Attachment 9

Geotechnical Interpretative
Report prepared by Beca

Geotechnical Interpretative Report

May Road Development

Prepared for May 1 Limited

Prepared by Beca Limited

22 June 2022

Creative people together transforming our world

Revision History

Revision Nº	Prepared By	Description	Date
1	Kent Thomas	Feasibility Assessment	04/12/2020
2	Kent Thomas	Updated for Resource Consent Application	04/02/2022
3	Kent Thomas	Updated with Client Feedback	14/04/2022
4	Kent Thomas	Updated with additional groundwater information and changes in Earthworks Plans	22/06/2022

Document Acceptance

Action	Name	Signed	Date
Prepared by	Kent Thomas		22/06/2022
Reviewed by	Ross Paterson/David Anstiss		22/06/2022
Approved by	Dale Paice	22.06.2022	22/06/2022
on behalf of	Beca Limited		

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Executive Summary

May 1 Limited is considering future redevelopment of their May Road properties in Mount Roskill (the Site). Proposed future development of the Site includes using engineered fill to create a platform raised above the 1% Annual Exceedance Probability (AEP) floodplain. To compensate the fill in the floodplain, other areas are to be cut to create additional flood storage.

Geotechnical investigations have been undertaken on the 105a-109a and 119 May Road sections of the site to assess ground conditions and undertake preliminary analysis of expected settlement to inform concept design for the future development of the Site. No investigations or assessment has been undertaken for 105 May Road portion of the site, currently leased, and occupied by Watercare's contractors.

The ground profile of the Site includes varying quantities of existing fill, overlying organic rich recent alluvium material. This recent material was deposited on a layer of Auckland Volcanic Field – Ash which lies above stiffer alluvial soils of the Tauranga Group, with East Coast Bays Formation soil and rock at depth. Basalt rock was encountered in only one borehole on the Site near the north-eastern boundary and the extent of the basalt is poorly defined. The borehole did not extend through the basalt which was at least 10.5 m thick in this location.

Based on this ground profile, analysis indicated that settlement in the order of 300 - 500 mm could be expected in areas for a fill depth of 1.5m. Most settlement will likely occur within 2 years of placement. Additional settlement is expected to occur due to future loading from structures. The Site is also considered susceptible to liquefaction induced settlement under a large (that is, ultimate limit state) seismic loading.

Settlements in the areas underlain by basalt rock should be limited to approximately 25 – 50 mm for 1.5 metres of fill. Because of the contrast in settlement behaviour between the areas underlain by the organic materials and the basalt rock, large differential settlement along the interface between the two materials is a significant risk to future development.

It is recommended, that when the Site is filled, settlement monitoring is undertaken to better define the areas where differential settlement may be greatest, as well as to monitor the rate of overall settlement. Some overfill to compensate for future settlement will be required so that finished levels remain above floodplain levels.

Once the engineered fill is placed, shallow foundations are likely applicable for lightweight buildings designed to cope with the expected total and differential settlements, while deep piled foundations are recommended for larger or heavier structures. The positioning of structures should be planned to avoid spanning the basalt interface (where significant differential settlement can be expected) as well as choosing areas best suited for the building typology. Areas where shallow foundations are proposed can be preloaded with an additional fill to reduce post construction settlement. Larger structures would ideally be placed where depth to founding rock is shallower, to reduce the cost of piled foundations.

From the analysis undertaken it is apparent the Site can be feasibly developed so long as steps are taken to control the risks in future design development stages.

1 Introduction

1.1 Background

Beca Limited (Beca) has been commissioned by May 1 Limited to undertake an assessment of the ground conditions at their May Road properties (the Site). The Site is located on May Road in the suburb of Mount Roskill and encompasses the properties of 105, 105a-109a, and 119 May Road. The land at 54 Roma Road directly north-west of the Site will host a shaft for Watercare Services Limited (Watercare)'s Central Interceptor tunnel and 105 May Road is currently being leased to facilitate construction activities. Figure 1 shows the Site, Watercare's land and adjacent lots.

This report forms part of a suite of Beca reports prepared to describe the future Site development and assess potential effects. The works are described in the Resource Consent Drawings (June 2022) and the other reports are:

- Geotechnical Factual Report.
- Ecology Assessment.
- Land Contamination Assessment.
- Contaminated Soils Management Plan
- Civil and Stormwater Assessment.
- Erosion and Sediment Control Plan.

Figure 1: Site Plan

1.2 Proposed Works

The proposed works comprise earthworks across the majority of the Site in order to form platforms suitable for future development, to realign and naturalise an existing stream channel and to recontour floodplain areas within the Site to suit future developments and manage potential flood hazard effects. In addition to earthworks, the proposed works include landscape planting within floodplains and riparian margins and some modifications to public stormwater pipework to suit the final form.

The proposed works are shown on the Beca Concept Design Drawing Set and Figure 2 below shows cut-fill depths of the proposed bulk earthworks within the Site.

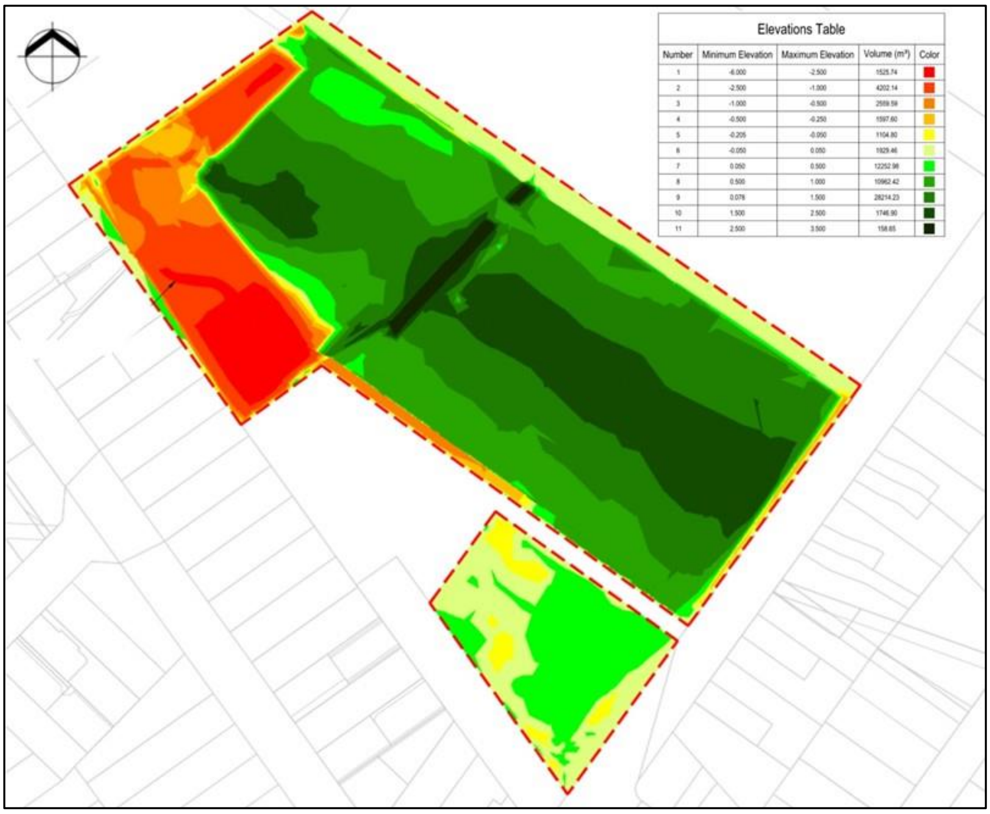


Figure 2. Earthworks Proposed Cut/Fill

1.2.1 Interim works on 105 May Road

Watercare is currently leasing part of the Site (105 May Road) until 2030 from May 1 Limited to facilitate construction of the Central Interceptor project. Watercare's contractors are currently in control of the area. Prior to the establishment of the final proposed works construction activities planned for the 105 May Road property include site offices, truck access, and earthworks to create working platforms and stormwater management areas. Watercare is responsible for any land distributing activities during the lease period including obtaining necessary consents and carrying out land contamination and geotechnical investigations.

Because of this, and because access is currently limited, no land contamination or geotechnical investigations or assessment for earthworks to on 105 May Road have been carried out specific to this application (although Watercare has shared information that they have gathered to date). Any necessary investigations and analysis will be carried out at the end of the lease period when 105 May Road is returned.

1.2.2 Adjacent works on 54 Roma Road

Watercare holds a resource consent to form the permanent tunnel shaft access at 54 Roma Road northeast of the Site under an outline plan of works (OPW60341982). Construction is underway on this site with completion assumed to be before 2030 (that is, the end of the lease). The form of these earthworks is indicated on Figure 3. We assume that the finished works proposed at the Watercare site following the completion of the Central Interceptor construction will return the ground levels to predevelopment levels at the boundary at the Site.

Figure 3. Earthworks Proposed Cut/Fill at 54 Roma Road.

1.3 Purpose and Scope

The purpose of this Geotechnical Interpretive Report is to present an assessment of the geological conditions of the 105a-109a and 119 May Road portion of the Site from factual information gathered during geotechnical investigations specifically undertaken for this project, publicly available data, and data provided by WaterCare Services Limited. It provides geotechnical parameters and a ground model that can be used for future design work. This report also provides the results of the settlement analysis undertaken to assess the magnitude of settlement that could be expected during filling and future development of the Site, approaches to mitigate the effects of this settlement, and general commentary on future development.

This report is to be read in conjunction with the Beca (2022)[1] Geotechnical Factual Report prepared for May 1 Limited.

[1] Beca (2022) Geotechnical Factual Report – May Road Development

2 Site Description

The Site is located on May Road in the suburb of Mount Roskill and encompasses the parcels of 105 (Legal Description SEC 2 SO 4685230), 105a-109a (Legal Description Lot 1 DP 586970, and 119 May Road (Legal Description Lot 3 DP 40979). The Site is located to the northwest of Mount Roskill, it is typically flat between elevations 49 and 51 mRL, and rises gently to the west (slopes up to 6°), with a low-lying area in the north-western corner of the 105 property. The layout of the Site and property parcels is shown in Figure 4.

A north-west aligned drainage channel follows the north-eastern boundary of the Site before discharging to a culvert in the adjacent 54 Roma Road property. A second perpendicular drain follows the boundaries between 105 and 105a-109a May Road.

A number of large warehouse and smaller sheds structures are present on the 105a-109a May Road lots, with various hardstand areas containing stockpiles of wood, refuse, and soil. 105 and 119 May Road are predominately vacant. 105 May Road is currently being leased and the hard stand area serves as the location of the contractor's site offices as part of Watercare's Central Interceptor project. 119 May road is a completely vacant grassed lot, with a few trees on the Site, the south-west corner had been utilised as a laydown area for works installing a wastewater pipeline along the southern edge of the Site.

Figure 4: Site Parcels (red) and Main Drainage Channels (dashed blue) (Image Source: Nearmap Australia Pty Ltd).

3 Geology and Ground Profile

3.1 Published Geology

The relevant published geological map - Geology of the Auckland area 1:250,000 (Edbrooke, 2001)[2], shows the geology of the Site to be basaltic lava flows consisting of dense, fine grained basalt rock, underlain by alternating sandstone and siltstone beds of the East Coast Bays Formation which outcrop to the south and west. Auckland Volcanic Field (AVF) Ash consisting of lapilli and lithic tuff material is also shown on the south-eastern edge of the Site, on the flanks of Mount Roskill.

The distribution of these units is shown in Figure 5 below.

