



Port Waikato Landslide Assessments

Prepared for
Waikato District Council

Prepared by
Tonkin & Taylor Ltd

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1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by Waikato District Council (WDC) to undertake an assessment of land damage that has occurred within the Port Waikato township following Cyclone Gabrielle. The cyclone occurred in mid-February 2023 bringing heavy downpours to many areas of the North Island.

Immediately following the downpour, WDC assessed several properties along Maunsell Road and Tuakau Bridge – Port Waikato Road and assigned placards relating to observed structural damage and/or assessed risk of potentially imminent damage to dwellings and outbuildings. The following coloured placards were assigned during these assessments:

RED: dwelling to be evacuated due to suffering extensive structural damage or at perceived high level of risk of further damage.

YELLOW: dwellings / sleep-outs are not safe to stay in overnight but may be temporarily accessed during the day.

WHITE: no observed damage to dwellings or immediate risk of damage.

The purpose of this work is to provide WDC with the following:

- A high-level assessment of landslide failure mechanisms.
- Provide individual property damage assessments and note changes to placarded properties; and
- Provide context to the future landslide risk to facilitate future decision making around Council owned assets.

1.1 Scope of work

The scope of work has been based on the 21 March 2023 email between J. Ebenhoh (WDC) and D. Mills (T+T) and is documented within the 'Form of Instruction for Service' dated 5 April 2023. A summary of the agreed scope is provided below for clarity:

- 1 Initial meeting at Waikato District Council (WDC).
- 2 Project setup, scope communications, and health, safety, and environment paperwork preparation.
- 3 Desktop study, including review of available published geological information, existing T+T reports, available aerial photographs, and Council held contour maps.
- 4 Drawings: generate a maximum of three figures to show the landslide locations, mapped geomorphological features, and overall hazards associated with the land movement. The overall landslide hazard figure will indicatively present the current and future slope stability risk to dwellings and infrastructure adjacent to the slopes for current building assessment and to aid future planning purposes.
- 5 Summary report: to include the following:
 - Summary of relevant details gleaned from the desktop study and site walkover.
 - Comment on failure mechanisms associated with the recent landslides.
 - Discussion on the potential for larger global movements, if any.
 - Discuss the general slope stability across the areas of interest.
 - Provide WDC with lot specific land damage information on the recently affected dwellings, as well as potential for future re-inundation to occur on currently affected properties.

- Provide comment on future risk to dwellings and roads for properties not currently affected by the recent landslides. Only within the locations provided by WDC.
- High-level comment and indicative assessment on remedial options to reduce imminent risk to dwellings.

A variation order (VO1) dated 11 May 2023 was subsequently provided to WDC due to the wider scale of land damage observed than originally appreciated. A summary of the additional work is provided below:

- 1 Undertake additional site visit to assess affected properties. This will involve one full day of walkover, accommodation for one night, and mileage.
- 2 Report on additional findings within report.

1.2 Site description

The assessment of land damage by T+T comprises the following properties within the Port Waikato township:

- 115B Maunsell Road (Port Waikato Holiday Park).
- 117 to 211 Maunsell Road.
- 13 to 17 Tuakau Bridge – Port Waikato Road.

The affected properties are located on a low-lying terrace or estuary margin at the toe of a 20 m to 30 m high, moderately to steeply graded, escarpment slope.

The subject properties within Port Waikato lie immediately east of the Tasman Sea and to the south of the Waikato River Estuary. Specific elevations and landform changes are provided in the sections that follow.

The locations of the sites with respect to the landslides and surrounding natural features are presented on Figure 1 (1090905-F1.1) and Figure 2 (1090905-F1.2) in Appendix A.

1.2.1 Maunsell Road Properties

Affected properties are located on the southern side of Maunsell Road with most dwellings constructed on relatively level ground at elevations of between 3 to 5 mRL (the low-lying terrace).

The land to the immediate south of the low-lying terrace is moderately to steeply sloping (25 to 30 degrees) and rises from 5 mRL up to around 30 mRL. The slope height decreases to the north-east to an approximate elevation of 20 mRL. Beyond the crest of slope, the land continues to rise towards the south at a shallower gradient.

Property 115B Maunsell Road (Port Waikato Holiday Park) is located further to the north-west and has steeper slope escarpments to the rear (south) of the property, with a gradient of approximately 40 degrees. Within the south-western portion of the property the contours form a concave feature, which may be indicative of historic slope instability or surface erosion. Most of the holiday park is built over the lower lying terrace.

1.2.2 Tuakau Bridge – Port Waikato Road Properties

The subject dwellings along Tuakau Bridge – Port Waikato Road (13, 15, 17) are also located on the southern side of the Road, on relatively level sections, with dwellings constructed at elevations of approximately 5 mRL to 7 mRL.

Moderately to steeply sloping (35 to 40 degrees) escarpment slopes are present on the southern side of the properties up to around 30 mRL.

The affected properties and adjacent general landform indicates a gully between two ridgelines, where concentrated water flows are likely to be diverted following rainfall events. The land rises at a more moderate angle to the south of the affected properties up to approximately 100 mRL.

2 Desktop study

T+T has reviewed available published information to provide necessary background and context to the landslides that have occurred across the subject sites. The reviewed relevant information is presented in the sections that follow.

2.1 Site setting / geomorphology

Reference has been made to the contour information presented on the 'Contour Map' found on Waikato Regional Council online map collections site, with information retrieved during May 2023¹.

