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Omau Cliffs Subdivision

Geotechnical Assessment Report

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CONFIDENTIAL

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Disclaimers and Limitations

This report ('Report') has been prepared by WSP exclusively for Cape Foulwind Stable 2 Ltd ('Client') in relation to a geotechnical assessment of the Omau Cliffs Subdivision at Cape Foulwind, Westport ('Purpose') and in accordance with the Short Form Agreement dated 9 July 2021. The findings in this Report are based on and are subject to the assumptions specified in the Report and the results of shallow site investigations carried out within / in vicinity of the site. Variations in ground conditions may occur between the investigation locations, however, there may be other conditions in the subdivision which have not been revealed by the investigations etc and have therefore not been taken into account in this report. No warranty (either expressed or implied) that the actual conditions will conform exactly to the assessments contained in this report is included.

WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

In preparing the Report, WSP has relied upon data, surveys, analyses, designs, plans and other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in the Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable in relation to incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

This disclaimer shall apply notwithstanding that the report may be made available to the Buller District Council, and/or the West Coast Regional Council and other persons for an application for permission or approval to fulfil a legal requirement.

1 Introduction

WSP have been commissioned by Cape Foulwind Stable 2 Ltd ("Client") to carry out a shallow geotechnical investigation and a geotechnical assessment of the Omau Cliffs Subdivision at Cape Foulwind, Westport. The proposed development includes 27 building lots and formation of driveways. Lot 24 to 27 have been excluded from the scope of the project at this stage upon Client's request and will be assessed separately in a later stage of the development.

This report summarises the findings of the geotechnical investigation and assessment of Lot 1 to 23 and presents development conditions and recommendations for future works within the lots in terms of allowable building areas, earthworks, stormwater and foundations.

2 Site Description

2.1 Location

The proposed Omau Cliffs Subdivision (the Site) is located 8km west of Westport, refer to Figure 1.

Figure 1 Location plan

The 23 lots included in the geotechnical assessment have a total area of 12.91 Hectares and spans across 2 land parcels (Appellation Part Section 8 Block I Steeples SD and Lot 1 DP 5663), refer to Figure 2.

The land is bounded to the south by Cape Foulwind Road and to the north by Omau Road (paper road) adjacent to steep coastal cliffs (Omau Cliffs) and Buller Bay. The land is bounded by the Omau township to the west and the Gibsons Creek to the east. Access to the beach is available (low tide only) from a concrete ramp at the end of Larsen Street, east of Gibsons Creek.

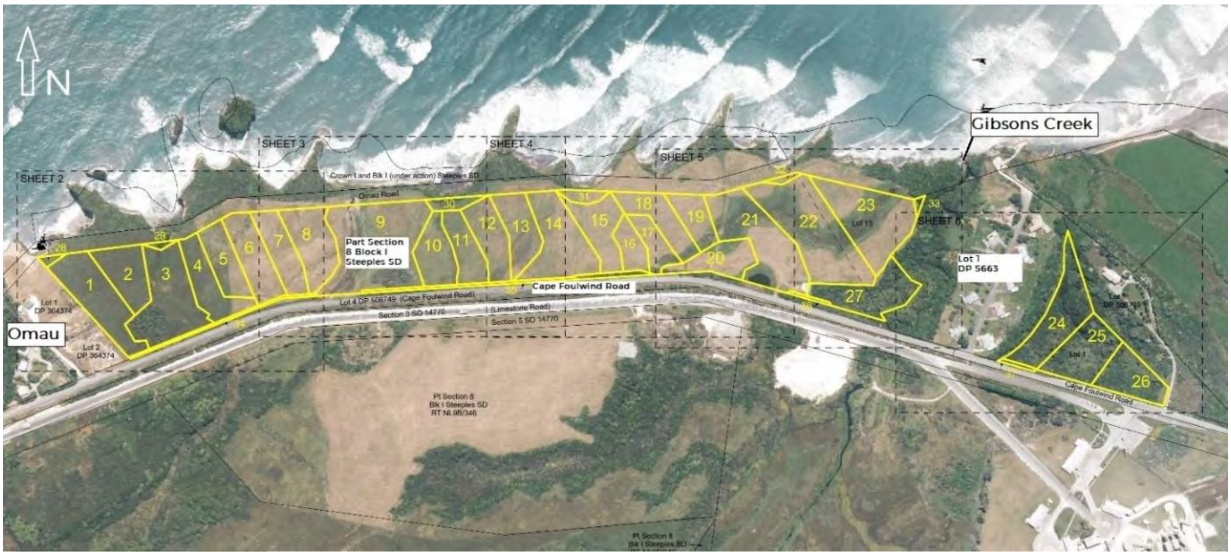

Figure 2 Omau Cliffs Subdivision overview.

2.2 Geology

Published geological maps[1] indicate the geology at the site is dominated by Miocene age blue-grey, micaceous muddy sandstone of the O'keffe Formation (Mbo) overlain by a thin cover of Quaternary age marine sands and gravels refered to as the Waites Formation (Q5b), refer to Figure 3. Oligocene age Limestone (on), Eocene age brown carbonaceous mudstone (Erk) and Carboniferous age biotite granite (Ckg) outcrop west of the site. East of the site is dominated by Postglacial dune sand (Q1d) and beach sand (Q1b) deposits.

A photograph showing the geological units encountered at the site has been presented in Figure 4.

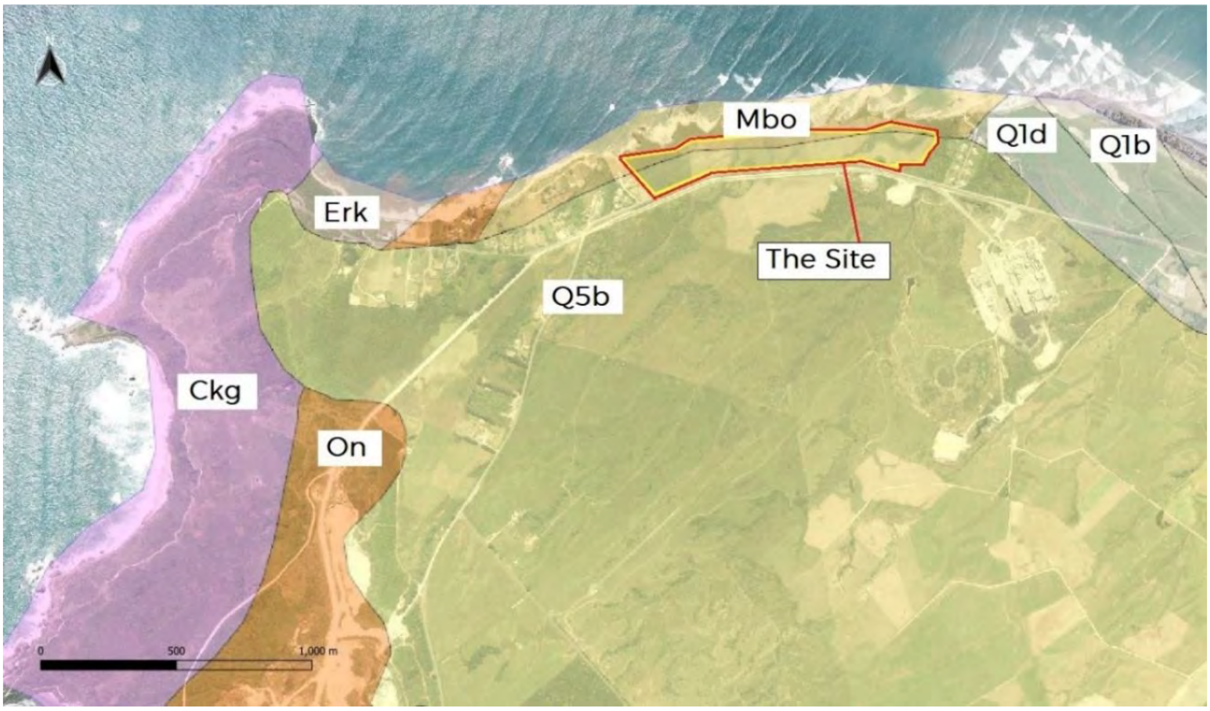

Figure 3 Geological map of the Cape Foulwind area, which indicates that the site (outlined in yellow) is dominated by Miocene age blue-grey, micaceous muddy sandstone of the O'keffe Formation (Mbo) overlain by a thin cover of Quaternary marine sands and gravels of the Waites Formation (Q5b).

[1] Institute of Geological & Nuclear Sciences Limited (2002). Geology of the Greymouth Area, 1:250,000.

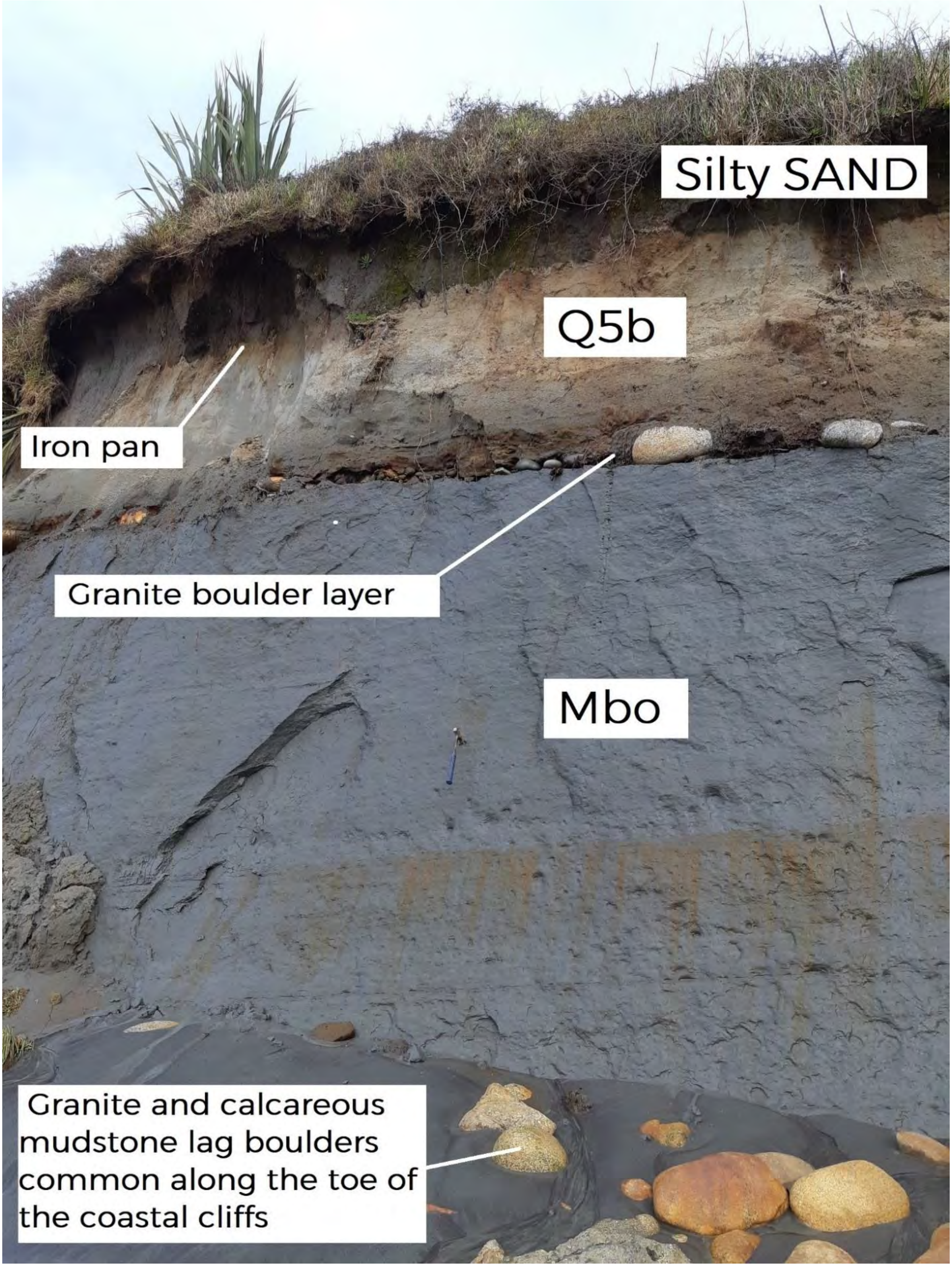

Figure 4 Typical cross section of geological units present at the site including blue-grey, micaceous muddy sandstone of the O'keffe Formation (Mbo) overlain by a thin cover of marine sands and gravels of the Waites Formation (Q5b). Surficial silty SAND are likely residual soils from weathering of the Waites Formation.

