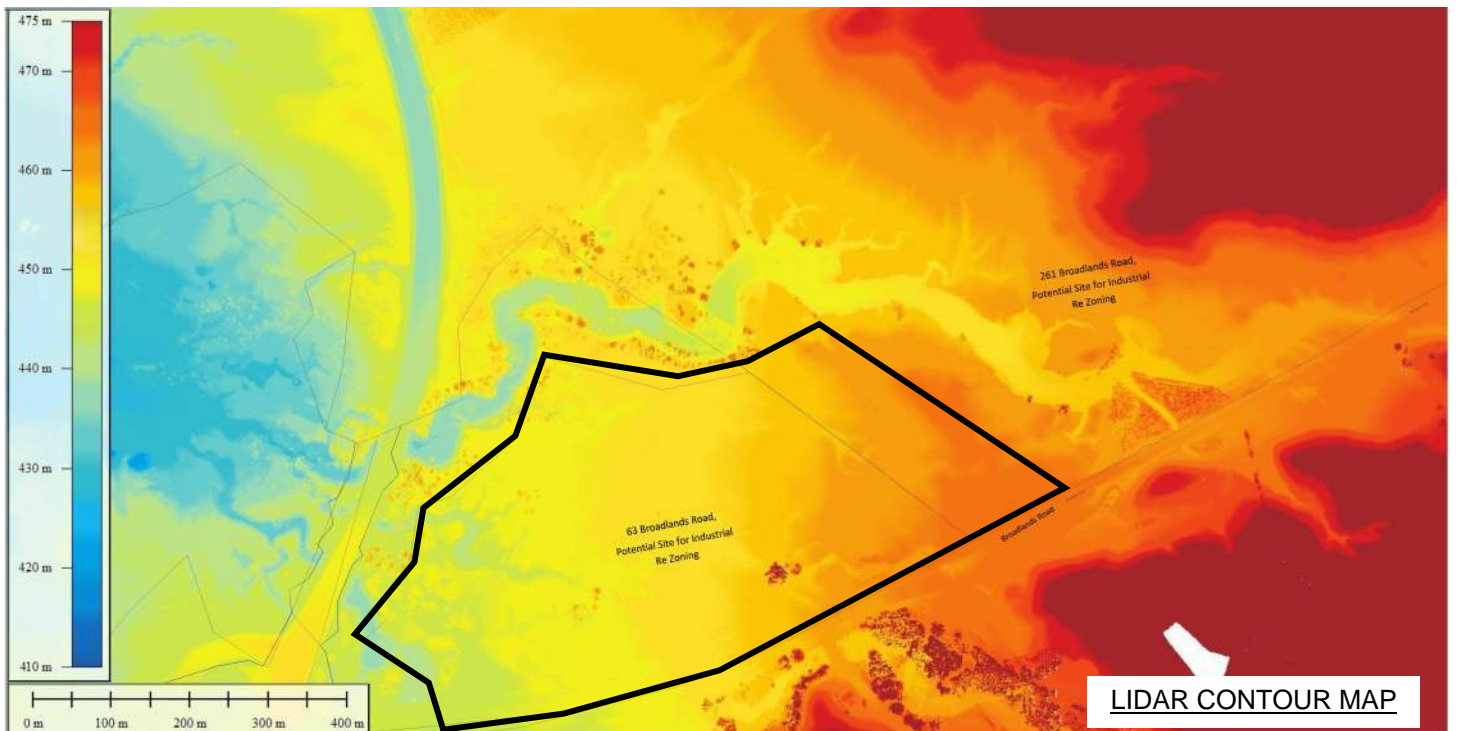
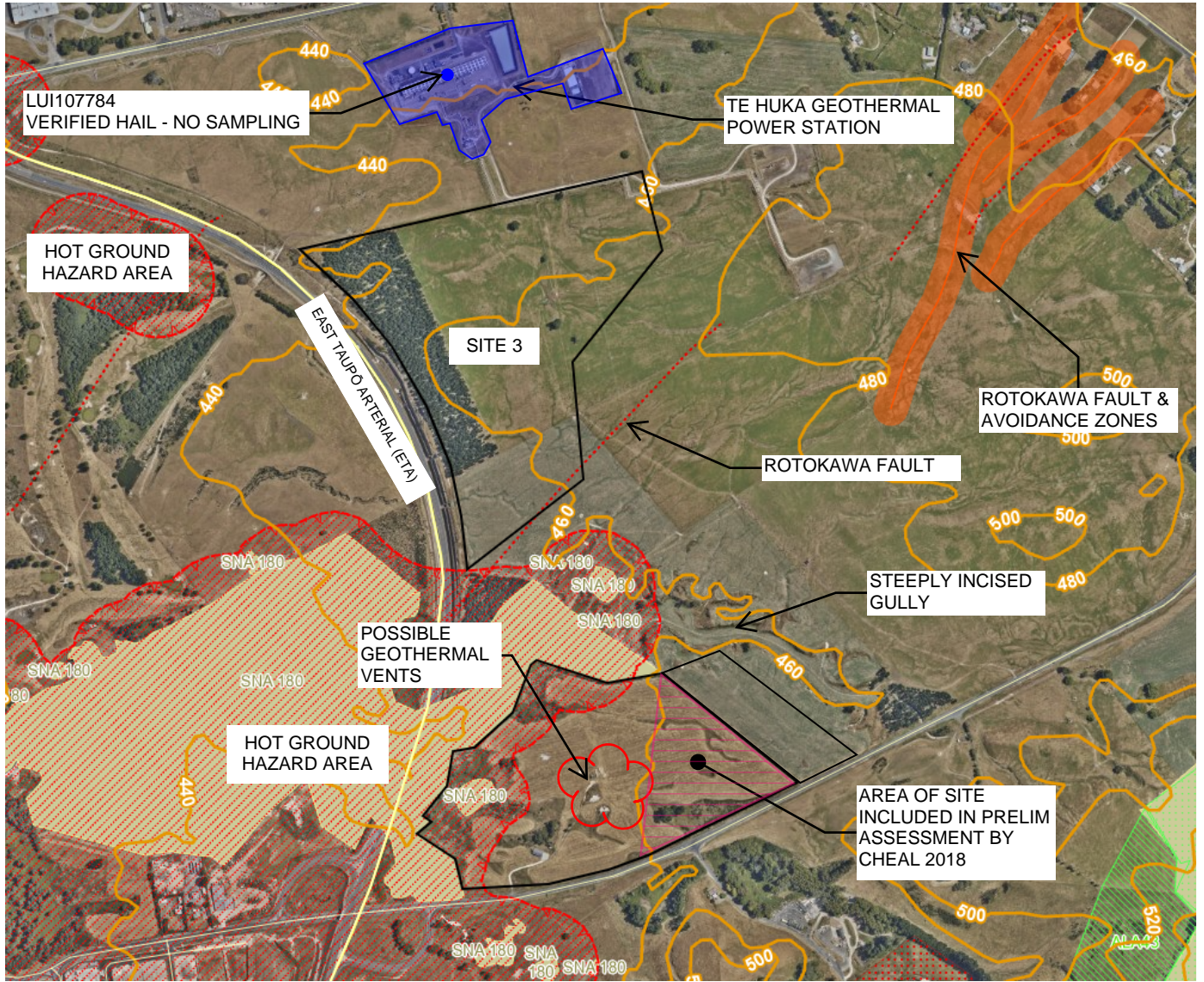