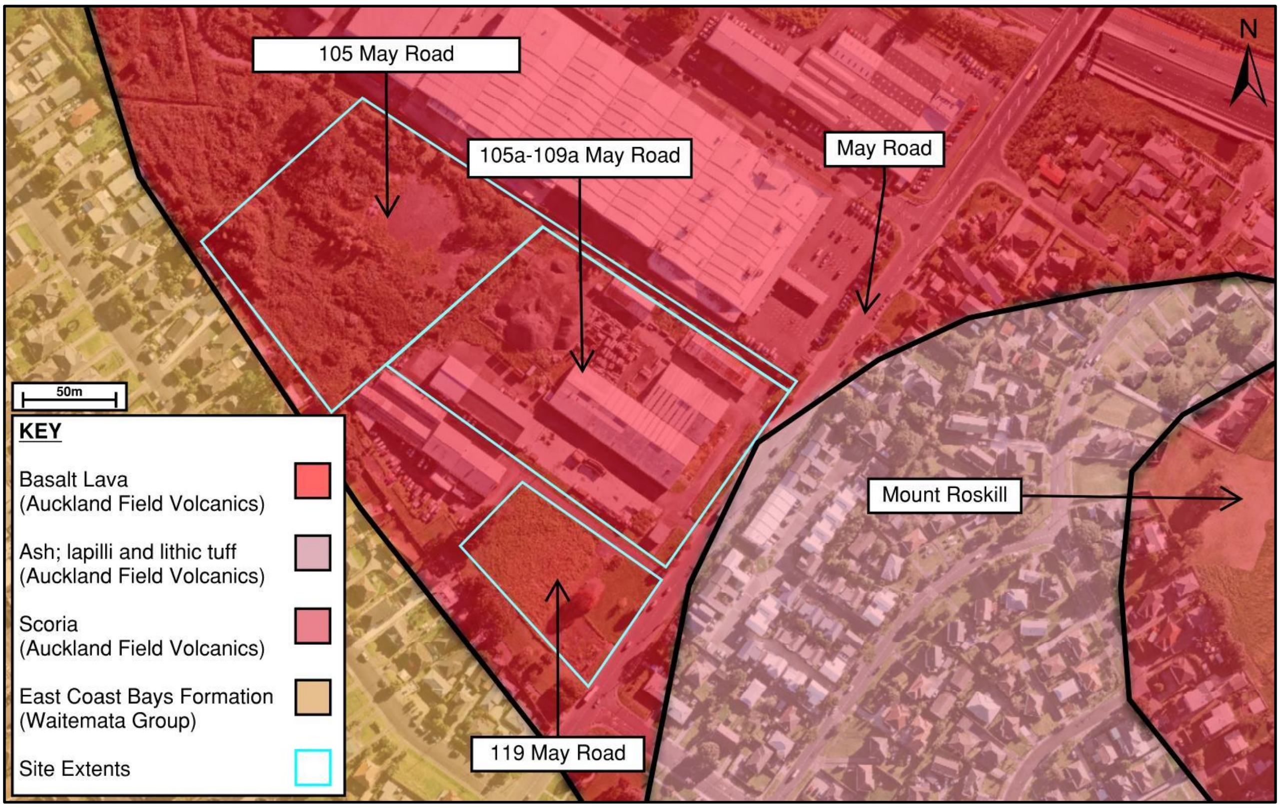


Figure 5: Mapped Geology of the Site (Edbrooke, 2001).

3.1.1 Seismicity

There are no mapped active faults (GNS Science, 2022)[3] beneath the Site. Inactive faults are inferred to be present near the Site by Kenny et al. (2012)[4] but there are no mapped inactive faults in the vicinity of the Site (Edbrooke, 2001).The closest mapped active fault is the Waikopua Fault, a normal fault, located approximately 25km to the south east of the Site, on the western margin of the Hunua Ranges.

[2] Edbrooke, S. W. (2001). Geology of the Auckland area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited.

[3] G.N.S Science (2020) Active Faults Database. https://data.gns.cri.nz/af/. Accessed on 20/11/2020

[4] Kenny, J. A., Lindsay, J. M., & Howe, T. M. (2012). Post-Miocene faults in Auckland: insights from borehole and topographic analysis. New Zealand Journal of Geology and Geophysics, 55(4), 323-343.

3.1.2 Other Geohazards

Given the contour of the Site, slope stability is not considered an issue unless slopes are steepened during earthworks. The Site is subject to moderate flooding risk from a tributary of Oakley Creek which runs through the site. The Site contains some flood prone areas and is generally classified as flood plain. The Site also lies within the active Auckland Volcanic Field and is therefore exposed to the hazard of future volcanic activity.

3.2 Project Specific Investigations

The following project specific ground investigations have been undertaken during October 2020.

- 4 rotary drilled geotechnical machine boreholes between 12.5 and 20.3m depth.
- 8 sonic drilled environmental monitoring boreholes between 4.7 and 5.0m depth.
- 33 environmental test pits between 0.5 and 4.6m depth

The location of these recent investigations is presented in Appendix A.

3.3 Ground Model

This section details the geotechnical conditions encountered at the Site. The inferred ground model is based on publicly available investigations data, data supplied to May 1 Limited by Watercare Services Limited, and the project specific geotechnical investigations. No project specific investigations were undertaken on the 105 May Road property or on the 54 Roma Road site for this assessment. Geological cross-sections for the Site have been developed from this information and are presented in Appendix B. A summary of the engineering units and their depths, as encountered in project specific investigations, is presented in Table 1 below. It should be noted that the ground conditions present at the Site differ from those mapped by Edbrooke (2001), which are described in Section 2.1 of this report. A revised geology map based on the content of the collated information is shown in Figure 6 below. Note, the ground information is still quite limited in relation to the size of the Site and the location of the basalt, depth to rock, extent of softer soils is not well defined.

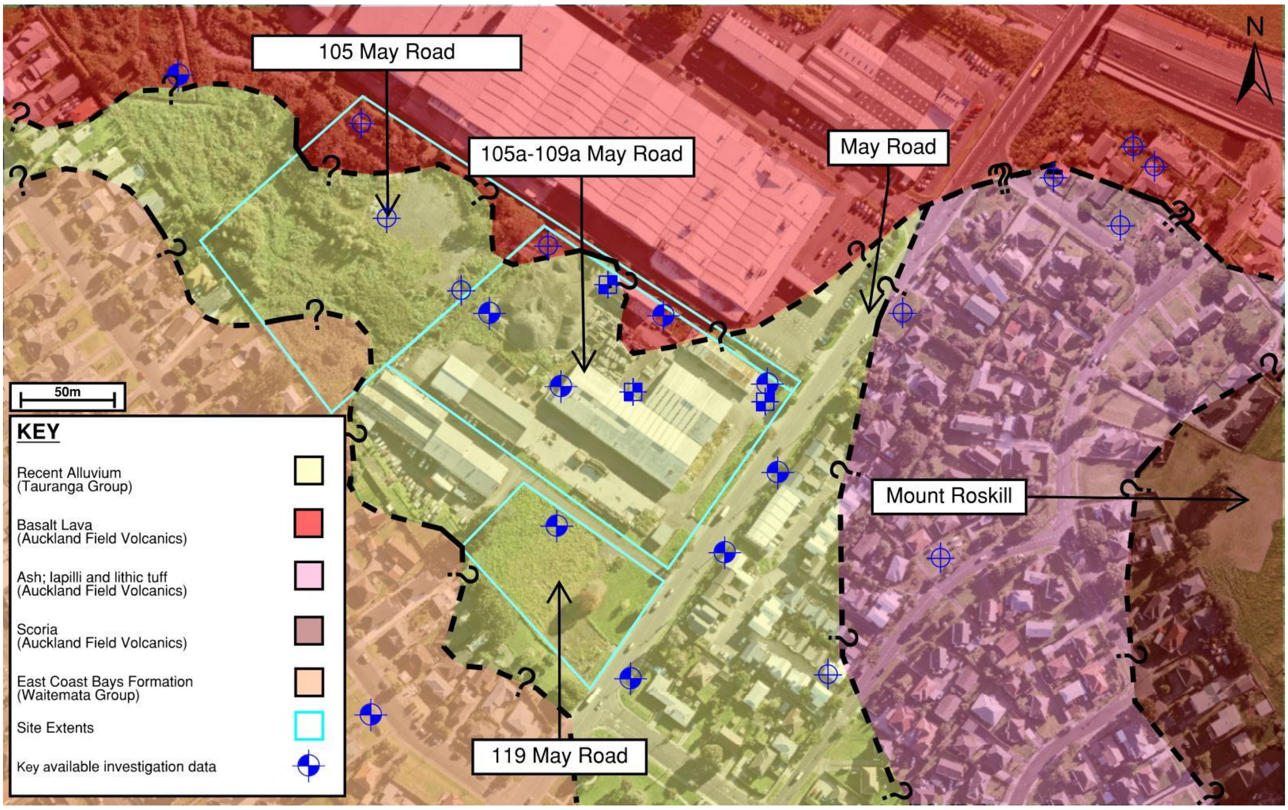


Figure 6: Revised geology of the Site following investigations

The project specific investigations found that the majority of the 105a-109a and 119 May Road Site was underlain by relatively recent Holocene alluvium of the Tauranga Group consisting of soft to stiff clayey silts, peat, and organic silt material. This material was overlying a relatively thin Auckland Volcanic Field – Ash layer likely derived from nearby Mount Roskill. Below this was older Tauranga Group material of the Puketoka Formation consisting of firm to very stiff sandy silts, and clayey silts, overlying East Coast Bays formation soils and rock. Basalt rock material was only identified in discrete locations along the north-eastern boundary of the Site and was generally encountered at shallow (~2.0 - 4.7m) depth. The basalt in BH04 was at least 10.5m thick and the underlying material was not proven.

Uncontrolled fill material was encountered across the Site and was highly variable in nature ranging from scoria cobbles to sandy clays. The thickness of the fill material was also highly variable and was mostly estimated from downhole observations due to service clearance procedures for the borehole investigations.

Table 1: Materials encountered on the Site

Unit Name	Strength	Description	Unit	Depth to Top of Layer (mbgl)*	Thickness (m)*
1	Very stiff	GRAVEL, gravelly clay.	Fill	0	0.8-1.1 (0.9)
2	Stiff	Clayey SILT	Holocene Alluvium	0.8-1.1 (0.9)	0.7-1.7 (1.2)
2a	Soft to Firm	Fibrous PEAT		1.5-2.8 (2.1)	0.3- 1.0 (2.2)
2b	Soft to Stiff	Organic SILT		3.85-4.75 (4.3)	0.0-2.0 (0.6)
3	Moderately Strong	Unweathered basalt (BH03 only)	AVF – Basalt	2.0 (2.0)	N/A
4	Firm to Very Stiff	Sandy SILT, gravelly SILT	AVF – Ash	2.4-6.7 (4.9)	0.8-2.9 (2.2)

5a	Stiff to Very Stiff	Sandy SILT	Puketoka Formation	7.3-11.0 (8.6)	Interbedded with 5b for 2.7-5.5 (3.7)
5b	Firm to Stiff	Clayey SILT		4.9-9.5 (7.1)	Interbedded with 5a for 2.7-5.5 (3.7)
6a	Very Stiff to Hard	Clayey Silts, Sandy Silts	East Coast Bays Formation	10.9 -14.2 (11.5)	0.8-1.5 (1.0)
6b	Extremely Weak	Sandstone, Siltstone		10.9 - 15.0 (12.5)	1.3-3.3 (1.7)
6c	Very Weak	Sandstone, Siltstone		12.4 - 17.3 (14.2)	N/A

* Note: values in brackets () are averaged values.

3.4 Groundwater Conditions

Groundwater conditions adopted for the analyses were derived from measurements made in the groundwater monitoring standpipe piezometers. Further details of these levels are provided in the Land Contamination Assessment[5].

The groundwater level at the Site is generally high and for analysis a depth of 1.2m below ground level (bgl) was used. Groundwater levels (GWL) will vary seasonally, and it is noted that in 2020 rainfall in the Auckland region has been lower than normal. This GWL measured is likely a perched ground water level and it is likely that a deeper regional groundwater table is present within the basalt and East Coast Bays Formation unit.

A summary of the piezometer water levels is provided below:

Table 2: Summary of Monitored Piezometer levels.

Borehole ID	Ground Level (mRL)	Groundwater Level (mbgl)	Groundwater Level (mRL)	Screen Depth (mbgl)	Date Monitored
BH201	50.0	1.21	48.79	1.5 – 4.7	09/11/2020 08:08
BH202	50.0	1.25	48.75	1.5 - 5.0	06/11/2020 13:20
BH203	50.0	0.34*	49.66	1.5 - 5.0	06/11/2020 15:33

* Note: measurement considered to be inaccurate as a result of surface water entering piezometer.

