

**PROJECT**  
Subdivision Report  
Allotment 231 Parish of Waipu  
and Section 2-4 SO69477  
Waipu

**DATE**  
30 May 2019  
REV02

**JOB REFERENCE**  
#87315

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# Wilton Joubert Ltd.

## Subdivision Report

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30 May 2019

Dear Ian,

**Subdivision Report for Proposed 3 Lot Subdivision at:  
Allotment 231 Parish of Waipu and Sections 2-4 SO69477, Whangarei**

### EXECUTIVE SUMMARY

#### Development Review

- The Client has provided a preliminary Subdivision Scheme Plan prior to our fieldwork investigation and written report which is the basis of the outlined proposal. Once both the finalised Scheme Plan is available and location of the proposed building sites are confirmed, the plans should be reviewed by WJL to verify that the recommendations contained in this Subdivision Report remain valid.
- WJL Review to be upon both Client request and by separate engagement.

#### Ground Conditions

- In general terms the site investigated consists of Silty CLAY overlying very stiff COMPLETELY WEATHERED GREYWACKE (Silty CLAY). 0.2m of topsoil consistently overlies subsoils across the property.
- The soil on the site is assessed as expansive and will need to be assessed for each site's specific developments.
- The site soils fall outside the scope of NZS 3604:2011 and therefore will require specific engineering design for foundations.
- Groundwater was not encountered during our fieldwork investigation.
- Provided that all the recommendations of this report are adhered to and subject to satisfactory Development Review, there should be little or no stability problems.

#### Foundations and Structures

See Section 6

- Since the property does not currently have an instability zone, WJL recommended that as part of a conditions of consent for this subdivision that site specific geotechnical assessments be undertaken at BC Stage to identify and managed geotechnical risks appropriately.

#### All Foundations

- As a precaution, it is recommended that all building foundations are offset 8m from slopes exceeding 15°. It is recommended that any foundations located within this offset should require SED by a Chartered Professional Engineer and / or a site specific geotechnical assessment undertaken by a Chartered Professional Engineer.
- If the recommendations contained in this report are followed an allowable bearing capacity of 100kPa can be used for foundation design.

- We consider the requirement for shallow foundations other than specifically designed raft floor slabs, being a minimum founding depth of 600mm into original ground.
- Any foundation wall that exceeds a height of 0.6m will require SED by a Chartered Professional Engineer.

**Typical Foundations:**

- **Reinforced Concrete Raft Type Floor Slab on Engineered Fill**
  - **Specific Engineering Design (SED): NZS3604 Type Foundations**
- For concrete slab footings and timber floors suspended on timber piles, both the footing design and embedment depth must allow for expansive soils in accordance with NZBC B1. Footings may be excavated or bored.

**Earthworks and Construction**

- All works must be undertaken in accordance with the Health and Safety at Work Act 2015.
- All earthworks and foundation excavations are to be inspected by a Engineer familiar with both this site and the contents of this geotechnical report.
- All deleterious material should be removed from building site areas and replaced with compacted hardfill as appropriate.
- Unretained cuts in close proximity to buildings and up to height of 2m should be battered back at a gradient no greater than 1V:3H or retained by a suitably designed retaining structure / wall.
- Unretained cut faces should be re-grassed and/or planted as soon as practicable to reduce the risk of erosion. Appropriate cut-off drains should be installed at the base of all unretained cut faces.
- Unretained fills can utilise a 1V:3H batter grade.
- We recommend that earthworks are not undertaken during wet conditions.
- We strongly recommend that a minimum of 100mm of clean compacted hardfill is placed over the cleared subgrade to help control soil surface conditions.

**Access and Carparking/Manoeuvring**

- WDC EES complying sight distances are available at all proposed Lot access entrances.
- New crossings and private driveways will need to be constructed in compliance with the WDC EES and included in engineering plans for the development.

## Services

- Rainwater storage tank(s) will be required at each Lot for water supply. We recommend a minimum tank size of 25,000L is installed at each Lot with all downpipes from future building roofs connected to the storage tank(s).
- Previously, we have consulted the Fire Department and have been advised that only 10m<sup>3</sup> as a permanent water supply is required for fire-fighting within a 90m distance from the furthest point of a dwelling. It is recommended that the Fire Department is contacted for a definitive conclusion regarding the above.
- It should also be noted that the Client has indicated that stormwater ponds are likely to be constructed at each proposed Lot. Depending on their volume and installation being within 90m from the furthest point of a dwelling, these may suffice for fire-fighting requirements.
- The lots are suitable for secondary treatment wastewater management systems, discharging to pressure compensating drip irrigation lines within planted areas, to be installed for new buildings to aid in maintaining the environmental integrity of the area.
- New wastewater treatment systems can be installed at all proposed Lots in compliance with the NRC Water and Soil Plan and therefore will not require Discharge Consents.

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## **1. INTRODUCTION**

This Subdivision Report has been prepared by Wilton Joubert Ltd. (WJL) for Ian Fox in accordance with instructions received from him with regard to the above property.

The purpose of WJL's work was to evaluate the surface and subsurface conditions at identified potential building sites by undertaking a geotechnical investigation and an assessment of the site and on-site services to determine the suitability of the existing property for the proposed development.

This report presents the results of the geotechnical investigation, describes the existing conditions, details any identifiable geological hazards affecting the site and provides geotechnical recommendations against the requirements of NZS3604:2011 where appropriate.

Previous site assessment and report has been carried out by WJL as part of a smaller proposed development (Ref: 76701, dated: 28 May 2018).

Assessments for proposed access entrances, carparking/manoeuvring capabilities and required on-site services (water supply, fire-fighting, wastewater management and stormwater management) were also undertaken. Conclusions and recommendations regarding these assessments are provided in this report.

This subdivision report is provided based solely on our fieldworks assessment, and the Client information provided to WJL at the time of report writing.

Therefore, we strongly recommend as follows:

- i. Should any additional relevant information become available, then WJL must be contacted to ensure that this report and the recommendations contained therein are appropriate, and;
- ii. Once the final Scheme Plan, location and arrangement of the proposed building sites are known, that the plans be reviewed by WJL, to;
  - Verify that the recommendations contained in this Subdivision Report remain valid, and;
  - That with regard to geotechnical aspects only, that proposed foundation designs both aligns satisfactorily with the recommendations provided in this Subdivision Report and are appropriate.