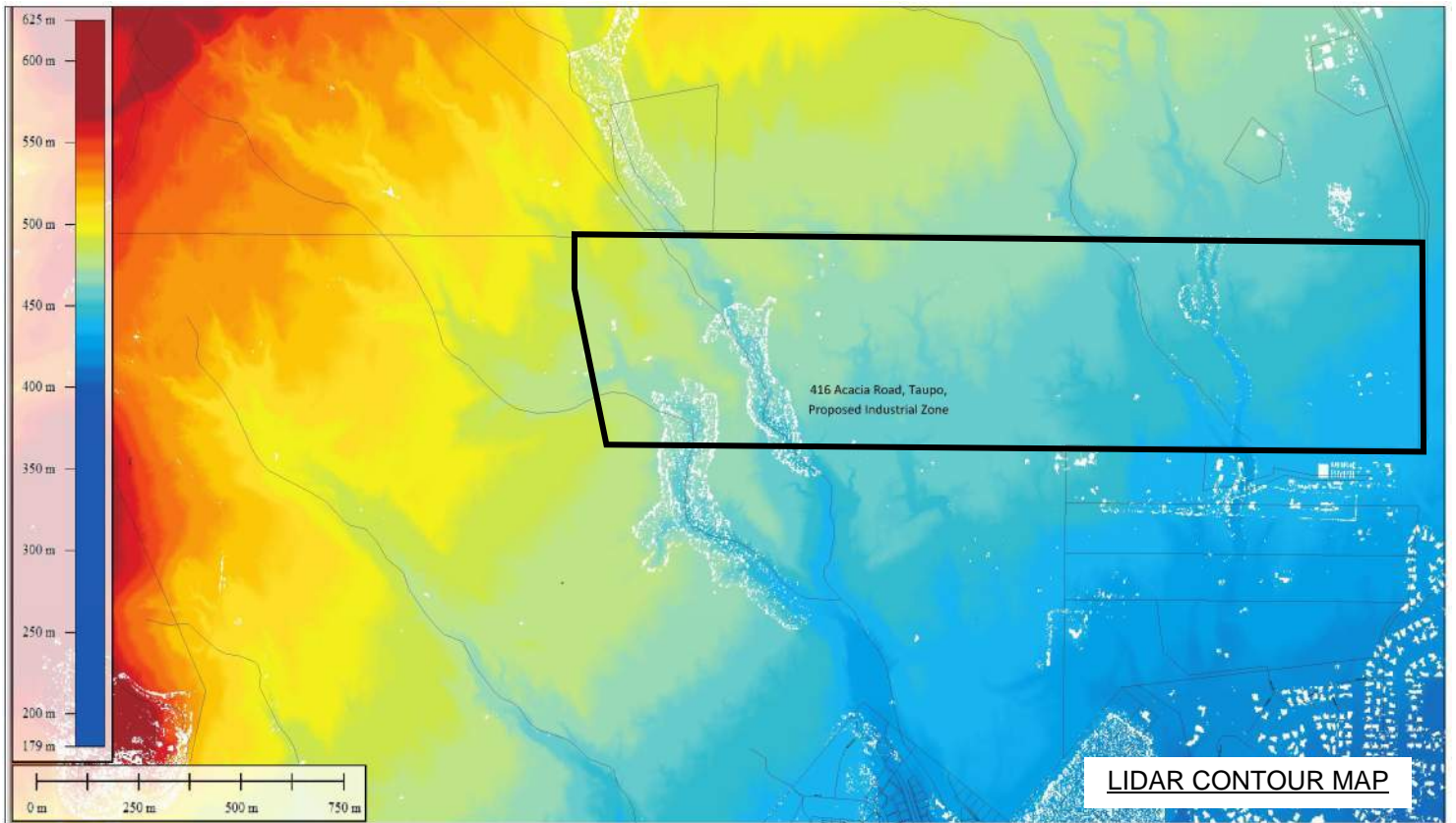
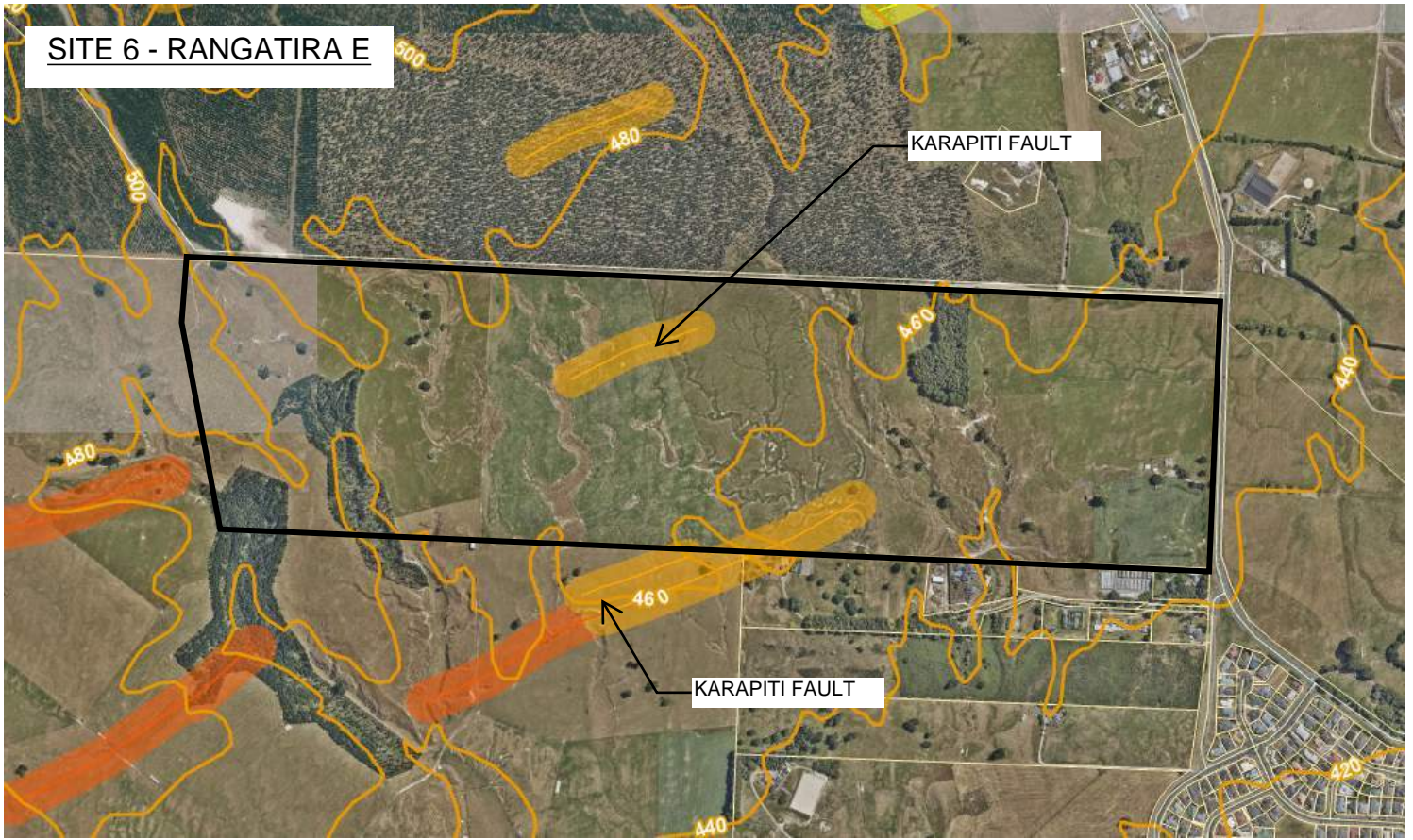
# SITE 3 - CENTENNIAL SOUTHERN EXTENSION