Long-term ground water monitoring data has also been supplied by Watercare Services Limited from a monitoring piezometer (PZ01) installed in the southwestern corner on the 105 May Road property. This piezometer measures groundwater level at three different screen intervals – 5.5, 30, and 60mbgl every 6 hours.

For the period Jan 2021 to May 2022 the groundwater levels recorded by the shallowest monitoring point (5.5mbgl) fluctuated between 48.2 and 49.5 mRL (3.0 - 4.3m bgl).

This is consistent with the groundwater monitoring data obtained during the Beca investigations.

[5] Beca 2022, Land Contamination Assessment – May Road Development.

4 Geotechnical Design Parameters

The design soil parameters have been assessed for each soil/rock unit and are presented in Table 3. The soil parameters provided in Table 3 have been derived based on published correlations with in-situ tests e.g. SPT-N values, Shear Vane test Su, laboratory test data, etc. and our experience with similar soils at other sites in Auckland. The median values listed in Table 3 were typically adopted for the design.

Table 3: Design parameters

Soil Unit No.	Designated Colour	Geological Unit	Field Parameters		Design Parameters			
			SPT N (blows/ 300mm)	Su (Vane Shear Strength) (kPa)	Unit Weight, ɣ' (kN/m3)	Su (kPa)	Cohesion c' (kPa)	Friction angle, φ' (degrees)
1		Fill	-	90-149	17	110	4	30
2		Holocene Alluvium	6	35-178	17	40	3	27
2a	Peat		1	43-57	15	30	1	25
2b	Organic Silt		0	19-97	16	40	2	26
3		AVF - Basalt	50	-	28	-	30	40
4		AVF - ASH	0-7	-	17	100	2	27
5a	Sandy	Puketoka Formation	0-9	73-UTP*	17	100	3	29
5b	Clayey		0-9	46-UTP*	17	50	3	28
6a		Waitemata Group	28-32	-	18	150	5	31
6b			50+	-	20	-	9	32
6c			50+	-	20	-	14	33

* Note: UTP=Unable to Penetrate

5 Settlement Analysis

The proposed development of the Site includes raising the ground level across much of the Site by 1.0 - 1.5 metre to form a building platform above expected flood level. This will be achieved by placing and compacting engineered fill across the Site. Analyses to determine the expected settlement were undertaken using the software analysis program Settle3D version 5.004. The filling may occur in stages and be an iterative process, however for simplicity in modelling, the fill was assumed to be a large, rectangular platform placed in one operation encompassing 105a-109a, and most of the 105 May Road properties. No assessment of the settlement associated with fill placement on 119 May Road has been undertaken.

5.1 Settlement Parameters

Settlement parameters have been determined from laboratory testing, boreholes, and experience in similar soils. The non-linear settlement parameters across a stress range of 25-50kPa are summarised in Table 4.

Table 4: Settlement Parameters

Layer Name	Cc	Cr	e0	Cc/(1+e0) %	Cv (m2/yr)
Existing Fill and Holocene Alluvium clayey silt (Units 1 & 2)	0.1	0.1	1.3	4.3	5
Peat (Unit 2a)	4.2	0.43	10.2	37.5	5
Organic silts (Unit 2b)	0.4	0.10	2.8	10.5	5
AVF Ash (Unit 4)	0.1	0.06	2	3.3	2
Puketoka Formation (Units 5a and 5b)	0.10	0.04	0.7	5.9	2
Residual Waitemata Group soils (Units 6a)	0.03	0.03	0.7	1.8	2

5.2 Expected Primary Consolidation

The analysis concluded that placement of a 2-metre layer of engineered fill would result in settlements in the range of 300 - 500mm localised to the area under and immediately adjacent to the constructed platform and maintain a platform above the design finished surface levels. Most of this settlement will occur in the soft to firm alluvium/organic (silt and peat) layers and existing fill near the surface. The magnitude of settlement is therefore sensitive to changes in the thicknesses of these layers which could vary across the Site. A plot showing settlement with depth is shown in Figure 7. Figure 7 also indicates that T90 (time for 90% of the settlement) will occur within 1-2 years of the completion of fill placement.

In the area where basalt rock is encountered at shallow depth (as seen in BH04), the magnitude of settlement is expected to be in the range of 25 - 50mm, due to the consolidation of the weak existing fill layer overlying the basalt. Because limited settlement occurs at locations where basalt is present, significant differential settlements (250-500mm) can be expected across the basalt contact. The extent of the basalt is not well defined at this time but appears to be limited to the eastern part of the Site.

An additional post filling load equivalent to two-storey building (say up to 20kPa) will result in a further 100-150 mm of settlement. The use of an additional 1 metre of temporary fill as a preload for 2 years would likely reduce post construction settlements to less than 25mm.

Further to this, groundwater drawdown resulting from the excavation for the stormwater pond could potentially dewater some of the peat resulting in additional settlement under the constructed platform. Previous groundwater levels have been recorded between 48.2 and 49.6mRL and a drawdown in the order of 0.5m is anticipated. Given the elevation for the top of peat identified during investigations was generally 47.0-48.5mRL) settlement resulting from dewatering of the peat is anticipated to be minor relative to the significant settlement already estimated from the platform load.

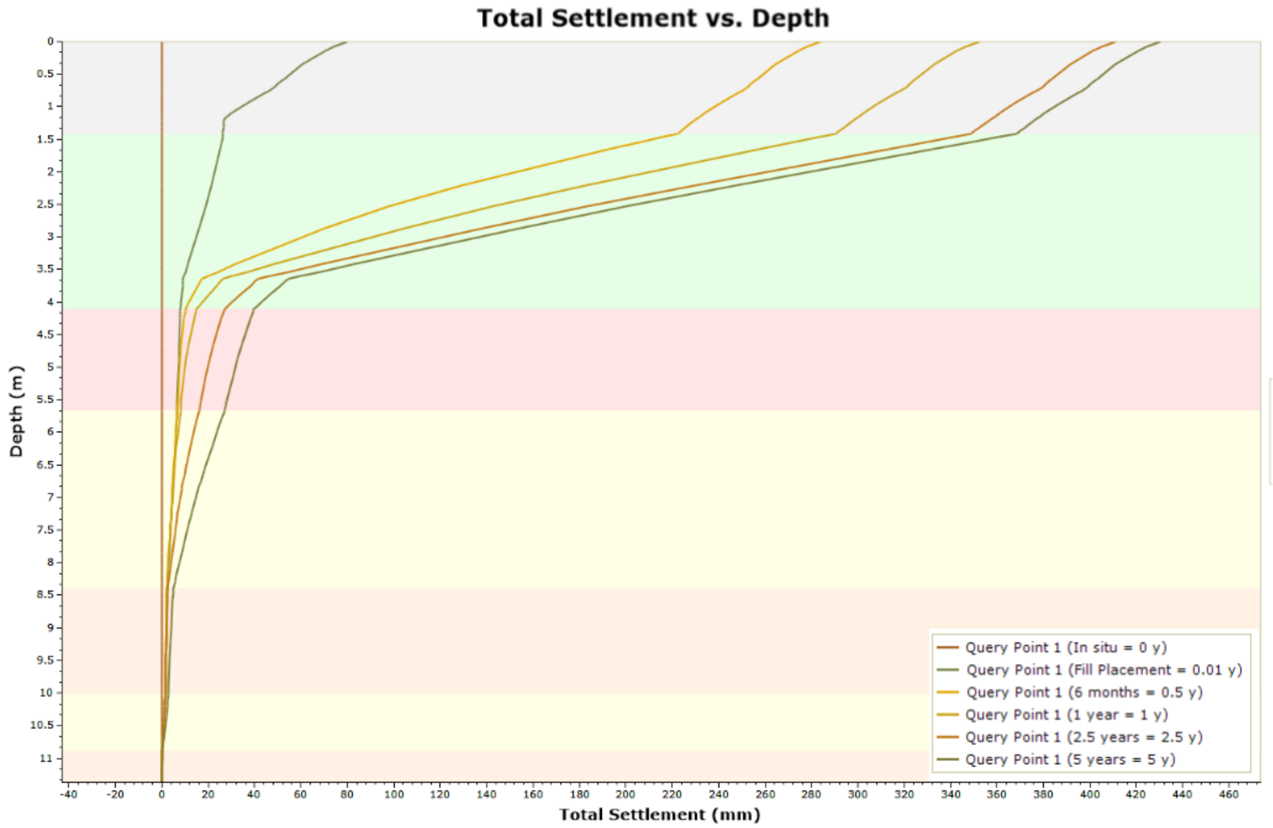


Figure 7: Total settlement with depth over time. Output from Settle3D analysis.

5.1 Secondary Consolidation

The Site is underlain in areas by organic rich silts and peats. These soils are susceptible to secondary consolidation. Secondary consolidation is related to the physical breakdown of materials and therefore occurs over considerably longer timeframes than the primary consolidation and is often referred to as creep settlement. Given the high organic content (Laboratory test result =60% of dry mass) in the peat unit present across the Site, it is likely secondary consolidation will occur. This will increase the magnitude of expected settlement and the time frame over which settlement will occur. Short of removal of the organic matter there is little that can be done to prevent this and structures will need to be specifically designed to cope with this ongoing settlement in foundation design.

6 Seismic Design

6.1 Site Subsoil Class

Based on the strength of the near surface soils and depth to Waitemata Group rock, a site Subsoil Class C has been determined in accordance with Table 3.2 of NZS1170.5:2004 (Standards New Zealand, Structural Design Actions – Part 5: Earthquake design actions – New Zealand).

6.2 Peak Ground Accelerations and Earthquake Magnitudes

For liquefaction analysis, the following parameters have been adopted;

- Design life – 50 years
- Importance Level (in accordance with NZS 1170.0:2002 (Standards New Zealand, Structural Design Actions – Part 0: General principles) – IL3 (Multi occupancy Industrial/Commercial)

Table 5 below presents the peak ground accelerations (PGA) for the Serviceability Limit State (SLS) and Ultimate Limit State (ULS) derived in accordance with NZS1170.5. In all cases an earthquake magnitude (M_w) of 7.5 was adopted .

Table 5: Summary of Horizontal Seismic Loading for Subsoil Class C (Based on NZS1170.5)

Design Event	Annual Probability of Exceedance	Return Period Factor (Ru)	Hazard Factor, Z	PGA (g)
SLS	1/25	0.25	0.13	0.04
ULS	1/1000	1.3	0.13	0.22

6.3 Liquefaction

The potential for liquefaction induced settlement has been assessed using SPT strength values in conjunction with laboratory testing results. Laboratory tests indicated that the AVF – Ash and also the sandier Puketoka Formation materials may be potentially liquefiable, based on their Plasticity Index (PI) values. The determination of potentially liquefiable units is defined by Ministry of Business, Innovation and Employment (2016)[6] as having a PI <12, with liquefiable units possessing a PI <7. In both cases the AVF – Ash and Puketoka Sandy Silts have PI values >7 but <12. Where laboratory testing was not undertaken on a unit e.g. fill, the material was treated as potentially liquefiable if the description suggested a high granular content.

The likely magnitude of liquefaction settlement was determined for BH01 and BH03. With BH03 representing a more conservative scenario, with the greatest thickness of soils, and in particular the greatest thickness of AVF – Ash material observed during investigations.

Results show:

- Under the SLS event, both boreholes indicated there would be no liquefaction induced settlement.
- Under the ULS event, BH03 indicated 100 - 150 mm of settlement could be expected, while BH01 was slightly lower at 80 - 100 mm.

[6] MBIE 2016, Earthquake geotechnical engineering practice, Module 3: Identification, assessment and mitigation of liquefaction hazards.

For detailed design of structures to be built on Site, specific Cone Penetrometer Tests (CPTs) are recommended to better quantify the liquefaction potential of the soils.

