

2. SITE DESCRIPTION

The site is located at 332 Komokoriki Hill Road, Ahuroa approximately 20km southwest of Warkworth. The subdivision site contains a number of titles including Lot 3 DP 81832 (4.84ha), Pt Allotment 90 (24.75ha), Allotment 91 (27.48ha), Pt Allotment NE95 (12.41ha), Allotment S94 (3.77ha) and Allotment NE94 (23.47ha) Psh of Komokoriki with a total area of 96.73ha. Auckland Council planning maps indicate that the property is located within an East Coast Rural Zone. Some flood susceptible areas are mapped at the subdivision site but are typically confined to the watercourse margins that are present through the site.

The property is currently operated under an ecological farming regime and has been a certified organic farm for the previous 10 years. A majority of the site is in rolling pasture and is used for grazing by livestock, however large areas of bush are present in the east on the more elevated and hilly topography. A number of wetlands are also present within the property, positioned in the low lying watercourse margins and gullies that dissect the site. Scattered trees and isolated areas of bush are also present within the subdivision.

Figure 1 below taken from Auckland Council GIS shows the site and surrounds including the existing vegetation, buildings and access arrangements.

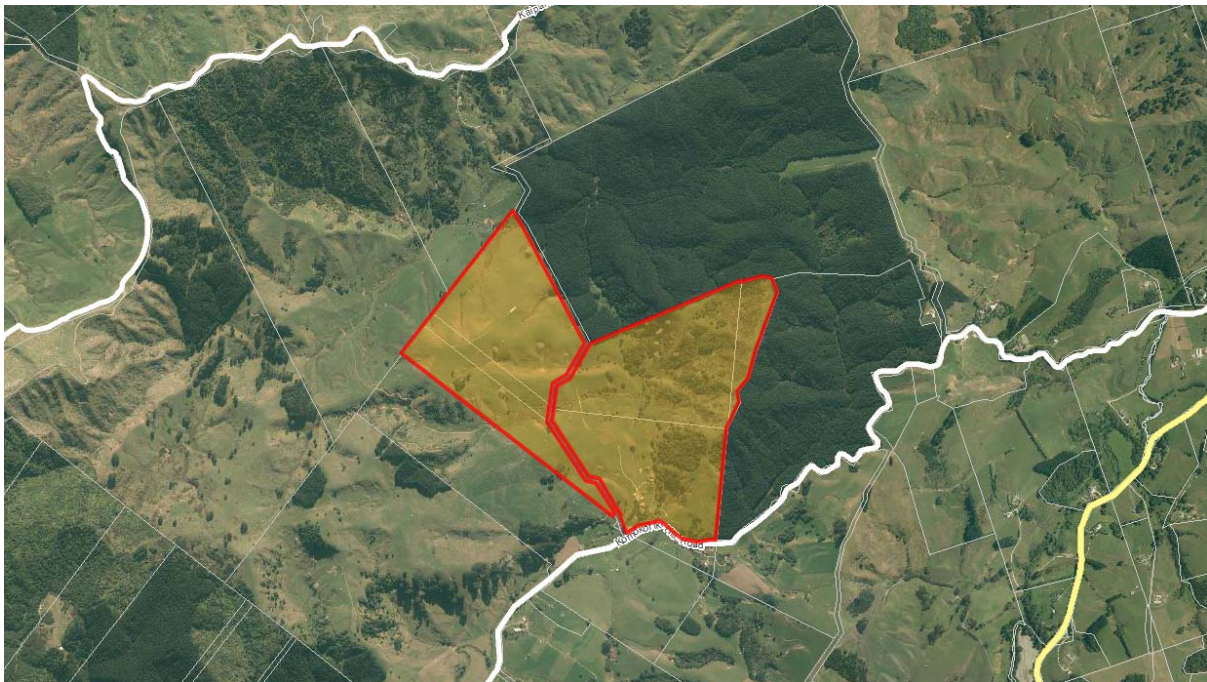


Figure 1: Auckland Council GIS aerial image

Secondary buildings and implement sheds associated with the farm operations are present at the property and typically include an old wool shed with stock yards plus a general storage and implement shed near the main dwelling within proposed Lot 1 as indicated in Figure 1. The wool shed and stock yards are located within proposed Lot 9. An existing farm shed used for hay storage is also present on the property and is positioned within proposed lot 7.