2.3 Geomorphology

A series of 8 topographical sections have been extracted from recent LIDAR survey data from the Westport area to assess the geomorphology in detail. The approximate positions of the topographical sections are shown on a Detailed Site Plan presented in Appendix A.

The site is a slightly undulating raised coastal terrace, which slopes very gently towards the east (overall gradient of 0.6^0), refer to Figure 5 and Site Photograph 1 in Appendix B.

The land is bounded towards the north (Buller Bay) by the near vertical coastal Omau Cliffs with crest heights of 27m in the west and 15m in the east above Gibsons Creek, refer to Figure 6. Slope gradients of the coastal cliffs typically vary between 60^0 to 90^0 to horizontal in mudstone of the O'keffe Formation and 40^0 to 90^0 to horizontal in sand and sandstone of the Waites Formation.

The irregular coastline has a series of narrow headlands separated by coves. Three bush topped sea stacks are located within 50m of the coastline at the western end of the subdivision.

A series of natural watercourses with invert levels of up to 4m are draining the terrace and discharging over the cliff at positions of coves, which suggests a correlation between high erosion rates and discharge of surface water.

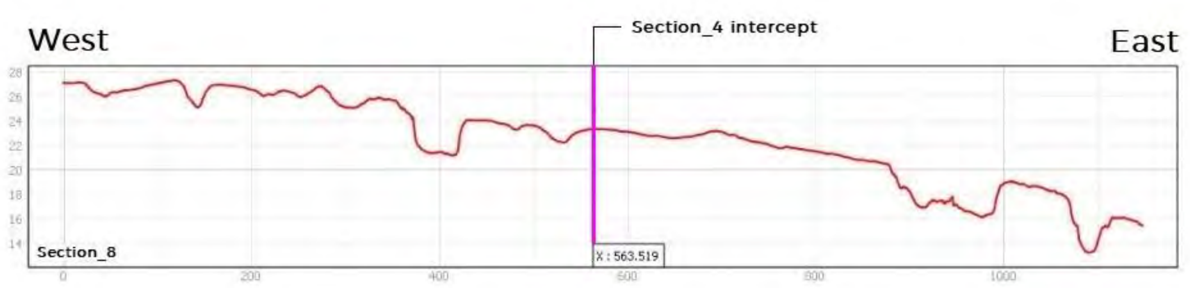

Figure 5 Topographical section (West-East) from LIDAR Digital Elevation Model (DEM). The tie point of South-North orientated Section_4 is marked in purple, refer to Figure 6.

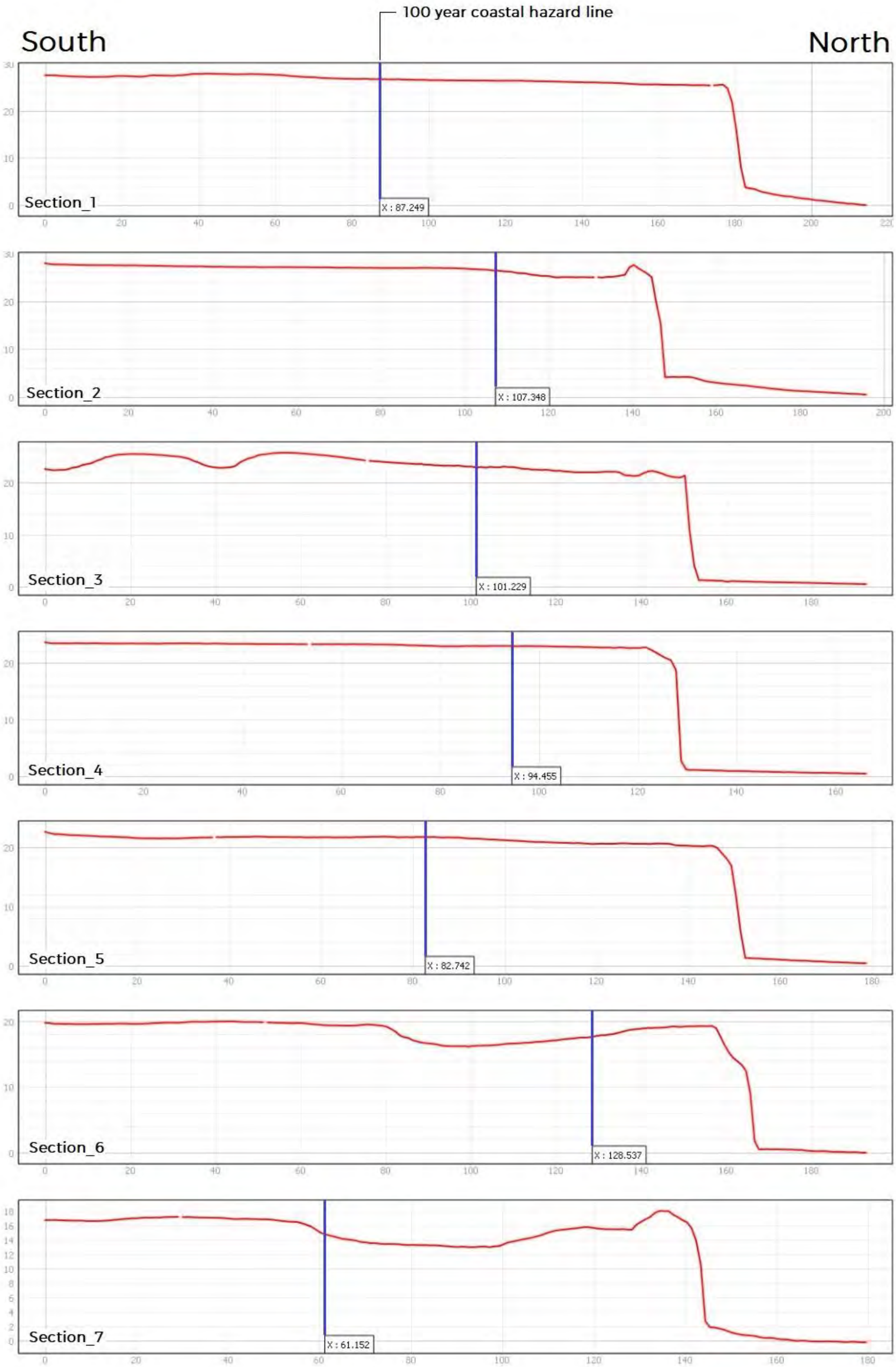

Figure 6 Topographical sections (South-North) from LIDAR Digital Elevation Model (DEM). The 100-year coastal hazard line is marked in blue line, discussed in section 2.6.

2.4 Seismic Hazards

The Westport area has a series of known local active faults, including SW-NE striking Paparoa Reverse Fault (Buller Fault) located 15km ESE of the site and Maimai Inangahua Fault located 38km ESE of the site. A NIWA study from 2013[2] based on existing seismic reflection and bathymetric data identified a series of offshore faults, refer to Figure 7. The SW-NE striking Cape Foulwind 2 Fault is located ~10km offshore of the site. The fault is 100km long, 15km deep and dips 50^0 ESE. The Cape Foulwind 2 Fault has potential of M7.8 with a recurrence interval (RI) of 27800 years.