The subject site properties are all located on the lower lying terrace on top of coastal deposits. The geomorphological setting for the affected properties is summarised as follows:

- The Port Waikato Spit lies to the north of Maunsell Road and to the west of Tuakau Bridge-Port Waikato Road and to the west of the Putukaka Headland. The spit has been formed through longshore drift creating an aggregation of sand deposits from the southern extent of the Waikato River estuary northwards. This feature is low-lying but undulating as sand dunes have established. Elevations range from 3 mRL to 15 mRL.
- The Waikato River estuary runs from east to west and drains into the Tasman Sea. The affected properties lie to the south of the river.
- It is anticipated that prior to the formation of the spit a fluvial channel (Waikato River) would have been located adjacent to the toe of the escarpment slopes, potentially undermining the toe, and causing the over-steepened landscape that is observed today.
- The affected properties along Maunsell Road are backed by a ridgeline that runs south-west to north-east.
- An arcuate shaped feature to the south of the affected properties is reticent of a large-scale ancient landslide that may have been active before the formation of the Port Waikato spit.
- The Tuakau Bridge – Port Waikato properties are constructed at the toe of an erosional gully, where two ridgelines of competent bedrock flank the broader incised gully floor. The toe of the slope is located adjacent to the Waikato River estuary margin, separated only by the road.

Several concave features on the contour plan indicate the possible for larger historical landslides or gully features, which are considered unlikely to be active. These areas have been identified on Figure 1 in Appendix A.

2.2 Published geology

The broad geological units relevant to the site are published on the GNS 1:250,000 series geological maps². The lower lying portions of the site are typically underlain by recent alluvial coastal sediments comprising 'mobile dunes' (Q1d), particularly around the Maunsell Road sites. Although not specified on the geological map, the lower-lying portions of the Tuakau-Port Waikato Road sites could be located on Waikato River estuary deposits or on colluvial deposits associated with previous historic land instability.

The escarpment slopes to the south of the subject properties comprise the following geological units:

- Maunsell Road Sites: Pliocene era Awhitu Group (Pad) consisting of a cemented dune sand and associated facies form the younger deposits, which are largely confined to the coastline.

¹ <https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=8d6d6fda779b4e59951953ae97d0ec4a>

² Edbrooke, S.W (compiler) 2001. Geology of the Auckland area. Institute of Geological and Nuclear Sciences 1:250 000 geological map 3. 1 sheet + 74 p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Limited.

The Jurassic Marine Basement Rocks of the Apotu Group (IJa), which is part of the Murihiku Supergroup underlie the Awhitu Group and comprise siltstone, sandstone, and conglomerate which are carbonaceous near top.

- Tuakau Bridge – Port Waikato Road Sites: Jurassic Basement Rocks comprising the units within the Murihiku Supergroup, namely the Huriwai Group (Ijh) comprising non-marine alternating mudstone, sandstone, and conglomerate with abundant plant fragments and rare thin coals.

Both sites sit within a geological complex system of faulted stratigraphy, which has been subject to structural deformation in the past. The site lies to the south-west of the Kaimango Syncline and several fault lines. The fault lines are presented on the geological map below but the ones closest to the site are the Waikato Fault, the Waikato Heads Fault, the Huriwai Fault, and the Walkawau Fault. These are all considered inactive as no active faults are mapped within this area based on the New Zealand Active Faults Database³.

A depiction of the key geological units and features discussed above is presented in Figure 2.1.

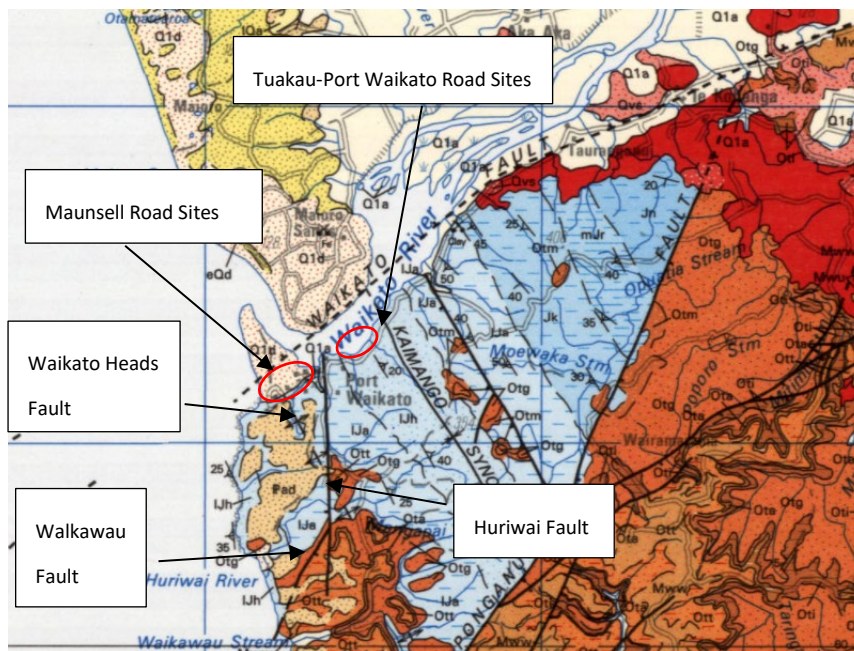
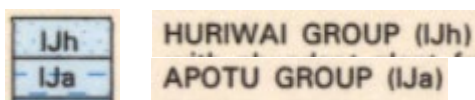


Figure 2.1: Published geological map

Legend:



2.3 Aerial photographs

A review of the Retrolens online platform⁴ presents historical aerial imagery between 1942 and 1997. These images are taken on a relatively broad scale and so only generalised information can be drawn from them.

³ GNS Science. (2016). New Zealand Active Faults Database 1:250,000 scale [Data set]. [New Zealand Active Faults Database - GNS Science | Te Pū Ao](#)

⁴ <https://retrolens.co.nz/map>

The historical imagery in 1942 and 1949 does indicate some potential historic landslides towards the western end of Maunsell Road. More recent aerial images indicate that the steeper elevated landform as part of the wider site setting has been subject to shallow landslides in the past, with no indication of larger global land movements.

2.4 Drone Survey

WDC undertook a series of photographic drone surveys shortly following the Cyclone Gabrielle event. These photos show the extent of the landslides from an aerial perspective and formed the basis for targeting our site walkovers.

Temporary access to the WDC ArcGIS platform was also provided where extracts were inserted into a PDF format for use on site.