### **1.1 SITE DESCRIPTION**

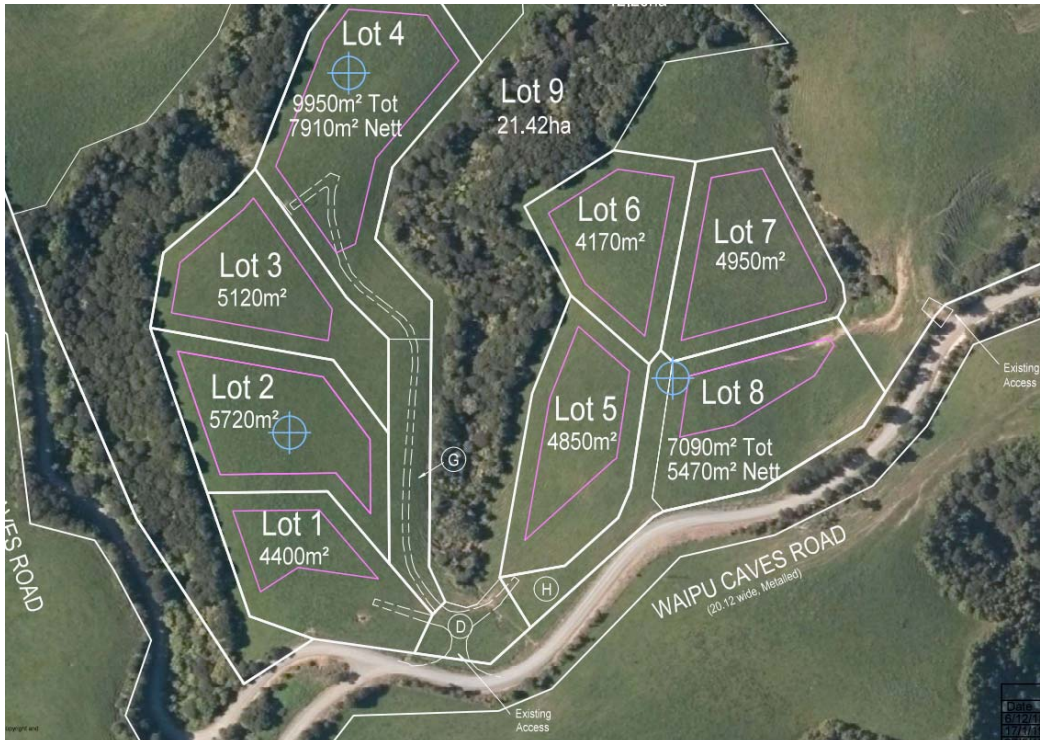
The existing 30.2ha (more or less) Notable Landscape property is located adjacent to the north-eastern intersection of Waipu Caves Road and Palmer Road, Whangarei. The property has two differing topographies with the transition located approximately at the central area of the property.

The southern portion of the property is located on a gentle to moderate sloping (averages less than 20°), north facing flank. The flank falls from a west to east running ridgeline that borders the southern boundary. The area is generally covered in pasture with southwest to northeast aligned valley areas covered in regenerating bush located at the western, central and eastern ends of the area.

The northern portion of the property is located on a moderate to steep sloping (generally over 20°), south facing flank. The flank falls from an east to west running ridgeline that borders the northern boundary. The area is generally covered in regenerating bush with a pastured area located at the north-western end of the property.

## 1.2 PROPOSED DEVELOPMENT

The Client proposes to subdivide the existing property which will involve 8 new vacant individual allotments, suitable for residential construction. The proposed layout is shown below;



*Proposed Scheme Plan Layout*

The balance area of approximately 21.42ha will be contained within proposed Lot 9 with an identified building site located at the southern end of the existing property. Existing regenerating bush areas are to be subject to land covenants to aid in maintaining the integrity of the environment.

## 2. GEOLOGY

The property is noted on the GNS Science New Zealand Geology Web Map 1:250,000 Scale as being within two differing geological zones located and described as follows:

- **Southern End of Property:** Waipapa Group Sandstone and Siltstone (Waipapa Terrane) – Massive to thin bedded, lithic volcanoclastic metasandstone and argillite, with tectonically enclosed basalt, chert and siliceous argillite.

This geological zoning covers the north facing flank that falls to the northern ridge. Identified building sites tested during our geotechnical investigation are located within this geological zoning.

- **Northern End of Property:** Whangarei Limestone of Waro Subgroup (Te Kuiti Group) – Styrolitic, bioclastic limestone with conglomerate and calcareous sandstone beds.

This geological zoning covers the northern ridge which is covered in regenerating native bush, refer; GNS Science Website.

The development is within Waipapa Group and our subsoil investigations have confirmed this geology. Waipapa Group has an age of between 154 and 270 million years old and is also the underlying basement rock. The limestone and sandstone towards the north is much younger in age (21-34million years) and is overlying Waipapa Group. We are satisfied that there are no underlying voids beneath identified building sites for this development.

### **3. FIELDWORK SUMMARY**

The purpose of the following intrusive fieldworks investigation was to provide information on the general soil profile, the variability, relative density and strength of soils together with any observed groundwater levels within identified building site areas.

Wilton Joubert Ltd. carried out further ground investigation on 10 June 2019, comprising of an additional seven hand auger boreholes (BH) of 50mm diameter to a target depth of 1.5m bgl. The approximate locations of the BH tests are shown on the site plan, and along with the fieldwork results consisting of BH logs which are attached to this report.

Where possible, in cohesive materials, in-situ hand undrained shear vane tests were carried out at 0.3m/0.4m depth intervals in accordance with the New Zealand Geotechnical Society (NZGS); Guidelines for Hand Held Shear Vane Testing, August 2001, and classified in accordance with the NZGS Field Classification Guidelines; Table 2.10, December 2005.

Classification of the recovered soil and/or rock borehole arisings was carried out in accordance with the "Field Description of Soil and Rock", NZGS, December 2005.

Assessments for the proposed Lots: access entrances, carparking/manoeuvring capabilities and required on-site services (water supply, fire-fighting, wastewater management and stormwater management) were also undertaken whilst WJL was on-site.

### **4. GEOTECHNICAL ASSESSMENT**

#### **4.1 GROUND CONDITIONS**

The ground conditions encountered during the ground investigation have been interpreted from the BH logs and Shear Vanes undertaken. The natural subsurface conditions encountered are considered to be generally consistent with the published geological information.

In general terms the site investigated consists of 0.2m – 0.6m of very stiff friable Silty CLAY overlying very stiff COMPLETELY WEATHERED GREYWACKE (Silty CLAY). These subsoils were all overlain with approximately 0.2m TOPSOIL. Refer; Borelogs.



We conclude that the subsoil profile of the soils tested is consistent with the geological mapping described. However, it should be noted that actual conditions may vary across the proposed development sites, and in some locations may differ from those described.

From our site visit and discussion with the property owner, some historic filling has occurred within proposed lot 8 towards the eastern end.

## **4.2 SOILS SHEAR STRENGTHS**

Shear vane dial readings (corrected) of the soil tested in these boreholes ranges from 112kPa (39kPa remoulded) to in excess of 190kPa.

Where measurable the average of peak and remoulded shear strength ratio for the site soils investigated is generally of a range of approximately 1.8 to 2.9 indicating that the soils are Moderately Sensitive as per the NZGS Guidelines.

## **4.3 EXPANSIVE SOILS**

Based on the results of our Site Investigation, along with our knowledge and experience with these soils we classify the soils onsite are expansive. It is anticipated that soils will be between a CLASS M and CLASS H in accordance with NZBC B1 Structure. As the sites are yet to be developed, the expansiveness of the soils is expected to vary and therefore will need to be assessed as part of the site-specific developments. However, at this stage it is anticipated that the soils will be expansive and will require further assessment at BC stage when site earthworks and foundation systems are known. See attached notes.

Reworking or exposure of these soils during wet weather or winter months can result in much lower bearing capacities, and the potential for seasonal shrinkage and swelling and this should be considered especially in regard to potential slab cracking. See recommendations.

## **4.4 GROUNDWATER**

No groundwater was encountered during the site fieldworks.

Due to the underlying geology and elevation of the property, groundwater is not considered to be an issue at the proposed Lots and potential building sites.

## **4.5 SITE STABILITY**

At the time of report writing WJL are not aware of any mapped stability hazards.

Aside from minor shallow surface creep and erosion effects present in valley areas covered in regenerating bush, no evidence of previous ground movement was observed on site during our site fieldworks. The building sites are undeveloped and there are no existing retaining structures present at any of the proposed building sites.

