REPORT

Tonkin+Taylor

MILLWATER SUBDIVISION - ARRANS HILL PRECINCT 5 STAGE 3A

Geotechnical Completion Report

Prepared for
WFH Properties Ltd
Prepared by
Tonkin & Taylor Ltd
Date
October 2018
Job Number
21854.0031/AHP5S3A.v1

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Executive summary

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd to monitor and provide earthworks certification for the 23 No. Residential Lots contained within Stage 3A of Arrans Hill Precinct 5 at the Millwater Subdivision in Silverdale. Stage 3A comprises Residential Lots 37 to 47, 155 to 163 and 213 to 215, and Road Lot 902 (parts of Roads 1, 2, 4, 5 and 6 within Stage 3A) inclusive as shown on the Woods Final Contour AsBuilt Plan (Woods Ref 37503–03A–100–AB) in Appendix A1.

This Geotechnical Completion Report contains information required for subdivisional earthworks completion reporting, as well as outlining geotechnical design issues that need to be considered for subsequent building design and construction on each residential Lot.

Previous geotechnical investigation work across the subdivision was undertaken by T+T and reported in:

a 2000 and 2001 Preliminary feasibility reporting (Ref. [1] and [2]).

b 2003 Major reconnaissance report covering land in the Silverdale North and Orewa West areas (Ref. [3]).

c March 2013 Geotechnical Investigation Report for the North Bridge to Grand Drive (Ref. [4]).

d December 2015 Geotechnical Investigation Report for Arrans Hill Precinct 5 (Ref. [5]).

Woods Ltd (Woods) undertook the engineering design for this stage and the overall subdivision.

Bulk earthworks associated with development of Stage 3A of Arrans Hill Precinct 5 commenced in February 2018 and were completed by June 2018. Earthworks comprised the following:

a Stripping of vegetation, organic materials and topsoil to stockpile.

b Installation of subsoil drains.

c Cut to fill earthworks across the entire Stage 3A area as shown on the Woods Cut & Fill As–Built Plans (Woods Ref 37503–03A–110–AB to –112–AB) in Appendix A1.

d Construction of 2 No. Palisade Walls (PW6 and PW7) as shown on T+T Drawing 21854.0031–AHP5S3A–101 in Appendix A2.

e Construction of a 8m high, 1 in 2 (V:H) engineered fill batter slope (RE 6) along the eastern boundary of Residential Lots 156 to 163 as shown on T+T Drawing 21854.0031–AHP5S3A–101 in Appendix A2.

f Construction of a 11m high, 1 in 1.5 (V:H) engineered fill batter slope (part of RE 7) along the northern boundary of Residential Lots 37 to 47 as shown on T+T Drawing 21854.0031–AHP5S3A–101 in Appendix A2.

Civil earthworks commenced on site in May 2018 and were completed by September 2018, and comprised the following:

a Minor cut to fill earthworks across parts of the site as part of final Lot development.

b Installation of roading and services.

Overall subdivisional soil types are moderately expansive (Class M), based on laboratory testing undertaken in accordance with AS 2870:2011 (Ref. [7]). Due to this classification, soils lie outside the definition of good ground within NZS 3604:2011 (Ref. [8]). Building foundations will require either specific foundation design for expansive soils or foundation design in accordance with AS 2870:2011 (Ref. [7]). Subject to design issues outlined in Section 3, and CSIRO recommendations outlined in the Appendices relating to expansive soils foundation design and home owner maintenance, each residential Lot is considered to have a building platform area generally suitable for domestic residential development subject to specific geotechnical assessment and foundation design due to the presence of expansive soils and where Lots contain, or are adjacent to, land with slopes steeper than 1 in 4 (V:H).

Foundation design for residential development should proceed in accordance with Sections 6.5 to 6.10 of this report.

1 Introduction

1.1 General

Tonkin + Taylor Ltd (T+T) was engaged by WFH Properties Ltd to monitor and provide earthworks certification for the 23 No. Residential Lots contained within Stage 3A of Arrans Hill Precinct 5 at the Millwater Subdivision in Silverdale. Stage 3A comprises Residential Lots 37 to 47, 155 to 163 and 213 to 215, and Road Lot 902 (parts of Roads 1, 2, 4, 5 and 6 within Stage 3A) inclusive as shown on the Woods Final Contour AsBuilt Plan (Woods Ref 37503–03A–100–AB) in Appendix A1.

Previous geotechnical investigation work across the subdivision was undertaken by T+T and reported in:

a 2000 and 2001 Preliminary feasibility reporting (Ref. [1], [2]).

b 2003 Major reconnaissance report covering land in the Silverdale North and Orewa West areas (Ref. [3]).

c March 2013 Geotechnical Investigation Report for the North Bridge to Grand Drive (Ref. [4]).

d December 2015 Geotechnical Investigation Report for Arrans Hill Precinct 5 (Ref. [5]).