Images provided by WDC are presented in figures 2.2 and 2.3.



Figure 2.2: Aerial photograph looking south-east towards Maunsell Road.

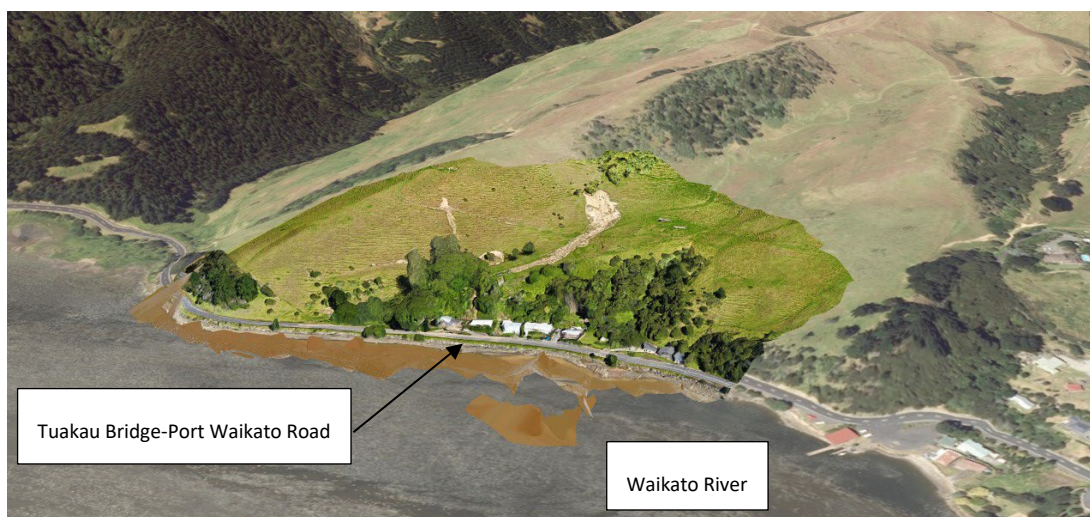


Figure 2.3: Aerial photograph looking south towards land damage on and above properties.

The above photographs indicate that there are several relatively shallow landslides along the escarpment slopes above the subject properties. In general, these landslides appear to be isolated events rather than being indicative of a larger global landslide.

2.5 Rainfall data

A review of available rainfall records closest (12km SE) to the site were assessed to provide a hydrological context for the landslides. Key figures are presented below, which have been taken from the Waikato Regional Council environmental maps⁵.