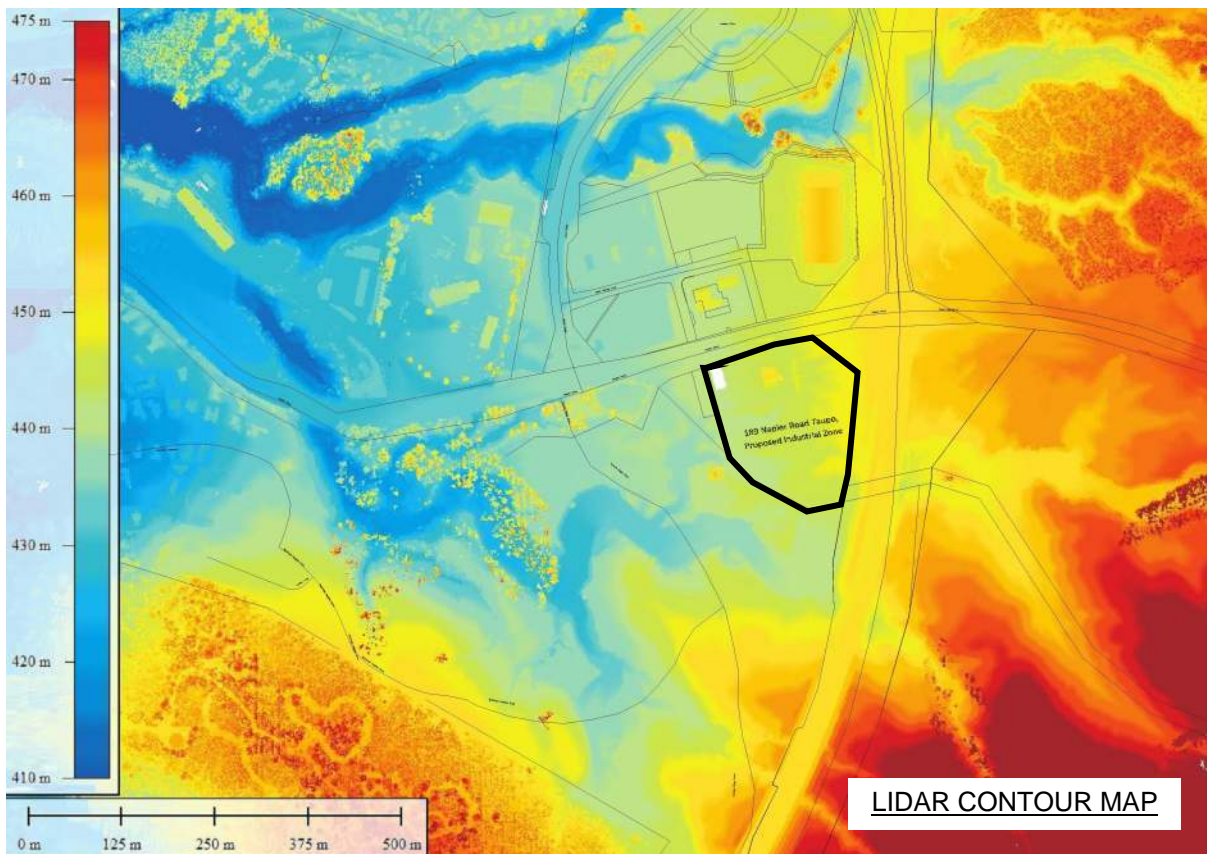
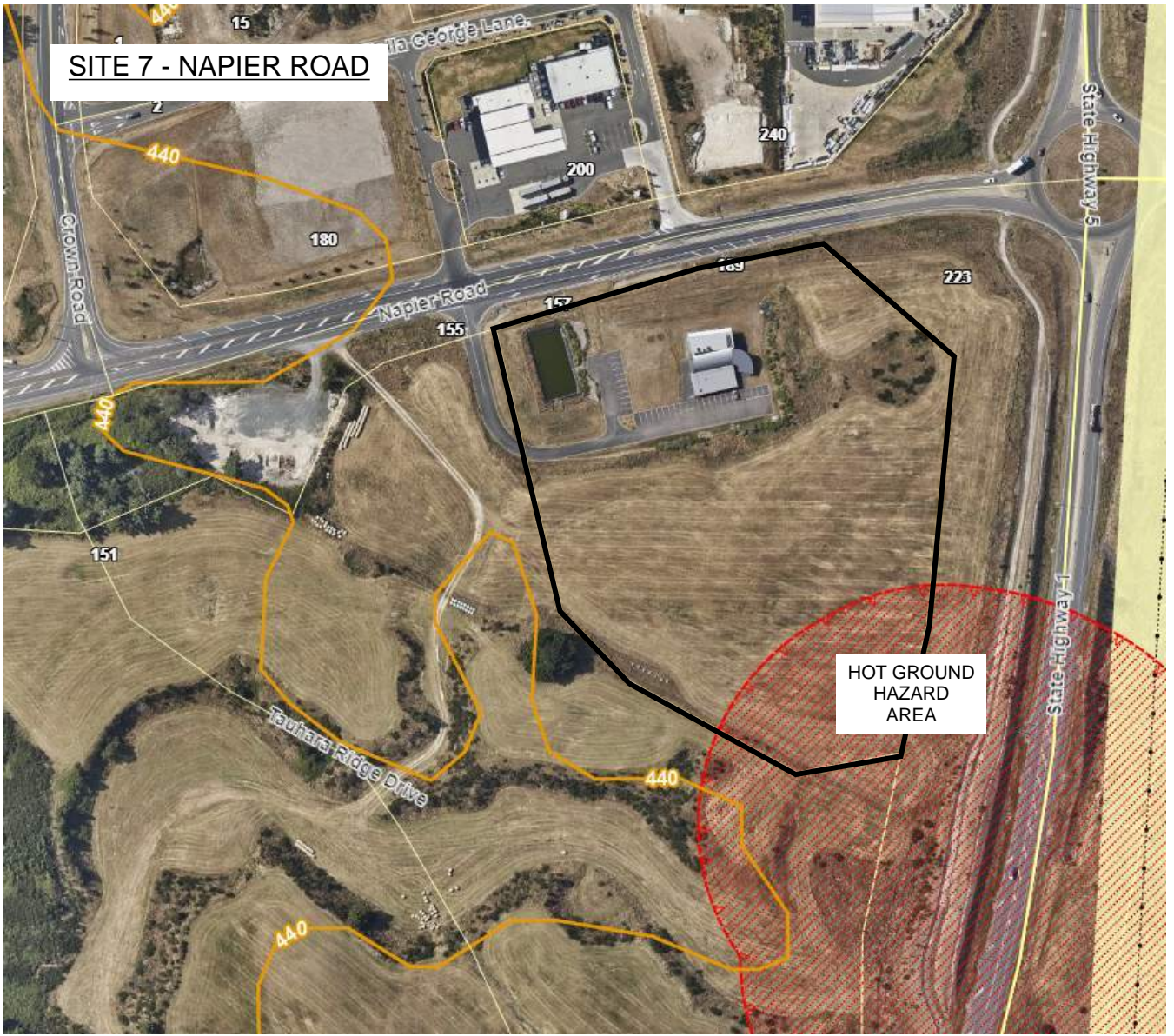