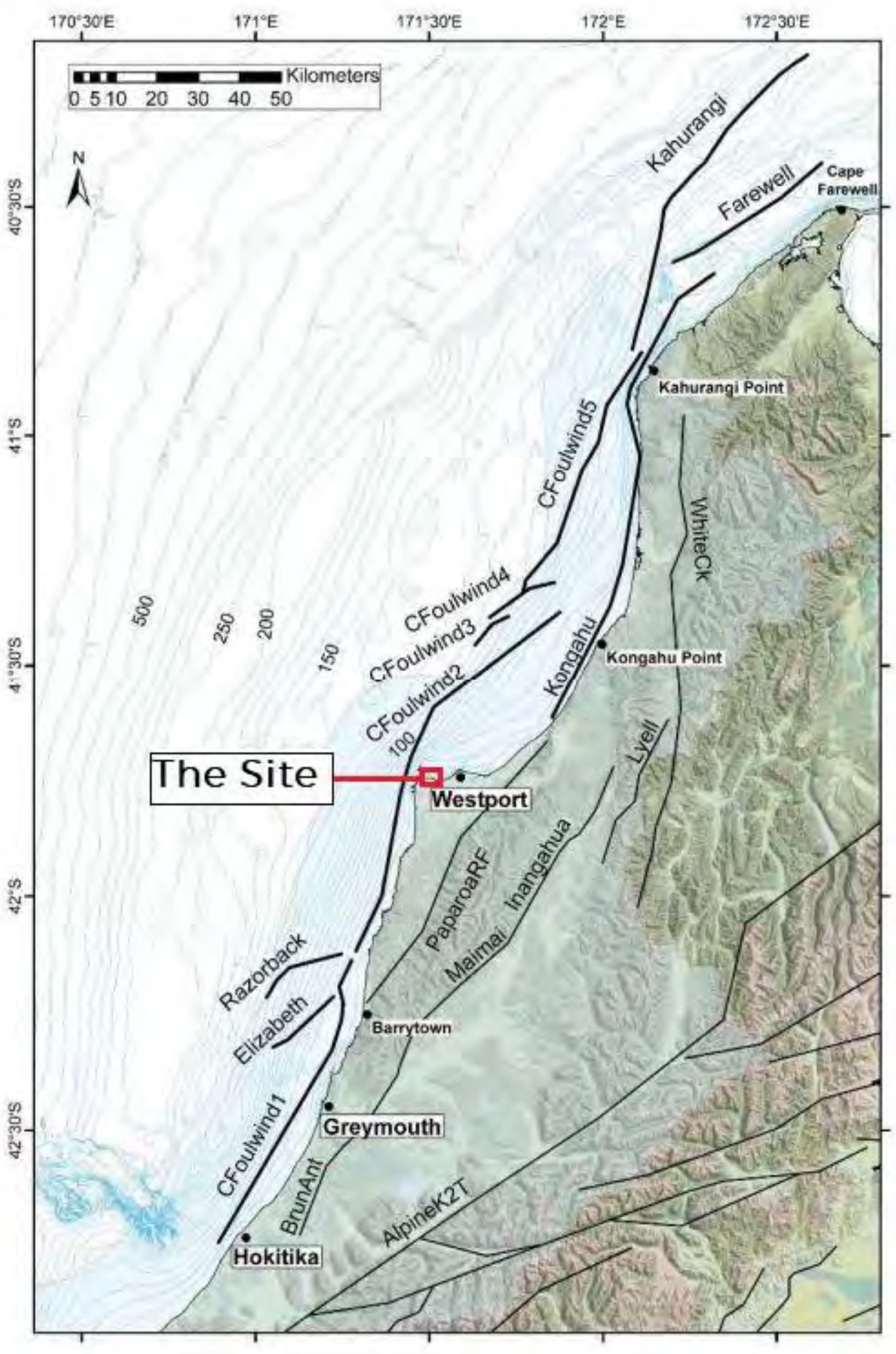

Figure 7 Map of onshore and offshore faults in the Westport area (NIWA 2013).

[2] Offshore faulting and earthquake sources, West Coast, South Island: Stage 2. MBIE Envirolink West Coast Regional Council Advice: 1237-WCRC114. Prepared for West Coast Regional Council. NIWA (2013).

The site is located 90km northwest of the Alpine Fault. A lifeline study from 2006 by Buller District Council[3] on Alpine Fault Earthquake Scenario estimated Modified Mercalli intensity of MM VII (*Slight to moderate damage to well built, ordinary structures and considerable damage to poorly built structures*) for the Westport area, refer to Figure 8. The fault rupture is likely to cause an estimated \Peak Ground Acceleration (PGA) of 0.1g for the site, refer to Figure 9.

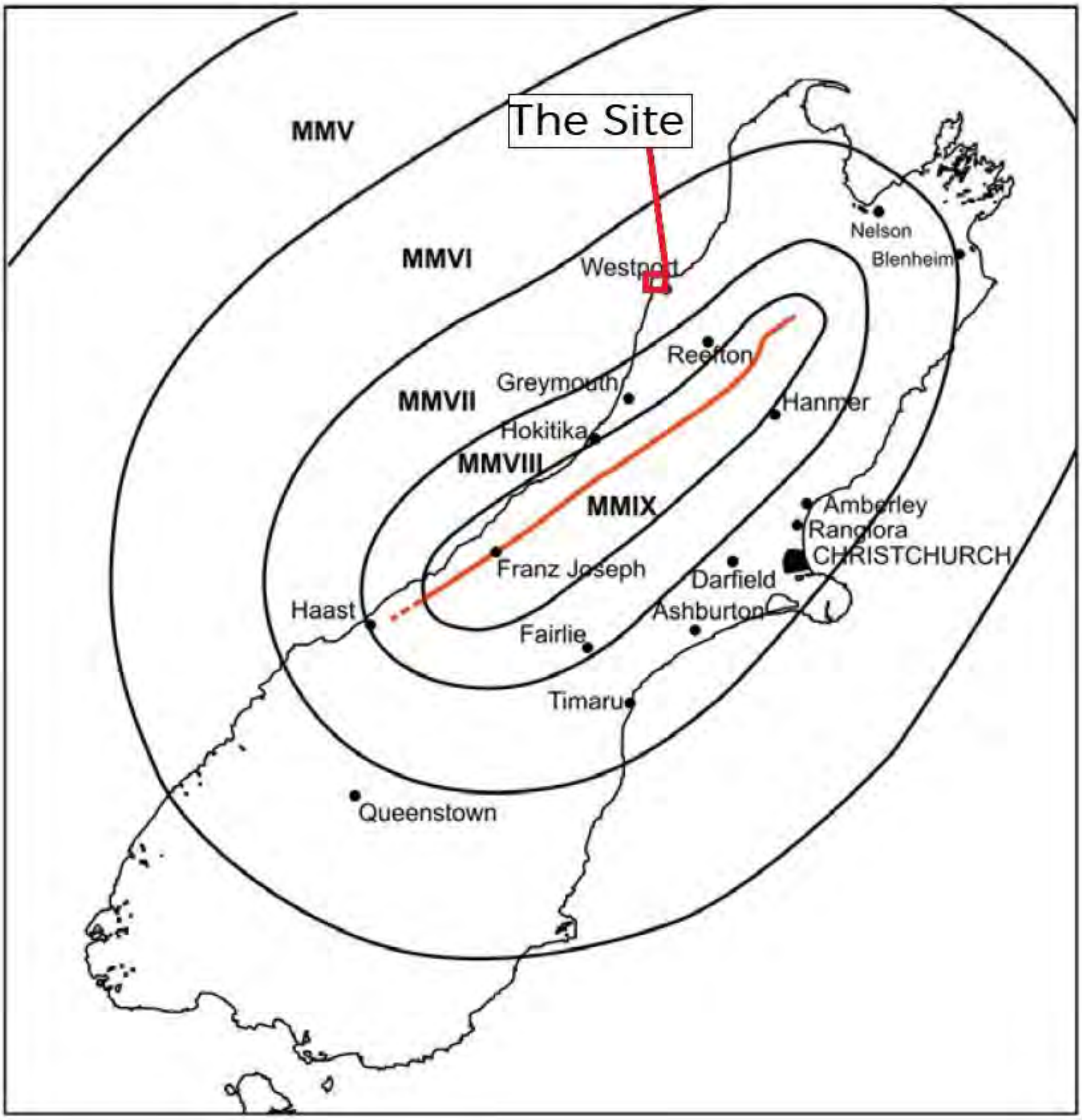

Figure 8 Estimated Modified Mercalli intensity isoseismals (lines defining equal shaking intensity) for the Alpine Fault earthquake scenario indicating an intensity of MM VII for the Westport area (BDC, 2006).

[3] Buller District Council Lifeline Study - Alpine Fault Earthquake Scenario. BDC (2006).

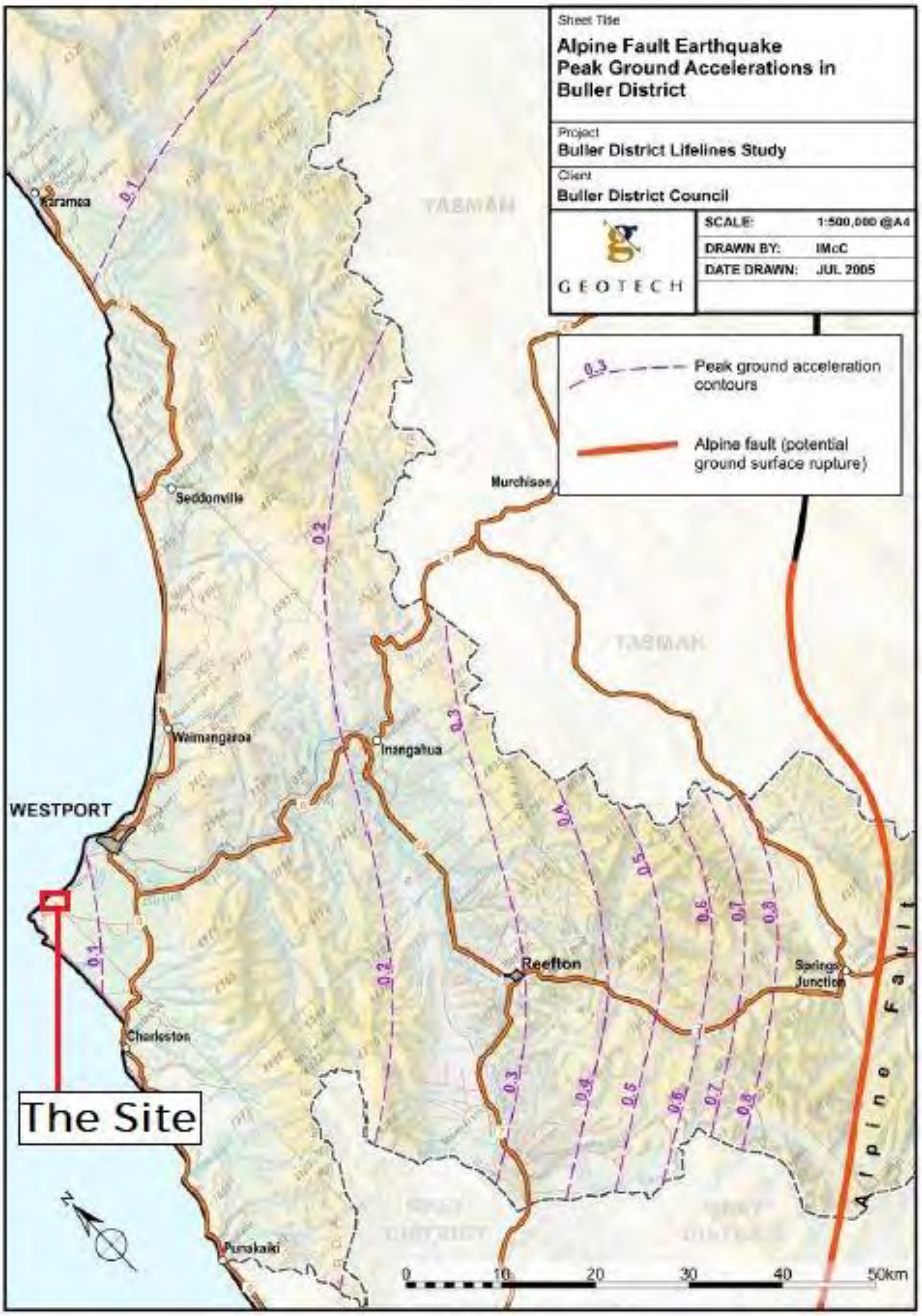

Figure 9 Map of peak ground acceleration in the Buller District for an Alpine Fault Earthquake Scenario (BDC, 2006).

2.5 Slope Instability Features

A review of available LIDAR data from the area found no signs of global instabilities developing across the terrace, refer to Figure 10. LIDAR data provides 3D information of the terrain with high accuracy and high spatial resolution and is commonly used for detection and characterisation slope instability features. Field observations (from a site walkover by WSP dated 2 August 2021) confimed that only a few areas are affected by minor slumping, which are mostly associated with scour along a natural water course draining the site and cut slopes associated with an access ramp to a creek crossing, refer to Figure 10 and Site Photo 2 in Appendix B.

Slope instability associated with coastal retreat has been discussed separately in section 2.6 below.