The property has road frontage with Komokoriki Hill Road and is accessed via an existing vehicle bridge crossing Kotorengaru Stream. Access to the proposed building sites within proposed Lots 5-9 will be achieved via a shared Right of Way (RoW) access from Komokoriki Hill Road shown as easements A, C & D on the enclosed scheme plan.

The site has variable graded topography with rolling pasture in the western parts of the site forming proposed Lots 5-9. The nominated building sites within the lots are elevated on the ridge lines and crests of the land offering expansive views of the surrounding countryside. Stormwater runoff follows the natural topography via overland sheet flow collecting and concentrating in a series of unnamed watercourses that drain east and south towards Komokoriki Hill Road. The watercourses that dissect the site are unnamed tributaries of Kotorengaru Stream which runs parallel with Komokoriki Hill Road and forms the southern boundary of the subdivision site. Kotorengaru Stream drains west to Araparera River before discharging to Kaipara Harbour approximately 8km southwest of the property.

3. GEOTECHNICAL

3.1 Ground Investigations

A site visit and walkover inspection of the subdivision property was carried out on 9th July 2015. A follow up visit was carried out on 11th August and a series of shallow subsurface ground investigations were carried out consisting of eight hand auger borehole with in-situ shear vane tests and 37 dynamic cone scala penetrometer tests across the building platforms and ROW access.

The location of all tests within the property and results of the ground investigations are included within Appendix 2.

3.1.1 Boreholes

A total of eight hand auger boreholes were carried out across the subdivision with two boreholes undertaken at the nominated building sites within proposed Lots 5 & 6 and a single borehole within each of the Lot 7-9 building sites. The boreholes were typically taken to 3m below ground level except where conditions were too hard to dig by hand. The boreholes revealed a general trend of moist, highly plastic, orange brown silty clay surficial soils grading to light grey silty clay with some weak gravels encountered at depth. Orange and grey mottling was observed within the groundwater fluctuation zone and standing water level where encountered was typically recorded at 1.7m - 2.4m below existing ground level.

3.1.2 Shear strength

Undrained shear strengths were measured at 0.5m intervals during excavation of the hand auger boreholes to determine the in-situ shear strength properties of the surficial soils.

The results included in Appendix 2 indicate that the peak undrained shear strengths vary significant with borehole location and depth, however are typically in excess of 80kPa with results varying between 56kPa to >208kPa. The surficial soils at the site are considered to be stiff and sensitive.

3.1.3 Scala penetrometer

A total of twenty seven dynamic cone scala penetrometer tests (SP) were undertaken within the nominated building platforms to determine the available bearing capacity for foundation design. A single test was carried out at the base of each borehole with the remainder carried out from existing ground level.

The tests recorded variable results but identified a general increase in bearing resistance with depth. At normal foundation level of 0.45m b.e.g.l. an inferred allowable bearing capacity in excess of 70kPa is considered to be available.

An additional series of ten dynamic cone scala penetrometer tests (SP) were carried out along the alignment of the existing farm track and vehicle RoW to determine the available bearing capacity for pavement design. It is expected that a design CBR of 3% is available for the vehicle access.

The allowable bearing pressures established by the scala penetrometer testing are based on the methods described by Stockwell (New Zealand Engineering (32, 6) 15 June 1977) using a correlation of mm/blow and bearing pressure. This approach is intended to ensure against

slow plastic movements of underlying soft strata and rapid local soil shear failure of the soil beneath the foundations. The inferred allowable bearing pressure includes a factor of safety of three against soil shear failure. If these allowable pressures are used, settlement should generally be within the following limits:

- (i) maximum settlement of any one of a group of footings = 25 mm
- (ii) maximum differential settlement between footings = 20 mm

These deflections are regarded as the acceptable limits a modern building can withstand without distress.

The assessed available bearing capacity does not consider gradual settlement of the foundation caused by consolidation (expulsion of air and water from the soil matrix voids) of underlying compressible strata such as peat or soft clay. Based on the findings of the subsurface investigations peat or soft clay is unlikely to be present beneath the nominated building platforms and consolidation settlement is not expected to affect the foundations.