# SITE 4 - BROADLANDS ROAD WEST







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Project Number: 2-38030.00

# Taupō Industrial Plan Change

## Preliminary Geotechnical Assessment Addendum Report

15 September 2022

CONFIDENTIAL



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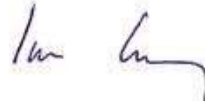
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## Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
A	07.09.2022	M. Phillips	I. Gray	H. Crawford	FINAL
B	15/09/2022	M. Phillips	-	-	FINAL

## Revision Details

Revision	Details
A	Original document
B	Updated total area for Site 4 and associated maps



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## Disclaimers and Limitations

This report (**'Report'**) has been prepared by WSP exclusively for Taupō District Council (**'Client'**) in relation to preliminary geotechnical assessment to inform the Taupō Industrial Plan Change (**'Purpose'**) and in accordance with the Consultancy Services Order dated 1 August 2022. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

In preparing the Report, WSP has relied upon data, surveys, analyses, designs, plans and other information (**'Client Data'**) provided by or on behalf of the Client. Except as otherwise stated in the Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable in relation to incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

# 1 Introduction

WSP has been engaged by Taupō District Council to carry out a preliminary geotechnical assessment to inform the proposed Taupō Industrial Plan Change (TIPC). The TIPC proposes to rezone rural land to industrial land.

This geotechnical assessment will form part of a Section 32 and Planning Assessment in support of additional industrial land supply to enable business growth and development in Taupō.

A desktop geotechnical assessment was completed by WSP and summarised in the report titled 'Taupō Industrial Plan Change, Preliminary Desktop Geotechnical Assessment' dated 7 September 2022. The assessment was a limited desktop study to screen proposed plan change sites for significant geotechnical risks, areas of concern and to form the basis for more detailed assessment in the future.

Following the initial assessment, WSP completed a walkover at the following sites:

- Site 3 - Centennial Southern Extension
- Site 4 - Broadlands Road West
- Site 7 - Napier Road

This addendum report summarises observations from these walkovers for each of the sites and further details geotechnical hazards to potential industrial development. An indication of geotechnical investigation requirements is also included where required.

This report must be read in conjunction with WSP's Preliminary Desktop Geotechnical Assessment Report dated 7 September 2022.

## 2 Site Description

Sites 1 and 2 have been removed from the proposed plan change at the time of reporting due to constraints on potential re-zoning.