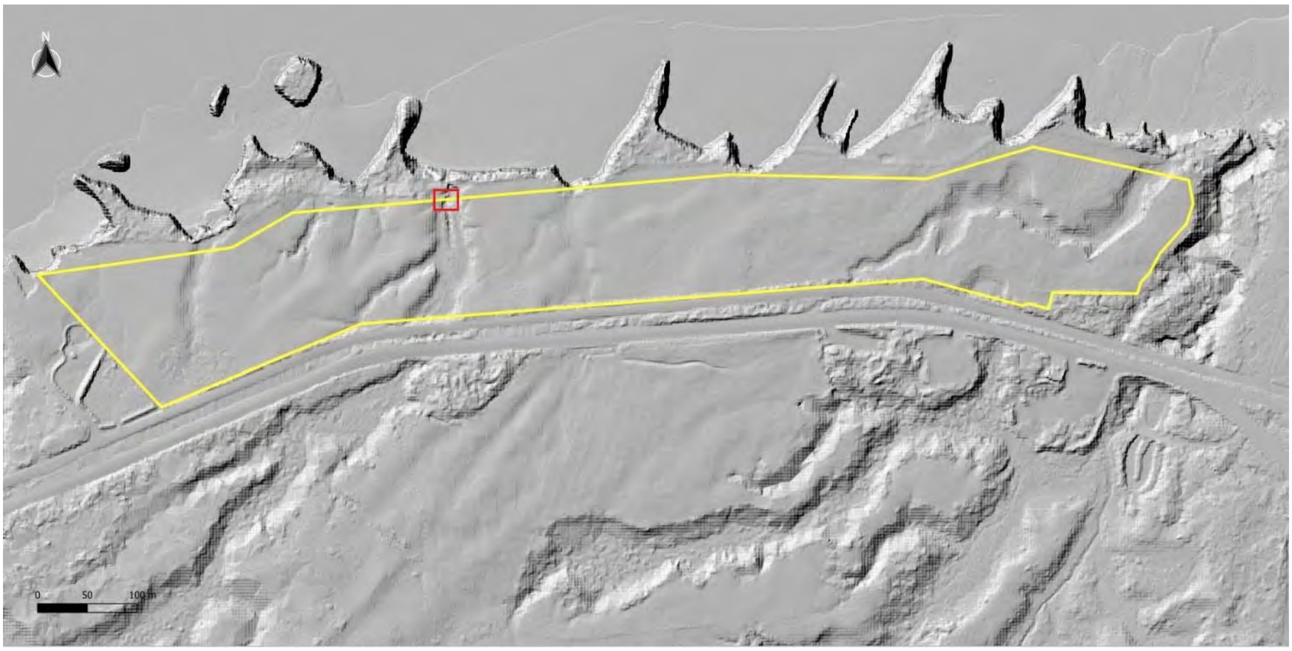

Figure 10 LIDAR digital Elevation Model (DEM) of the Cape Foulwind area. The topography model inside the outline of the proposed 23 Lot subdivision (yellow outline) is very smooth and free of surface features typically associated with developing slope instability (surface depressions above slope crests, tension cracks). The LIDAR data clearly shows the positions of natural water courses draining the raised coastal terrace towards the northeast. The red outline indicates an area with cut slopes (ramp down to creek crossing).

2.6 Coastal Hazard Assessment

A Coastal Hazard Assessment Report[4] was completed for the proposed subdivision by Beca Ltd in September 2020, refer to summary in Section 2.6.2. The report describes the geomorphology of the coastline in detail and concludes the following:

- The primary mode of slope failure along the coastal cliffs is '*slab failure parallel to the cliff face*' caused by undercutting from wave action.
- Bands of calcareous mudstone (with occasional concretions and muddy limestone beds) form erosion resistant promontories along the coastline. Difference in coastal erosion rate is likely associated with a lower calcareous content in the coves between the headlands.
- The overlying sands from the Waites Formation are more easily eroded than the mudstone and are standing at angles between 45^0-90^0 to horizontal near the top of the sea cliffs. These sands are in the order of 2m to 6m thick.

2.6.1 Site walkover

WSP completed a site walkover on 2 August 2021 to qualitatively assess the stability of the cliffs. Selected site photographs are presented in Appendix B. The main additional findings from the walkover are summarised below:

- Typical slab failures in the mudstone are orientated SW-NE and WNW-ESE, very steeply inclined to subvertical, planar, moderately widely spaced (0.2 - 0.6m) and joints are

[4] Cape Foulwind – Holcim Site Coastal Hazard Assessment Report (BECA, Sept 2020).

persistent for >10m. The intact strength of the mudstone ranges from *extremely weak to weak (as per NZGS (2005) guideline)*, refer to Site Photo 3 in Appendix B.

- Recent significant failures likely due to undercutting of the toe by wave action causing collapse of the overhanging rockmass, refer to Site Photo 4 in Appendix B.
- Structural complexity (low angle trust fault with a small drag on the hanging wall block) was observed in the mudstone from the beach, which shows potential for a range of failure modes including larger complex failures, block slides, refer to Photo 4 in Appendix B.
- Groundwater seepage was commonly observed from the contact between the sand (Waites Formation) and the mudstone (O'keffe Formation). The mudstone is relatively impermeable and groundwater seepage becomes confined to depressions on top of the mudstone and contributes to erosion and weakening in areas where discharging onto the cliff face from the geological contact.

2.6.2 Coastal Assessment Report summary (BECA, 2020)

Assessment of the extent of coastal hazard at the site was made by Beca in 2020 on the basis of the established principles set out in:

- New Zealand Coastal Policy Statement 2010
- The 2012 Envirolink publication Defining coastal hazard zones for setback lines - A guide to good practice,
- subsequent refinements arising from IPCC in relation to understanding of climate change and specifically interpreted by MfE for New Zealand conditions,
- MfE 2017 publication Coastal Hazards and Climate Change – Guidance for Local Government
- and further research into the response of cliffed coastline types which has resulted in an industry standard approach to this process.

The approach used has been applied for several cliffed sites on the New Zealand coast and is currently the preferred standard.

Establishment of the projected extent of coastal erosion effects on this cliffed coastline was based on the physical nature of the geological components and observed stable cliff slope angles, cliff heights along the coastal frontage, long term rates of cliff retreat as established from aerial photography, and allowance for the effects of projected effective sea level rise in contributing to increasing coastal retreat. Ministry for the Environment guidance (Ref 2017) provides specific sea level rise projections from a base value to 0.11m in 2020 and 1.36m in 2120 in accordance with emissions scenario RCP8.5 H+ which is a business as usual emissions case. Thus, a nett increase of 1.25m (= 1.36 – 0.11) of sea level rise has been allowed for in the 100-year planning timeframe recommended for land use consents.

The combination of these components was used to calculate Area Susceptible to Coastal Erosion (ASCE) values for 50- and 100-year timeframes at 17 points along the existing coastline, refer to Figures 11 and 12 adopted from the Beca report. Setbacks are greatest at the western end of the site as the result of the significant localised retreat of up to 0.54m/year (Lot 1 and Lot 2).

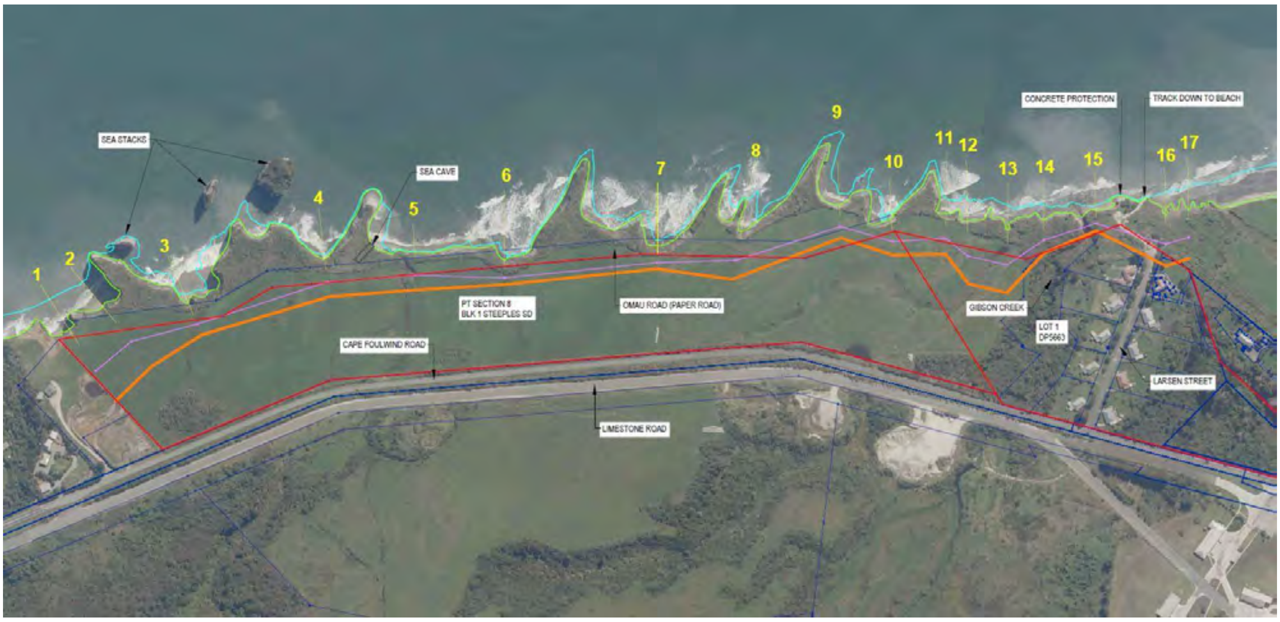

Figure 11 Map of 17 points along the existing coastline where ASCE values have been calculated, refer to Figure 12 (from Beca, 2020)