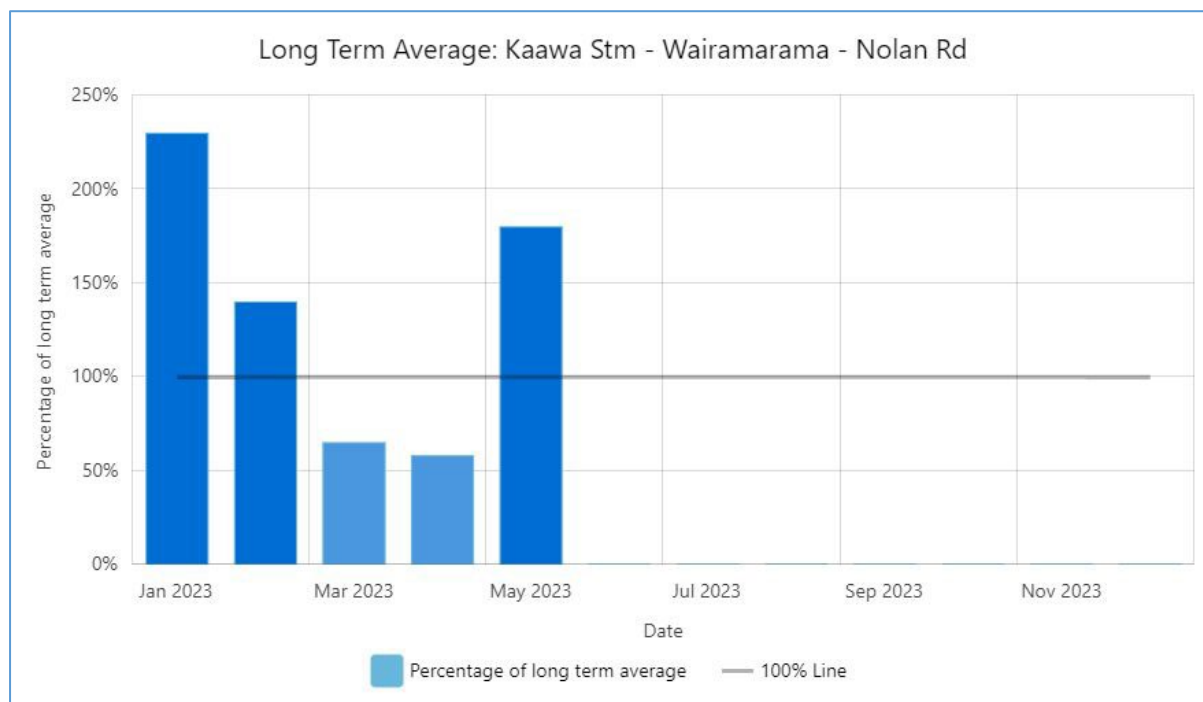


Figure 2.4: Long term average rainfall compared to rainfall during 2023

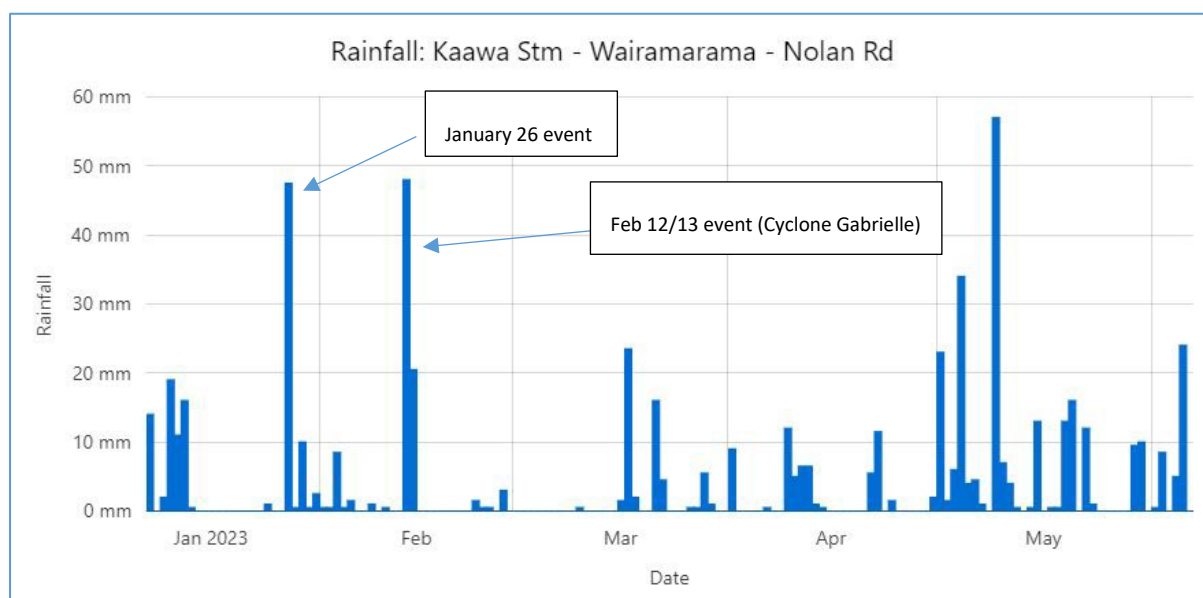


Figure 2.5: Daily rainfall totals during 2023

⁵ <https://waikatoregion.govt.nz/environment/envirohub/environmental-maps-and-data/station/24281/RF?dt=Rainfall>

As a general note, July, September, October, and November 2022, received between 120% and 210% of the long-term average rainfall. During this time there were at least six occasions where the 24-hour rainfall total was greater than 40mm.

Figure 2.4 indicates that during January 2023 there was over 200% of the long-term average rainfall, with most of this rain coming towards the end of the month. The ground would have therefore been heavily pre-soaked prior to the Cyclone.

During February Port Waikato also received around 140% of the long-term average rainfall amount, noting that February is usually a wetter month than January.

Figure 2.5 affirms the above conclusions with nearly 50 mm of rainfall occurring during the January 26 event and an additional 60 to 70 mm during Cyclone Gabrielle.

May 2023 also received large amounts rain, recording up to 200% of the long-term average at this weather station. No further land instability has been noted because of this rainfall.

The data above is shown over a 24-hour period, but hourly rainfall intensities were not readily available to assess. This data may help to explain why landslides did not occur in January or May.

The heavy rainfall depths discussed above are considered a key driver in contributing to the landslides that occurred during the Cyclone. It is also considered likely that a combination of two extreme rainfall events occurring within two weeks of each other has led to the damage.

It is noted that the above rainfall data is from the closest weather station within the Waikato at Kaawa Stream, Wairamarama (Nolan Road), approximately 12 km SE of the site and provides indicative values only. Actual rainfall within this catchment may have been greater than or less than the values assessed above given the location of the subject site to the monitoring station.

3 Site observations

Following the desktop study, T+T carried out site walkovers on 14 April and 16 May 2023, which largely focussed on assessing the scale and nature of the landslides that occurred at a property level. Where access was possible an assessment of the wider landform was also undertaken.

T+T engaged with property owners where possible to understand the circumstances around the individual landslides. All property owners that were spoken to indicated that land damage occurred following Cyclone Gabrielle and not the preceding January 26 rainfall event.

Faulted rock exposures are present along the western coastline, which typically comprise sub-horizontally to sub-vertically dipping interbedded mudstones and sandstones within the vicinity of subject area.

Land and property damage has been summarised on the table presented in Appendix B and sections 3.1 and 3.2. Commentary on the suitability of the coloured placards placed on behalf of WDC has also been made based on the site observations. Photographs from the site visit are presented in Appendix C.

3.1 Land damage

A summary of the key findings from the site visits relating to land damage is provided as follows:

- Geological units observed at the properties were consistent with the published geological information, typically comprising interbedded sandstones and mudstones with a soil veneer.
- A total number of 25 landslides were assessed during the visits, with 22 of these occurring on the moderately to steeply graded escarpments slopes to the south of the properties. Most of the damage was a result of debris inundation at or towards the toes of the slope.
- Landslides typically had head scarps between 3 m and 15 m wide, with landslide heights typically between 3 m and 5 m.
- Some larger landslides were observed with headscarps up to 32 m wide, with two of these located on the upper steeper slopes behind properties on Tuakau Bridge – Port Waikato Road.
- The landslides observed were indicative of shallow rotational failures, debris flows, and translational landslides. Failure surfaces mostly occurred at the interface between the soil veneer or extremely weathered bedrock and the more competent underlying bedrock. Schematic diagrams of the above failure mechanisms are presented in Figure 3.1.
- Many of the landslides occurred within the lower to middle portions of the slope, with an isolated number occurring near the crest of the slope. Landslide locations were likely controlled by geomorphology and hydrogeological conditions.
- Debris made it to the toe of the slope and beyond impacting buildings on several properties. In some cases, debris run out from the shallow landslides was limited towards the lower slopes and caught up within vegetation on the slope.
- Landslide 19 (115b Maunsell Road) was one of the larger failures observed, with a 22 m wide headscarp located on a 40-degree slope approximately 16 m from the crest (overall slope height of around 60 m). The height of the landslide headscarp is estimated to be approximately 20 m. Debris run out for this was in the region of 12 m to 14 m from the toe of the natural escarpment slope.
- No large tension cracks or other forms of slope movement were identified during our walkover, nor was any evidence provided by property owners. We do note that access was limited due to the heavily vegetated escarpment slopes, so a walkover to higher elevations was only undertaken around 171 to 175 Maunsell Road. Such tension cracks may be present on parts of the slope that were not accessed.