WSP's initial desktop assessment identified several geotechnical risks and areas of concern on Site 6 and therefore, without extensive geotechnical investigation and assessment, WSP is not able to make conclusions about the potential presence of intolerable risks on the site. For this reason, a site walkover was not completed for Site 6.

This report, therefore, covers three general land areas, identified as Sites 3, 4 and 7, as detailed in Table 1. The location of the sites is shown in Figure 1. The sites are generally located to the east and south of the established Taupō industrial area.

Table 1: Site details

Site No.	Site Name	Address	Legal Description	Approx. Land Area (ha)
3	Centennial Southern Extension	261 Broadlands Road	Part of Lot 1 DP 445148	28
4	Broadlands Road West	63 Broadlands Road	Part of Section 14 SO 438782	20
7	Napier Road	189 Napier Road	Lot 2 DP 499406	4



Figure 1: Approximate location of sites (ref: TDC Mapi Online)

### 3 Centennial Southern Extension (Site 3)

The Centennial Southern Extension is a parcel of land between Broadlands Road and Centennial Drive, just south of the Te Huka Power Station. The site is just north of a geothermally active landform and a fault line cuts through the southern portion of the site. The site is currently undeveloped with a portion covered in pine trees and the rest of the site appears to be used for grazing.

A walkover of the site was completed by WSP staff on 3 August 2022.

The walkover confirmed that there are some localised erosional issues scattered over the site associated with preferential overland flow of stormwater. Stormwater generally track east to west, towards the steep roadside cuttings of the East Taupō Arterial (ETA). There are several stormwater attenuation systems located within the roadside cuttings to manage the flow of stormwater from Site 3.

Due regard to changes in the stormwater conveyance regime must be given, particularly if earthworks were proposed which modify existing overland flow paths. For example, an industrial development will result in increased impermeable ground cover, and therefore an increased volume of stormwater that is potentially conveyed towards the ETA. The downstream effects of this increase in stormwater conveyance must be considered as part of industrial development of the land, particularly the potential for erosion and subsequent instability of the roadside cuttings. Some form of holistic stormwater management plan should be considered. The potential for preferential flows (subterranean tracking) underground due to modification to the landform must also be considered as part of land development.

Slope instability was not identified as a risk in the desktop assessment, however the rolling hills observed during the site walkover along the eastern property boundary do indicate stability issues to be considered. Some shallow erosional scars were observed but no evidence of large-scale or deep seated instability were observed. Quantitative stability analysis will be required to inform any modification in and around the hills as part of future development.

Expression of geothermal activity at ground surface was not identified outside the area designed as the 'Hot Ground Hazard Area'. Ground temperature readings during geotechnical investigation will be required to determine if the hot ground hazard extends beyond the perimeter of the hazard area. We would also recommend comment be sought from GNS as to the most likely future state/migration/reduction of those features to inform suitable development boundary or building offsets.

Expression of tomos at ground surface were not specifically identified during the walkover but this does not exclude the site from the risk of tomos.

Expression of the Rotokawa Fault that is mapped through the southern boundary of the parcel was not immediately obvious during the site walkover. It should be acknowledged that the definitive identification of this type of feature is very specialist work and beyond the high level of this initial work stream. Trenching to accurately map the fault and define a Fault Avoidance Zone is required. Development should not be allowed at least 20m either side of the mapped fault and may need to be increased depending on the ability to accurately map the fault.

Whilst certain areas of the site are not suitable for development due to the fact that intolerable risk from natural hazards exists (faulting), geotechnical hazards present within the remaining areas are likely to be able to be reasonably mitigated as part of engineering design of future industrial development. Having said that, geotechnical investigation is required to confirm this statement.

Subsidence due to extraction of geothermal fluids is potentially a significant constraint for industrial development to overcome at this site. Potential differential settlement based on measurements from the 2017-2021 period are in the order of 15mm over a distance of

approximately 760m. Contact Energy engaged GNS to re-forecast future subsidence within the area, and the assessment is summarised in GNS Science Consultancy Report 2021/63. The centre of the Spa-Rakaunui subsidence bowl is estimated to subside an additional 4mm by 2030, before pressures result in an uplift of 6mm by 2061 at the end of the forecasted period.

Subsidence in the order of 4mm over a significant distance is unlikely to result in differential settlement greater than is typically allowed for / is tolerable for building construction (for example, when projecting these ground changes across a foundation for the design life of that structure). There are, however, considerable uncertainties when considering estimation of future subsidence and therefore risk mitigation may still be appropriate for the site. It should also be noted that some industrial activities can be extremely sensitive to differential settlement and may not be appropriate for these sites.

Geotechnical investigation, fault trace mapping and liquefaction analysis should be completed prior to re-zoning of the land or included as a requirement within an Outline Development Plan to confirm the ability to mitigate against geotechnical hazards described in this report through engineering design. Currently, no site specific testing has been completed at the site.

Geotechnical investigations should be carried out in accordance with the recommendations included in the Earthquake Geotechnical Engineering Practice Module 2 unless specific reasons are provided and accepted by the Territorial Authority for deviation from the recommendations. Based on recommendations in Table 2.1 of Module 2, a total of 16 deep intrusive geotechnical investigation points are required to inform a detailed assessment and guide a plan change of this size.

