Report

Minden Rural 3 Zone Structure Plan Geotechnical Appraisal

Prepared for Western Bay of Plenty District Council (Client)

By Beca Carter Hollings & Ferner Ltd (Beca)

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Revision History

Revision N°	Prepared By	Description	Date
A	Harry Wahab		

Document Acceptance

Action	Name	Signed	Date
Prepared by	Harry Wahab		
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1 Introduction

Western Bay of Plenty District Council (Council) has commissioned Beca Carter Hollings & Ferner Ltd (Beca) to develop an update to the District Plan covering the Minden area and Te Puna commercial area. The site is around 1,150 hectares and includes both gently sloping and steeply sloping terrain.

The area is currently zoned as a mix of rural and rural-residential. The proposal is to concentrate future rural lifestyle sub-division within the area by allowing a minimum sub-division of 3,000m^2, with an average of 5,000m^2.

1.1 Purpose & Scope

Council have requested that Beca provide a high level geotechnical appraisal to assist with the preparation of a Plan Change for the site development. The appraisal is intended to be incorporated into a high level constraints assessment to help define future development opportunities.

There is a history of past instability within the Minden area. Council had previously commissioned a geotechnical appraisal to identify stability zones within the existing Minden Rural Residential Zone (Tonkin & Taylor, 1992). This study identified the Minden Stability Zones A, B1, B2 and C.

This assessment is based on a review of existing information including aerial photography and a site inspection by a senior engineering geologist. No site investigations have been carried out as part of this assessment therefore recommendations provided herein would be subject to revision once more site investigation data became available.

1.2 Limitation

This report has been prepared solely for the benefit of Western Bay of Plenty District Council as our client with respect to the particular brief given to us, and data or opinions in it may not be used in other contexts, by any other party or for any other purpose. To the maximum extent permitted by law, Beca Carter Hollings & Ferner Ltd disclaims all liability and responsibility (in contract or tort, including negligence, or otherwise) for any loss or damage whatsoever which may be suffered as a result of any reliance by any third party on this report, whether that loss is caused by any fault or negligence on the part of Beca Carter Hollings & Ferner Ltd or otherwise.

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Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

2 Site Description

The site occupies an area of approximately 1,150 hectares in a predominantly rural setting to the west of Tauranga in the Bay of Plenty. The overall site is about 6km wide and 2km long with elevations ranging from RL 0m to RL 286m above sea level. The site is situated largely on the slopes above Te Puna village on State Highway 2 (SH2). The Wairoa River and valley is located to the east of the site and the Te Puna Stream lies to the west forming the northwestern boundary to the site.

The topography of the site varies considerably. The northern parts of the site near SH2 are relatively low lying with elevations typically around RL 20m to RL 40m above sea level, mostly forming gently sloping terraces with steep stream banks. The land then undulates significantly and becomes steeply sloping as it rises towards the ridgeline of the Minden volcanic dome where the elevations are typically RL 240m to RL 270m above sea level. The land here is characterized by the presence of many steep-sided gullies. The highest point is at Minden Peak which is RL 286m above sea level.

In some locations the escarpment is prominent, e.g. at the west of the site around the Te Puna Quarry area. There are a number of plateaus at the escarpment, particularly at the southwestern end of the site.

The topography and contour information for this site can be seen on Figures 1 and 2 appended to this report. The existing Minden rural residential zone lies at the centre of the Rural 3 Zone and is mostly clustered around Minden Road.

3 Geology

3.1 Geological Setting

The Minden Rhyolitic Dome dominates the topography and forms the basement rock underlying the western and central sections of the site. The flanks of the dome spread radially from the Peak, where the lower section is steep and deeply incised, reflecting the historic flows of volcanic material. The dome has a broad crest with well rounded landforms and gentle slopes.

Pleistocene aged (1.8 million to 10,000 year old) Ignimbrite (pryoclastic airfall) flows flank the Minden Dome to the east and west and similar aged marine deposits comprised of variable volcanic sediments flank the north of the Dome.

These volcanic derived materials have been terraced by multiple historic sea-level changes. The terrace faces have eroded and are generally over-steep. Movement along the lower terrace faces (typically those below RL40m) is generally active. Many of the higher terraces are surrounded by dry stream beds, and the large-scale movement appears dormant. However creep and shallow movement are observed along the terrace faces, in the historic landslides scarps and landslide debris.