6.4 Cyclic Softening

A review of cyclic softening potential of the soils was undertaken using borehole shear strength measurements comparing with cyclic shear strength (CSS) in accordance with Idriss and Boulanger (2014)[7]. From this analysis with the limited shear vane strength values available, no unit indicated a propensity for cyclic softening under the SLS or ULS event. Similar to liquefaction, additional CPT testing for detailed design of structures is recommended to confirm these initial findings.

[7] Boulanger, R. W., & Idriss, I. M. (2014). Report No. UCD/CGM-14/01: CPT and SPT based liquefaction triggering procedures. Centre for Geotechnical Modelling, Department of Civil and Environmental Engineering. Davis, CA: University of California

7 Development Considerations

A significant thickness of soft, compressible material exists across the Site at a shallow depth. As a result, significant settlement will occur when loaded (e.g. when the proposed engineered fill is placed as well as when future structures are constructed). The majority of this settlement is expected to occur within 2 years of final placement. Issues that should be considered with respect to future development are set out in sections below.

7.1 Filling and Earthworks

Watercare is currently leasing part of the Site (105 May Road) until 2030 from May 1 Limited to facilitate construction of the Central Interceptor project. Watercare's contractors are currently in control of the area. Prior to the establishment of the final proposed works construction activities planned for the 105 May Road property include site offices, truck access, and earthworks to create working platforms and stormwater management areas. Watercare is responsible for any land distributing activities during the lease period including obtaining necessary consents and carrying out land contamination and geotechnical investigations. When the property of 105 May Road is vacated it is anticipated that the site will not be returned in predevelopment condition but handed back to May Road Property Limited who will arrange completion of the earthworks to the final form shown in Figure 2.

Earthworks and construction monitoring should be undertaken to ensure the engineered fill achieves the required density and strength as outlined in the earthwork specification. The specification previously provided (Appendix C) gives an indication of the standard that should be applied. This would be more easily achieved during the summer months (earthworks season from 1st October to 30th April).

Proposed filling should include an additional contingency to compensate for elevation loss as a result of the settlement (300-500mm). It is recommended that when the fill is placed settlement monitoring be undertaken, with more fill placed if required to meet the design levels. Provided sufficient survey points are used, monitoring settlement (including visual assessment) of the initial fill emplacement could potentially be used to identify the extents of basalt, defined by areas exhibiting less settlement.

The deeper cuts shown in Resource Consent drawings are positioned in areas not investigated as part of this assessment. They are located within 105 May Road which is currently leased to Watercare for construction of the Central Interceptor and therefore not accessible for investigation. Those areas will require specific investigations and design. Cut slopes in the stiff residual ECBF soils, such as those inferred on the western edge of the site (See Figure 6), are generally not cut steeper than 3H:1V, slopes in Tauranga Group alluvium are often not steeper than 5H:1V. Steeper slopes could be achieved through additional engineering measures such as retaining walls. Specific investigation, analysis, and design will need to be undertaken to determine appropriate slope profiles and/or remedial measures.

All cut slopes deeper than 1m should also be subject to specific investigation and stability analyses during detailed design to determine the factors of safety. Cut slopes close to the boundary should assume a 12kPa surcharge loading on the boundary. Factors of safety for long term slopes should exceed 1.5, with temporary cases such as elevated groundwater exceeding 1.3.

The lowest recorded groundwater level observed at the site was 48.2mRL recorded in PZ01 during March 2021 (Refer section 4.4) and groundwater levels up to 49.6mRL have been observed in the same piezometer during winter months. Excavations are currently proposed below these levels (47.75mRL within 50m vicinity of PZ01) and are likely to encounter groundwater and may require short-term pumping or gravity drainage (i.e. sump and pump) to facilitate construction. The effects of this is discussed further in Section below.

Care should be exercised in the design of erosion and sediment control ponds as storage volume may not be available below the groundwater table.

7.2 Groundwater Considerations

Excavation works have been identified as occurring up to approximately 0.5m below the seasonal low groundwater levels recorded since January 2021. This will necessitate dewatering activities and may result in some groundwater drawdown effect.

Whilst the diversion of groundwater (i.e. the change in level that will result from any dewatering) is expected to meet the Permitted Activity standard of E7.6.1.10, the duration of the dewatering activities will likely extend for more than 30 days. Therefore, the duration of the groundwater take will not be compliant with Auckland Unitary Plan (AUP) Standard E7.6.1.6 and a consent will likely be required.

An assessment of groundwater effects (Beca, 2020) resulting from dewatering activities has been undertaken to facilitate Watercare's construction of the deep Central Interceptor shafts in the adjacent property of 54 Roma Road. The resulting drawdown was modelled to be at least 2m within the alluvium and ECBF soils, and up to 5m within the ECBF rock material at the location of the excavation works proposed as part of this Resource Consent application.

The 0.5m drawdown resulting from the proposed excavation in this application, is much smaller than the drawdown previously assessed for the Central Interceptor project in this area. Given that the Central Interceptor shafts are expected to be sealed from late next year, and we understand there has been negligible drawdown in the shallow soils to date, cumulative effects are not expected.

Given the very small drawdown (< 0.5 m) the effect of the groundwater take is likely to be no more than that if the take were a Permitted Activity but regardless, an assessment of effects against the matters for discretion as outlined in E7.8.1 is as follows:

Table 6: Drawdown Effects Considerations

Matter For Discretion		Effect
(6) (a) (i)-(iii), (xi)	Effects on surface water bodies	Natural surface water bodies are located ~1km distance from the site and outside the zone of calculated drawdown. Surface water bodies on the site are stormwater drainage channels and would not be adversely affected by drawdown.
(6) (a) (iv)	Effects on existing lawful groundwater takes or diversions	The ECBF is a low yield material and unlikely to support groundwater wells. 0.5 m drawdown is unlikely to adversely affect any wells.
(6) (a) (v)	Effects on groundwater pressures, levels or flow paths	Any changes to groundwater level will be < 0.5 m and are not expected to change the overall flow and direction of groundwater.
(6) (a) (vi)	Effects of ground settlement on existing buildings, structures, and services.	Drawdowns anticipated to facilitate these construction works are considerably smaller than those estimated for the Central Interceptor works. Drawdown induced consolidation settlement resulting from 0.5m of drawdown is expected to be negligible and well within the range already assessed, but not realised as a result of the Central Interceptor construction activities. Neighbouring existing structures are founded on ECBF residual soils or in areas where surrounding investigations (TP207, TP101, TP109, TP110) suggest have minimal (i.e <0.6m peat present) at elevations above observed groundwater levels or below excavation depth/anticipated drawdown level.

(6) (a) (vii)	Effects on surface flooding	The works described here are to control flood risk and will not raise the groundwater level to the surface. As such, there is no potential for flooding of, or damage or nuisance to other properties.
(6) (a) (viii)	Cumulative effects of groundwater diversion in the area	As there are negligible long-term changes in groundwater level anticipated, there are not expected to be any cumulative effects.
(6) (a) (ix)	Effect of discharge of groundwater containing sediment or contaminants	Appropriate controls to be implemented in accordance with the site-specific Contaminated Soils Management Plan (Beca, 2022) and in compliance with the General Standards specified under the AUP-op and any relevant consent conditions.
(6) (a) (x)	Effects on scheduled heritage places	There are no scheduled historic places within the zone of influence of any works that extend below the groundwater level.
(6) (b)	The need for dewatering for mineral extraction activity.	Not applicable to this application.
(6) (c)	Monitoring and reporting requirements	Given the very small drawdown no specific monitoring is proposed.
(6) (d)	The duration of the consent and the timing and nature of reviews of consent conditions.	Not considered necessary
(6) (e)	The requirements for and conditions of a financial contribution or bond	Not considered necessary
(6) (f)	The requirement for a monitoring and contingency plan or contingency remedial action plan.	Not considered necessary

7.3 Foundations

7.3.1 Shallow Foundations

Additional settlement will occur on placement of additional loads on the fill. Where a light, one or two storey development is proposed, shallow foundations within the placed engineered fill would likely be applicable. In most instances it would be practical to preload the ground with a surcharging load (fill) over the footprint of proposed building locations. This would induce additional settlement before construction and, after removal of the fill, minimise settlement in the completed structure. Any surcharge load should be left in place for as long as possible prior to building construction, but at least 2 years is estimated to achieve approximately 90% of the total settlement.

For any building proposed to straddle the interface between basalt and alluvium the potential for differential settlement is significantly increased, requiring more specialised foundation design. Where possible this should be avoided.

7.3.2 Deep piles

Should larger structures be desired, piles could be used to support the structure. Piles would likely be founded in competent rock material, either East Coast Bays Formation (ECBF) or basalt. From the investigations undertaken the ECBF rock level is shallowest on the western edge of the Site (14.0 mbgl in BH01), increasing in depth to the east, with a possible paleo-valley running from west to east through the centre of the Site (17.0mbgl in BH03).

The basalt encountered during investigations is likely thick enough to serve as a sound founding stratum however the limited lateral extent that was encountered in these investigations indicate there may be few locations on the site where this is possible. Any basalt would need to be better proven by additional investigation for piling design. Rock level should therefore be considered when planning the positioning of future large structures.

Because of the presence of significant peat layers, additional testing may be required during design for acid sulphate soils to quantify the corrosivity of the soils and their interaction with piled foundations. The oxidation of sulphate rich organic layers, creating acidic conditions, can be increased by groundwater drawdown which could occur during excavation works in the adjacent Watercare land for the Central interceptor Project. If the soils are found to be corrosive, this will need to be accounted for in the design of all subsurface concrete structures.

7.4 Site Development

The following general commentary is provided with respect to site development.

7.4.1 Site Preparation

- Tree stumps and any other obstructions are to be removed and locations over excavated and fill compacted to engineering standards;
- Non-engineered fill should not be placed on the Site;
- Earthworks should be graded at least 1V:200H to allow for surface water runoff;
- Any proposed fills and cuts greater than 0.6m in height should be reviewed by an experienced geotechnical engineer.

7.4.2 Road Design

- For preliminary pavement design a Californian Bearing Ratio (CBR) of 3% is recommended for pavements constructed on cohesive engineered fill. Verification of the subgrade strength should be undertaken during construction, any material not meeting this requirement should be undercut and replaced with GAP65 aggregate.

7.4.3 Retaining Walls

- All retaining walls proposed are to be subject to additional specific ground investigations to inform their design;
- Retaining walls will require specific design undertaken by a qualified engineer which includes appropriate surcharges, provision for elevated groundwater, and seismic loading conditions.
- For retaining walls founded on engineered fill material with no backslope, we propose the following parameters for design; K_a =0.3, K_p = 3, K_o = 0.5.

7.4.4 Underground Services and Trenches

- All underground services should be backfilled with well compacted material;
- Excavations within the roads should use granular fills and fills outside road or pavement areas may use well compacted cohesive fills above the level of the pipe/ducts;
- Development over service trenches should be restricted;
- Perched or raised groundwater levels during winter months could cause problems with trench construction. Subsoil drainage, pumping or stabilisation of the trench sides may be required.

7.5 Construction Monitoring and Testing

Construction monitoring and testing should be undertaken throughout construction, according to technical specifications issued with design drawings.

The following are some of the main items that should be inspected, tested, and approved by an experienced geotechnical professional:

- Suitability of existing ground prior to engineered fill placement;
- Unforeseen ground conditions;
- Pile construction;
- Engineered fills at regular intervals;

Pavement subgrade prior to placement of granular layers.

All density testing is to be undertaken by an independent International Accreditation New Zealand (IANZ) accredited laboratory to be commissioned by the Contractor.

7.6 Sustainability

Sustainability considers the economic, environmental, and social impacts and responsibility of the development. A number of geotechnical and earthwork practises can improve the sustainability of developments. We recommend consideration of the following:

- Separate out materials recovered during demolition of existing structures for reuse when possible. This would include materials such as rocks, timber, roofing iron, glass, concrete. Many of these materials could be re-purposed into general hard fill or other engineering products.
- Any excavated local basaltic lava or scoria rock from the proposed development area could be re-use in the development as drainage material or hardfill.
- There is good potential to reduce truck movements for the earthworks by working with Watercare to reuse temporary platform hardfill from the Central Interceptor works as well as reusing inorganic soils derived from earthworks as structural fills where possible (potentially good fill sources a southwestern and north eastern boundaries).
- Reduce truck movements by stock piling on site.
- Collect and store rainwater for general use such as dust suppression and vehicle washdown during construction.
- Utilise remote monitoring when possible to reduce carbon emissions from travel. This can include CCTV monitoring of earthworks activities and drone surveys.