3.2 Mapped Geology

The geology of the area is defined on the Institute of Geological and Nuclear Sciences Geological Map of the Auckland Area as Pakiri Formation of Warkworth Subgroup (Waitemata Group) being alternating thick-bedded, volcanic-rich, graded sandstone and siltstone with an area of (Holocene sediments) river deposits consisting of sand, silt, mud and clay with local gravel and peat beds in the south of the site on the Kotorengaru Stream alignment.

The geomorphology of the general area is that of dissected hill terrain of Waitemata Group Pakiri Formation rock.

New Zealand Land Inventory map NZMS 290 Sheet R 08/09 defines the pedology as Warkworth clay and sandy clay loam within proposed Lots 5-9 being well to moderately well drained soils of rolling land (strongly leached to weakly podzolised yellow brown earths) and Whangaripo clay loam in the hilly eastern parts of the site being well to moderately well drained soils of hilly land (moderately to strongly leached yellow brown earths).

3.3 Stability

The existing topography of the site is resultant from the regional geologic events, the natural weathering and erosion processes common to a high rainfall temperate climate zone, and the underlying geological formations. The moderately to steeply graded topography of the dissected hillsides have a significant influence on the stability of the property.

The proposed building sites are typically positioned on the gently graded terrain occupying the ridge lines however the land falls away at steeper grades below the nominated building platforms within some of the sites (lots 5-7). Land underlain by Waitemata Group Pakiri Formation residual soils at grades of up to 15° are generally considered to have a low slope instability potential. Typically, the lower lying areas, including flood plains have the lowest surface relief and therefore lowest slope instability potential.

Inspection of the site and review of historical aerial images reveals extensive areas of hummocked and undulating surface morphology due to historic land instabilities and movement on the steeper slopes and watercourse margins. The more elevated and steeper slopes within the eastern part of the site show signs of large scale historic land movement as

visible in Figure 2 below from 1976. The west of the property containing the proposed development site and residential building sites has more rolling terrain and the observed land instabilities is largely related to surface creep and shallow regolith slippage associated with saturated surface soils. A number of recent instabilities with associated head scarps were observed at the site, however the nominated building platforms within proposed Lots 5-9 do not show signs of recent instability.

The historic images indicate that the proposed building sites have remained stable over the past 40 years with no obvious signs of large scale instability over this period. However evidence of past land movement reinforces the stability sensitive nature of the development.



Figure 2: 1976 aerial image

Vegetation improves slope stability by binding of the soil, providing mechanical reinforcement to resist surface water erosion and by water uptake in transpiration processes. It is recommended that the existing vegetation within the property be retained, particularly on the gully side slopes and steeper topography below the nominated building platforms. Planting of vegetation is encouraged at site, particularly on the slopes immediately above and below the building site.

Groundwater was encountered during excavation of the boreholes at various depths across the site. The surface clays encountered at the site are of low permeability with water tending to perch within the topsoil layer creating wet to saturated conditions commonly supporting reeds that would normally grow in flat swampy areas or around springs. Below this zone the soils typically comprise silty clays and clayey silts with gravel sized fragments of the more competent materials derived from the underlying parent rock.

The widespread presence of swamp reeds growing over the elevated slopes at the property is due to the very low permeability of the surficial soils and indicates perched water with wet to saturated topsoil conditions.

Extensive cut batters and fill embankments are not required for the development but if required the batters should be constructed no steeper 5H:1V and once revegetated are

considered to remain stable. It is recommended that all cut batters in excess of 1m be retained with consideration given to the use of timber pole retaining walls.

3.4 Expansive Soils

The surficial clay soils at the site are considered to be expansive and subject to shrink/swell effects with changes in moisture. It is recommended that the subgrade within the building footprint be maintained close to its natural moisture content to avoid drying out and associated shrinkage, which may result in subgrade swelling after building construction. Subgrade swelling can have adverse effects including heaving and cracking of the floor slab plus associated cracking of the brittle cladding from differential movement. The risk of damage can be reduced during construction by placement of a 300mm minimum thick granular layer (or other barrier to water loss) within three days of excavation of the building subgrade.

If a concrete floor slab is proposed and the exposed building subgrade be subject to excessive drying prior to the placement of the barrier to soil water loss, consideration should be given to wetting up the building subgrade prior to the placement of the barrier.