Recent ash deposits of varying thickness mantle the majority of the study area. Site inspection confirmed that a thin cover (1 to >4m, observed, up to 6m thick reported) of ash mantles all the older deposits. This unit will therefore dominate the stability of the surrounding slope and shallow foundation conditions.

3.2 Geologic Units

The published geology for the site (after Briggs, *et al,* 1996) is shown on Figure 1.

Sand, silt and gravel of modern streams (fa): Localised thin recent stream deposits mapped immediately adjacent to the Te Puna Stream and Wairoa River. Highly variable materials comprising: silts, sands, clays, gravels with organic lenses.

Recent Ash/Tephra Deposits: Not mapped, but observed in all road cuttings and is believed to overly the older deposits over most of the site. Comprises: Hamilton Ash, Rotoehu Ash and Post-

Rotoehu Ash Tephras, mostly derived from recent eruptions in the Taupo Volcanic Zone. Sequence of 1-3m thick unweathered, highly erodible sands and silty sands overlying 1 to 4m thick weathered clayey silts with paleosols (old topsoil horizons) between deposits.

Fluvial Terrace deposits post-dating the Waiteariki Ignimbrite (tm): Mapped along the northern flanks of the Minden Dome. Known as the Matua Subgroup, these estuarine deposits with ash layers are 2.18 to 0.35 million years old and comprise both pumiceous and marine clayey silts, silty sands, with peats and distal ignimbrite lenses. Distinguished by its interbedded stratigraphy and sedimentary structures.

Waiteariki Ignimbrite (wk): Mapped surrounding the eastern flanks of the Minden Dome, this pyroclastic deposit is partially welded light grey to light brown pumice–rich extremely weak to weak ignimbrite. Often forms bluffs and is columnar jointed.

Te Puna Ignimbrite (tp): Mapped in the NE corner of the site, this ignimbrite deposit is older but similar to Waiteariki Ignimbrite. Non-welded to partially welded, brown, crystal and pumice-rich deposit.

Minden Rhyolite (mr): Underlies the western and central section of the site, where it is a dome comprised of rhyolitic lava. Grey to pink, often flow banded, with some phenocyrsts in a fine glassy matrix. Unweathered rock is very to extremely strong with moderately widely spaced randomly spaced joints.

3.3 Geotechnical Investigation and Assessment Reports

Geotechnical reports in the area which have been submitted to WBOP have been reviewed and the sub-surface data is summarised in Table A1 in Appendix A.

All sites investigated and where units are defined have encountered ash, including the telecom tower site at the top of Minden Peak, where it is between 1 to 3m thick.

4 Geotechnical Hazards

This geotechnical hazard assessment is based on a desktop review of available information, a walkover of the accessible areas of the site as well as a flyover reconnaissance of the site, and an assessment of instability features using aerial photographs. No site investigations have been carried out as part of this assessment. The results of this hazard assessment are discussed in the following sections:

4.1 Slope Instability

Evidence of historic and recent instability was found to be widespread across the site. Active deep seated movement was found on slopes steeper than about 1V:2.5H (20 to 22 degrees). Shallow movement (e.g. creep) was observed on slopes steeper than 16 degrees. Much of this instability appears to be shallow seated and may be restricted to the ash deposits that mantle the slopes sliding over the weaker soils below. Many areas of recent instability were observed to be associated with saturation following heavy rainfall, surface water flows and significantly, changes in land form, e.g. cutting (see Photo 1). Localised erosion was also noted.

Photo 1: Recent slips adjacent road cut into existing slope following a period of heavy rainfall

Some of the historic areas of instability may only be marginally stable and subject to further movement under adverse conditions or if modified. Potential natural triggers include elevated groundwater levels, loss of recent ash mantle and earthquakes.

Development can also have an adverse effect on the existing slope stability. Loading the top of the slope, excavating at the toe, concentrating surface water runoff or impeding existing springs will all tend to decrease stability.

Both large and small scale slope instability was particularly evident at the southeastern end of the site approximately between Walden Lane and the Wairoa Valley.

4.2 Erosion

Erosion caused by surface water runoff towards the Tauranga Harbour, Wairoa River and Te Puna Stream has created a system of gullies across the site. Many of the soils on site and in particular the ash layers that mantle the site are susceptible to erosion.