8 Conclusions and Recommendations

The results of the site investigations found a limited extent of basalt material on the north eastern boundary of the site, significantly less than indicated on published geologic maps. The majority of the site was instead underlain by soft, organic rich, recent alluvium material, with a portion of the western edge likely comprising of stiffer residual ECBF material. This residual ECBF material could be excavated and re-purposed as cohesive fill.

Because of the presence of soft organic material and loose sandy layers, much of the Site will be subject to significant settlement due to applied loads. This settlement is expected under and immediately adjacent to the proposed platform when additional fill is placed and to a lesser degree across the Site should liquefaction induced settlement occur during a significant earthquake event.

Excavation works up to approximately 0.5m below groundwater levels will necessitate dewatering activities and as the duration will likely extend for more than 30 days a consent will be required. Additional settlement resulting from 0.5m of drawdown is expected to be negligible.

The proposed future development includes placing engineered fill to raise the elevation of the majority of the Site by 1.0 - 1.5 m so that it is above the 1% AEP floodplain. The resulting platform is expected to settle 300 – 500 mm and will require additional fill to maintain the desired finished levels. Most (that is, the 90%ile) of the settlement is expected to occur within 2 years of the completion of fill placement. This should be confirmed by monthly settlement monitoring across the Site.

Additional settlements will occur due to the load of any structures when they are constructed, and specific foundation design is required. The risk to future development arises from both the total and the differential settlement that can occur over the footprint of the structure. Differential settlement is most significant across the interface between soft compressible soils and incompressible basalt. Investigations show such an interface is likely near the north eastern boundary of the site. Differential settlement can be costly to manage in structure design.

Our recommendation is to carefully consider the positioning of the structures at an early stage. The main considerations include:

- Position structures to avoid straddling the interface of areas of high settlement and low settlement to reduce the magnitude of differential settlement;
- Plan the position of lightweight structures and preload their locations to minimise the post construction settlements.

Regardless of positioning and development typology additional, ground investigations will be required to inform specific design of the foundations.

In general, development of the site is considered feasible, provided steps are taken to minimise the impact of these geotechnical risks.

9 Applicability Statement

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

This report is prepared solely for the purpose of the assessment of potential geotechnical conditions related to the proposed works (Scope). The contents of this report may not be used for any purpose other than in accordance with the stated Scope.

This report contains information obtained by inspection, sampling, testing or other means of investigation. Unless specifically stated otherwise in this report, Beca has relied on the accuracy, completeness, currency and sufficiency of all information provided to it by, or on behalf of, the Client or any third party, including the information listed above, and has not independently verified the information provided. Beca accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the information provided. Publicly available records are frequently inaccurate or incomplete.

This report should be read in full, having regard to all stated assumptions, limitations and disclaimers.

10 References

Beca (2020) Beca Central Interceptor - May Road: Assessment of Groundwater Effects

(2022) Geotechnical Factual Report - May Road Development

Beca (2022) Ecology Assessment - May Road Development

Beca (2022) Land Contamination Assessment - May Road Development

Beca (2022) Civil and Stormwater Study - May Road Development

Boulanger, R. W., & Idriss, I. M. (2014). Report No. UCD/CGM-14/01: CPT and SPT based liquefaction triggering procedures. Centre for Geotechnical Modelling, Department of Civil and Environmental Engineering. Davis, CA: University of California

Edbrooke, S. W. (2001). Geology of the Auckland area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited.

G.N.S Science (2020) Active Faults Database. https://data.gns.cri.nz/af/. Accessed on 20/11/2020.

Kenny, J. A., Lindsay, J. M., & Howe, T. M. (2012). Post-Miocene faults in Auckland: insights from borehole and topographic analysis. New Zealand Journal of Geology and Geophysics, 55(4), 323-343.

Standards New Zealand. (2002). NZ Standard 1170.0:2002 Structural design actions - Part 0: General Principles. New Zealand: Standards New Zealand.

Standards New Zealand. (2004). NZ Standard 1170.5:2004 Structural design actions – Part 5: Earthquake actions – New Zealand. New Zealand: Standards NZ.

A

Appendix A – Site Investigation Plan

N

Key

Machine Borehole

Test Pit

Site Extents

FOR INFORMATION
NOT FOR CONSTRUCTION

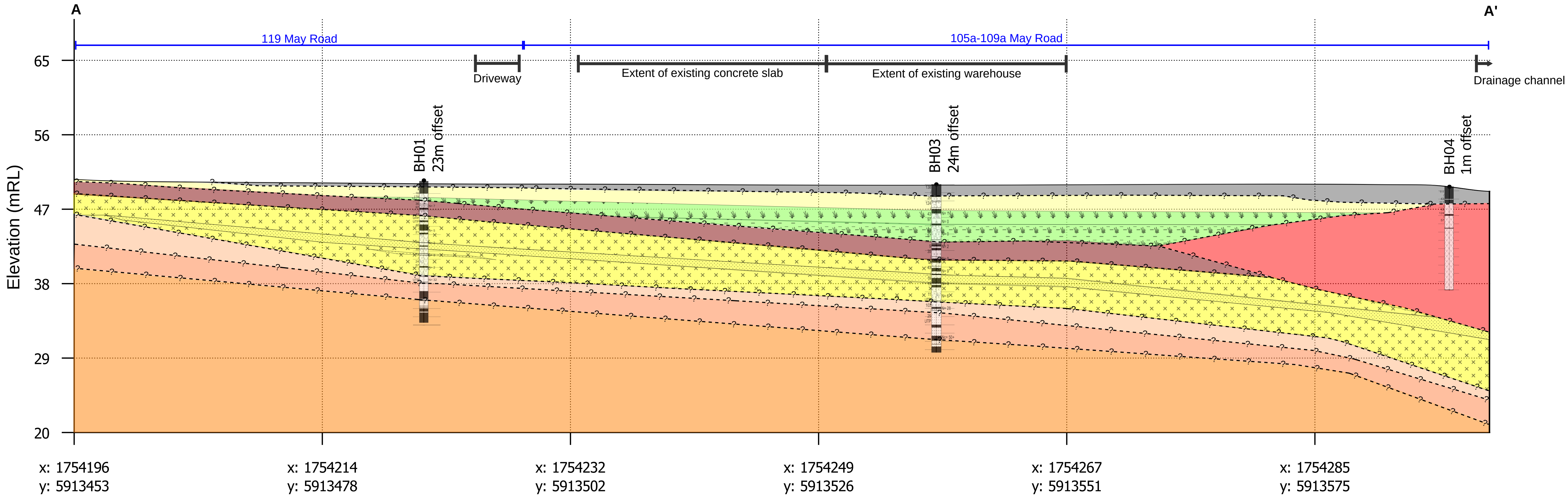
Beca

Client:	Project:	Title:		
May 1 Limited	105 May Road	Site Specific investigation Location Plan	Produced By: KAT Date: 02/02/2022	Scale: 1:2000 Project ID: 3126366

B

Appendix B – Geological Sections

SECTION A-A'



Location

A: 1754196, 5913453

A': 1754297, 5913592

Scale: 1:500 @ A3

Vertical exaggeration: 1x

0m 50m

LEGEND

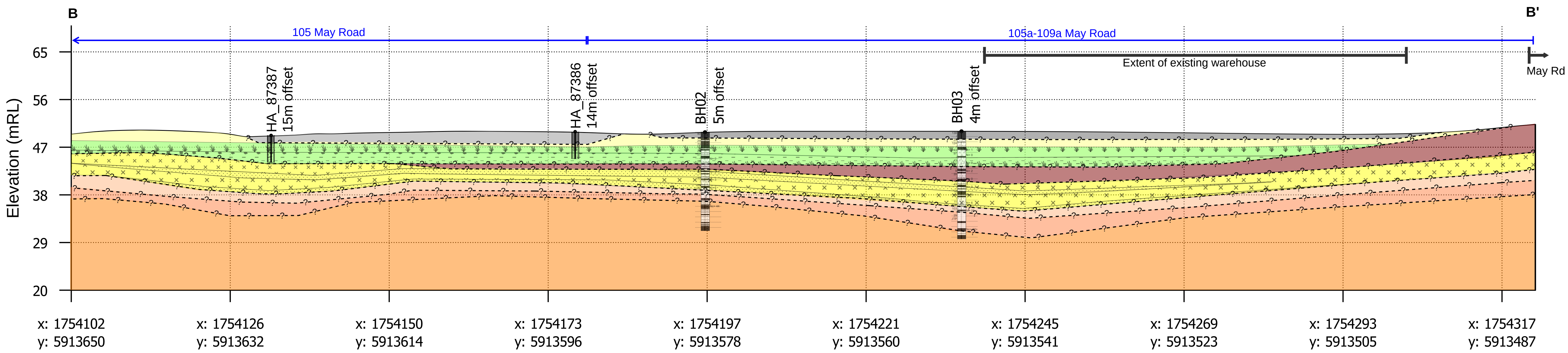
- 1 Fill
- 2 Holocene Alluvium/Swamp Deposits - Firm to Stiff Clayey Silt
- 2a Holocene Alluvium/Swamp Deposits - Soft to Firm Peat
- 2b Holocene Alluvium - Soft to Stiff Organic Silt
- 3 AVF Basalt - Moderately Strong
- 4 AVF Ash - Firm to Very Stiff Sandy Silts
- 5a Puketoka Formation - Stiff to Very Stiff Sandy Silts
- 5b Puketoka Formation - Firm to Stiff Clayey Silts
- 6a HW ECBF - Very Stiff Sandy and Clayey Silts
- 6b MW ECBF - Extremely Weak Sandstone and Siltstone
- 6c SW ECBF - Very Weak Sandstone and Siltstone

Project specific investigation

Publically available investigation

Figure Title: GEOLOGY GROUND MODEL SECTION A-A'		Date: 17/11/2020
		Drawn By: KAT
Beca	Job Name: MAY ROAD DEVELOPMENT	Client: MAY 1 LIMITED

SECTION B-B'



Location

B: 1754102, 5913650

B': 1754322, 5913483

Scale: 1:750 @ A3

Vertical exaggeration: 1x

0m 50m

LEGEND

- 1 Fill
- 2 Holocene Alluvium/Swamp Deposits - Firm to Stiff Clayey Silt
- 2a Holocene Alluvium/Swamp Deposits - Soft to Firm Peat
- 2b Holocene Alluvium - Soft to Stiff Organic Silt
- 3 AVF Basalt - Moderately Strong
- 4 AVF Ash - Firm to Very Stiff Sandy Silts
- 5a Puketoka Formation - Stiff to Very Stiff Sandy Silts
- 5b Puketoka Formation - Firm to Stiff Clayey Silts
- 6a HW ECBF - Very Stiff Sandy and Clayey Silts
- 6b MW ECBF - Extremely Weak Sandstone and Siltstone
- 6c SW ECBF - Very Weak Sandstone and Siltstone

Project specific investigation

Publically available investigation

N

1:3000

Figure Title: GEOLOGY GROUND MODEL SECTION B-B'		Date: 17/11/2020
		Drawn By: KAT
Beca	Job Name: MAY ROAD DEVELOPMENT	Client: MAY 1 LIMITED

C

Appendix C – Draft Earthworks Specification

DRAFT C0203 - EXCAVATION AND FILLING (INCLUDING TOPSOIL AND GRASSING)

C0203.1 DESCRIPTION

The work covered by this section includes but is not necessarily limited to the supply of all Labour, Materials and Plant for the clearing and removal of all obstructions within the limits of the earthworks (except where provided for otherwise), the excavation of cuts, including excavation below the final subgrade surface; the excavation of borrow areas, benches and surface drainage facilities; the carting of the excavated material to fill, stockpiles or waste; construction of the fills and subgrade; shaping; trimming, grassing and maintaining of the works; all in accordance with the drawings and specification.