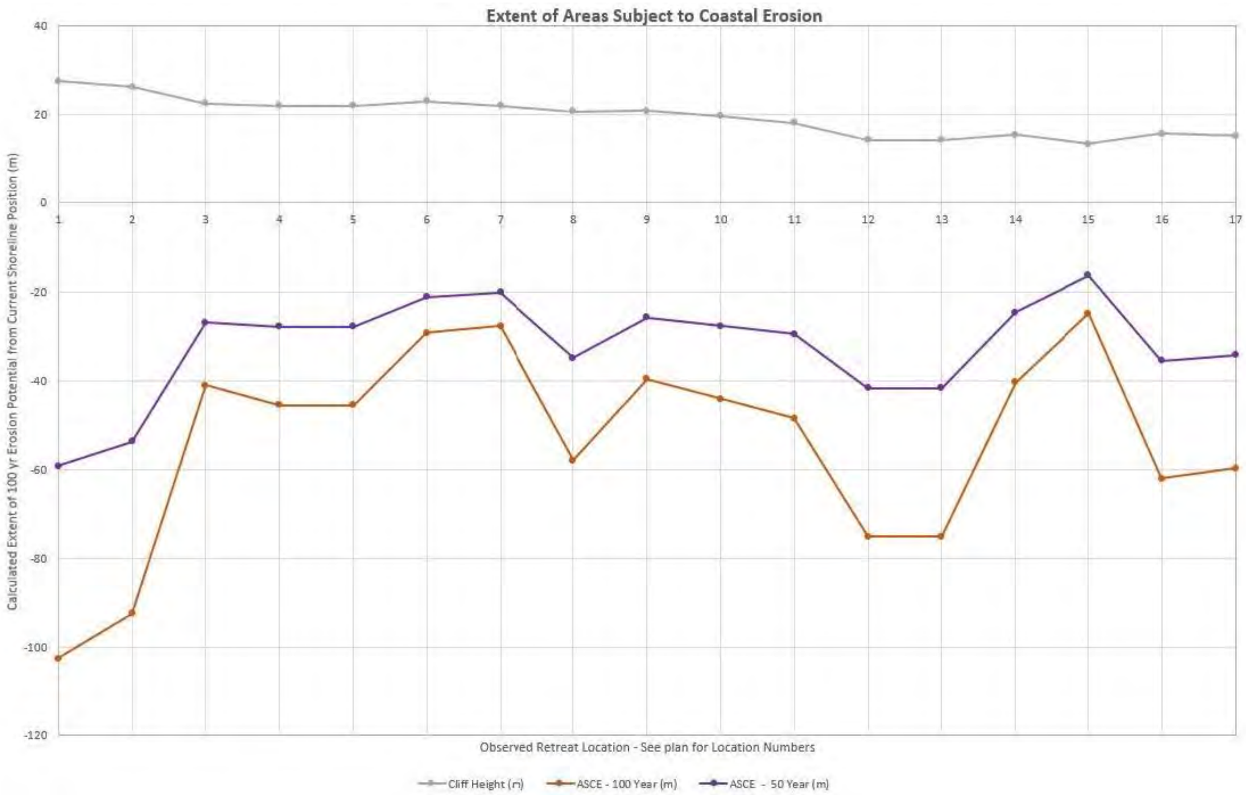

Figure 12 Comparison of ASCE setbacks (50 year and 100 year) from existing shoreline position based on quantified historical shoreline retreat between 1938-2018 (from Beca, 2020)

3 Summary of Geotechnical Site Investigation

3.1 Scope of Investigations

A shallow ground investigation was undertaken by WSP on 3 and 4 August 2021. The Investigation was undertaken across the extend of the subdivision in close proximity to the currently proposed building platforms (12 out of 23). The investigation comprised:

- 12 No. machine excavated test pits (TP_01 – TP_12)
- 12 No. Dynamic Cone Penetrometer (DCP) or Scala penetrometer (adjacent to each test pit).

Soils from the test pits were logged on site by a WSP Geologist and described in accordance with the NZ Geotechnical Society (NZGS) Field Description of Soil and Rock (NZGS, 2005). The maximum depth of the test pits was 2.70m in TP_09.

A Detailed Site Plan including the test pit locations has been included in Appendix A.

Test pit logs and Scala penetrometer testing results are presented in Appendix C.

Photographs of excavated soils from the test pits are shown in Appendix D.

4 Ground and Groundwater Conditions

4.1 Ground Profile

The test pits showed the site is underlain by a thin layer of topsoil (very soft) between 0.05m to 0.20m in thickness, underlain by fine to medium sand and silty sand (very loose to loose) and sandy silt (very soft to firm) encountered between 0.05m to 1.90m depth. These soils are underlain by fine to medium sand (dense to very dense) to depth of at least 2.70 m depth. Iron pans are common throughout the site, but the degree of iron oxide cementation is highly variable. The sands were logged as sandstone in areas with extensive iron pan development.

It is expected that the exposed sands of the Waites Formation extend to depth of up to 6m based on observations of outcrop along the coastal cliffs. The O'keffe Formation mudstone was not exposed in the 12 test pits completed across the site.

4.2 Groundwater

The regional groundwater was only encountered at depth in test pit TP_10, where the ground was saturated below 1.55m due to the absence of iron pans.

Surface conditions were very wet and soft in the western half of the subdivision at the time of the site investigation due to developed iron pans creating an impermeable barrier near surface. Surface water was observed in topographical lows. Stagnant water was present in a small pond in the eastern end of the subdivision next to Cape Foulwind Road.

5 Geotechnical Assessment

5.1 Site Subsoil Class

Based on the available geotechnical information, it is expected that the site subsoil class is 'Subsoil Class C – Shallow soil' in accordance with the requirements of NZS 1170 (2004). The site is underlain by less than 6m of soft fine soils and partly consolidated sands, underlain by a thick formation of very weak to moderately strong rock.

5.2 Ground Shaking

Although the distance to the Alpine Fault is relatively significant (90km), very strong shaking is to be expected for an Alpine Fault Earthquake Scenario with slight to moderate damage to well built, ordinary structures and considerable damage to poorly built structures, as presented in Figure 8.

A Peak Ground Acceleration in excess of 0.1g is to be expected for an Alpine Fault Earthquake for the Westport area, as presented in Figure 9.

As for West Coast sites in general, the potential for high levels of ground shaking to occur at the site will need to be considered in design.

5.3 Liquefaction Potential

Liquefaction is typical in saturated soils ranging from non-plastic silts to gravelly sands. It is most common in saturated fine sands and coarse silts of loose consistency at depths less than 15 m below ground level. It is also further mostly prevalent in geologically recent (Holocene age) deposits, as consolidation and cementation tends to be more advanced in older aged deposits (Geotech Consulting, 2013).

Although surficial loose sandy and silty soils were encountered within the test pits, regional groundwater was only observed at a depth of 1.55m in one of the test pits (TP_10). Instead, perched groundwater was encountered in the upper soil profile across the site due to the presence of iron pans and poor surface drainage.

The relatively lack of regional groundwater as well as the geological setting of the site suggests that the liquefaction potential of the soils encountered at this site is expected to be low. The only exception is TP_10 (near lots 19 and 18), where the test pit walls became unstable during excavation due to water ingress in loose ground conditions. We recommend further investigations (as part of foundation design) be undertaken at all lots, in particular lots 19 and 18, to assess the liquefaction susceptibility and effects.

5.4 Good Ground and Ultimate Bearing Capacity

One of the objectives of the shallow investigation undertaken at the site was to confirm the existence of Good Ground in accordance with the New Zealand Building Code (or otherwise) to determine if the land is suitable for subdivision. The New Zealand Building Code, MBIE (2014)[5], defines the criteria for good ground as any soil or rock capable of permanently withstanding an ultimate bearing pressure of 300kPa, but excludes:

- Potentially compressible ground such as topsoil, soft soils such as clay which can be moulded easily in the fingers, and un-compacted loose gravel which contains obvious voids;
- Expansive soils being those that have a liquid limit of more than 50% when tested in accordance with NZS 4402 Test 2.2, and a linear shrinkage of more than 15% when tested, from the liquid limit, in accordance with NZS 4402 Test 2.6; and,
- Any ground which could foreseeably experience movement of 25mm or greater for any reason including one or a combination of: land instability, ground creep, subsidence, (liquefaction, lateral spread – for the Canterbury earthquake region only), seasonal swelling and shrinking, frost heave, changing ground water level, erosion, dissolution of soil in water, and effects of tree roots.

The New Zealand Building Code, MBIE (2014) provides a criteria for Good Ground based on DCP (or Scala) testing results for shallow foundations whereby if a certain penetration resistance is achieved an ultimate bearing capacity of 300kPa may be assumed. Testing in accordance with NZS 4402 Test 6.5.2, shall be acceptable as good ground for building foundations if penetration resistance is no less than:

a. 5 blows per 100mm at depths down to twice the footing width; and,

b. 3 blows per 100mm at depths greater than twice the footing width.

Based on the results from the site investigations, "Good Ground" was encountered at depths varying between 0.4m and 1.9m. The contact to dense fine to medium sand or weak sandstone (in

[5] New Zealand Building Code Handbook. Ministry of Business, Innovation and Employment (MBIE, 2014).

areas with extensive iron pan developed) is considered to be the depth to "Good Ground" due to the loose/soft nature of the overlying silty sand and surficial soft silt.

Specific site investigations, including Scala penetrometer testing, will be required at the building platform locations (once confirmed) to confirm the depth to "Good Ground" at each lot.

5.5 Bearing Capacity

Based on shallow investigations, we recommend that all near-surface soft soils and loose granular soils not meeting the Good Ground criteria are excavated and replaced with suitable compacted granular fill for building pads and access roads. The depth to the underlying 'Good Ground' ranges from 0.4m to 1.9m across the site. An ultimate bearing capacity of 300kPa is recommended for shallow foundations founded into these soils to be sufficient to support dwellings and outbuildings associated with the proposed residential development.

Excavations should be inspected by a suitably qualified Geotechnical Engineer prior to fill placement and compaction.

6 Suitability of Residential Development

Based on the results of the site investigations and land stability assessment, it is our professional opinion, that the lots are suitable for residential development, subject to the development conditions outlined in Section 7 below.

As shown on the Detailed Site Plan (refer Appendix A), all building platforms are currently positioned behind the '100-year coastal hazard' line developed by Beca. However, several building platforms (specifically in regards to Lot1 , Lot 2, Lot 8, Lot 12, Lot 16, Lot 17, Lot 18, Lot 19 and Lot 23) are situated very close to the '100-year coastal hazard' line. Given the risk-based approach to determine this line, we recommend moving these building platforms further back from the 100-year ASCE line (towards the south) where possible to provide a greater safety margin and reduce the long-term risk to property.

7 Development Conditions

7.1 Proposed Development and Foundations

Any development within the lots should take into account the effect of the proposed works on land stability of the lot itself and the adjacent properties.

Design of the new development including foundations for structures should take into account the potential for the presence of local soft fine soils, loose sands and groundwater seepage.

Design of the new development including foundations for structures should be undertaken by a Chartered Professional Engineer and reviewed by a Chartered Professional Engineer competent in the geotechnical practice area.

Specific site investigations are required for each lot to provide information for the foundation design.

7.2 Earthworks

All earthworks shall comply with NZS 4431:1989 Code of Practice for Earth Fill for Residential Development. The following general conditions on earthworks shall apply:

- Topsoil and any soft and organic soils must be stripped off areas where fill is to be placed.
- All fill should be benched appropriately into the natural ground.

- All cut and fill batters should be vegetated as soon as possible after construction to limit the potential for erosion and promote the stability of the slopes.

In addition to above, the following needs to be considered:

- Fill is not to be placed in the natural drainage channels (i.e. the low gullies as indicated on Figure 10).
- The Contractor should include a suitable methodology to drain excavations and control surface water run-off.