Internal piping or tunnel gulley erosion was also evident in the ash layers.

Measures to address this risk include careful consideration of stormwater flow paths, avoiding soakage, mapping erosion features and setting back development from such areas.

4.3 Earthquakes

A moderate to large earthquake is a potential trigger for future slope instability, in particular for those slopes that are marginally stable under static loading conditions. All development works should consider a seismic load in accordance with an appropriate design code, i.e. NZS 1170.5.2004, Structural design action Part 5: Earthquake Actions.

4.4 Liquefaction

Liquefaction occurs when loose saturated soils are sheared during an earthquake, causing pore pressures to rise and significant strength loss within the affected soils. Liquefaction can cause large and variable lateral movement and settlements, and short term loss of bearing support to shallow foundations. Lateral spreading may occur where liquefaction prone land is close to a water body such as a pond or lake.

Recent loose alluvial deposits on the more gently sloping parts of the site maybe susceptible to liquefaction in a moderate to large earthquake event, depending on the nature and density of the underlying soils and on groundwater levels. The elevated areas are less likely to be prone to liquefaction as the ash cover is relatively thin and groundwater levels are likely to be deep.

Construction of residential dwellings within areas subject to liquefaction risk has occurred in low lying alluvial areas. However, we recommend that further study is undertaken to better understand the risk and consequences for development within the low lying northern areas of the site that are likely to contain weak recent sediments.

4.5 Flooding

Existing Council maps of floodable areas do not indicate there to be a risk of flooding affecting the Minden Rural 3 Zone even in the relatively low lying northern and northwestern parts of the site.

Some of the gullies within the zone may have no defined permanent water course and are likely to be dry except in heavy rainfall events. The potential development of such areas should allow for the effects of the 1% AEP.

A localised flooding risk may occur where development restricts the existing surface water runoff within these gullies. This risk must be addressed in stormwater design.

5 Stability Zoning

We have developed a Stability Risk Zone plan based on the published geology combined with the slope gradients across the Minden Rural 3 Zone. This is shown on Figure 3. In developing the plan, for ease of referral, we have applied the existing Minden residential rural Stability Zones A, B1, B2 and C (Tonkin & Taylor, 1992) to the wider Minden Rural 3 Zone. The Stability Zones are described as follows:

Stability Zone A: *subject to or likely to be subject to instability*

A zone in which processes or factors have been identified which indicate that past or active erosion or mass movement is evident or is likely to occur and which presents or may present an identifiable hazard to structures within the delineated zone.

It includes slopes steeper than 26.5 degrees (e.g. stream banks, terrace faces, historic land slide scarps and landslide debris), active landslides and creep, suspended landslides with actively eroding base.

Zone A may be summarised as land subject to or likely to be subject to instability.

Stability Zone B1: *potentially subject to instability*

Zone B1 is land where mass movement is evident or where the slope gradient is such that instability or erosion could occur, particularly if developed.

It includes slopes predominately between 20 to 26.5 degrees, historic landslides that are adjacent to areas of recent movement, banks of ephemeral streams, swampy areas, recent terraces adjacent to current streams.

Zone B1 may be summarised as land potentially subject to instability.

Stability Zone B2: *potentially subject to instability (to a lesser degree)*

Zone B2 is land where the slope gradient is such that instability is not considered likely to occur, and mass movement if present is historic and any slide debris has been removed. It is similar to land where instability and erosion has occurred elsewhere in the Western Bay of Plenty in similar materials due to cutting and/or filling and/or on site disposal of stormwater.

It includes slopes predominately between 12-20 degrees, historic landslides that are not adjacent to areas of active movement, historic landslides where most of the debris has been eroded, narrow spurs and ridges which have moderate to steep slopes below.

The risk of instability or erosion is greater in zones delineated B1 than B2.

Zone B2 may be summarised as land potentially subject to instability (to a lesser degree); if there is no on-site disposal of sewage or stormwater, no significant vegetation removal, no significant cutting or filling.

Stability Zone C: *unlikely to be at risk from instability*

Zone C is land considered unlikely to be at risk from instability, provided there would be no significant cut or fill. A stability analysis or detailed stability assessment and investigations would not generally be required.