C0203.2 PROJECT SPECIFICATION

.1 Scope

This section includes all bulk earthworks associated with achieving the final grading. It also includes ground improvements required prior to filling.

.2 Conditioning

It is anticipated that the fill material will need conditioning by either wetting or drying to achieve the required compaction levels. During the earthworks season the contractor shall allow to condition the fills by spreading, mixing and naturally drying or mechanically wetting.

Where a provisional quantity is included in the Schedule of Prices for lime drying of fill material, this will only be expanded on instruction by the Certifying Engineer (see section 203.5.8 for definition).

C0203.3 STANDARD SPECIFICATIONS

This Specification shall be read in conjunction with the following Standards, which are deemed to form a part of this Specification. In the event of this specification being at variance with any provision of the Standards, the requirements of this specification take precedence over the provision of the Standards. Reference to any Standard shall include any amendments thereto and any Standard in substitution, therefore. All materials and workmanship shall comply with these Standards unless expressly noted otherwise.

TNZ F/1:1997	Specification for Earthworks Construction
TNZ F/2	Pipe Subsoil Drain Construction
TNZ F/7	Specification for Geotextiles
NZS 4402:1986	Methods of Soil Testing for Civil Engineering Purposes (& Supplement 1:1988).
NZS 4404:2010	Land Development and Subdivision Infrastructure
NZS 4407: 2015	Methods of Sampling and Testing Road Aggregates
NZS 4431:1989	Code of Practice for Earth Fill for Residential Development

Construction work performed under this Specification shall also:

(a) Comply with the general requirements of the latest revisions of all other Standards and Specifications and Codes of Practice referenced in this Specification.

(b) Be carried out in full consideration of and in full compliance with the Resource Consents issued for this project by the Auckland Council and of any associated management plans.

(c) Be carried out in accordance with the "Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region June 2016 (Guideline Document 2016/005).

C0203.4 DEFINITION OF MATERIAL TYPES

.1 Engineered Fill

Defines material that makes up the filling to form final design contours where a high-quality engineered fill is required. Fill shall generally consist of Tauranga Group (firm to stiff clay, silts, sands) or East Coast Bay Formation material (very weak siltstone and sandstone rock) with no organics derived from excavation activities related to the Central Interceptor Project Fill material shall be cleanfill. Clean fill is defined by MfE (2002) as: *"Material that when buried will have no adverse effect on people or the environment. Clean fill materials include virgin natural materials such as clay, soil and rock, and other inert materials such as concrete or brick that are free from:*

- *Combustible, Putrescible, degradable, or leachable components.*
- *Hazardous substances.*
- *Products or materials derived from hazardous waste treatment, hazardous waste stabilisation or hazardous waste disposal practices.*
- *Materials that may present a risk to human or animal health such as medical and veterinary waste, asbestos, or radioactive substances.*
- *Liquid waste"*

Engineered Fill shall not contain unsuitable material, rubbish or topsoil .

Other materials may be used only with approval of the designer

Engineered Fill shall be placed with batter slopes no steeper than 3H:1V.

The grading of non-cohesive material used for Engineered fill shall be submitted to the designer for approval. Uniformly graded sands and gravels will not be acceptable. Where required the contractor shall blend on site materials prior to compaction.

.2 Unsuitable Material

Unsuitable material is defined as any soil which, because of its physical or chemical composition, strength and/or moisture content, is unsuitable to have fill constructed over it or cannot be satisfactorily reconditioned by wetting and drying for use as Engineered Fill. It shall include, unless approved by the designer:

- organic materials (excluding topsoil);
- Highly expansive clays;
- clay having a liquid limit exceeding 80 and/or a plasticity index exceeding 55;
- materials from swamp, marshes or bogs, running silt, peat, logs, stumps, perishable materials, slurry or mud;

- ashes or any materials containing compounds harmful to other elements of construction or the environment.

Unsuitable material can be placed in non-building platform area at the absolute discretion of the designer and shall be placed at batters no steeper than 5H:1V. The contractor shall not place unsuitable material within the site without the written approval of the Certifying Engineer.

.3 Rubbish

Rubbish is defined as inorganic material e.g. steel, concrete, plastic, refuse and other debris found during cut and fill operations. It shall also include soil which is contaminated e.g. by heavy metals, asbestos, hydrocarbons etc. All rubbish material is to be handled in a manner to reduce the hazard to human health and reduce the spread of contamination. Rubbish material is to be disposed of at an appropriate off-site disposal site e.g. approved landfill.

.4 Hardfill

Hardfill is defined as a well graded, durable, granular aggregate which meets specified grading, strength, and durability criteria as defined below.

Hardfill shall be GAP65 supplied from a quarry and shall consist of a well-graded granular aggregate. The aggregate shall be free from organic, calcareous, or other deleterious materials.

Hardfill shall have a minimum crushing strength of 130kN (NZS 4407:1991 test 3.10) and weathering quality grade of AA, AB, AC, BA. (NZS 4407:1991 test 3.11). Maximum Plasticity Index of the fines content is to be 10%.

The grading envelopes for GAP65 are shown on Table 203.4.4 below.

Table 203.4.4 – GAP65 Hardfill Grading Envelope Requirements

Sieve Size	% Passing by Weight
63 mm	100
37.5 mm	80 – 90
19 mm	50 – 70
9.5 mm	30 – 55
4.75 mm	20 – 40
2.36mm	15 – 30
1.18 mm	10 – 22
0.6mm	6 – 18

.5 Drainage Materials

Drainage material shall consist of NZTA F/2 filter material, GAP20, GAP50 free draining crushed stone, drainage materials shall be placed at the type and levels shown on the drawings.

GAP20 drainage material shall comprise of well graded clean gravel or crushed rock with non-plastic fines, minimum crushing strength of 80kN (NZS 4407:1991 test 3.10) and a minimum weathering quality grade of AA, AB, or BA (NZS 4407:1991 test 3.11). The material shall be clean and free from organic matter and other deleterious materials. The grading of the material shall fall within the following envelope (NZS 4407:1991 Test 3.8.1) and shall meet Table 203.4.5 and the maximum Plasticity Index of the fines content is to be 5%.

Table 203.4.5 - GAP20 Drainage Material Grading Envelope Requirements

Sieve Size (mm)	% Passing by Weight
20mm	100
9.5mm	60-100
1.18mm	15-45
0.6mm	0-25
0.15mm	0- 5

.6 Run of Pit Rock

Run of pit rock shall be non-plastic granular soils (sand or gravel) with a maximum fines content (i.e. passing a 0.075 mm sieve) of 12% and a maximum particle size of 100mm. This material may be approved for used in undercuts of low-lying areas where some groundwater may be present, and placement of cohesive fills is impractical. The Certifying Engineer may direct the contractor to use alternative hardfill materials, such as crushed basalt or imported processed materials.

C0203.5 GENERAL

.1 Drainage Control

All earthworks shall be carried out in a manner which prevents water from causing deterioration to the subgrade, formation, foundations, cut areas or fill areas.

Cut and fill areas shall be sloped and graded adequately so that they do not pond water or allow water to infiltrate.

All fill surfaces shall be graded and rolled at the end of each day's work to prevent any ponding and erosion. Prior to commencement of the following day's filling operations, the previously graded and rolled surface shall be scarified or worked to prevent the formation of sub-standard, or weak layers within the fill.

.2 Erosion and Sediment Control

The contractor is responsible for the design and implementation of all temporary works including the Erosion and Sediment control devices. Earthworks shall be undertaken in a controlled manner so that erosion of disturbed areas is kept to a practical minimum and eroded material is confined on site as far as possible. Haul roads shall be treated as disturbed areas. Stormwater from disturbed areas shall be directed to temporary silt ponds with erosion and sediment controlled in accordance with the Resource Consents and the Auckland Council guidelines listed in the section entitled "Standard Specifications", in this Specification.

Any necessary temporary silt control measures for a particular area of the Works shall be in place and operational before commencing any earthworks in that area. The silt control measures shall be adequately maintained throughout the period of any earthworks in that area. Wherever possible, clean water from catchment areas above any exposed earthworks areas shall be diverted around those areas in order to avoid contamination and reduce erosion.

.3 Dust Control

Water trucks shall be used as required during periods of dry weather to suppress dust on site.

.4 Earthworks Methodology Plan

Prior to the commencement of works on site, the contractor shall submit an Earthworks Methodology Plan to the Certifying Engineer. This plan shall address all aspects of the earthworks and shall include but not necessarily be limited to the following:

Programme/sequencing

Compaction and earthmoving equipment (type, details, number of)

Borrow area management

Material movement on site

Handling/mixing of fill materials

Drying and wetting methods

Areas used for drying/wetting

Proposed benching of fill/insitu ground

Identification, excavation, and backfilling of unsuitables

Testing/Quality control plan/schedule

Erosion and sediment control measures

Proposed locations for stockpiling

Stockpile management (wind, runoff, sediment etc)

Subgrade protection measures

Details of mulching and hydro seeding

Methodology for compliance with consent requirements

Installation of drainage

.5 Preservation and Maintenance

The contractor shall preserve and maintain all earthworks, including partially completed earthworks, and make good at no cost to the principal any earthworks which have deteriorated below the specified standards for any reason.

.6 Tolerances

Prior to any material movement, placement or excavation the site should be surveyed to define the current ground surface.

All earthworks shall be carried out to the lines, levels and grades shown in the drawings. The accuracy of surfaces to be overlain by specified pavement layers or concrete structures shall be such as to preserve the minimum thicknesses of the overlying layers. Subgrade tolerances shall be in accordance with TNZ F/1, other tolerances shall be as follows:

Earthworks Surface	Surface Tolerance
Foundations	0mm to -25mm
Batters	-75mm to +75mm
Top soiling	-25mm to +25mm
Other surfaces	-25mm to +50mm

Additionally, finished earthworks surfaces shall be of neat and regular shape, free of abrupt irregularities or low areas that could pond water.

.7 Construction Monitoring and Testing

Construction monitoring and testing shall be carried out as outlined in section C0203.12 of this document.

All testing is to be undertaken by an independent soils laboratory IANZ accredited for the appropriate tests and commissioned by the contractor.

.8 Earthworks Certification

The Certifying Engineer: an Auckland Council approved chartered geo-professional (CPEng/PEngGeol) is to:

Produce the Completion Documentation as laid out in NZS4404 section 1.8.10 and sign Schedule 2A Statement of Professional Opinion of Suitability of Land for Building Development as per NZS4404

Comply with the general requirements of NZS4431:1989 Code of Practice for Earth Fill, Auckland Council Code of Practice for Land Development, as well as any consent conditions such as those listed in the (earthworks) Resource Consent(s).

C0203.6 SITE CLEARANCE & DISPOSAL

.1 General

The work specified in this Section includes clearing, grubbing and removal of vegetation and debris within the designated limits of the Site and disposal on/off Site.

Except where provided for otherwise, it shall also include the demolition, removal and disposal of any structures or fences that obtrude into or encroach upon or obstruct the work.

The designer will designate by indication on the drawings all trees, shrubs, plants, and other objects to remain.

Vegetation and objects to remain shall be preserved free from injury or damage.

In fill areas, holes resulting from removal of obstructions shall be backfilled and compacted with suitable hardfill material.

.2 Construction

The contractor shall apply for and uplift all permits necessary and pay all fees in connection thereof lawfully demanded by the Territorial or other relevant Authority.

.3 Vegetation Clearance

The site shall be cleared of vegetation in stages (trimmed) in accordance with the drawings. Trimming shall include the removal of brush, roots sod, grass, sawdust, decayed vegetable matter and other deleterious material from the ground surface.

No clearance shall be done except where necessary to enable the Contract works to be carried out as detailed. No earthworks shall be carried out in any area until clearance has been completed in that area and approved by the Certifying Engineer.

All vegetation when cleared shall be stockpiled in a suitable location to be agreed with the Certifying Engineer.

Cut or scarred surfaces of trees or shrubs that are designated to remain shall be painted with an approved asphaltum based paint prepared especially for tree surgery.

.4 Topsoil Stripping

Topsoil shall generally be stripped and stockpiled in accordance with TNZ F/1:1997 and this specification.