The identified building site are located on broad ridgelines with the underlying geology being Waipapa Group (Greywacke). The grades over the building sites are generally less than 15°. No site development is proposed at subdivision stage on any of the proposed new allotments. No springs or elevated groundwater was identified during our site visit.

Typically, Greywacke Rock can remain stable up to 30° without failure but can experience soil creep of the residual clay layers on slopes in excess of 20°. From the contours provided in the scheme plan, the identified building envelopes on each allotment are well setback from grades of greater than 20°. From review of the subsoil testing undertaken over the property, in-situ shear strengths are high and consistent. The sites are likely to be developed with light-weight dwellings constructed in general accordance with NZS3604. From our assessment of the subsoil conditions, subsoil investigations revealed basement

rock with high strengths, all building sites exhibited no signs of instability and no groundwater present we assess the risk of instability as low. However, it is important to recognise that further site works will be undertaken at Building Consent stage and that geotechnical risks will need to be assessed and managed appropriately at Building Consent stage.

From experience in the area, the underlying weathering profile is consistent and in places can become blue greywacke rock at a shallow depth. The target depth for the boreholes was to confirm whether the residual soils above the weathered rock was consistent and progressively remained consistent in shear strength. At the base of the boreholes, we are comfortable that moderately weathered greywacke is present at a shallow depth. Further to this it is observed on the road cut faces upslope of the development are near vertical and have remained intact. This demonstrates that the underlying soils / geology is consistent in weathering and has high shear strengths. Further to this, with the ground conditions present, it is not anticipated that the foundations loads from a building designed in general accordance with NZS3604 would have significant impact at depth.

As a precaution and to ensure that any future development is not susceptible to soil creep or movement, it is recommended that all building foundations are offset 8m from slopes exceeding 15°. It is recommended that any foundations located within this offset should require SED by a Chartered Professional Engineer and / or a site-specific geotechnical assessment for the proposed siteworks be undertaken by a Chartered Professional Engineer. From the LiDar contours provided, we do not anticipate that this setback will be critical to site developments within the identified proposed building envelopes, however this should be assessed at site development stage specific to the works being undertaken within the proposed allotments.

Since the property is not currently within a WDC instability hazard zoning and that future earthworks are likely, WJL recommends that a condition of consent for this development that a site-specific assessment be undertaken at BC stage. This assessment should address any site geotechnical hazards applicable to the site development and to ensure that the geotechnical risks are managed appropriately.

Once the final locations and level of the development has been determined, an Engineer familiar with the site and contents of this report should review the plans.

Based on our investigation, we consider that there should be little to no risk of instability provided that all the recommendations in our report are adhered to.

With regard to the Resource Management Act 1991; Section 106, we believe on reasonable grounds that;

- i. The land in respect of which a consent is sought, or any structure on the land, is not or is not likely to be subject to material damage by subsidence or slippage from any source; and,
- ii. Any subsequent use that is likely to be made of the land is not likely to accelerate, worsen, or result in material damage to the land, other land, or structure by subsidence or slippage from any source.

## **5. RECOMMENDATIONS**

### **5.1 BUILDING FOUNDATIONS**

The natural soils assessed on site are Moderately Sensitive, and in terms of expansiveness are anticipated to be a CLASS M to CLASS H, Moderately to Highly Expansive.

Hence, foundations will require both Specific Engineering Design (SED), and Council may require the SED certification by a Chartered Professional Engineer.

Building sites can be formed on a cut or an engineered cut/fill building platform to support the dwelling foundation.

We recommend to the designer of any site works that involve cutting or filling, that the proposal be discussed with a Chartered Professional Geotechnical Engineer at the early design stages.

All earthworks and structural stages as detailed in the following Section 6 will require a Site Inspection if specified in the Building Consent, or if specifically designed by WJL.

We strongly recommend that the excavations be inspected by an Engineer familiar with the contents of this Subdivision Report to confirm ground conditions are as anticipated. The final depth of foundations may be governed by structural loads. This aspect can be addressed during the design phase for the development.

All deleterious material should be removed from building site areas and replaced with compacted hardfill as appropriate.

Depending on the time of year and ground conditions (to be determined during the earthworks process), there may also be a requirement for the installation of a geo textile and/or geo grid.

As a precaution, it is recommended that all building foundations are offset 8m from slopes exceeding 15°. It is further recommended that any foundations located within this offset should require SED by a Chartered Professional Engineer and / or a site specific geotechnical assessment undertaken by a Chartered Professional Engineer.

A description of foundation options follows.

### **5.1.1 Reinforced Concrete Raft Type Floor Slab on Engineered Fill or Footings**

From the above site soil investigation and assessment, the following bearing capacity values are considered appropriate for design purposes for the foundation for the dwellings:

Ultimate Bearing Capacity	300 kPa
Allowable Bearing Capacity (F.O.S =3)	100 kPa
Dependable Bearing Capacity ( $\Phi=0.5$ )	150 kPa

We consider the requirement for shallow foundations other than specifically designed raft floor slabs, being a minimum founding depth of 600mm into original ground.

### **5.1.2 Specific Engineering Design (SED): NZS3604 Type Foundations**

For concrete slab footings and timber floors suspended on timber piles, both the footing design and embedment depth must allow for expansive soils. Footings may be excavated or bored.

On the basis of the above assessment, we consider that a minimum founding depth of 600mm into original ground provides an appropriate foundation embedment depth to minimise the effect of ground swelling and shrinkage. An Allowable Bearing Capacity of 100kPa is deemed as appropriate.

It should be noted that any cut/placement of fill will change the thickness of pile/footing embedment depths by a corresponding depth.

## **5.2 EARTH RETAINING STRUCTURES**

No retaining structures are proposed as part of the subdivision development. However for any future retaining structures on site, we recommend as follows.

These will need to be designed by a Chartered Professional Engineer and constructed in a safe manner.

Factors of safety and surcharge loadings appropriate to the conditions should be in accordance with “Retaining Wall Design Notes – MWD, NZ, Issue C: July 1973”.

Due consideration to surcharges should be undertaken for each retaining structure and be in accordance with Council surcharge requirements by boundaries.

All permanent retaining walls should be constructed with appropriate toe drainage and should be backfilled to within 0.3m of their full height with lightly tamped, free draining granular backfill material, accompanied by perforated pipe drain located at the base of the walls should be installed behind all retaining walls to avoid build-up of hydrostatic pressures.

Alternatively, an approved proprietary strip drain may be used. Toe drainage should be connected into an approved stormwater disposal system. All waterproofing details should be specified by the building designer.

## **5.3 CONSTRUCTION RISK MANAGEMENT**

All works must be undertaken in accordance with the Health and Safety at Work Act 2015.

Any open excavations should be fenced off or covered, and/or access restricted as appropriate.

With all site and retaining wall excavation and construction work there is a risk of batter / earthworks collapse. Whenever ground conditions are suspect, bad weather conditions are forecast or when there is a risk of damage to adjacent property, excavations for any retaining walls should be carried out in a “hit and miss” pattern.

The Contractor is responsible for determining the width of each excavation to suit his plant and construction programme.

The Contractor is responsible at all times for ensuring that all necessary precautions are taken to protect all aspects of the works.

## **5.4 EARTHWORKS**

### **5.4.1 General**

Earthworks for the development are to involve the formation of rights-of-way to provide access to each allotment.