- Soil creep occurred across most of the slopes, which would be anticipated on slopes of this gradient where a veneer of soil is present. This was most demonstrated from trees bending at the base of the trunk because of adjusting to downslope movement.
- Three landslides (23, 24 and 25) were assessed above 13, 15, and 17 Tuakau Bridge - Port Waikato Road properties. These landslides were consistent with other observed failure modes and did not inundate properties below.
- Typical sections through landslides are presented in Figure 3 and Figure 4 in Appendix A, with measurements taken using a Trupulse rangefinder on site.

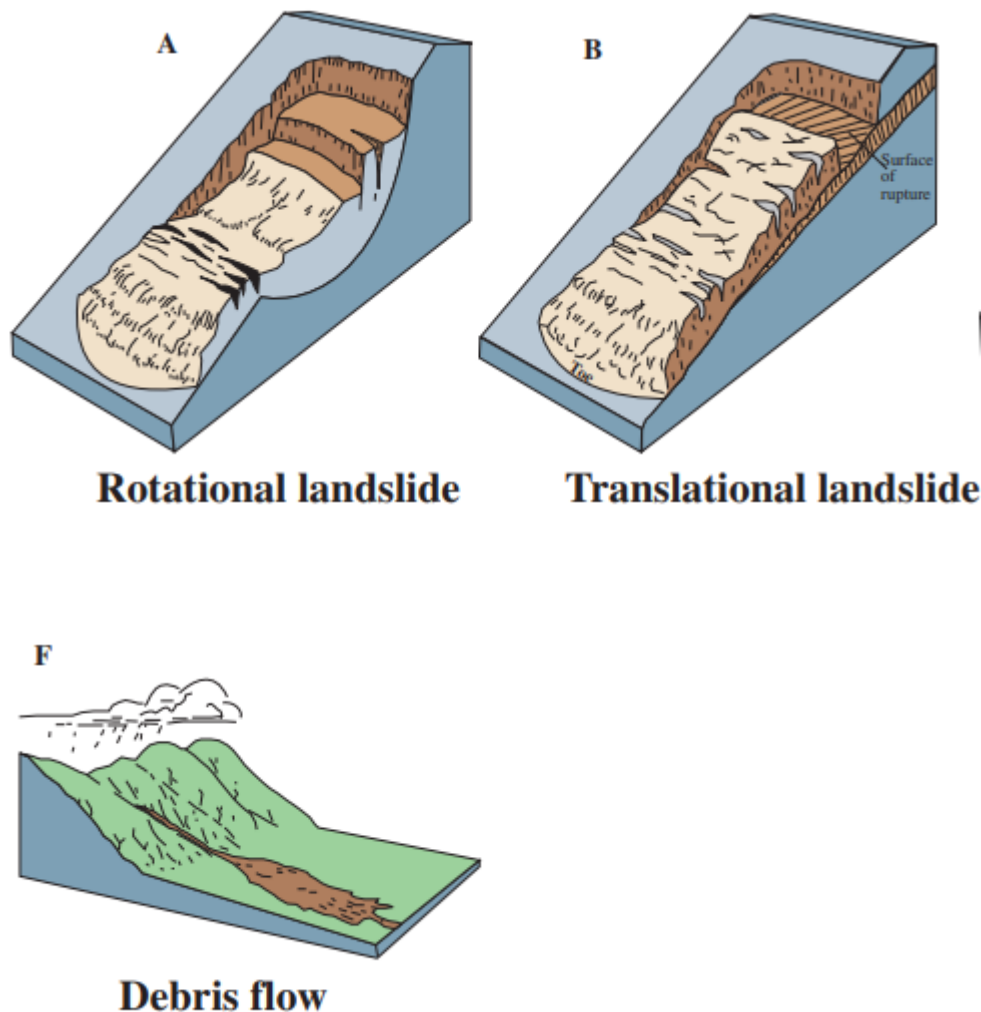


Figure 3.1: USGS Landslide failure modes⁶

3.2 Property damage

As discussed in Section 3.1, several properties sustained damage because of landslide debris impacting dwellings, sleep-outs, garages, and other infrastructure such as retaining walls and tanks. In most cases the debris caused minor impact damage, however in a number of cases the damage was major, particularly where structures were located adjacent to the toe of the slope.

⁶ U.S. Department of the Interior, U.S. Geological Survey, Landslide types and processes, Fact Sheet 2004-3072, July 2004.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

4 Causes of failures

Many factors contribute to the stability of slopes. These include:

- a Slope height
- b Slope steepness
- c Geology
- d Soil thickness
- e Weathering
- f Rainfall
- g Groundwater

For the Port Waikato slopes a number of the items listed here are not known due to the high-level nature of this assessment but, as discussed in the preceding sections, the failures observed during this work occurred during and following the heavy rainfall associated with Cyclone Gabrielle in February 2023.

A summary of the weather-related factors contributing to the slope failures observed, to help provide context for the future risk to properties along the southern side of Maunsell Road and along Tuakau Bridge - Port Waikato Road, is provided as follows:

- 1 Extreme rainfall event in January with over 50 mm of rainfall in 24 hours.
- 2 Large rainfall event during Cyclone Gabrielle in February 2023 with over 70 mm of rainfall within 48 hours.
- 3 An unseasonably wet spring / summer where the closest rain gauge to Port Waikato received 140 % to 210 % of the long-term average rainfall during October and November 2022 respectively.
- 4 A relatively high (20 m to 60 m) and steep escarpment slope (30 to 40 degrees) slope with a veneer of soil and weak rock overlying more competent marine basement rocks (interbedded mudstone and sandstone).
- 5 Heavily jointed / fractured sandstone beds on unfavourably dipping planes were present particularly around Landslide 5 (201 Maunsell Road), allowing for movement perpendicular to the slope face.