Topsoil shall mean the surface layer of organic soil, which is suitable for respreading after completion of earthworks, and is suitable for the cultivation of grass. This does not include surface material that may be contaminated with hazardous substances e.g. asbestos. Contaminated surface material shall be considered rubbish as defined in section C203.4.1 of this specification and dealt with accordingly.

.5 Stockpiling

All excavated materials requiring temporary stockpiling shall be separately stockpiled by type as directed by the Certifying Engineer. Material stockpiled on site should be demarcated from existing underlying soil by placement of a geotextile or similar. The exposed surface of all stockpiles shall be compacted sufficiently or covered to prevent slumping, excessive erosion or wind-blown dust becoming a nuisance.

All stockpiles shall be formed in such a manner that they and the surrounding areas are well drained and are more than 20m away from watercourses with appropriate silt control measures installed in accordance with Section C0203.5.2. If any surface runoff from stockpiles of potentially contaminated material is directed towards streams/ drains, or if water is pumped from the stormwater pond to the streams/ drains then upon demobilisation from the site, the contractor is required to clean the drains and remove potentially contaminated sediment prior to exiting the site.

All stockpiles shall be either used in the works or removed from site and disposed of before the start of the maintenance period. Any material for disposal off site shall be tested to determine appropriate disposal classification (e.g. cleanfill, managed fill or contaminated fill) and the approval of the receiving facility granted prior to material removal off site.

C0203.7 EXCAVATION

.1 General

The contractor shall inform and satisfy themselves as to the character, quantity and distribution of all material to be excavated. The contractor shall immediately inform the Certifying Engineer of any deleterious material such as peat, running sand, buried vegetation, groundwater flows, organics soils, non-engineered fill, refuse.

The contractor shall not excavate beyond the designated profiles without specific instruction from the Certifying Engineer. Any unauthorised excavation beyond the designated profiles shall be made good at the contractors expense using the materials and methods instructed by the Certifying Engineer.

At all times the excavation shall be maintained with adequate falls and drainage to minimise any penetration of water and to allow the ready runoff of water incident thereon.

If it is necessary to interrupt existing surface drainage or under drainage, the contractor shall be responsible for providing temporary diversions. When such features are encountered, the contractor shall notify the Certifying Engineer.

Excavation shall be performed as indicated on the drawings to the lines, grades and levels shown or as directed by the Certifying Engineer and shall be made so that the requirements for construction of fills and the subgrade can be followed.

Excavations shall be undertaken from the top down so as not to reduce the stability of the slope. The Certifying Engineer requires to inspect cuts as they proceed (at a maximum of 3m vertical height) to determine if additional subsoil drainage and/or slope stabilisation is required. A minimum 24 hours' notice is to be provided for these inspections. Where drainage has been specified this shall be installed without delay.

.2 Management

The earthworks shall be managed so the best material available is reserved for use as Engineered Fill based on the available geotechnical investigation results. In particular the contractor should assess the volumes of different materials available, their locations relative to proposed fill areas, the need for stabilisation/conditioning and the degree of drying and conditioning required for the various materials.

.3 Formation Testing

Formation testing shall be undertaken prior filling (stripped ground prepared for filling). Testing is to comprise of Scala penetrometer or hear Strength testing as outlined in Table 203.7.3.

Subgrade testing is to be undertaken as per section 203.10.

Table 203.7.3 - Test on Formation

Test	Standard	Frequency	Acceptance Criteria
Scala Penetrometer	NZS 4402 Test 6.5.2	One test per 400m^2 or a minimum of 3 per 1000m^2. Tests to be taken to a depth of 1m.	Designer for approval prior to filling
Shear Strength	NZ Geotechnical Society guideline	One test per 400m^2 or a minimum of 3 per section[1]. Tests to be taken to a depth of 1m at 200mm vertical centres.	Designer for approval prior to filling
Proof Roll	Inspection by Certifying Engineer	Full Coverage	Designer for approval prior to filling

C0203.8 UNDERCUTTING OF UNSUITABLE MATERIAL

The contractor shall carry out testing to establish the suitability and load bearing capacity of in-situ materials exposed in, and underlying, excavated surfaces, and surfaces of areas stripped of surface soil on which earth fills, pavements or structures are to be built. Such testing may include proof rolling, test pits, shear vanes and Scala penetrometer testing.

Material with a corrected undrained shear strength of less than 50 kPa i.e. “soft” to firm material shall generally be undercut and removed.

The contractor shall draw the Certifying Engineer’s attention to any suspected unsuitable material. The Certifying Engineer will determine whether the material is unsuitable or not and agree the extent of the unsuitable material with the contractor.

Identification of unsuitable materials where filling is proposed shall be by visual inspection and testing methods as specified within this specification and on the drawings.

Identification of unsuitable materials in areas of cut where pavements or structures are proposed shall be by visual inspection and testing methods as specified within this specification and on the drawings.

The contractor shall excavate unsuitable materials from such areas, to such depths as specified or instructed by the Certifying Engineer. The resulting excavation shall be backfilled with materials as directed by the Certifying Engineer and shall be placed and compacted in accordance with this specification.

The unsuitable material shall be removed to an approved disposal area for temporary storage as shown on the drawings or as directed by the Certifying Engineer. Unsuitable material shall be laid, graded and rolled in uniform layers not exceeding 300mm thickness to result in a self-draining, tidy area.

C0203.9 FILLING

.1 Compaction: General

Compaction of fill layers shall be carried out uniformly using systematic procedures with generally horizontal layers, to ensure that each loose layer achieves the required compaction criteria before further material is placed.

.2 Conditioning and Spreading of Fill

Prior to compaction, the fill materials shall be spread uniformly in horizontal layers and, if necessary, uniformly conditioned to an appropriate water content by aeration and drying or wetting (as the case may be), and/or by blending and mixing “wet” and “dry” materials. When soil is to be dried, the contractor shall disc the soil and allow it to dry uniformly to its full depth. When the soil is to be wetted, this shall be done with sprinkling equipment ensuring uniform and controlled distribution of water in conjunction with blading and disking. In all cases the fill shall be mixed and conditioned thoroughly so that immediately prior to compaction the material type and the water content of the fill is reasonably uniform within one area and at the Optimum Moisture Content (OMC).

For Cut to Fill, material shall be compacted in layers of less than 200mm thickness with fragments of less than 100 mm maximum dimension.

For Hardfill, material shall be compacted in layers greater than 1.5 times and no thicker than 2.5 times the maximum particle size of the aggregate, or as determined by compaction trials.

No new fill shall be placed over previously placed fill that has not achieved the required standard of compaction, or has become contaminated, or has deteriorated from the required fill standards. Previously placed fill that does not comply shall be removed or reworked by scarifying, conditioning and recompacting so as to meet the specification or alternatively it shall be removed and replaced with complying material.

Where fill is to be placed against sloping surfaces 4(H) to 1(V) or steeper, then the sloping surface shall be excavated or "benched" such that horizontal benches at no greater than 1.0 m height intervals are formed.

Where different fill types are placed within the same fill embankment e.g. Drainage aggregate beside Engineered Fill, the two fills types shall be constructed and brought up at the same rate as much as possible. Different adjacent fill types shall at no time have a difference in level of more than 1m, unless approved by the designer.

In order to ensure adequate compaction of the materials forming the final fill surface profile, all fill batter faces shall be overfilled and trimmed back to the required design profile.

.3 Borrow Materials

Borrow areas shall be at locations determined by the Certifying Engineer, the use, depth, location and dimensions of any borrow areas shall be subject to the approval of the Certifying Engineer.

Borrow areas shall be cleared and stripped of topsoil in accordance with this specification. The borrow areas shall be kept drained as far as is practicable, and the work shall be executed in a neat and workmanlike manner. On completion all borrow areas shall be drained and profiled to the approval of the Certifying Engineer. Any re-profiling instructed by the Certifying Engineer shall be at the contractor’s expense. Following the Certifying Engineer’s approval, the areas shall be left in a presentable condition with all slopes dressed uniformly and grassed.

The Certifying Engineer shall inspect the cut materials to confirm their suitability.

.4 Compaction around Monitoring Instrumentation

Care shall be taken when filling near monitoring instrumentations and other structures (e.g. any buildings). Fill placed within 1m of monitoring instrumentation or other structures shall be placed with care using suitable equipment and hand effort to ensure good compaction. Fill placed in these areas shall be placed in 100mm thick layers.

.5 Testing of Fill Source Materials

The contractor shall carry out laboratory tests on representative samples of the fill materials. The locations of the soil samples are to be as directed by the Certifying Engineer. The minimum number of tests shall be according to Table 203.9.5 below.

Table 203.9.5 : Fill Source Material Tests (prior to construction)

Fill Material[3]	Parameter	Test	Frequency
Cohesive soil	Maximum Dry Density Optimum moisture content[2]	NZS 4402 Test 4.1.1	3 of each test per source[1]
	Liquid Limit Plastic Limit Plasticity Index Solid Density	NZS 4402 Test 2.2 NZS 4402 Test 2.3 NZS 4402 Test 2.4 NZS 4402 Test 2.7.2	
Non-cohesive soil	Maximum Dry Density Optimum moisture content	NZS 4402 Test 4.1.2	3 of each test per source[1]
All	In-situ moisture content	NZS 4402 Test 2.1	Each sample tested above

1. A source shall be defined where a consistent fill material is supplied. Any changes in the nature of the fill material excavated from such an area shall constitute a new source.

2. Vane Shear Strengths shall be measured at each moisture content.

3. Test reports shall include soil descriptions in accordance with NZGS 2005 Field Description Guidelines.

.6 Hardfill– Compaction and Test Frequency

The contractor shall be responsible for ensuring that all fill meets the requirements of this specification and shall carry out such testing as is needed to ensure the consistent quality of the fill. The minimum testing requirements of this specification are presented in Tables 203.9.6 below.

Table 203.9.6: Tests Source Material Tests before and After Compaction – Hardfill		
Test	**Standard**	**Frequency**
Compaction	Min 95% MDD based on NZS 4407:2015, Test 4.3	1 test per 500 m^3 of hardfill placed and at least 1 test per 0.5m depth of hardfill per fill area worked
Crushing Resistance	NZS 4407:2015, Test 3.10	1 per source per material type.
Weathering Quality Index	NZS 4407:2015, Test 3.11	1 per source per material type.
Particle Size Distribution	NZS 4407:2015, Tests 3.8.1	1 per source per material type.
Maximum Dry Density & OMC determination (Vibrating)	NZS 4402:1986, Test 4.1.3	1 per source per material type.

CO203.10 COMPACTION STANDARDS AND TESTING

.1 General

The fill placement and compaction shall be in accordance with NZS4431, except where modified in this specification.

Where drying is necessary this shall be accelerated by aeration. The method adopted shall avoid segregation of the material.

Fills placed against ground steeper than 1V:4H shall be benched into the existing ground.

The tests and testing frequency described and defined in this section will be used to confirm the classification and compaction standards of the fill materials.

Approximate or other test methods may be employed to obtain rapid indicative results, but such methods shall not be used for final acceptance purposes unless approved by the designer.

The locations and levels of tests within the fill shall be recorded within tolerances of 0.2 m horizontally and 0.1 m vertically and shown on a scale plan of the whole site.

All testing, both in-situ and laboratory, are to be carried out using an IANZ accredited testing organisation, with all equipment calibrated to relevant standards and required frequency.

.2 Testing of Compacted Engineered Fill

The Certifying Engineer may temporarily suspend earthworks operations in any area in order to determine by site testing if the specified compaction is being achieved.

The contractor shall be responsible for ensuring that all fill meets the requirements of this specification and shall carry out such testing as is needed to ensure the consistent quality of the fill. The minimum testing requirements of this specification are presented in Tables 203.10.2 below.