It includes slopes predominately less than 12 degrees, relict landslides where the debris has been completely eroded (vacated) and are not adjacent to areas of active/recent movement, as well as wide terraces. Setbacks from steeper land, such as terrace faces, stream banks, old scarps is required. The setback distance is recommended to be at least 3 times the height of the steep slope below.

Stability Zone Accuracy

The geotechnical zone maps have been produced at broad scale (1:20,000) with boundaries having an estimated accuracy of ±20m. In some areas topographic data was either not available or limited by the thick bush cover. Similarly bush cover limits aerial assessment of slope instability. Areas that have these limitations are shown on the map (Figure 3).

We recommend that these geotechnical zones are used as a guide only, with each site requiring further and more detailed geotechnical assessment at the subdivision stage.

6 Geotechnical Opportunities & Challenges for Future Development

The following assessment of opportunities and challenges for future development is based on observations made on site and from past experience with similar soils.

6.1 Development

Development within the Minden Rural 3 Zone should be guided by the Stability Zoning plan provided in Figure 3 to this report. Whilst we have identified a number of areas which are not well suited to development, there are a number of locations which may be more suited such as the elevated plateaus in the southwest of the site and the wide terraces to the northwest and south east.

Setback from steeper land that surrounds the terraces and plateaus is required. The setback distance is recommended to be at least 3 times the height of the steep slope below.

6.2 Stormwater

A significant challenge for development within the new Rural 3 Zone will be the control of stormwater. We understand that sewage will be treated onsite and that stormwater will not be reticulated. It will therefore be important for all stormwater and treated sewage to be collected and piped to suitable discharge locations. Careful consideration should be given to these discharge locations to avoid instability and tunnel gulley erosion.

The impact of a development on the land downstream should also be considered. In particular whether the development will result in greater stormwater flows and seepage into unstable slopes.

Stormwater detention ponds should be located within gently sloping areas with overflows discharging into existing surface water flow paths. Checks should be carried out to confirm that such soakage does not have adverse effects, e.g. tunnel erosion or saturation of the adjoining slopes causing instability. These risks can be mitigated by lining the stormwater ponds to reduce seepage.

6.3 Roads

Construction of roads within the Minden area will require careful consideration. Field evidence suggests that roads (public and access) that have been constructed largely along existing contours by cutting into existing slopes may cause instability, due to the loss of ash mantle. We recommend that all road construction, including access roads, should be subject to detailed geotechnical assessment.

6.4 Earthworks

All earthworks that involve filling at the top of slopes, excavating at the toe of slopes, cutting or filling can cause instability and we recommend that they should be subject to a geotechnical assessment. All such actions would disrupt the ash mantle and may trigger instability.

6.5 Other development options

There are significant proportions of the land inspected that may be unsuitable for development owing to their steepness. However, these areas may be utilised for other uses such as farming, forestry, parks and other recreational land uses.

7 Recommendations

We recommend that these geotechnical zones are used as a guide only, with each site requiring further and more detailed geotechnical assessment at the subdivision stage.

Land Zoned C, may not require detailed stability analyses, provided that setbacks (equal to 3 times the height of the adjoining slope) are applied to land adjacent to steep slopes.

All earthworks including road/access construction shall be subject to specific geotechnical assessment. In addition, all stormwater and sewage treatment for each development will require detailed assessment, including 3-D groundwater modelling.

8 Conclusions

The main conclusions from this appraisal are as follows:

- There is wide spread evidence of instability across the Minden Rural 3 Zone;
- The active instability appears to be associated with the saturation of the ash that mantles the slopes, cutting of the toe of slopes, filling at the top of slopes and tunnel gulley erosion;
- Historic instability is widespread, however much of the debris appears to have eroded away and trigger mechanism is no longer current. For example, the historic movement appears to have been associated with sea-level changes, such as retrogressive movement along a terrace face;
- Other geotechnical hazards to consider include earthquakes, liquefaction (in the low lying areas in particular) and flooding;
- We have developed zones showing risk of instability based on the geology, geomorphology and slope gradients across the site. Future development should be guided by these Stability Zones identified in Figure 3 to this report;
- For land Zone C, detailed stability assessment may not be required, if setbacks (equal to 3 times the height of the adjoining slope) are applied to land adjacent to steep slopes;
- The control of stormwater will require careful consideration to mitigate against causing further instability or erosion. Surface water and sewage treatment options accompanied by 3-D groundwater modelling must accompany all development applications;
- Further geotechnical assessments will be required for all development applications. This shall include assessment of road and access construction, all earthworks, stormwater and sewage treatments.