To ensure slope stability, the following conditions shall be complied with unless otherwise assessed, designed and certified by a by a Chartered Professional Engineer with competency in geotechnical engineering or by an experienced engineering geologist (recognised as such by the Council):

- Lot-specific site investigations and slope stability assessment are required to be carried out in areas where deep excavations or filling (typically greater than 1m in depth/height) might be considered.
- The Contractor's Earthworks Management Plan is required to be reviewed and approved by the Geo-professional, prior to starting any earthworks
- Cut and fill slopes shall be restricted to a maximum of 1.5 m in height and should be protected against erosion by vegetation.
- Retaining walls over 0.5 m in height should be assessed by a Chartered Professional Engineer with competency in geotechnical engineering or by an experienced engineering geologist (recognised as such by the Council).
- Depending on the in-situ soil conditions some cut slopes may need to be battered back to a shallower angle or require a retaining wall.
- Earthworks should be targeted for drier seasons (i.e. summers), and construction in wet periods needs to consider the site stability and the adverse effect of water on the strength and compaction of in-situ and imported soils.

7.3 Stormwater

The following general conditions on stormwater shall apply:

- No uncontrolled stormwater should be allowed either during construction or subsequently.
- All stormwater within each lot should be effectively drained and piped to positions allocated by stormwater engineer (WSP stormwater design report has been commissioned).
- All stormwater runoff from roofs, sealed and paved areas should be collected and piped to positions allocated by stormwater engineer.
- Overland flow shall be controlled to ensure it doesn't cause problems to ensure it doesn't cause problems to the adjacent land further down slope.
- During construction, measures such as localised channels and swales should be constructed to control and divert stormwater so as to prevent erosion and undercutting.
- Drainage measures should be carefully designed and routinely inspected and maintained to offset the effects of fill loadings and to guard against softening of soils underneath fill and foundations.

7.4 Geotechnical Supervision

Any site investigations and construction of earthworks, foundations for dwellings and driveways shall be supervised by a Chartered Professional Engineer with competency in geotechnical engineering or by an experienced engineering geologist (recognised as such by the Council).

This person should confirm that ground conditions are consistent with those described in this report.

The supervision should pay particular attention to examining the ground for:

- Soft or loose ground conditions in areas where the soil has been flipped or disturbed. Such areas have the potential to cause instability of earthworks and/or the slope overall.
- Signs of seepage or wet ground in the excavation for foundations or cuts.

Evidence of seepages or waterlogged ground, or soft or highly plastic clay layers in subsurface investigations or in excavations for the foundations or cuts should be noted and any need for mitigation measures (or changes to design) assessed.

8 Conclusions & Recommendations

The main conclusions from the investigation and assessment are presented below.

- The proposed subdivision is located on a raised coastal terrace of gently sloping (east) undeveloped land with steep coastal cliffs towards the north. The proposed development covered in this report includes 23 building lots and formation of driveways.
- Based on the review of published geological maps, the site is underlain by Miocene age blue-grey, micaceous muddy sandstone of the O'keffe Formation overlain by a thin cover of Quaternary age marine sands and gravels, referred to as the Waites Formation.
- Based on a site walkover undertaken by a WSP Engineering Geologist, the dominant failure mode in the mudstone along the beach below Omau Cliffs is confirmed to be slab failure along SW-NE and WNW-ESE orientated, very steeply inclined to subvertical, planar, moderately widely spaced (0.2-0.6m) persistent joints. The intact strength of the mudstone ranges from extremely weak to weak with moderately strong calcareous mudstone layers common. The potential for larger and more complex slope failures from undercutting and collapse of overhanging rock mass was also evident from recent rockfall.
- Based on a coastal hazard assessment by Beca in 2020, historical rates of coastal retreat have been assessed to be up to 0.54m/year in the worst affected western end of the proposed subdivision. Area Susceptible to Coastal Erosion (ASCE) values for 50- and 100-year timeframes along the existing coastline reported by BECA have been reviewed and considered in the geotechnical assessment.
- Information relating to the ground conditions at the site has been obtained from the recent site investigation comprising 12 test pits and 12 Scala Penetrometer tests. The shallow investigations indicated the ground profile comprises thin topsoil (very soft) between 0.05m to 0.20m in thickness, underlain by fine to medium sand and silty sand (very loose to loose) and sandy silt (very soft to firm) encountered between 0.05m to 1.90m depth. These soils are underlain by fine to medium sand (dense to very dense) to depth of at least 2.70 m depth. Iron pans are common throughout the site, but the degree of iron oxide cementation is highly variable.
- The regional groundwater was only encountered at a depth of 1.55m in TP_10. The regional groundwater at the site is expected to be at depth of 1.50m to 6m below ground level, at/near the contact between the sand (Waites Formation) and the mudstone (O'keffe Formation).
- Pockets of perched water, associated with surface run-off, was encountered within the test pits. Surface conditions in the western half of the site was found to be relatively wetter and boggier than the eastern half. The perched water is likely due to the presence of impermeable iron pans within the near-surface sands, impeding the drainage properties.
- Based on the expected groundwater depth and the geological setting of the site, the risk of liquefaction affecting the site is considered to be low. However, given the variability of soils, the liquefaction risk needs to be further assessed in specific site investigations for each lot (specifically in regard to Lot 18 and Lot 19).
- Based on the results from the site investigations, "Good Ground" was encountered at depths varying between 0.4m and 1.9m. The contact to dense fine to medium sand or weak

sandstone (in areas with extensive iron pan developed) is considered to be the depth to "Good Ground" due to the loose/soft nature of the overlying silty sand and surficial soft silt. Specific site investigations, including Scala penetrometer testing, will be required at the building platform locations (once confirmed) to confirm the depth to "Good Ground" at each lot.

- Based on the results of the site investigations and coastal hazard assessment, it is our professional opinion, that the lots are suitable for residential development, subject to the development conditions outlined in Section 7 of this report.

The main recommendations are as follows:

1. WSP recognises that the ASCE rates presented in the Beca (2020) report have been calculated and founded on a risk-based approach. As shown on the Detailed Site Plan (refer Appendix A), all building platforms are currently positioned behind the '100-year coastal hazard' line developed by Beca. However, several building platforms (specifically in regard to Lot 1, Lot 2, Lot 8, Lot 12, Lot 16, Lot 17, Lot 18, Lot 19 and Lot 23) are situated very close to the '100-year coastal hazard' line. Given the risk-based approach to determine this line, we recommend moving these building platforms further back from the 100-year ASCE line (towards the south) where possible to provide a greater safety margin and reduce the long-term risk to property.

2. Given the mode of cliff erosion, it is our opinion that quantitative slope stability modelling of the coastal cliffs is unlikely to provide additional value to predicting future coastal retreat and risk to the individual lots in the proposed subdivision. Instead, we consider the ASCE approach adopted by Beca likely to be representative of the coastal erosion risk over the next 100 years.

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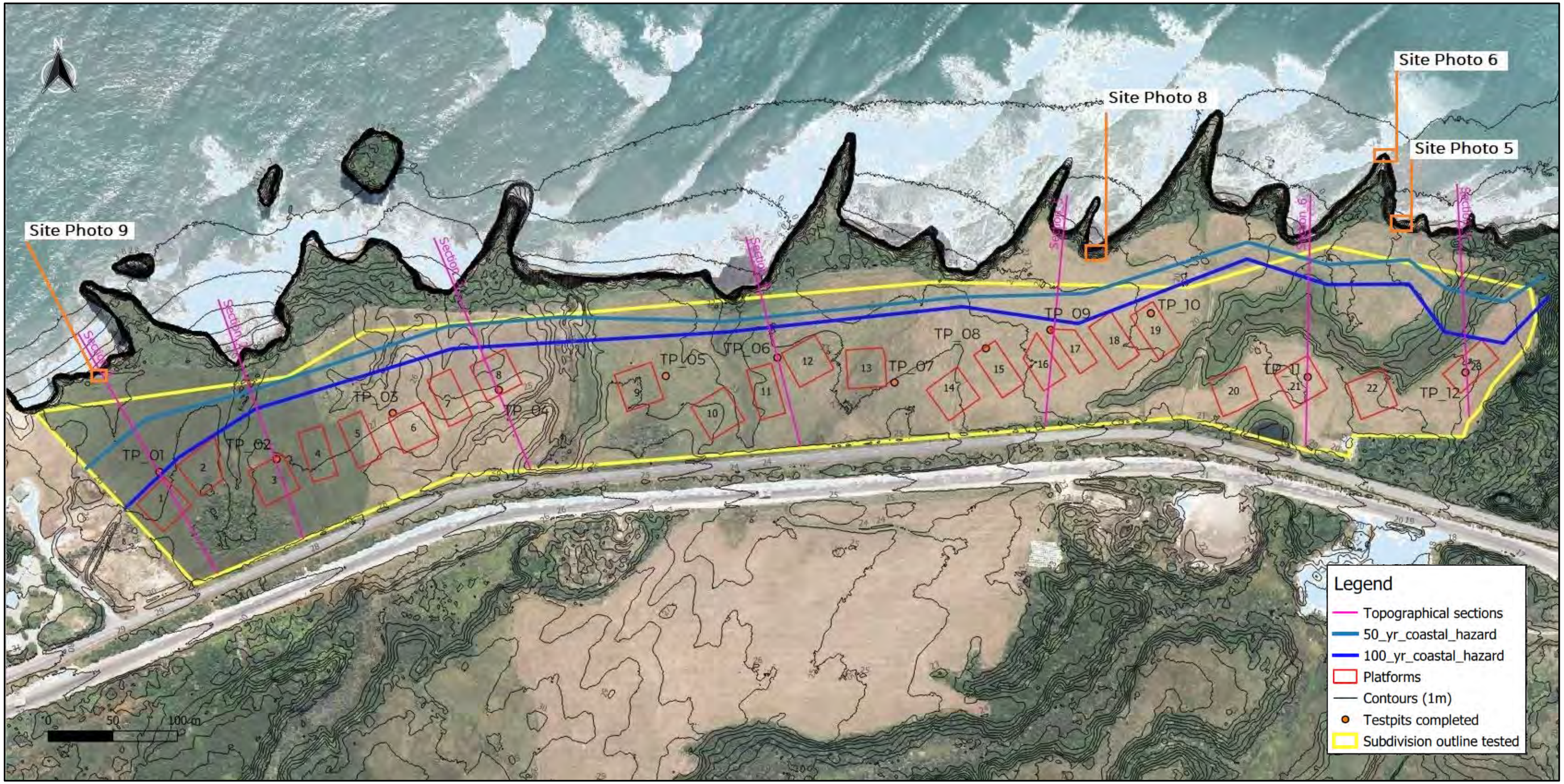
Appendix A – Detailed Site Plan

Detailed Site Plan – Geotechnical Site Investigation 2021



Appendix B – Site Photos

Site Photo 1 The proposed Omau Cliffs Subdivision is located on a slightly undulating raised coastal terrace overlooking Buller Bay.

Site Photo 2 Minor slope instability associated cut slope along an access ramp to a creek crossing

Site photo 3 Typical slab failure along SW-NE and WNW-ESE orientated, very steeply inclined to subvertical, planar, moderately widely spaced (0.2-0.6m) persistent joints observed in the mudstone along the beach below Omau Cliffs. The intact strength of the mudstone ranges from *extremely weak to weak*.