It is considered that combinations of the above have contributed to the recent landslides occurring around these Port Waikato sites. In addition, the geomorphology, geology, steepness, and weathering profile are considered to make the escarpment slopes around Port Waikato susceptible to landslides in the future.

5 Future risk

The combination of factors outlined in Section 4 highlights that the sites recently affected at Port Waikato are at risk from future landslides should heavy rainfall or seismic events occur. Given the potential for climate change to affect weather patterns and bring more extreme events, (Ministry of Environment, January 2023⁷), the future likelihood of these landslides occurring will also increase. Not only are the frequency of larger rainfall events likely to increase but also their intensities, the latter of which is considered to be a key influencing factor on the instability observed.

It is worth noting that rainfall in May was also significant (Figure 2.4 and Figure 2.5), where total rainfall over a 24-hour period exceeded the 26 January and Cyclone Gabrielle events with nearly 60 mm of rain depth in one day. No further landslides were noted to have occurred during this month.

Despite the future landslide risk, relatively few buildings, dwellings and minor structures were severely damaged during Cyclone Gabrielle. This was partly down to chance, but other factors include vegetation on slope (catching the debris), distance of the buildings from the slope toe and geomorphology sheltering some properties from landslide debris (i.e. directing it elsewhere).

The above said, landslides similar to those observed are considered likely to occur along the same slopes in the future. With the forecast increases in storm frequency and higher intensity storms the likelihood (and therefore risk) of landsliding on slopes also increases. Within the area observed this will increase the landslide risk for properties at the slope toes, i.e. those on the southern sides of Maunsell Road and Tuakau Bridge – Port Waikato Road.

⁷ The science linking extreme weather and climate change, 3 February 2023, Ministry of Environment article: [The science linking extreme weather and climate change | Ministry for the Environment](#)

6 Recommendations

Assessment of the properties placarded by WDC has been undertaken, and considerations for each lot have been provided within the table presented [REDACTED]

Once remedial works have been undertaken all the assessed properties are at the same risk of inundation as before the event. It is acknowledged that dwellings and structures that are rebuilt will be safeguarded by either larger setbacks or other remedial solutions to meet the requirements of the current New Zealand Building Code.

Existing homeowners in all sites at the base of the steep escarpment slopes should consider approaches to reduce the instability risk to their properties including further assessments and/or constructing suitable mitigation measures. The form and extent of these should be assessed by the property owners and should be done with consideration to the effects potential mitigation measures may have on adjacent properties.

Careful consideration should be given to new buildings that are constructed on vacant lots or where current buildings are replaced. Any new buildings constructed at the toe of the steep slopes should give due consideration to the landslide hazard. This also extends to WDC infrastructure, where located on the slopes or within the debris runout zone at the slope toes.

For the Holiday Park site (115B Maunsell Road), it is recommended that location of any structures and tent sites give due consideration to the instability risk of the slope. This may include implementing a suitable offset from the slope toe.

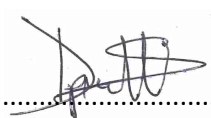
7 Applicability

This report has been prepared for the exclusive use of our client Waikato District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

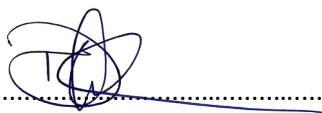
Tonkin & Taylor Ltd
Environmental and Engineering Consultants

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Authorised for Tonkin & Taylor Ltd by:



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Senior Geotechnical Engineer



David Milner
Project Director

12-Jun-23

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Appendix A Figures

- **Figure 1 – Landslide Summary Plan Maunsell Road**
- **Figure 2 – Landslide Summary Plan Te Okuroa – Port Waikato Road**
- **Figure 3 and 4 – Landslide Cross-sections**

LEGEND

PROPERTY BOUNDARIES

EXISTING CONTOURS (20m)