9 References

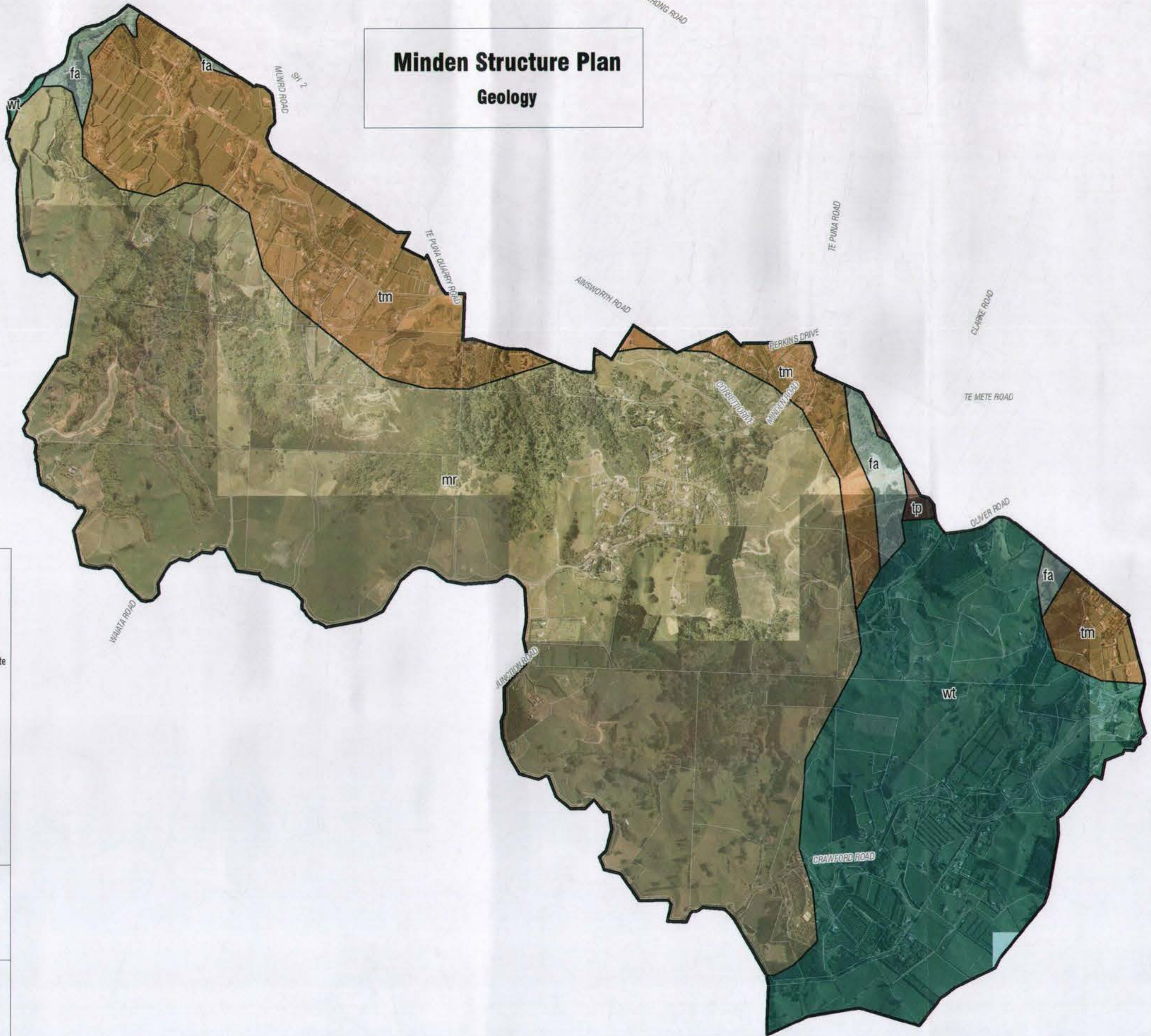
Briggs, RM, Hall, GJ, Harmsworth, GR, Hollis, AG, Houghton, BF, Hughes, GR, Morgan, MD & Whitbread-Edwards, AR (1996). *Geology of the Tauranga Area.* Occasional Report No. 22, Department of Earth Sciences, University of Waikato, Hamilton, New Zealand.