The surficial soils observed during the field investigations are considered to be expansive and are interpreted as Class M to Class H1 in accordance with AS2870. It is recommended that specific engineering design of foundations for future dwellings at the site be carried out. Any strip or pad foundations at the site should be taken a minimum of 0.45m below cleared ground level.

3.5 Building Platforms

3.5.1 Proposed Lot 5

Proposed Lot 5 is sized 1.22ha and is positioned on the south facing slope of a northeast trending ridge adjacent to the southwestern property boundary. The nominated building platform is located on the elevated ridgeline at approximately RL66m with the land falling away south at an average grade of 11° to a watercourse and associated wetland area at RL45m. The slopes below the building platform exhibit hummocky surface morphology indicating that the land has been subject to past movement comprising surface creep and extending to shallow regolith slippage. Two boreholes (HA1 & HA2) were completed at the building site which were terminated at 1.9m and 2.4m depth where the soil became too hard to auger. Standing water was recorded at 1.7m depth and the presence of swamp reeds reflecting the very low permeability of the surficial soils with wet to saturated topsoil conditions. The wet conditions in the surficial clay soils plays a significant factor in the ongoing creep movement and overall stability of the building platform.

Although no evidence of recent large scale land instability was observed at the nominated building platform, given the evidence and likelihood of previous movement and nature of the underlying geology the building site is considered to be stability sensitive, reinforcing the need for good stormwater management. Any building work on the property should be designed to enhance the stability of the site through a combination of structural solutions (foundations, retaining, palisade walls), stormwater controls and earthworks.

It is recommended that future buildings on this site incorporate pile foundations taken 5m deep on the downslope side of the building. The use of pile foundations pinned to the more

competent soils and underlying weathered rock will provide a robust foundation solution to mitigate surface creep and will also aid in enhancing the overall stability of the building platform. Design parameters for the building foundations are included in Section 3.6.

3.5.2 Proposed Lot 6

Proposed Lot 6 is sized 2.06ha and is positioned north of Lot 5 on the north facing slope of the northeast ridge line that separates the two lots. The nominated building platform is sited on a north trending spur that is defined by a spring fed incised watercourse to the east and undulose topography with extensive reed growth to the west. The lot falls north to a watercourse from RL63m at the building platform to RL45m at the watercourse and associated wetland. The building site itself is gently graded at approximately 6° but the toe of the spur falls away steeply to the watercourse grades of up to 30° which show signs of instability. The spring fed watercourse to the east of the building site has created saturated ground conditions and HA3 excavated to 2.8m depth at this location recorded standing water at 1.0m depth. HA4 was excavated to 3.3m depth within the nominated building platform and did not encounter groundwater.

Given the evidence of instability and ground conditions in proximity to the building platform the recommendations for improving site stability as outlined for Lot 5 are considered applicable to Lot 6. Any building work on the property should be designed to enhance the stability of the site through a combination of structural solutions (foundations, retaining, palisade walls), stormwater controls and earthworks.

Future buildings on this site should look to incorporate pile foundations taken 5m deep on the downslope side of the building. The use of pile foundations pinned to the more competent soils and underlying weathered rock will provide a robust foundation solution to mitigate surface creep and will also aid in enhancing the overall stability of the building platform. Design parameters for the building foundations are included in Section 3.6.

3.5.3 Proposed Lot 7

Proposed Lot 7 is sized 1.33ha and occupies the north facing slope immediately east of Lot 6 and contains the existing hay shed. The land within Lot 7 falls northeast from RL64m to RL40m at an average grade of 10° to the watercourse and wetland forming the base of the slope and northern extent of the development area. The slopes within Lot 7 exhibit undulose topography indicating that the land is likely to have been subject to past movement comprising surface creep and extending to shallow regolith slippage.

The proposed building site within Lot 7 is positioned at a lower elevation below the existing hay shed at approximately RL53m. HA8 was taken to 2.8m depth within the nominated building platform with standing water recorded at 1.8m depth. The building site has gently graded topography and minor earthworks will be required for creation of the flat building platform. Batters should be constructed no steeper 5H:1V and cut batters in excess of 1m should be retained with consideration given to the use of timber pole retaining walls. Any building work at the site should be designed to enhance the stability of the site through a combination of structural solutions (foundations, retaining, palisade walls), stormwater controls and earthworks.