Geotechnical investigation and assessment should focus on:

- Defining the Rotokawa Fault trace;
- Preliminary stability analysis of rolling hills to the east of the site;
- Developing a ground temperature profile starting from the margins of the mapped hot ground hazard area;
- Determining the groundwater profile and hence susceptibility to liquefaction and risk of subsurface water flows;
- Understanding the most likely future state of the thermal features.
- An appropriate stormwater management plan.

The following photos are included as a representation of the site walkover that was completed.



*Figure 2: View roughly northwest, with rolling hill to the right*



*Figure 3: Example of localised instability due to erosional issues*

## 4 Broadlands Road West (Site 4)

Site 4 is located between State Highway (SH) 5 and Broadlands Road. The site is largely undeveloped, with one building located towards the Broadlands Road access. The site slopes downwards from east to west, towards a mapped geothermally active area.

A Preliminary Geotechnical Assessment Report was prepared by Cheal in 2018<sup>1</sup> to inform design of a commercial development over part of the site. The report concluded that the site is geotechnically suitable for the commercial development proposed subject to recommendations in the report. The Cheal assessment included a site walkover and shallow hand investigation.

A walkover of the site was completed by WSP on 3 August 2022.

Expression of geothermal activity at ground surface was identified outside the area designed as the 'Hot Ground Hazard Area'. The walkover confirmed the presence of hot ground in the centre of the site, where possible vents were identified on aerial photography. Steam was not venting at the time of the site walkover but the ground was warm to touch and no vegetation was growing in the area. Hot ground will need to be investigated and development should be excluded where geothermal activity is expressed at ground surface. Ground temperature readings during geotechnical investigation will be required to determine how far the hot ground hazard extends beyond the perimeter of the mapped hazard area. Specialist assistance from GNS should be sought to better quantify what may happen with these features in the future,

Expression of tomos at ground surface were not specifically identified during the walkover but small sinkholes were noted in the Cheal 2018 report and therefore warrants more investigation.

Similarly, to Site 3, due regard to changes in the stormwater conveyance regime must be given, particularly if earthworks were proposed to modify the existing overland flow regime. The downstream effects of this increase in stormwater conveyance must be considered as part of industrial development of the land. The potential for preferential flows underground due to modification to the landform must also be considered as part of land development. This is particularly the case where deeply incised landform features (gullies) sit in close proximity to ground disposal networks for the stormwater systems. In these cases, gully sides provide an easy pathway for concentrated stormwater to 'short circuit' out the gully sides.

The Rotokawa Fault is mapped to the northeast of the site, but no traces have been identified within the parcel of land.

Whilst certain areas of the site are not suitable for development due to the fact that intolerable risk from natural hazards exists (hot ground), geotechnical hazards present within the remaining areas are likely to be able to be reasonably mitigated as part of engineering design of future industrial development. Having said that, geotechnical investigation is required to confirm this statement.

In addition, subsidence due to extraction of geothermal fluids is potentially a significant constraint for industrial development to overcome at this site. Potential differential settlement based on measurements from the 2017-2021 period are in the order of 15mm. Contact Energy has engaged GNS to re-forecast future subsidence within the area and the assessment is summarised in GNS Science Consultancy Report 2021/63. The centre of the Spa-Rakaunui subsidence bowl is estimated to subside an additional 4mm by 2030, before pressures result in an uplift of 6mm by 2061 at the end of the forecasted period.

Subsidence in the order of 4mm is unlikely to result in differential settlement greater than is typically allowed for / is tolerable for building construction. There are, however, considerable uncertainties when considering estimation of future subsidence and therefore risk mitigation may

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<sup>1</sup> Cheal, 63 Broadlands Road, Taupō, Preliminary Geotechnical Assessment Report for Mega Food Services Ltd. (ref: 17685), 22 March 2018

still be appropriate for the site. It should also be noted that some industrial activities can be extremely sensitive to differential settlement.

Geotechnical investigation, ground temperature recordings and liquefaction analysis should be completed prior to re-zoning of the land or included as a requirement within an Outline Development Plan to confirm the ability to mitigate against geotechnical hazards described in this report through engineering design. Currently, only limited hand investigation has been completed on the site by Cheal in 2018.

Geotechnical investigation should be carried out in accordance with the recommendations included in the Earthquake Geotechnical Engineering Practice Module 2 unless specific reasons are provided for deviation from the recommendations. Based on recommendations in Table 2.1 of Module 2, a total of 13 deep intrusive geotechnical investigation points are required to inform a plan change of this size.

Geotechnical investigation and assessment should focus on:

- Developing a ground temperature profile starting from the margins of the mapped hot ground hazard area;
- Determining the groundwater profile and hence susceptibility to liquefaction and risk of subsurface water flows;
- Understanding the most likely future state of the thermal features.
- An appropriate stormwater management plan.