Tonkin & Taylor (January 1992), *Geotechnical Appraisal, Minden Area, Western Bay of Plenty District Council.* Report Ref. 10899.

Figures

Minden Structure Plan

Geology



Legend

- Sand, silt and gravel of modern streams
- Fluvial terrace deposits post-dating the Waiteariki Ignimbrite
- Waiteariki Ignimbrite
- Te Puna Ignimbrite
- Minden Rhyolite

This map contains data derived in part or wholly from sources other than Beca, and therefore, no representations or warranties are made by Beca as to the accuracy or completeness of this information.

Scale: 1:20,000 at A3

Map intended for distribution as PDF document. Scale may be incorrect when printed.

Geological information sourced from 'Geology of the Tauranga area' 1 : 50,000 map.

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Figure 1

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Minden Structure Plan

Slope Gradient

Legend

- Zone A (>26.5 Degrees)
- Zone B1 (>20-26.5 Degrees)
- Zone B2 (>12-20 Degrees)
- Zone C (<= 12 Degrees)

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Figure 2

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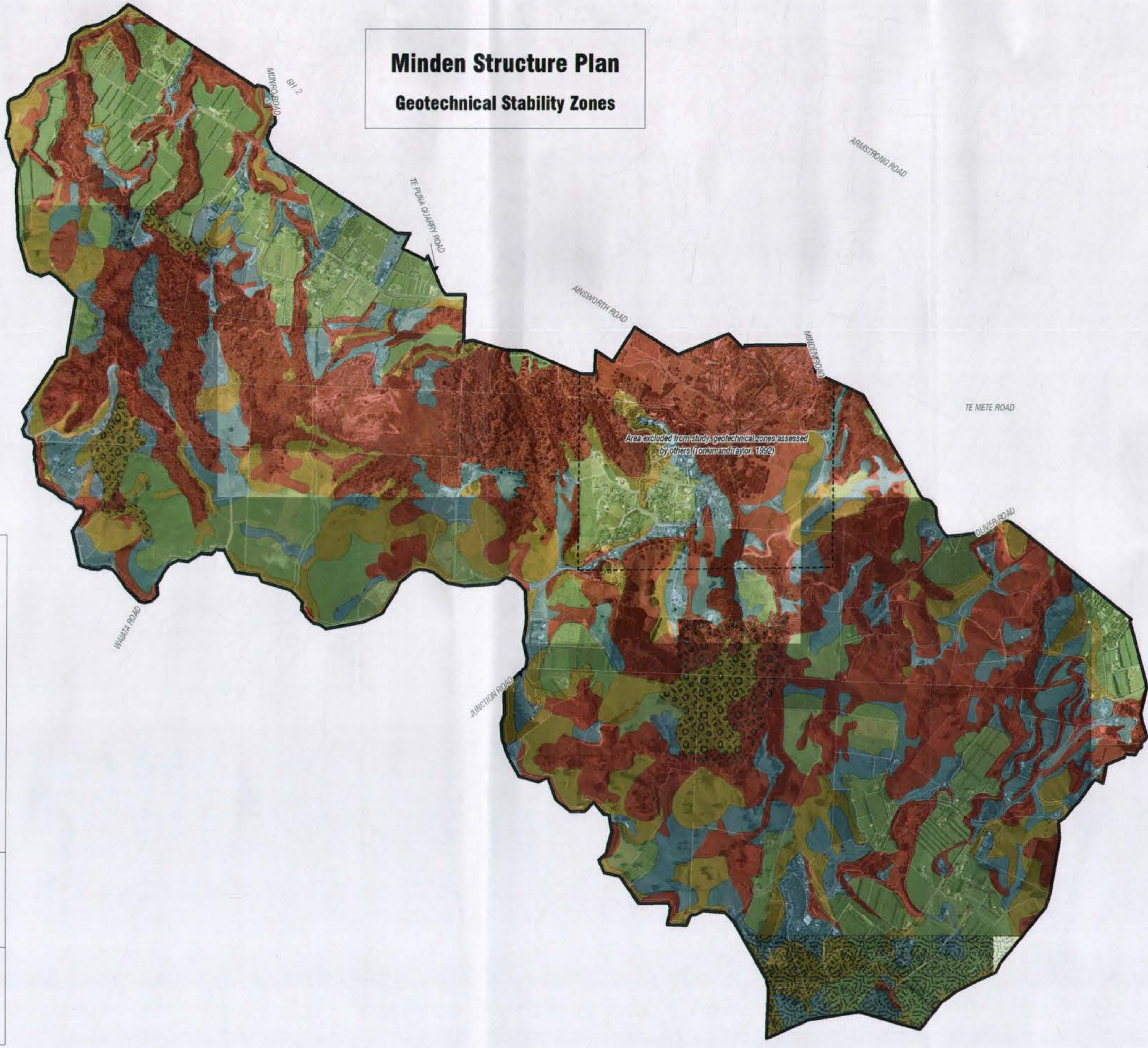
Minden Structure Plan