Table 203.10.2a : Tests During Construction – Cohesive Fill

Location	Test	Standard	Frequency
Compacted Engineered Fill (as indicated on the Drawings)	Surface Levels	Topography survey	10m grid on finished surface only
	Density Moisture Content Air voids Scala Penetrometer	NZS 4407 Test 4.2.1 NZS 4402 Test 2.1 Calculated from above NZS 4402 Test 6.5.2	1 set of these tests per 900m^3 per layer Scala to 0.9m at density test locations
	Vane shear strength	NZ Geotechnical Society "Guideline for handheld shear vane test" (2001)	20m grid[1] for each 1m height of fill, and 200mm below final level
	Standard Compaction test Solid density	NZS 4402 Test 4.1.1 NZS 4402 Test 2.7.2	1 per 10,000m^3 placed and 1 per fill/borrow type

Table 203.10.2b : Tests during Construction – Non-Cohesive Fill

Test	Standard	Frequency
Surface Levels	Topography survey	10m grid on finished surface only
Density Moisture Content Air voids Scala	NZS 4407 Test 4.2.1 NZS 4402 Test 2.1 Calculated from above NZS 4402 Test 6.5.2	1 set of these tests per 900m^3 per layer
Heavy compaction	NZS 4402 Test 4.1.3	1 per 5000m^3 placed, and 1 per fill/borrow type
Proof Roll	Refer note 2	Each 1m height of fill

Notes:

1 The testing shall be carried out in accordance with an agreed grid system. Each test shall be reported with the grid number and the RL for reference purposes or the survey coordinates and levels be provided.

2 The proof rolling shall be by a grader, a fully loaded truck, motor scraper, or similar plant item approved by the Certifying Engineer.

The test results for each 1.0m lift height of fill are to be provided in a clear and legible format to the Certifying Engineer promptly, within 3 working days of test completion. No additional fill is to be placed until the Certifying Engineer has reviewed the results and given approval for filling to recommence.

Notwithstanding the reviewing of the results by the Certifying Engineer, the contractor shall also check the test results immediately and carry out whatever remedial action is necessary. All non-complying test results shall be reported. Where a test result does not comply with the specification the whole area affected shall be reworked, retested and these results forwarded to the Certifying Engineer. These results shall clearly state that they are retests and reference the original test results that they supersede.

The test shall be performed, and results reported in accordance with an agreed grid system and these results shall also include the approximate RL of each test.

.3 Acceptance Criteria

The acceptance criteria for the compacted fill are given in Tables 203.10.3 below.

Table 203.10.3a : Acceptance Criteria – Cohesive fill

	Engineered Fill
Air voids	12 % maximum
Vane shear strength	Average to be > 140 kPa No single value to be < 120 kPa
Scala penetrometer	3 blows / 100mm
Proof Roll	No visible deflections

Table 203.10.3b : Acceptance Criteria _ Non-Cohesive Fill

	Bulk Fill
Maximum dry density	Minimum 95% maximum dry density (MDD) NZS 4407 Test 4.2.1
Scala penetrometer	5 blows / 150mm
Proof Roll	Refer TNZ F/1 clause 10.5.1

C0203.11 ROAD PAVEMENT SUBGRADE

.1 Subgrade Protection

The contractor shall be responsible for the protection and care of the subgrade at all times, particularly during wet weather, and shall provide at no extra cost all necessary temporary drains to affect such protection. The whole of the subgrade shall be kept graded at all times to ensure that no areas pond water.

The contractor shall protect the subgrade from damage by overfilling/cutting above the final subgrade level, with a final cut to subgrade level immediately (1 day) prior to placement of pavement.

In no case shall vehicles be allowed to travel in a single track. If ruts are formed, the subgrade shall be reshaped and recompacted. Storage or stockpiling of materials on the top of the subgrade shall not be permitted.

Should the Certifying Engineer consider that the contractor has not fulfilled his obligations to the extent that softening of, damage to or failure of the subgrade occurs and that, in the opinion of the Certifying Engineer remedial measures are necessary to restore the subgrade and any subsequent work to their original condition, the contractor shall carry out such remedial works at no cost to the principal.

.2 Testing of Subgrade

The subgrade shall be inspected and tested by the contractor immediately before the construction of any overlying layer. The testing shall be carried out from the finished surface of the subgrade and all preloads or other overlying layers shall be removed prior to the testing.

(a) Fill Sections

Testing of the fill sections of the subgrade shall be carried out at the frequencies and to the acceptance criteria given in Table 203.11.1.

Table 203.11.1 : Tests on Fill Subgrade

Test	Standard	Frequency	Acceptance Criteria
Surface Levels	n/a	10m intervals/lane	Refer TNZ F/1 clause 11.2.2
Straight edge	TNZ F/1	Continuous	Refer TNZ F/1 clause 11.2.1
Dry Density Moisture Content Air voids	Refer Tables 203.10.2	10m intervals/lane	Refer Table 203.10.3 for cohesive fill
Scala Penetrometer	NZS 4402 Test 6.5.2	10m intervals/lane to a depth of 1m	Minimum 3 blows / 100mm for subgrade and compacted fills.
Proof Roll	Refer Table 203.2	Continuous	No visible deflections

Should any area fail to meet the above criteria, the contractor may elect to wet or dry the fill materials, rework and apply additional compactive effort to the top of the subgrade layer and then perform further testing.

Should any area still fail to meet the above criteria, additional tests shall be carried out at closer intervals as directed by the Certifying Engineer to define areas of weak subgrade. The Certifying Engineer may then direct that the contractor arrange for further testing to be carried out on the weak subgrade to verify that:

The subgrade material is as specified.

The compacted density and moisture content of the subgrade is as specified.

Should the results of the above tests prove satisfactory, the Certifying Engineer may authorise that pavement construction proceeds, or may direct that a section of the subgrade be stabilised or undercut and backfilled with a nominated material at additional cost.

If the results of the above tests prove unsatisfactory, the Certifying Engineer shall specify remedial measures to be carried out by the contractor at no additional cost to the principal.

(b) Cut Sections

Testing of the cut sections of the subgrade shall be carried out at the frequencies and to the acceptance criteria given in Table 203.11.2.

Table 203.11.2 : Tests on Cut Subgrade			
Test	**Standard**	**Frequency**	**Acceptance Criteria**
Surface Levels	n/a	10m intervals/lane	Refer TNZ F/1 clause 11.2.2
Straight edge	TNZ F/1	Continuous	Refer TNZ F/1 clause 11.2.1
Scala Penetrometer	NZS 4402 Test 6.5.2	10m intervals/lane to a depth of 1m	TBC
Shear Vane	NZ Geotechnical Society	20m intervals/lane to a depth of 1m	TBC
Proof Roll	Refer Table 203.2	Continuous	

Note 1: Cut subgrade conditions and improvement options will vary along the road alignments.

These results shall be submitted to the Certifying Engineer within 1 working day for review. Following this review the Certifying Engineer may require the contractor to carry out additional testing to assess material properties (e.g. reactivity) and confirm in-situ treatment options and pavement compatibility; or undercut and backfill any areas of the subgrade which are deemed to be unsuitable.

.3 Undercut and Backfilling

Prior to undercutting, the Certifying Engineer shall confirm the extent of the undercut and the volume of material to be removed. The contractor shall then undercut the subgrade and backfill the void as directed by the Certifying Engineer. The edges of all undercut areas shall be benched or battered at approximately 45 degrees to allow a smooth transition to the surrounding area.

The contractor shall compact the replacement fill material to attain a surface of equal or greater stiffness to the design subgrade.

.4 Final Acceptance

When the contractor considers that the preparation of the subgrade is complete in accordance with the above criteria and that the condition and strength of the subgrade is suitable for the construction thereon of the sub-basecourse and basecourse layers, he shall request that an inspection of the subgrade be carried out by the Certifying Engineer. The contractor shall supply the results of all subgrade tests to the Certifying Engineer prior to the inspection and shall carry out such further tests as the Certifying Engineer considers to be necessary to confirm the strength and condition of the subgrade.

If so directed by the Certifying Engineer, the contractor shall test roll the subgrade in the presence of the Certifying Engineer. This test rolling shall be by a 10 to 15 tonne rubber tyred roller, grader, or similar plant item approved by the Certifying Engineer. Any yielding or otherwise unsatisfactory performance of areas of the subgrade which become evident during such testing shall be treated in accordance with the Certifying Engineer's instructions.

The contractor shall not commence construction of the sub-basecourse layer until the Certifying Engineer's acceptance of the subgrade is given.

C0203.12 TOPSOIL SPREADING AND GRASSING

.1 General

All areas that are not to be immediately occupied by buildings or pavements except where noted otherwise in the drawings shall be top soiled and revegetated.

.2 Materials

Topsoil shall be uplifted from the approved stockpiles as specified or as directed by the Certifying Engineer.

Topsoil shall be the surface layer of soil with no admixture of refuse or any material toxic to plant growth, and it shall be free from weeds, sticks, stumps, roots, brush, stones 10mm or more in diameter, clay lumps or similar objects.

.3 Preparing the Ground Surface

Immediately prior to dumping and spreading topsoil the surface shall be loosened by discs or spike-tooth harrows, or by other means approved by the Certifying Engineer, to a minimum depth of 50mm to facilitate bonding of the topsoil to the subgrade soil. The surface of the area to be top soiled shall be cleared of all stones larger than 10mm in diameter and all litter or other material which may be detrimental to proper bonding, the rise of capillary moisture, or the proper growth of the desired planting.

.4 Placing Topsoil

The topsoil shall be evenly spread on the prepared areas to produce a uniform depth of 150mm after compaction. Spreading shall not be done when the ground or topsoil is excessively wet, or otherwise in a condition detrimental to the work.

A fertiliser mix comprising an approved granulated 8:13:10 NPK fertiliser shall be uniformly spread over the topsoil at the rate of 25 gms/m² The topsoil shall then be rotary hoed, levelled and trimmed to a uniform fine tilth free of lumps, stones, roots, litter, or any foreign matter.

Following hoeing, the topsoil shall then be lightly compacted by rolling or by other means approved by the Certifying Engineer.

Any topsoil falling upon pavements as a result of carting or handling shall be promptly removed.

.5 Sowing/Planting

Planting plans and associated specifications will be provided by others.

.6 Maintenance/Acceptance

The contractor shall be responsible for watering and maintaining the grass to achieve 100% coverage of fine leafed grass, free from broad leafed weeds. The grass shall be mown to 20 mm when it reaches a height of approximately 50 mm. Mowing shall then be carried out monthly until the issue of the Defects Liability Certificate.

.7 Hydroseeding

The contractor shall apply an approved hydroseed and straw mulch to top soiled surfaces in accordance with TNZ F/1. The contractor shall submit to the Certifying Engineer for approval the proposed seed, fertiliser and mulch mix and application rates. Approval of the proposal shall not in any way relieve the contractor from responsibility to achieve adhesion and growth of the grass.

C0203.13 MONITORING

.1 Construction Monitoring

Construction monitoring and testing should be carried out as outlined and in conjunction with NZS 4404 and NZS 4431:1989 Earth fill for residential development and the project inspection and Testing Plan (ITP).

In addition, the following shall be inspected or observed and approved by the Certifying Engineer:

Cuts and Fills at 1m intervals.

Undercut excavations below fills.

Drainage excavations prior to placement of aggregates.

Stockpiled aggregates

Subsoil drain placement.

Flushing/CCTV inspection of subsoil drains.

All borrow/imported fill materials.

All stockpile sites.

Any unforeseen ground conditions, soft zones, organic material, non-engineered fill etc. that may affect construction or future development.

Access Road cuts

Stormwater ponds.

All geosynthetic and drainage materials prior to placement including: Geogrids, Geofabrics, pavement, sand blankets, drainage materials, subsoil drains.

Retaining and in ground wall foundation excavations, piles, cuts and fills.

The contractor shall allow and facilitate such inspections at no cost to the principal.

.2 Settlement Monitoring

Monitoring of ongoing settlement shall be undertaken on all completed fill areas through the installation and regular monitoring of settlement markers. The number and position of the settlement markers shall be indicated by the Certifying Engineer on drawings. Monitoring of these points shall be undertaken on a monthly basis for a period of 2 years after completion of bulk earthworks.

Additional filling shall be undertaken as requested by the Certifying Engineer to maintain design levels where settlement results in the finished levels falling outside of the tolerances outlined in C0203.5.6.