Site photo 4 Recent significant failure likely due to undercutting of the toe by wave action causing collapse of the overhanging rockmass. Daypack in the centre of the photo for scale. Note the typical steep planar failure plane behind the spoil indicating

Site photo 5 Structural complexity observed in the mudstone from the beach. Likely low angle thrust fault (F) with a small drag on the hanging wall block (RHS of photo) truncated by erosional unconformity and overlain by Quaternary sands and gravels. Although the area appears relatively stable it shows potential for a range of failure modes including larger complex failures, block slides.

Site photo 6 Typical headland with relatively stronger mudstone (strength: weak). Note the subvertical joints in the upper section of the mudstone and overlying iron oxide cemented sandstone (visible open joints by white marker).

Site photo 7 Calcareous concretions (strength: moderately strong) observed in the mudstone on the beach by Gibsons Creek outlet.

Site Photo 8 Recent failure in Quaternary unconsolidated sands along the crest of the Omau Cliffs. Lack of extensive iron cementation makes this section more prone slope failures

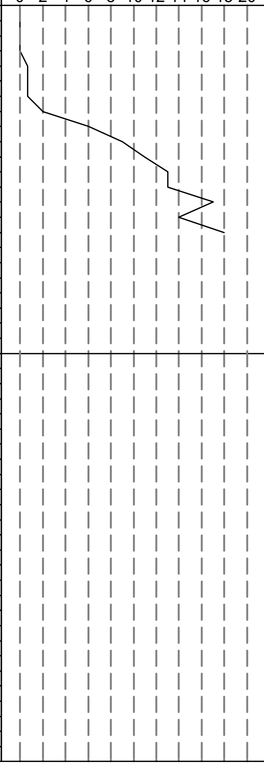
Site Photo 9 Recent slope failure along the cliff crest caused by water intrusion from natural drainage of the terrace. West end of the subdivision. Lack of extensive iron cementation makes this section more prone slope failures

Appendix C – Testpit Logs

Test Pit No. TP_01

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474049 E 5377127 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 27 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Sandy SILT with some clay; greyish brown. Very soft; moist to wet; moderate plasticity [TOPSOIL].								
		Silty SAND with minor clay; light brownish grey. Loose; moist to wet; well graded; sand, fine. Rootlets common.								
		Peaty SAND with some silt; brown. Loose to medium dense; moist; well graded; sand, fine to medium. Rootlets common.								
	1				26	1				
		Fine to medium SAND; brownish grey. Dense; moist; well graded. Trace of coarse sand. Iron nodules and thin iron pans common.								
		Fine to medium SAND; grey. Dense; moist; well graded. Trace of coarse sand.								
	2					2				
		END OF PIT AT 2.3m - Target Criteria Achieved								
	3				24	3				
	4					4				



PHOTOGRAPHS

Testpit TP_01

Date Tested:	4/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Notes:
Testpit positioning with handheld GPS.
Slow groundwater seep at 1.40m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

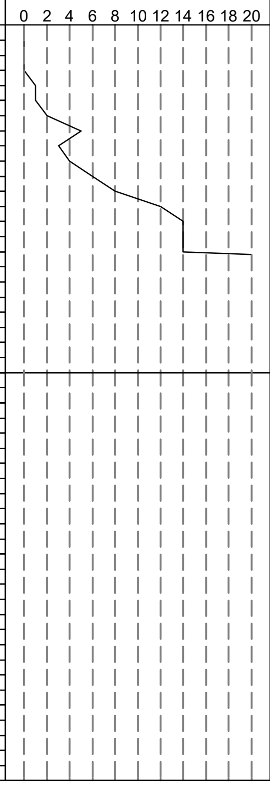
Scale 1:50 @ A4

Test Pit No. TP_02

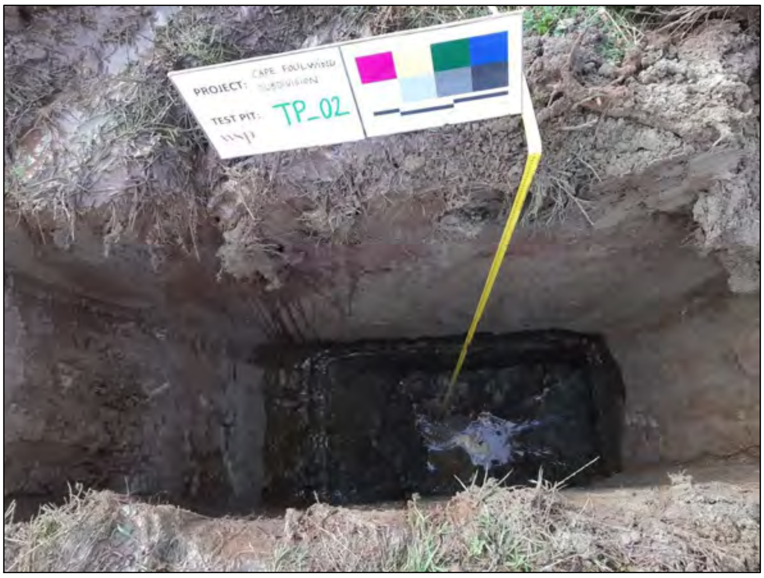
Project:	Cape Foulwind Subdivision	*Coordinates:*	1474139 E 5377137 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 27 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

DEPTH (m)	DESCRIPTION	R.L. (m)
0	Sandy SILT with some clay; greyish brown. Very soft; wet; low plasticity. Rootlets common [TOPSOIL]. Soil texture (category/classification): 3 Fine sandy loam	
	Silty SAND with minor clay; light brownish grey. Very loose; moist; well graded; sand, fine to medium, silt/clay, low plasticity. Rootlets common. Soil texture (category/classification): 2 Sandy loam	
1	Fine to medium SAND with trace silt; brownish grey. Loose to dense; moist to wet; well graded. Soil texture (category/classification): 2 Loamy sand	26
2	Fine to medium SAND; grey. Dense; moist; well graded. Trace of coarse sand. Weakly cemented in parts.	
3	END OF PIT AT 2.3m - Target Criteria Achieved	24
4		

SOIL TESTS — SCALA PENETROMETER (Blows per 100mm); SHEAR STRENGTH (kPa); OTHER TESTS; SAMPLES



PHOTOGRAPHS



Testpit TP_02

Notes:
Testpit positioning with handheld GPS.
Slow groundwater seep at 1.40m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

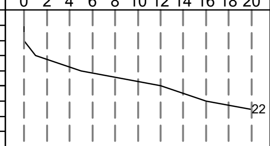
Scale 1:50 @ A4

Date Tested:	4/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Test Pit No. TP_03

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474229 E 5377173 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 26.5 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Sandy SILT with some clay; greyish brown. Very soft; wet; sand, fine; low plasticity [TOPSOIL].								
		Silty SAND with minor clay; light brownish grey. Very loose to medium dense; moist to wet; well graded; sand, fine to medium; silt/clay, low plasticity.			26		22			
	1	Moderately weathered, dark orange, homogeneous, fine to medium SANDSTONE. Very weak. Iron oxide cemented sand.				1				
		END OF PIT AT 0.9m - Unable to Advance Auger - Too Hard								
	2				24	2				
	3					3				
	4				22	4				



PHOTOGRAPHS

Testpit TP_03

Notes:
Testpit positioning with handheld GPS.
Test pit dry.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	4/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

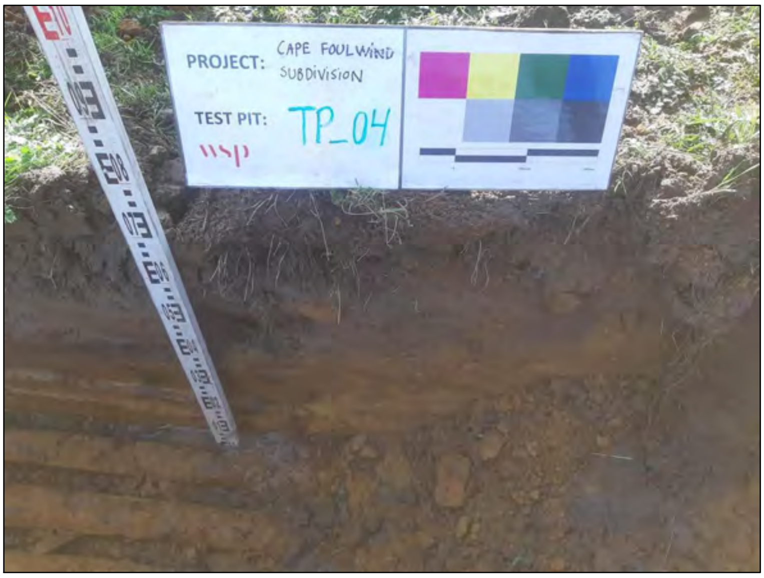
Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.
Scale 1:50 @ A4

Test Pit No. TP_04

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474312 E 5377191 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 25 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Sandy SILT with some clay; greyish brown. Very soft; wet; sand, fine; low plasticity. Rootlets and organics common [TOPSOIL]. Soil texture (category/classification): 3 Fine sandy loam								
		Silty SAND with minor clay; brownish grey. Very loose; moist to wet; well graded; sand, fine to medium; silt/clay, low plasticity. Soil texture (category/classification): 2 Sandy loam								
	1	Moderately weathered, orange, homogeneous, fine to medium SANDSTONE. Very weak. Iron oxide cemented sand.			24	1				
		END OF PIT AT 0.75m - Unable to Advance Auger - Too Hard								
	2					2				
	3				22	3				
	4					4				

PHOTOGRAPHS



Testpit TP_04

Notes:
Testpit positioning with handheld GPS.
Test pit dry. Minor groundwater seep at 0.40m

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	4/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

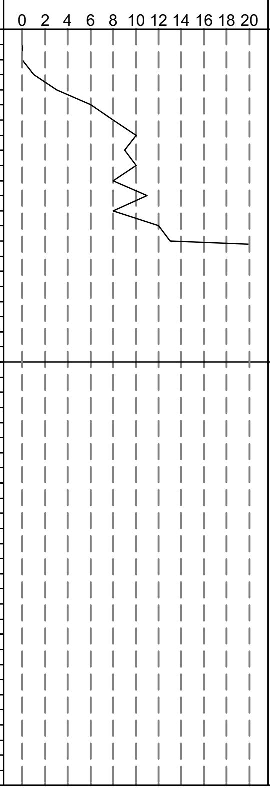
Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Test Pit No. TP_05

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474441 E 5377202 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 24 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SCALA PENETROMETER (Blows per 100mm)	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Sandy SILT with some clay; greyish brown. Very soft; wet; low plasticity. Rootlets and organics common [TOPSOIL].								
		Silty SAND with trace of clay; brownish grey. Medium dense to dense; moist to wet; well graded; sand, fine to medium, silt/clay, low plasticity. Rootlets common.								
	1	Fine to medium SAND; grey. Dense; moist to wet; well graded. Trace of coarse sand. Iron oxide nodules common, weakly cemented in parts.				1				
		Fine to medium SAND; orange grey. Very dense; dry to moist; well graded. Trace of coarse sand. Iron pan cementation.								
	2	Fine to medium SAND; grey. Tightly packed; moist to wet; well graded. Trace of coarse sand. Iron nodules common, weakly cemented in parts.			22	2				
	3	END OF PIT AT 2.2m - Target Criteria Achieved				3				
	4				20	4				