Geotechnical Stability Zones



Legend

- Stability Zone A: land subject to or likely to be subject to instability.
- Stability Zone B1: land potentially subject to instability.
- Stability Zone B2: land potentially subject to instability (to a lesser degree); if there is no on-site disposal of sewage or stormwater, no significant cutting or filling and no significant vegetation removal.
- Stability Zone C: is land unlikely to be at risk from instability.
- No topographic data
- Obscured by bush cover and / or topographic information may not be accurate.
- Area excluded from study, geotechnical zones assessed by others (Tonkin and Taylor, 1992)

Scale: 1:20,000 at A3

Map intended for distribution as PDF document. Scale may be incorrect when printed.

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Figure 3

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Appendix A

Table A1: Existing WBOP Geotechnical Data

Street Name	No.	WBOP S/B Ref.	Within Existing Hazard Zone	Ground Conditions								Potential Instability
				Fill	Peat	Younger Ash	Rotuehu Ash	Hamilton Ash	Rhyolite	Ignimbrite	Ground water	
Ainsworth Rd	52	P/1308/7/4	Yes	Undefined	No	Yes	Yes	Yes	Undefined	Undefined	Undefined	Yes
Ainsworth Rd	52	5280	Yes	Undefined	No	Yes	Yes	Undefined	Undefined	Undefined	Undefined	No
Ainsworth Rd	52	8389	Yes	Undefined	No	Yes	Yes	Yes	Undefined	Undefined	Undefined	No
Ainsworth Rd	52	9205	Yes	Yes	No	Yes	Yes	Yes	Undefined	Undefined	Undefined	Yes
Hayward Rd	18	P/1214/112/4	No	Yes	Undefined	Yes	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Munro Rd East	22	6387	No	Yes	No	Yes	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Minden Rd - Telecom Tower	N/A		No	Undefined	No	Yes	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Minden Rd	376	6718	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Minden Rd	378	6718	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Minden Rd	656	6780	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Minden Rd	671	9119	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Unknown
Minden Rd Extension	N/A	9387	No	Yes	Undefined	Yes	Undefined	Yes	Undefined	Undefined	Undefined	Yes
Munro Rd	132	7572	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Unknown
Munro Rd	150	7935/1	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Unknown
Munro Rd	150	7935/1	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Unknown
Florence Lane		P/1301/1027/4	Yes	Yes	Undefined	Yes	Yes	Undefined	Yes	Undefined	Yes	Yes
Quarry Rd (Te Puna)		P/1305/420/4	No	Undefined	Undefined	Yes	Yes	Yes	Undefined	Undefined	Yes	No
Quarry Rd (Te Puna)		P/1305/244/4	No	Yes	Undefined	Yes	Yes	Yes	Undefined	Undefined	Yes	No
Walden Lane		8613	No	Yes	No	Yes	Yes	No	No	Yes	No	Yes
Oliver Road	55	P/1322/35/4	No	Yes	No	Yes	Undefined	Undefined	Yes	No	Undefined	
Crawford Rd	37	8432	No	Undefined	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Crawford Rd		P/1304/69/4	No	Yes	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Crawford Rd		6215	No	Undefined	Undefined	Yes	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Crawford Rd	79	6000	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Crawford Rd		8200	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Yes
Crawford Rd	217	8569	No	Undefined	Undefined	Yes	Undefined	Undefined	Undefined	Undefined	Undefined	Unknown
Crawford Rd		5401	No	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Unknown