Shallow pad or strip footings are considered suitable for use at this location subject to the provisions included in Section 3.6 below.

3.5.4 Proposed Lot 8

Lot 8 sized 1.61ha is positioned in the centre of the development area immediately east of lot 5 and contains a gently graded area south of the proposed RoW access before falling south at an average grade of 13° to a watercourse and wetland area. The nominated building platform is positioned on the elevated flat area of the lot adjacent to the RoW access at RL60m. The south facing slopes that fall away below the proposed building area exhibit signs of surface creep and shallow regolith slippage consistent with the adjacent slopes in Lot 5. The building site however is located on flat topography and is considered to be sufficiently setback from the crest of the slope. HA5 was excavated to 3m depth within the nominated building platform and recorded standing water at 2.4m depth. Swamp reeds were observed growing on the elevated flat topography at the building site, reflecting the very low permeability of the surficial soils with wet to saturated topsoil conditions.

Buildings within Lot 8 should be set back from the crest of the south facing slopes as much as practical. Shallow pad or strip footings are considered suitable for use at this location subject to the provisions included in Section 3.6 below.

3.5.5 Proposed Lot 9

Proposed Lot 9 is sized 13.14ha and comprises the eastern part of the development area and contains the existing wool shed and stock yards. The lot extends north from the existing house and implement sheds within Lot 3 to include the RoW access plus rolling land and watercourse in the northern extent of the development sites. The lot contains varying topography but the nominated building platform is located on flat topography adjacent to the RoW access and lot 8 building site.

The steeper slopes within the lot shows signs of instability with surface creep and shallow regolith slippage consistent with the remainder of the property. HA6 was excavated to 3m depth within the nominated building platform and recorded standing water at 2.4m depth which is consistent with Lot 8. Swamp reeds were observed growing on the elevated flat topography at the building site, reflecting the very low permeability of the surficial soils with wet to saturated topsoil conditions.

The recommendations for Lot 8 are considered appropriate for the Lot 9 building site and shallow pad or strip footings are considered suitable for use at this location subject to the provisions included in Section 3.6 below.

3.6 Building Foundations

The scala penetrometer results included in Appendix 2 do not meet the NZBC B1 threshold criteria for soils to be acceptable as good ground for building foundations, however the available bearing capacity is considered to be suitable for construction of light weight timber framed dwellings. For house design it is expected that a dependable bearing capacity in excess of 90kPa will be available (an ultimate bearing capacity of 210kPa in conjunction with a strength reduction factor of 0.45).

It is anticipated that waffle raft foundation slab systems will be suitable for use at the site. The surficial soils observed during the field investigations are considered to be expansive and are interpreted as Class M to Class H1 in accordance with AS2870. Specific engineering design of foundations by a Chartered Professional Engineer will be required.

The nominated building platforms within proposed lots 5 & 6 are positioned above slopes that fall away at moderately steep grades and exhibit signs of surface creep extending to shallow slippage. It is recommended that the building platforms be supported with a series of bored pile foundations (in-ground retaining or palisade wall) with capping beam on the downslope side taken 5m minimum below existing ground level. The piles should be designed to resist creep movement in the upper 2m of the soil profile using 'at rest' earth pressures ($K_0 = 0.58$) and should be spaced at two diameters centre to centre.

A geotechnical strength reduction factor of 0.45 should be applied to the geotechnical ultimate capacity, for assessment against ULS factored structural loads. Design of the foundations by a Chartered Professional Engineer will be required with details specific to the proposed pool.

Lateral load resistance of the piles foundations can be designed using the following parameters:

- Effective friction angle $\phi' = 25^\circ$
- Undrained shear strength $S_u = 80\text{kPa}$
- Unit weight $\gamma = 17\text{kN/m}^3$

For the vertical capacity of the pile foundations, adopting a design undrained shear strength value of 80kPa, an ultimate static bearing capacity of 700kPa is considered available. It is recommended that a strength reduction factor of 0.45 be adopted for limit state design in accordance with the requirements of AS/NZS 1170, resulting in a design (dependable) bearing capacity value of 300kPa.

An ultimate skin friction value of 30kPa can be used for the design of piled foundations. It is recommended that a strength reduction factor of 0.45 be adopted for limit state design, resulting in a design (dependable) skin friction value of 15kPa.