We recommend that all earthworks activities be carried out in full accordance with the following technical publications, in particular:

- i. Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region June 2016 Guideline Document 2016/005.
- ii. Auckland Council; Building on small sites - Doing it right. BC5850.

Refer for downloads the above Auckland Council documentation as below:

<https://ourauckland.aucklandcouncil.govt.nz/articles/news/2017/09/auckland-council-leads-the-way-in-erosion-and-sediment-control/>

<https://www.aucklandcouncil.govt.nz/building-and-consents/understanding-building-consents-process/starting-building-renovation-work/Documents/bc5850-building-small-sites-brochure.pdf>

- iii. New Zealand Standard Code of Practise for Earthfill for Residential Development, NZS 4431:1989.
- iv. Code of Practise for Urban Land Subdivision – NZS 4404:2010, and
- v. Any other relevant publications, including any of the above as superseded.

Some general recommendations are provided below, however where possible site-specific advice should be sought from an experienced Geotechnical Engineer.

We recommend that earthworks are not undertaken during wet conditions.

#### **5.4.2 Site Clearance and Preparation**

The Whangarei District Council (WDC) District Plan states the following regarding earthworks in a Rural Area (Rule RA 3.3.p):

##### *Earthworks:*

- i. Do not comply with the relevant standards in Whangarei District Council's Environmental Engineering Standards 2010.*
- ii. Cause changes to the natural range of water levels or the natural eco-system of flora and fauna in any indigenous wetland.*
- iii. Occur within a mapped Site of Significance to Māori or within 10m of any archaeological site.*
- iv. Occur within an Outstanding Landscape Area in excess of those permitted by Rule LAN.3.1.3.*

The above rule will need to be taken into consideration for all proposed Lots. All deleterious material including any uncontrolled fill, vegetation, topsoil, etc. should be removed from building site areas, or if stockpiled must be well clear of the works and in placed in an appropriate manner so that land stability and/or existing structures are not compromised.

Wherever any deposits of soft, or otherwise unsuitable material is encountered at the surface cut/foundation level, it should in general be undercut and replaced with approved compacted hardfill, or as otherwise recommended by the Engineer. Depending on the time of year and ground conditions, there may also be a requirement for the installation of a geo textile and/or geo grid.

Measures must be taken to protect the exposed moist soils from drying out. Maintaining the natural moisture content of the subgrade soils may be achieved by fine spraying with water. An impermeable membrane should be placed immediately above subgrades at building platform areas after the excavation of the topsoil.

### 5.4.3 Temporary and Permanent Earthworks

The WDC District Plan states the following regarding earthworks in a Rural Area (Rule RA 3.3.p).

#### *Earthworks:*

- v. *Do not comply with the relevant standards in Whangarei District Council's Environmental Engineering Standards 2010.*
- vi. *Cause changes to the natural range of water levels or the natural eco-system of flora and fauna in any indigenous wetland.*
- vii. *Occur within a mapped Site of Significance to Māori or within 10m of any archaeological site.*
- viii. *Occur within an Outstanding Landscape Area in excess of those permitted by Rule LAN.3.1.3.*

The above rule will need to be taken into consideration during the building design stage for each new allotment.

Particular care should be taken during construction phases with respect to excavations to form benches for building platforms, access driveways, retaining walls, etc.

Unretained cuts in close proximity to buildings and up to height of 2m should be battered back at a gradient no greater than 1V:3H or retained by a suitably designed retaining wall.

Unretained cut faces should be re-grassed and/or planted as soon as practicable to reduce the risk of erosion. Appropriate cut-off drains should be installed at the base of all unretained cut faces.

Unretained fills can utilise a 1V:3H batter grade.

Any excavation left open should be protected and or left in a state as to not pond water.

Saturating site soils may result in a reduction of bearing capacities.

## 6. ACCESS

### 6.1 Driveway Sight Distances

Access to the proposed Lots will be directly off Waipu Caves Road using an existing access and is designated by the WDC as a local road with a posted speed limit of 100km/hr. Following a drive over past the proposed driveway entrances during our fieldwork investigation, we conclude that a safe speed limit of 60km/hr is applicable for traffic coming from the eastern direction directions. As per Sheet 4 (appendices) of the WDC Environmental Engineering Standards (WDC EES), a minimum sight distance of 55m towards the east direction is required from the access entrance.

Due to the sharp S-bend, we conclude that a safe speed limit of 40km/hr is applicable in the western direction. As per Sheet 4 of the WDC EES, a minimum sight distance of 30m is required in this direction at the access entrance. It is recommended that the vegetation within the road reserve be cleared as best practicable and maintained to ensure maximum visibility is achieved. We conclude that this sight distance is available on-site.



## **6.2 Driveway Construction**

New crossings and private driveways will need to be constructed in compliance with the WDC EES and included in engineering plans for the development.

The existing formed track which is to become a right-of-way (ROW G) is setback 9-10m from any slopes in excess of 20°. Provided that earthworks are generally limited within the existing track alignment we are satisfied that that a suitable access can be achieved to lots 1 to 4. Access to proposed lots 5-8 is well setback from any steep slopes with a cross fall of 1V to 5H, we are satisfied that minor earthworks will be required to create a right-of-way. We are satisfied that provided works are undertaken in accordance with this report and the WDCEES, that suitable access can be achieved for proposed lots 1-8.

With regard to the Resource Management Act 1991; Section 106, we believe on reasonable grounds that;

- i. Sufficient provision can be made for legal and physical access to each allotment to be created by the subdivision.

## **7. CARPARKING/MANOEUVRING**

As per Sheets 26, 27 and 28 of the WDC EES, tracking curves in excess of 12.5m will be required in the vicinity of all proposed future dwelling locations. As all proposed Lots are to encompass areas greater than 4000m<sup>2</sup> and site topography, compliance with this requirement will be easily achieved.

## **8. WATER SUPPLY**

A reticulated water connection is not available to the proposed Lots and therefore rainwater storage tank(s) will be required. We recommend a minimum tank size of 25,000L is installed at each Lot with all downpipes from future building roofs connected to the storage tank(s).

## **9. FIRE-FIGHTING**

The Standards New Zealand Publicly Available Specification (SNZPAS) 4509:2008 New Zealand Fire Service Firefighting Water Supplies Code of Practice states that buildings require a minimum supply of 45m<sup>3</sup> of water within a 90m distance from the furthest point of a dwelling for fire-fighting purposes for non-reticulated water supply. Previously, we have consulted the Fire Department and have been advised that only 10m<sup>3</sup> as a permanent water supply is required. It is recommended that the Fire Department is contacted for a definitive conclusion and advice regarding the above.

If 10m<sup>3</sup> permanent storage is applicable, the required water storage for fire-fighting can best be achieved on-site by installing a water tank with domestic take above the permanent level.

It should also be noted that the Client has indicated that stormwater ponds are likely to be constructed at each proposed Lot. Depending on their volume and installation being within 90m from the furthest point of a dwelling, these may suffice for fire-fighting requirements. This will need to be confirmed during the stormwater design phase.

All fire-fighting water sources should be installed/positioned in compliance with Appendix B of SNZPAS4509.



## **10. WASTEWATER**

### **10.1 Overview**

A reticulated sewer connection is not available to the proposed Lots and therefore on-site wastewater management systems are required.

A preference for secondary treatment wastewater management systems, discharging to pressure compensating drip irrigation lines within planted areas, to be installed to aid in maintaining the environmental integrity of the area.