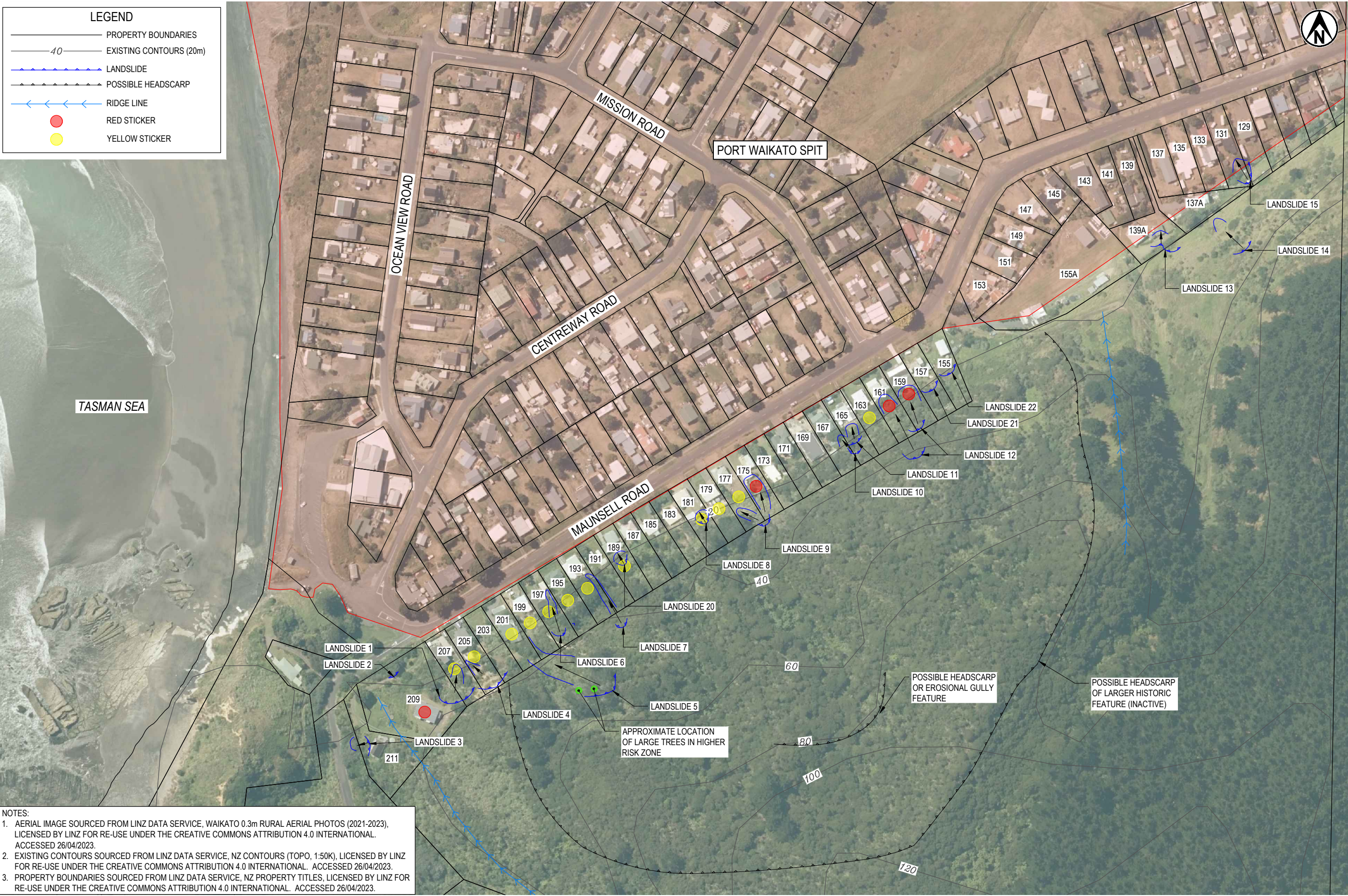
LANDSLIDE

POSSIBLE HEADSCARP

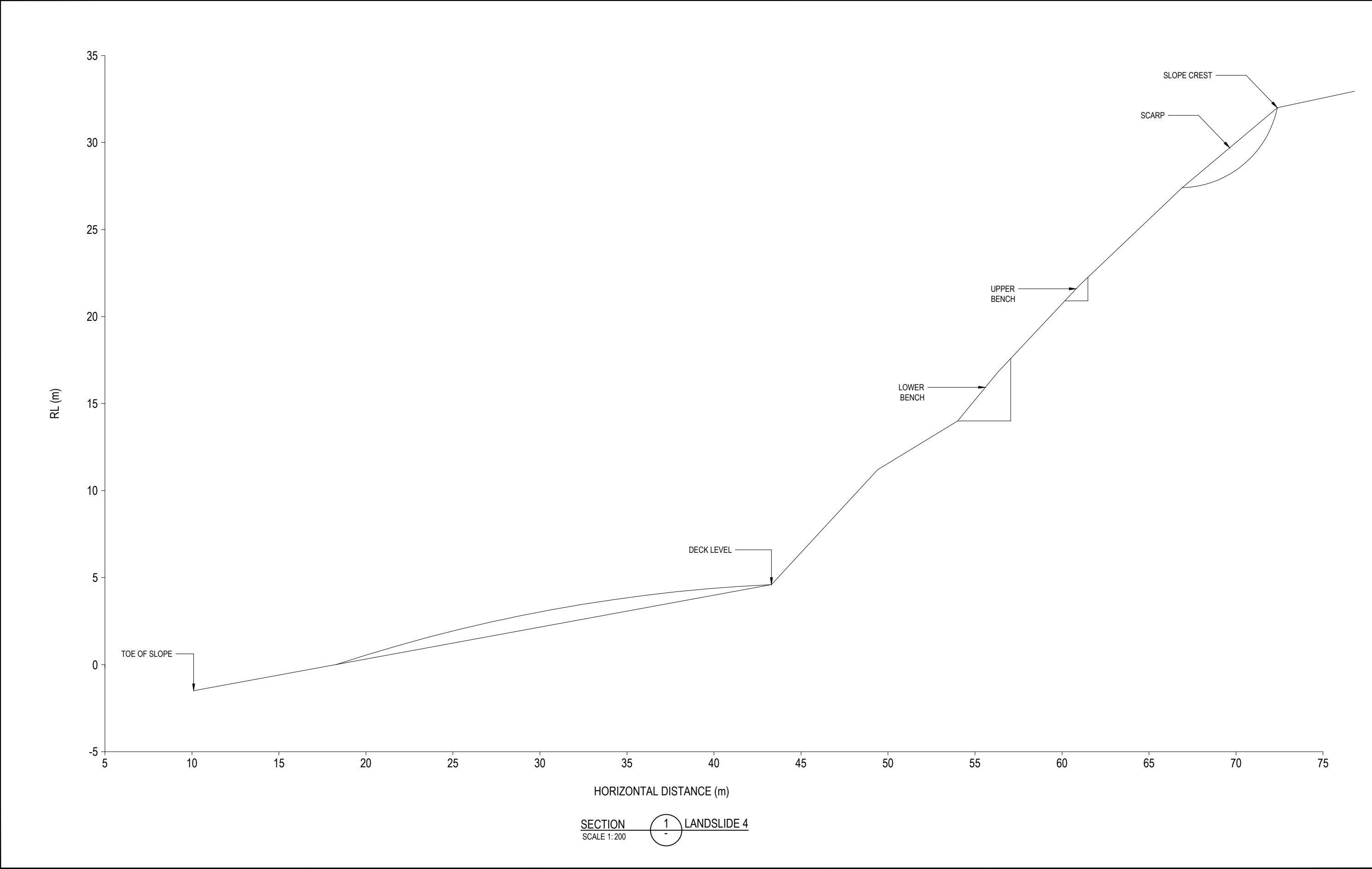
RIDGE LINE

RED STICKER

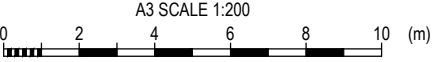
YELLOW STICKER





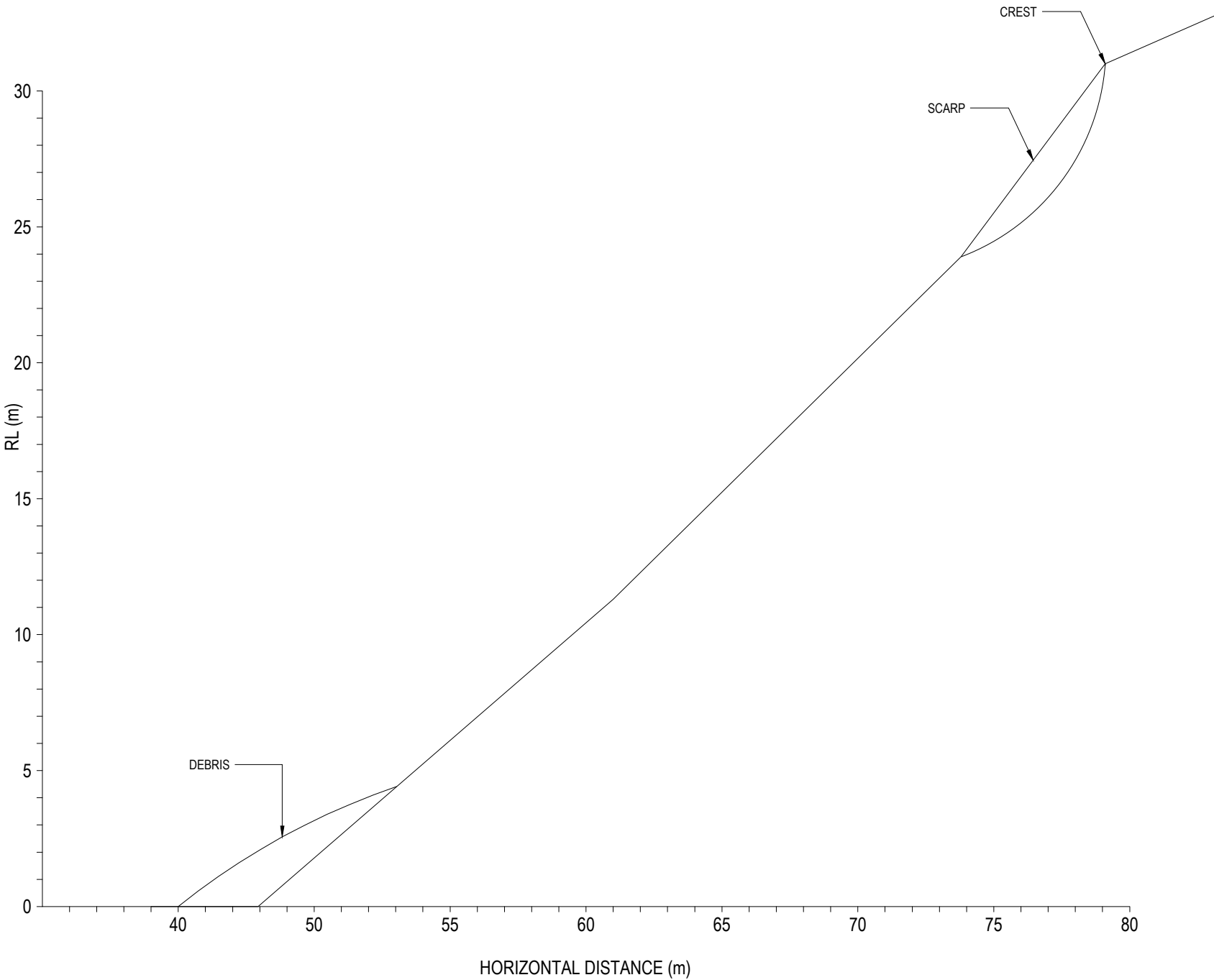


NOTES:
1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.



PROJECT No. 1090905			CLIENT	WAIKATO DISTRICT COUNCIL	
DESIGNED	DAMI	Jun.23	PROJECT	MAUNSELL ROAD, PORT WAIKATO	
DRAWN	KMJA	Jun.23	TITLE GEOTECHNICAL INVESTIGATION LANDSLIDE PROFILES		
CHECKED					

APPROVED		DATE	SCALE (A3)	1:200	FIG No. 1090905-F1.3
					REV 1



SECTION 1 LANDSLIDE 9 - LINE A
SCALE 1: 200

NOTES:
1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.



ORIGINAL IN COLOUR

PROJECT No. 1090905			CLIENT	WAIKATO DISTRICT COUNCIL		
DESIGNED	DAMI	Jun.23	PROJECT	MAUNSELL ROAD, PORT WAIKATO		
DRAWN	KMJA	Jun.23	TITLE	GEOTECHNICAL INVESTIGATION LANDSLIDE PROFILES		
CHECKED						

APPROVED		DATE	SCALE (A3)	1:200	FIG No.	1090905-F1.4
					REV	1

Appendix B Land and property damage summary

Appendix C Site photographs



Photograph 1: Dipping mudstone / sandstone beds view from beach



Photograph 2: Dipping sandstone beds view from beach



Photograph 3: Landslide 3 [REDACTED]



Photograph 4: View of Landslide 1 & 4 [REDACTED]



Photograph 5: View of Landslide 5



Photograph 6: Debris accumulation



Photograph 7: View of landslide 9



Photograph 8: View looking north from behind dwelling (Landslide 12)



Photograph 9: View of Landslide 13



Photograph 10: Landslide 15



Photograph 11: Landslide [REDACTED]



Photograph 12: [REDACTED] Large Landslide 19



Photograph 13: Landslide within [REDACTED]



Photograph 14: Damage to shed / car port [REDACTED]

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