The following photos are included as a representation of the site walkover that was completed.



*Figure 4: Example of hot ground present towards the centre of the site*





*Figure 5: Shallow gully that flows approximately east to west, towards hot ground hazard area. Broadlands Road and Mt Tauhara can be seen in the distance.*



*Figure 6: General form of the land*

## 5 Napier Road (Site 7)

The Napier Road site is located to the southwest of the Napier/Taupō Highway Roundabout. The site is currently home to a commercial building, paved carparking areas and a large water storage pond. The area south of the building is currently undeveloped.

It should be noted that large water storage ponds such as the one located on site, if they rupture or leak for any reason, have potential to cause significant damage to downstream infrastructure. A recent example is the damage caused by the stormwater retention pond on Crown Road which ruptured in 2019 and caused considerable damage to adjacent infrastructure.

HD Geo Ltd completed a Preliminary Geotechnical Assessment<sup>2</sup> for this site in November 2021 that was informed by a site-specific geotechnical investigation. The report was prepared to support a Resource and Subdivision Consent application for a commercial development on the site. The report concluded the following:

*“The site has no major geotechnical hazards or considerations and is geotechnically suitable for the proposed subdivision. Further assessment will be needed to inform development and foundation design across the site, particularly in the areas of uncontrolled fill”.*

A site walkover was completed by WSP on 12 August 2022. The site walkover was completed to verify WSP’s previously completed desktop assessment.

Based on the investigation and assessment by HD Geo Ltd and WSP’s desktop assessment and walkover, geotechnical hazards do not present an intolerable risk to development of the site for industrial purposes. As concluded by HD Geo, additional investigation and assessment will be required to inform development and foundation design across the site with a particular focus on the uncertified fill identified on site. Potential failure of the existing water storage pond on site should also be considered when preparing a development plan for the site i.e. consider what damage a failure could cause and how this could be minimised through design.

The following photos are included as a representation of the site walkover that was completed.

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<sup>2</sup> HD Geo Ltd, 189 Napier Road, Taupō, Preliminary Geotechnical Assessment, ref: HD2092, PGR-1, 1 November 2021



*Figure 7: View to the east, with water storage pond and existing building visible, ETA located in the distance*



*Figure 8: View north towards Mitre 10 and existing industrial development showing general landform*

## 6 Summary & Conclusions

A site walkover has been completed to complement WSP's preliminary desktop assessment recently completed to inform an Industrial Plan Change in Taupō. This assessment is intended to identify geotechnical and geo-environmental hazards which have potential to create 'intolerable risk' to future industrial development.

Sites 1 and 2 are excluded from this Addendum report as they no longer form part of the proposed plan change.

Site 6 requires extensive, deep geotechnical investigation and assessment to determine if geotechnical hazards present an intolerable risk to industrial land development. At this stage, no investigation has been completed at the site and therefore conclusions cannot be made as to the suitability of the site for industrial development.

The following conclusions can be made:

- Detailed fault trace mapping is recommended for Site 3. Appropriate fault avoidance zones should be enacted for industrial development.
- Liquefaction susceptibility should be reviewed once the regional assessment is completed by TDC, as liquefaction hazard for most of the sites is undetermined. Site specific testing is required for Site 3 and Site 4 to assess susceptibility of the sites to liquefaction and the impact this may have on industrial development.
- All sites are potentially affected by tomo formation which can be a considerable risk to industrial development.
- Geothermal hazards are present on or very close to Sites 3 and 4 and should have specialist input to define their most likely future performance.
- Subsidence from extraction of geothermal fluids is known to affect Sites 3 and 4. Future subsidence is entirely dependent on extraction and reinjection rates; development of these sites will require careful consideration of the implications of both total and differential settlement into the future.

Based on the investigation and assessment by HD Geo Ltd and WSP's desktop assessment and walkover, geotechnical hazards do not present an intolerable risk to development of Site 7 for industrial purposes. As concluded by HD Geo, additional investigation and assessment will be required to inform development and foundation design across the site with a particular focus on the uncertified fill identified on site.

Intolerable risk from natural hazards exists on Sites 3 and 4, however these risks can be mitigated by excluding development from discrete areas within the sites. Geotechnical hazards present within the remaining areas are likely to be able to be reasonably mitigated as part of engineering design of future industrial development. Having said that, geotechnical investigation is required to confirm this statement.

It is recommended that geotechnical investigation, including fault trace mapping and liquefaction analysis are completed for Sites 3 and 4 either prior to re-zoning of the land parcels or as a requirement within an Outline Development Plan (ODP).

Forecasted rates of subsidence as per GNS Science Consultancy Report 2021/63 are unlikely to result in differential settlement outside of limits typically acceptable for lightweight structures. It is also reasonable to assume that foundations can be designed for the forecasted rates to enable construction of heavier commercial and industrial buildings. However, in the event that future rates of subsidence are greater than those currently forecast by GNS for Contact Energy it may not be possible to mitigate differential settlement through design for Sites 3 and 4. This risk must be communicated to those who plan to develop Sites 3 and 4.

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