New systems should be designed and installed in compliance with either Auckland Regional Council Technical Publication No. 58: On-site Wastewater Systems: Design and Management Manual (TP58) or Standards New Zealand Australian/New Zealand Standard On-site Domestic Wastewater Management (AS/NZS1547:2012).

Compliance with the Regional Water and Soil Plan and Whangarei District Council District Plan should be maintained in conjunction with using the above design documents.

### **10.2 Northland Regional Council Compliance**

As per the Northland Regional Council (NRC) Regional Water and Soil Plan, the following are offset compliance rules outlined for a secondary treatment wastewater management system to be installed without requirement of a Discharge Consent;

- The lowest point of the disposal system is not less than 0.6m above the winter groundwater table.
- No part of the disposal area and reserve area is located within 20 metres, measured horizontally, of any existing groundwater bore located on any other property.
- No part of the disposal area and reserve area is located within 15 metres, measured horizontally, of any surface water.
- A relevant letter from the NRC states that no part of the disposal area and reserve area is located within 15 metres, measured horizontally, from the 5% AEP (20-year) flood level.
- A relevant letter from the NRC states that no part of the disposal field should be installed on a slope gradient exceeding 25°.
- A reserve area equivalent to 30% of the design disposal area has been allowed for and set aside.

Subsoil testing throughout the subdivision did not encounter an elevated groundwater. Furthermore, due to the underlying geology and elevation of the Lots, groundwater is expected to be at a significant depth.

No groundwater bores are located within the immediate vicinity of potential disposal fields.

Disposal fields should be offset 15m from valley areas covered in regenerating bush and driveway water table drains to ensure suitable separation from water ways, the 5% AEP flood level and slope gradients exceeding 25°.

It is recommended respective minimum separation distances of 3.0m from any building and 1.5m from any boundary are utilised.

Sufficient area is available on each proposed Lots for NRC Water and Soil Plan complying disposal and reserve areas to be installed. The layout of the proposed field should be considered as part of the site configuration for future dwellings / development prior to applying for Building Consent. Therefore, Discharge Consents will not be required for new systems provided they installed as per the recommendations of Sections 10.2 and 10.3, refer; Scheme Plan for complying areas.

### **10.3 Preliminary Wastewater Discharge Design Recommendations**

On-site wastewater management systems will need to be designed at the Building Consent stage to suit proposals. The following are recommended parameters for design;

- Secondary treatment wastewater management systems, providing both primary and secondary treatment are recommended.
- A per capita flow allowance for each person/day will need to be based on on-site roof water tank supply.
- From our fieldwork investigation results, we assess the subsoils on-site as Category 6 in terms of TP58 and Category 5 in terms of AS/NZS1547:2012.
- Daily loading rates ranging between 2mm - 3mm/day are deemed as applicable.
- Disposal should be via compensating drip irrigation line within suitably planted areas.
- Total disposal field areas for typical 3 and 4-bedroom dwellings are expected to range between 300m<sup>2</sup> - 540m<sup>2</sup> (additional 30% reserve area).
- Cut-off drains should be installed above disposal fields to direct surface water run-off away from the area.

## **11. STORMWATER**

Stormwater run-off at the existing property currently discharges towards valley areas covered in regenerating bush. Overflows from installed stormwater devices should be designed to disperse evenly at a conservative rate to aid in reducing the risk of erosion within valley areas.

### **11.1 Attenuation**

The development at subdivision stage is greater than 1ha with site coverage not exceeding 5%, therefore no attenuation is required as part of the subdivision development.

Proposed lots 1-8 are under 1.0ha in area and therefore once separate allotments, stormwater attenuation is required as specified in the WDCEES.

However, the Client has indicated that stormwater ponds are likely to be constructed at each proposed Lot to aid in maintaining the environmental integrity of the area.

Any pond with the intention to be used for attenuation should be constructed in accordance with the WDC EES.

### **11.2 Stormwater and Surface Water Control**

All surface water should be diverted around and away from the building site in accordance with E1 of the New Zealand Building Code.

Runoff from any higher ground should be intercepted by means of shallow surface drains or small bunds to protect the building platforms from both saturation and erosion. Water collected in interceptor drains should be diverted away from building sites to a disposal point as appropriate.

Concentrated stormwater flows from driveways, tanks, roofed and paved areas must be collected and carried in sealed pipes or drains and discharged to either a stormwater pond (if constructed) or in a controlled manner all as per the WDC EES. Stormwater flows must not be allowed to run onto or over site slopes, or to saturate the ground so as to adversely affect slope stability or foundation conditions.

## 12. LIMITATIONS

This report has been prepared solely for the use of our Client with respect to both the particular brief and specific purpose provided to Wilton Joubert Ltd. (WJL), with regard to the specific project described herein. Both no liability or any duty of care is acknowledged or accepted for the use of any part of this report in any other context or for any other purpose, or by any other person, other party or entity.

This document is both the property and copyright © of WJL. Any unauthorised employment or reproduction, in full or part is forbidden. This report may not be read or reproduced other than in its entirety. This report does not address matters relating to the National Environmental Standard for Contaminated Sites.

The opinions, recommendations and comments given in this report are the result from the application of accepted industry methods of site investigation.

As factual evidence has been obtained solely from boreholes and shear vanes which by their nature only provide information about a relatively small volume of subsoils at that exact location, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in our report.

Inferences are made about the nature and continuity of subsoils away from and beyond the testing locations but cannot be guaranteed. The descriptions detailed on the exploratory bore logs are based on the field descriptions of the soils encountered.

During construction, an Engineer competent to judge whether the conditions are compatible with the assumptions made in this report should examine the site. In all circumstances, if variations in the subsoil occur which differ from that described or assumed to exist, and then the matter should be referred back to WJL immediately.

The performance behaviour outlined by this report is dependent on the construction activity and actions of the builder/contractor. Inappropriate actions before or during the construction phase may cause behaviour outside the limits given in this report.

All future owners of this property should seek professional geotechnical advice to satisfy themselves as to its ongoing suitability for their intended use.

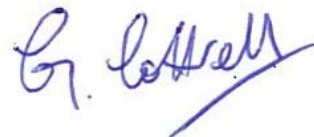
Yours faithfully,  
Wilton Joubert Ltd.

Prepared by:



David Leslie  
MEngNZ

Reviewed by:



Gareth Cottrell  
CMEngNZ, CPEng IntPE

## **REPORT ATTACHMENTS**

### **Field Investigation Data:**

- **Scheme Plan**
- **WJL Site Plan**
- **Borehole Logs**

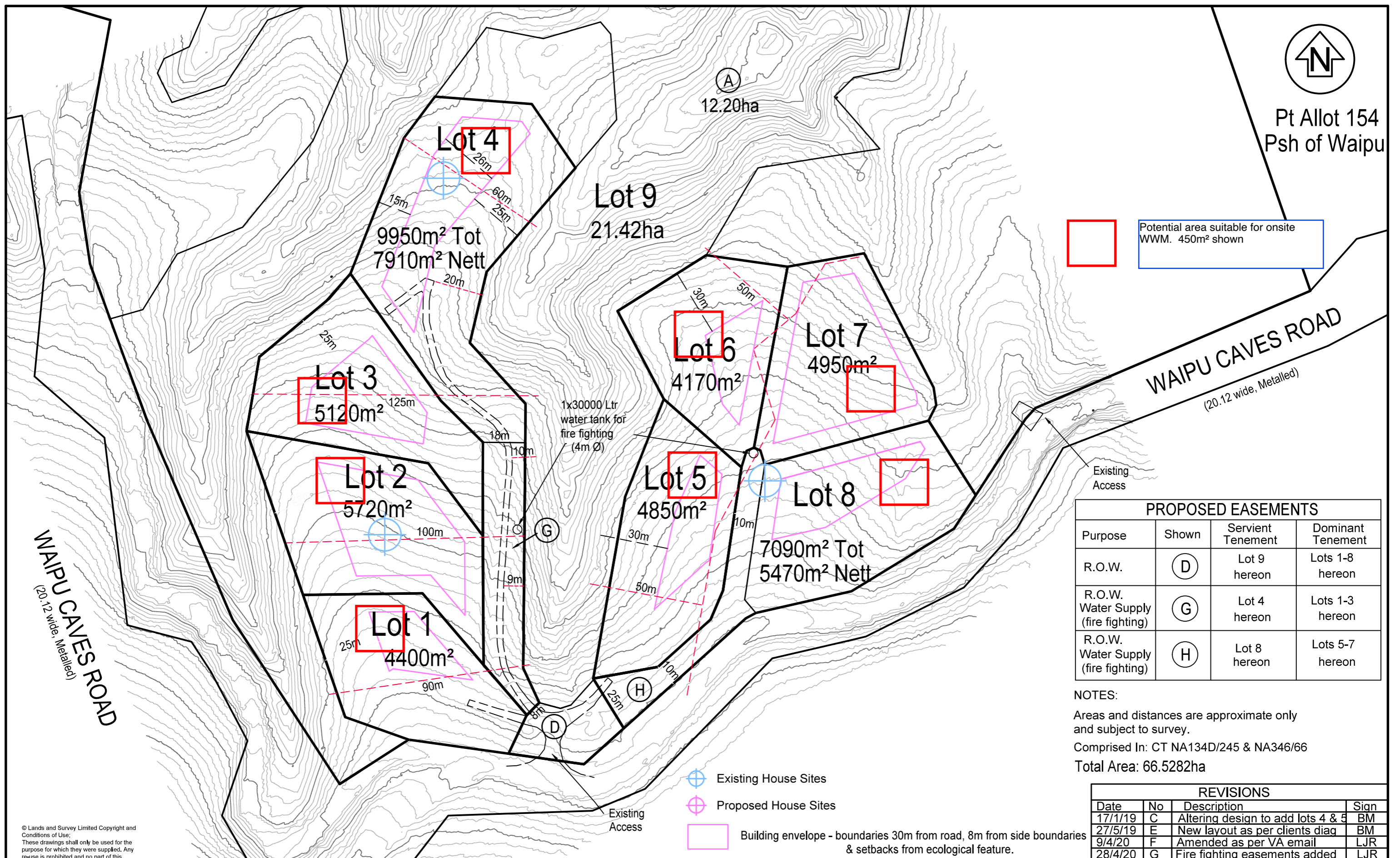
### **Notes**

- **Expansive Soils**



Pt Allot 154  
Psh of Waipu

Potential area suitable for onsite  
WWM. 450m<sup>2</sup> shown



PROPOSED EASEMENTS			
Purpose	Shown	Servient Tenement	Dominant Tenement
R.O.W.	(D)	Lot 9 hereon	Lots 1-8 hereon
R.O.W. Water Supply (fire fighting)	(G)	Lot 4 hereon	Lots 1-3 hereon
R.O.W. Water Supply (fire fighting)	(H)	Lot 8 hereon	Lots 5-7 hereon

NOTES:  
 Areas and distances are approximate only and subject to survey.  
 Comprised In: CT NA134D/245 & NA346/66  
 Total Area: 66.5282ha

REVISIONS			
Date	No	Description	Sign
17/1/19	C	Altering design to add lots 4 & 5	BM
27/5/19	E	New layout as per clients diag	BM
9/4/20	F	Amended as per VA email	LJR
28/4/20	G	Fire fighting easements added	LJR

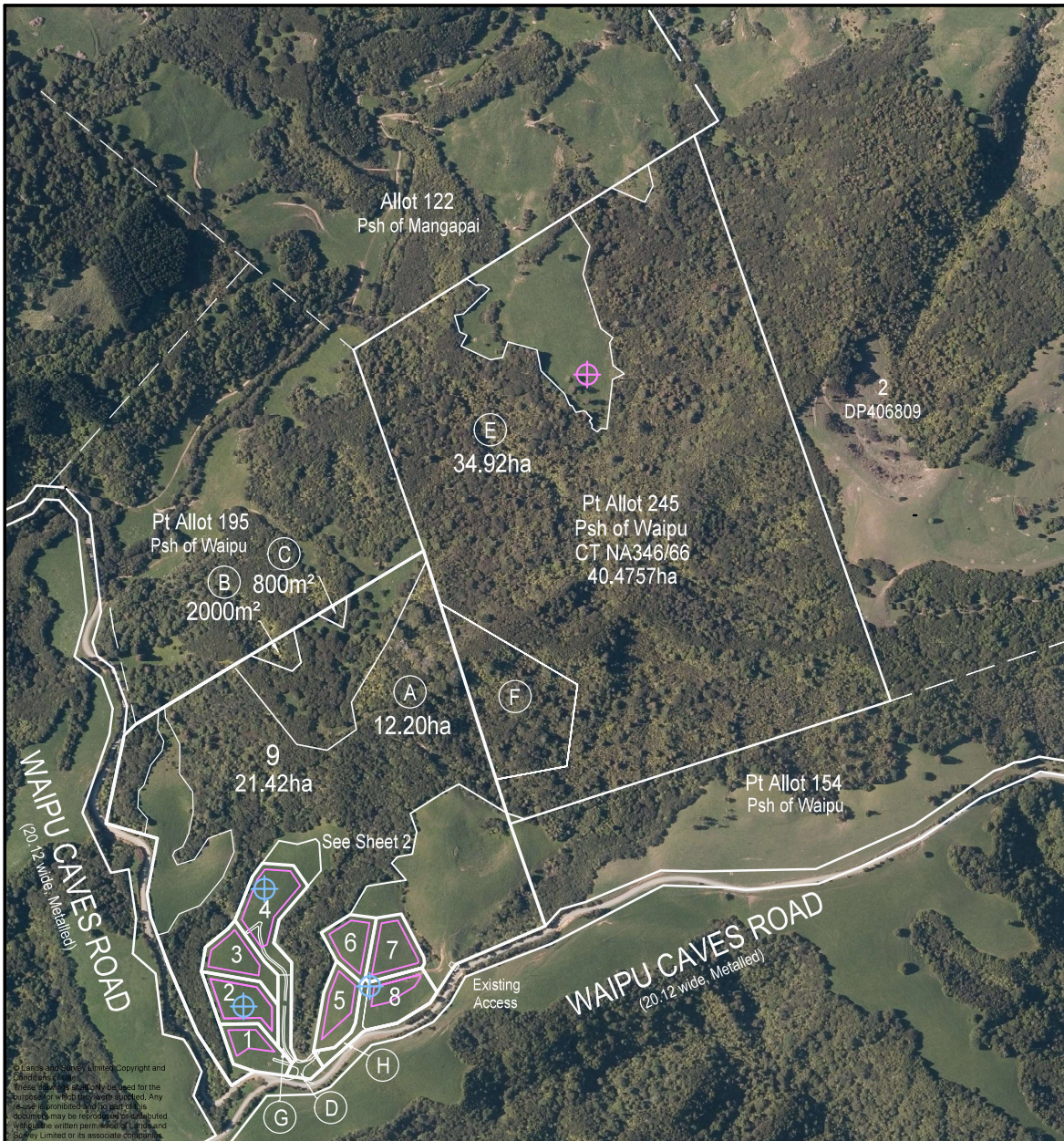
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## Proposed Subdivision of Allot 231 Psh of Waipu, Secs 2-4 SO69477 & Pt Allotment 245 Parish of Waipu