PHOTOGRAPHS

Testpit TP_05

Notes:
Testpit positioning with handheld GPS.
Groundwater seep at 0.30m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

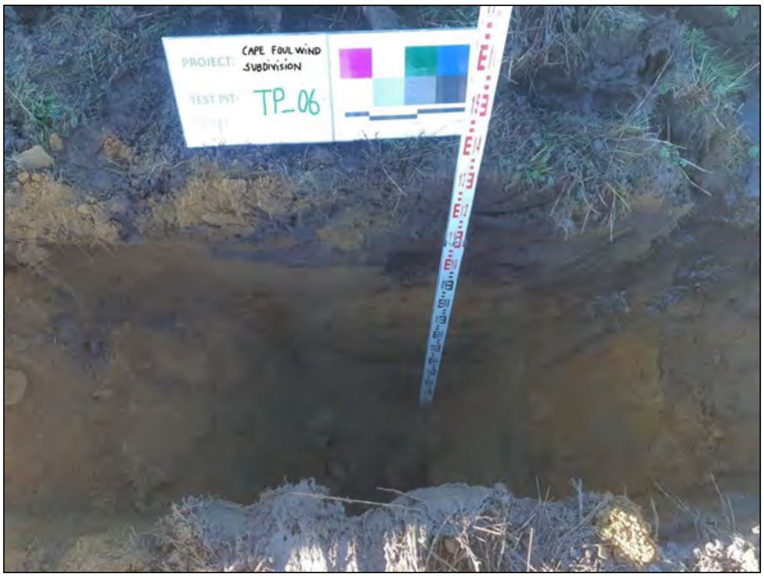
Date Tested:	4/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Test Pit No. TP_06

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474527 E 5377216 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 23 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		SILT with some sand and some clay; greyish brown. Very soft; saturated; sand, fine; moderate plasticity. Rootlets and organics common [TOPSOIL]. Soil texture (category/classification): 3 Silty loam								
		Silty SAND with trace clay; brownish grey. Very loose to dense; moist to wet to moist; well graded; sand, fine to medium; silt/clay, low plasticity. Soil texture (category/classification): 2 Sandy loam					21			
	1	Moderately weathered, orange, homogeneous, fine to medium SANDSTONE. Very weak. Iron oxide cemented sand.			22	1				
		END OF PIT AT 1.3m - Unable to Advance Auger - Too Hard								
	2					2				
	3				20	3				
	4					4				

PHOTOGRAPHS



Testpit TP_06

Notes:
Testpit positioning with handheld GPS.
Groundwater seep at 0.50m. Very soft and wet surface conditions. Otherwise test pit dry.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	4/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Test Pit No. TP_07

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474618 E 5377197 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 23 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm)	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Sandy SILT with some clay; greyish brown. Very soft; wet; sand, fine; low plasticity. Rootlets and organics common [TOPSOIL].								
		Sandy SILT with minor clay; light brownish grey. Very soft to soft; moist to wet; sand, fine; low plasticity. Rootlets and organics common.								
		Moderately weathered, orange, homogeneous, fine to medium SANDSTONE. Weak. Iron oxide cemented sand.								
	1	Fine to medium SAND; light orange grey/grey. Dense to very dense; moist; well graded. Trace of coarse sand. Weakly cemented with iron oxides.			22	1	22			
		END OF PIT AT 1.7m - Unable to Advance Auger - Too Hard								
	2					2				
	3				20	3				
	4					4				

PHOTOGRAPHS

Testpit TP_07

Notes:
Testpit positioning with handheld GPS.
Groundwater seep at 0.60m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	3/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Test Pit No. TP_08

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474688 E 5377223 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 22.5 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Silty SAND with minor clay; brown. Loose; moist to wet; well graded; sand, fine to medium; silt/clay, low plasticity [TOPSOIL].								
		Moderately weathered, dark orange, homogeneous, fine to medium SANDSTONE. Weak. Iron oxide cemented sand.			22					
		Sandy SILT with some clay; light brownish grey. Soft to firm; moist to wet; sand, fine; low plasticity.								
	1	Moderately weathered, dark orange, homogeneous, fine to medium SANDSTONE. Weak to moderately strong. Iron oxide cemented sand.				1				
		END OF PIT AT 1.15m - Unable to Advance Auger - Too Hard								
	2					2				
					20					
	3					3				
	4					4				
					18					

PHOTOGRAPHS

Testpit TP_08

Notes:
Testpit positioning with handheld GPS.
Groundwater seep at 1.15m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	3/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Test Pit No. TP_09

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474738 E 5377237 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 21.5 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Fine SAND with some silt; greyish brown. Very loose; moist; uniformly graded. Rootlets and organics common [TOPSOIL]. Soil texture (category/classification): 2 Loamy sand								
		Fine SAND with trace silt; light orange grey. Loose; moist to wet; well graded. Soil texture (category/classification): 2 Loamy sand								
	1	Sandy SILT with some clay; light brownish grey. Firm; moist; sand, fine; low plasticity. Rootlets and organics common. Soil texture (category/classification): 3 Loam				1				
		Fine to medium SAND; grey. Dense to very dense; moist to saturated; well graded.			20					
	2					2				
		PEAT; brown. Firm.								
		Fine to medium SAND; grey. Tightly packed; moist; well graded. Trace of coarse sand.								
		END OF PIT AT 2.7m - Target Criteria Achieved								
	3					3				
					18					
	4					4				

PHOTOGRAPHS

Testpit TP_09

Notes:
Testpit positioning with handheld GPS.
Groundwater seep at 1.50m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	3/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Test Pit No. TP_10

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474816 E 5377250 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 20.75 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Fine SAND with some silt; greyish brown. Very loose; moist; uniformly graded. Rootlets and organics common [TOPSOIL].								
		Fine to medium SAND; light orange grey/grey. Loose to very loose; moist to wet; well graded. Some iron oxide nodules.			20					
	1	Sandy SILT with some clay; light brownish grey. Very soft to soft; wet; sand, fine; low plasticity. Some rootlets and organics.		1.55m 3/08		1				
	2	Fine to coarse SAND; grey. Very dense; saturated; well graded. Iron oxide nodules (orange brown) common.				2				
		END OF PIT AT 2.5m - Unstable pit wall(s)			18					
	3					3				
	4					4				
					16					

PHOTOGRAPHS

Testpit TP_10

Notes:
Testpit positioning with handheld GPS.
Groundwater at 1.55m after 20min.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	3/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Test Pit No. TP_11

Project:	Cape Foulwind Subdivision	*Coordinates:*	1474938 E 5377201 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 20 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)	SOIL TESTS: SCALA PENETROMETER (Blows per 100mm) 0 2 4 6 8 10 12 14 16 18 20	SHEAR STRENGTH (kPa)	OTHER TESTS	SAMPLES
		Fine SAND with some silt; greyish brown. Loose; moist; uniformly graded. Rootlets and organics common [TOPSOIL]. Soil texture (category/classification): 2 Loamy sand								
	1	Fine to medium SAND with trace gravel; orange brown. Medium dense to dense; moist; well graded. Iron pan towards the base (weak to moderately strong). Soil texture (category/classification): 1 Sand				1				
		Sandy SILT with some clay; light brownish grey. Soft to firm; moist to wet; sand, fine; moderate plasticity. Soil texture (category/classification): 3 Fine silty loam								
	2	Moderately weathered, dark orange, homogeneous, fine to medium SANDSTONE. Weak. Iron oxide cemented sand.			18	2				
		END OF PIT AT 1.3m - Unable to Advance Auger - Too Hard								
	3					3				
	4				16	4				

PHOTOGRAPHS

Testpit TP_11

Notes:
Testpit positioning with handheld GPS.
Test pit dry.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	3/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

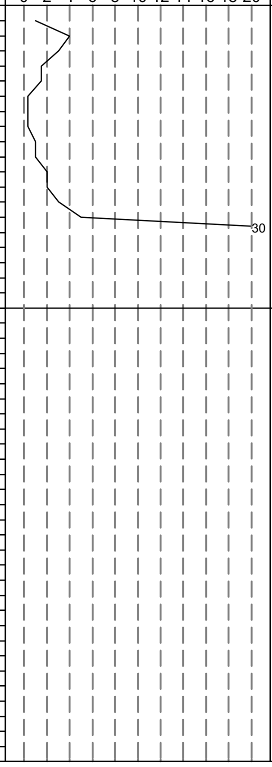
Test Pit No. TP_12

Project:	Cape Foulwind Subdivision	*Coordinates:*	1475060 E 5377204 N
Client:	Cape Foulwind Stable 2 Ltd	*Ref. Grid:*	NZTM
Project No.:	6-WCAP0.02	*R.L.:*	Approx. 17 m
Location:	Cape Foulwind, Westport	*Datum:*	Lyttelton 1937

GEOLOGY	DEPTH (m)	DESCRIPTION	GRAPHIC LOG	WATER LEVEL	R.L. (m)	DEPTH (m)
		Fine SAND with some silt; greyish brown. Very loose; moist; uniformly graded. Rootlets and organics common [TOPSOIL].				
		Fine to medium SAND with some silt and trace gravel; light orange light brown. Medium dense to loose; moist; well graded; gravel, fine. Rootlets. Likely flipped soil.				
	1	Sandy SILT with some clay; grey. Soft; wet; sand, fine; moderate plasticity.			16	1
		Moderately weathered, dark orange, homogeneous, fine to medium SANDSTONE. Weak. Iron oxide cemented sand.				
	2	END OF PIT AT 2m - Unable to Advance Auger - Too Hard				2
	3				14	3
	4					4

SOIL TESTS

SCALA PENETROMETER (Blows per 100mm) | SHEAR STRENGTH (kPa) | OTHER TESTS | SAMPLES



PHOTOGRAPHS

Testpit TP_12

Notes:
Testpit positioning with handheld GPS.
Groundwater seep at 1.50m.

Test Methods:
Determination of the Penetration Resistance of a Soil, NZS 4402 Test 6.5.2:1988
Guideline for Hand Held Shear Vane Test, NZ Geotechnical Soc., 2001

Date Tested:	3/08/2021
Excavator:	8 Ton excavator
Tested by:	T Fischer
Checked by:	N Taghipouran

Logged in accordance with NZ Geotechnical Society Guidelines (2005). See attached key sheet for explanation of symbols.

Scale 1:50 @ A4

Appendix D – Test Pit Spoil Photos

Spoil photo TP_01

Spoil photo TP_02

Spoil photo TP_03

Spoil photo TP_04

Spoil photo TP_05

Spoil photo TP_06

Spoil photo TP_07

Spoil photo TP_08

Spoil photo TP_09

Spoil photo TP_10

Spoil photo TP_11

Spoil photo TP_12

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