Prepared for <b>IAN FOX</b>		SHEET <b>3</b>
DRAWN BM	SCALES 1:1500 (A3)	SERIES OF 3 of 3
DATE July 2020		REF 10039/3/1/G





PROPOSED EASEMENTS			
Purpose	Shown	Servient Tenement	Dominant Tenement
R.O.W.	(D)	Lot 9 hereon	Lots 1-8 hereon
R.O.W.	(G)	Lot 4 hereon	Lots 1-3 hereon
R.O.W.	(H)	Lot 8 hereon	Lots 5-7 hereon



#### AMALGAMATION CONDITION

That Lot 9 hereon and Pt Allot 245 (CT NA346/66) be held in the same Computer Register.

Sec 220(1)(b)(ii)

Area shown (E) = Cat A Terrestrial Indigenous Vegetation and is to be subject to a conservation covenant. (34.92ha)

Area shown (F) = Cat B Resource Area and is to be subject to a conservation covenant. (2.41ha)

Area (F) defined from WDC GIS ONF layer

Areas shown (A)(B)(C) are to be subject to land covenants. (12.48ha) under SD1800104

#### NOTES:

Areas and distances are approximate only and subject to survey.

Comprised In: CT NA134D/245 & NA346/66

Total Area: 66.5282ha

Existing House Sites

Proposed House Sites

Building envelope - boundaries 30m from road & 8m side yards.

REVISIONS			
Date	No	Description	Sign
6/12/18	B	WDC new cov areas added	BM
17/1/19	C	Altering design to add lots 4 & 5	BM
27/5/19	E	New layout as per clients diag	BM



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## Proposed Subdivision of Allot 231 Psh of Waipu, Secs 2-4 SO69477 & Pt Allotment 245 Parish of Waipu

Prepared for IAN FOX		SHEET 1	
DRAWN BM	SCALE 1:6000 (A3)	SERIES OF 1 of 2	
DATE May 2019		REF 10039/1/1/E	



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

## Proposed Subdivision of Allot 231 Psh of Waipu, Secs 2-4 SO69477 & Pt Allotment 245 Parish of Waipu

Prepared for <b>IAN FOX</b>		SHEET <b>2</b>
DRAWN	BM	SCALE
DATE	May 2019	1:1500 (A3)
SERIES OF		2 of 2
REF		10039/1/2/E

REVISIONS			
Date	No	Description	Sign
6/12/18	B	WDC new cov areas added	BM
17/1/19	C	Altering design to add lots 4 & 5	BM
27/5/19	E	New layout as per clients diag	BM



**LEGEND:**

-  PREVIOUSLY TESTED SITE
-  PREVIOUS BOREHOLE TEST POSITION
-  NEW BOREHOLE TEST POSITION



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No.	Date	By	Issue/Revision
A	JUN '19	RDS	GEOTECHNICAL REPORT

**NOTES/KEY:**

- LOT BOUNDARIES AND AREAS ARE INDICATIVE ONLY AND SUBJECT TO SURVEY

DRAWN:	RDS
CHECKED:	DAL
REPORT:	DAL
SURVEYED:	OTHER
OFFICE:	OREWA-CIVIL
CONTACT:	09 527 0196

**PT ALLOT 231 PSH OF WAIPU**  
**876 WAIPU CAVES ROAD**  
**WAIPU**



**PROPOSED SUBDIVISION**

**SERVICES NOTE**  
WHERE EXISTING SERVICES ARE SHOWN, THEY ARE INDICATIVE ONLY AND MAY NOT INCLUDE ALL SITE SERVICES. WILTON JOUBERT LTD DOES NOT WARRANT THAT ALL, OR INDEED ANY SERVICES ARE SHOWN. IT IS THE CONTRACTORS RESPONSIBILITY TO LOCATE AND PROTECT ALL EXISTING SERVICES PRIOR TO AND FOR THE DURATION OF THE CONTRACT WORKS.

**GEOTECHNICAL**  
Design | Drawing subject to Engineer's Approval

ORIGINAL DWG. SIZE A3
SCALE: 1:1500
DRAWING No. <b>87315-G001</b>
SHEET No. <b>01</b> ISSUE <b>A</b>

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description		Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)	
Waipapa Group (Weathered Greywacke)	TOPSOIL, dark brown, moist, no plasticity, firm								
	Clayey SILT, brownish-orange, dry, low plasticity, very stiff	0.5		NO GROUND WATER ENCOUNTERED	3		45 / 143		
	Silty CLAY, orange, moist, moderate plasticity, very stiff				2.5		45 / 112		
			1.0			4.3		39 / 168	
						2		70 / 143	
	1.5				2.3		56 / 126		
<b>END OF BORE HOLE - Target depth at 1.5m</b>									
		2.0							
		2.5							
		3.0							
		3.5							
		4.0							
		4.5							

**LEGEND**

	<b>TOPSOIL</b>		<b>CLAY</b>		<b>SILT</b>		<b>SAND</b>		<b>GRAVEL</b>		<b>FILL</b>	In situ shear vane reading 
												Remoulded shear vane reading 
												Scala Penetrometer 

Average Scala Blows	n/a
Average Soil Sensitivity	2.9



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**BOREHOLE LOG No. 2**  
**JOB No. 87315**  
 Hole Location: Refer to Site Plan

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description	Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)
TOPSOIL, dark brown, moist, no plasticity, firm							
Waipapa Group (Weathered Greywacke)  Clayey SILT, brownish-orange, dry, low plasticity, very stiff  Silty CLAY, orange, moist, moderate plasticity, very stiff  Fine white weathered rock inclusions	0.5		NO GROUND WATER ENCOUNTERED	2.9		154 53	
				1.9		151 81	
				2.4		148 62	
				3.2		157 49	
				1.5		151 56	
<b>END OF BORE HOLE - Target depth at 1.5m</b>							
	2.0						
	2.5						
	3.0						
	3.5						
	4.0						
	4.5						

**LEGEND**

**TOPSOIL**     
 **CLAY**     
 **SILT**     
 **SAND**     
 **GRAVEL**     
 **FILL**

In situ shear vane reading   
 Remoulded shear vane reading   
 Scala Penetrometer

Average Scala Blows	n/a
Average Soil Sensitivity	2.6



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**BOREHOLE LOG No. 3**  
**JOB No. 87315**  
 Hole Location: Refer to Site Plan

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description	Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)
TOPSOIL, dark brown, dry, no plasticity, firm							
Clayey SILT, brownish-orange, dry, low plasticity, very stiff  Silty CLAY, orange, moist, moderate plasticity, very stiff  Trace carbonaceous inclusions  Fine white weathered-rock inclusions	0.5		NO GROUND WATER ENCOUNTERED	2.0		182	
				1.9		185	
	1.0			2.1		165	
	1.5			1.7		126	
				n/a		196	
<b>END OF BORE HOLE - Target depth at 1.5m</b>							
	2.0						
	2.5						
	3.0						
	3.5						
	4.0						
	4.5						

**LEGEND**

	<b>TOPSOIL</b>		<b>CLAY</b>		<b>SILT</b>		<b>SAND</b>		<b>GRAVEL</b>		<b>FILL</b>
--	----------------	--	-------------	--	-------------	--	-------------	--	---------------	--	-------------

In situ shear vane reading

Remoulded shear vane reading

Scala Penetrometer

Average Scala Blows	n/a
Average Soil Sensitivity	1.9



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**BOREHOLE LOG No. 4**  
**JOB No. 87315**  
 Hole Location: Refer to Site Plan

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description	Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)
TOPSOIL, dark brown, dry, no plasticity, firm							
Waipapa Group (Weathered Greywacke)  Clayey SILT, brownish-orange, dry, non plastic, very stiff  Silty CLAY, brownish-orange, moist, moderate plasticity, very stiff  Trace carbonaceous inclusions	0.5		NO GROUND WATER ENCOUNTERED	1.8		185 101	
				1.7		182 106	
				1.7		168 101	
				2.0		154 77	
				1.5	n/a	196	
<b>END OF BORE HOLE - Target depth at 1.5m</b>							
	2.0						
	2.5						
	3.0						
	3.5						
	4.0						
	4.5						

**LEGEND**

**TOPSOIL**     
 **CLAY**     
 **SILT**     
 **SAND**     
 **GRAVEL**     
 **FILL**

In situ shear vane reading   
 Remoulded shear vane reading   
 Scala Penetrometer

Average Scala Blows	n/a
Average Soil Sensitivity	1.8



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**BOREHOLE LOG No. 5**  
**JOB No. 87315**  
 Hole Location: Refer to Site Plan

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description	Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)
TOPSOIL, dark brown, dry, no plasticity, firm							
Waipapa Group (Weathered Greywacke)  Clayey SILT, dark-brown, dry, non plastic, very stiff  Silty CLAY, brownish-orange, moist, moderate plasticity, very stiff  Orange mottled grey	0.5		NO GROUND WATER ENCOUNTERED	2.1		73    155	
				1.9		89    168	
				1.9		78    147	
				1.8		84    154	
		1.5			2.1		168
<b>END OF BORE HOLE - Target depth at 1.5m</b>							
	2.0						
	2.5						
	3.0						
	3.5						
	4.0						
	4.5						

**LEGEND**

**TOPSOIL**   
 **CLAY**   
 **SILT**   
 **SAND**   
 **GRAVEL**   
 **FILL**

In situ shear vane reading   
 Remoulded shear vane reading   
 Scala Penetrometer

Average Scala Blows	n/a
Average Soil Sensitivity	2.0





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**BOREHOLE LOG No. 6**  
**JOB No. 87315**  
 Hole Location: Refer to Site Plan

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description	Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)	
TOPSOIL, dark brown, dry, no plasticity, firm								
Clayey SILT, dark-brown, dry, low plasticity, very stiff Silty CLAY, brownish-orange, moist, moderate plasticity, very stiff Fine white weathered-rock inclusions	0.5		NO GROUND WATER ENCOUNTERED	2.0		189 92		
				2.1		175 84		
				2.5		154 62		
		1.0			1.8		154 84	
		1.5					196	
<b>END OF BORE HOLE - Target depth at 1.5m</b>								
	2.0							
	2.5							
	3.0							
	3.5							
	4.0							
	4.5							

**LEGEND**

**TOPSOIL**     
 **CLAY**     
 **SILT**     
 **SAND**     
 **GRAVEL**     
 **FILL**

In situ shear vane reading   
 Remoulded shear vane reading   
 Scala Penetrometer

Average Scala Blows	n/a
Average Soil Sensitivity	2.1



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**BOREHOLE LOG No. 7**  
**JOB No. 87315**  
 Hole Location: Refer to Site Plan

**CLIENT:** Ian Fox      **SITE:** Lot SECS 1-4, SO 69477, 876 Waipu Caves Road, Waipu  
**Date Started:** 10/06/2019      **DRILLING METHOD:** Hand Auger      **LOGGED BY:** KEM  
**Date Completed:** 10/06/2019      **HOLE DIAMETER (mm):** 50mm      **CHECKED BY:** DAL

Soil Description	Depth (m)	Graphic Log	Water Level	Sensitivity	Recovery	Vane Shear Strength (kPa)	Scala Penetrometer (blows/100mm drop)
TOPSOIL, dark brown, dry, no plasticity, firm							
Clayey SILT, dark-brown, dry, non plastic, very stiff			NO GROUND WATER ENCOUNTERED	n/a		196	
Silty CLAY, orange, moist, moderate plasticity, very stiff with trace white... ...inclusions	0.5			n/a		196	
Fine to Medium white weathered-rock inclusions				n/a		196	
<b>END OF BORE HOLE - Refusal at 1.1m</b>	1.0			n/a		196	
	1.5						
	2.0						
	2.5						
	3.0						
	3.5						
	4.0						
	4.5						

**LEGEND**

	<b>TOPSOIL</b>		<b>CLAY</b>		<b>SILT</b>		<b>SAND</b>		<b>GRAVEL</b>		<b>FILL</b>	In situ shear vane reading	
												Remoulded shear vane reading	
												Scala Penetrometer	

Average Scala Blows	n/a
Average Soil Sensitivity	n/a

## **NOTES:**

### **Expansive Soils**

Expansive soils are soils which experience volume changes upon wetting and drying. Expansion and swelling appears to be the dominant factor under certain conditions with fine grained soil containing considerable amounts of clay. Expansion and swelling may cause distress which is often experienced in light buildings.

In many parts of New Zealand there is a significant hazard to foundations for light buildings including homes with concrete slab floors. The volumetric expansion and contraction can cause houses and other structures to heave or settle resulting in damage that is sometimes severe. Soil movement can occur in both directions (vertical and horizontal) at different rates which results in distress and subsequent damage to the structure.

The extent of the damage varies from relatively minor brick veneer cracking and internal cracking on wall corners with attendant door and windows jamming, through to extensive and severe cracking including cracking of driveways, sidewalks, etc.

Expansive soils such as clay, claystone, mudstone, argillaceous rocks and shale all contain clay minerals. These minerals are very sensitive to changes in humidity. When expansive clayey soils get wet, these minerals absorb water molecules and consequently expand. When dry they shrink, leaving large voids in the soil which result in a reduction in bearing capacity of the soil.

Apart from seasonal moisture changes (wet winters/ dry summer), other factors can influence soil moisture such as:

- Irrigation of garden close to the dwelling foundation.
- Site drainage close to the structure.
- Plantation of large trees close to building foundations on expansive soils. A wide range of tree and shrub species have high groundwater demands during summer months. The effects of such demands on expansive soils can be substantial and can lead to differential building settlements. Accordingly, it is good housekeeping measure to ensure that high water demand species (such as gum, willow, cypress, etc.) are not planted close to buildings.
- Plumbing leaks.
- Prevalent or initial moisture conditions at construction time.

It should be also noted that the shear strength of expansive soil also changes with variations in humidity, and a stability problem may arise.

Expansive soils cause major damage to light foundations and associated structures. Heavy foundations and structures can resist the swelling uplift pressure.

Damage is dependent on the amount of movement experienced by the foundation, the non-uniformity in movement, which are all related to percentage of clay in the expansive soil, variation in moisture content, type of foundation, building construction and materials, etc.