The preliminary (Ref. [1], [2]) and investigation (Ref. [3], [4], [5]) reports noted the presence of existing instability comprising landsliding, soil creep and shallow slope movement across much of Arrans Hill Precinct 5. These features were proposed to be stabilised, and/or undercut and replaced with engineered fill, during development works. While these stabilisation works are required across much of Precinct 5, such works were not generally required to achieve satisfactory factors of safety against instability for the finished development of Stage 3A. However, undercutting was required to enable installation of the geogrid reinforcement required within the reinforced earth slopes (RE06 and part of RE07), as well as to ensure the RE slopes were founded in competent ground.

Earthworks compaction control, in terms of minimum shear strengths and maximum air voids, was recommended, and, along with other recommendations, has been incorporated into our control of the works and, where applicable, included in completion reporting.

The scope of work covered by this completion report includes:

a Review of geotechnical investigation reporting for the site;

b Monitoring and certification of earthworks operations in compliance with NZS 4431:1989 (Ref. [6]), including construction of 2 No. reinforced earth slopes (RE 6 and part of RE 7);

c Assessment of soils for expansive conditions in accordance with AS 2870:2011 (Ref. [7]);

d Certification of completed Lots for residential development in accordance with NZS 3604:2011 (Ref. [8]).

Woods Ltd (Woods) undertook subdivision engineering design and civil works construction observations. As-built plans showing final contours and cut and fill depths have been prepared by Woods and are attached in Appendix A1.

1.2 Description of Subdivision

The Millwater subdivision is situated to the north of the Silverdale Township, and west of the Metro Park East reserve area, and comprises approximately 260 hectares. The subdivision is bound to the south and west by Wainui Road, to the north by the Orewa Estuary and to the east by the Orewa Estuary and Millwater Parkway. The original site comprised a mix of farm properties and associated dwellings and existing residential developments.

The Arrans Hill Precinct 5, Stage 3A area of the Millwater subdivision is located within what is known as Precinct 5 in the Orewa West Structure Plan.

The Arrans Hill Precinct 5 area is bound by State Highway 1 to the west, Grand Drive to the north, Arran Drive to the east, and the Orewa estuary to the south. The overall Arrans Hill Precinct 5 and Stage 3A areas are shown on T+T Drawing 21854.0031–AHP5S3A–100 in Appendix A2.

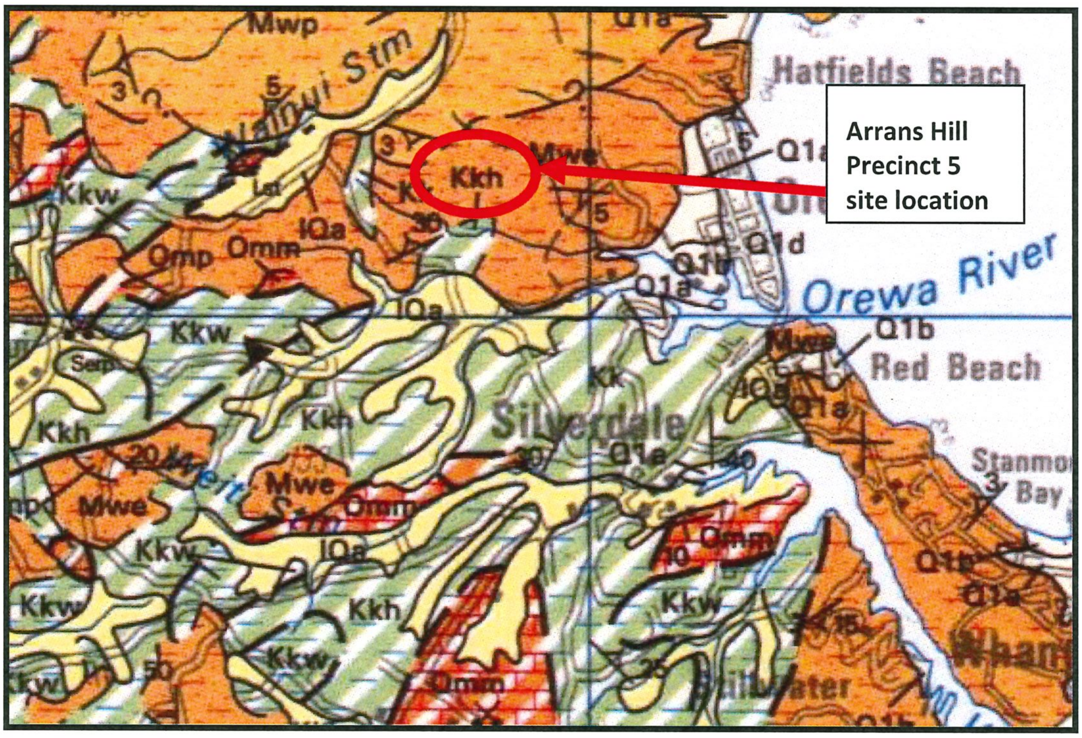
Pre-development gradients within the Stage 3A area were gentle to moderately steep (1 in 3, to 1 in 15 (V:H)) with an overall fall to the north.

Post-development gradients within the Stage 3A area generally remain gentle to moderately steep (1 in 3, to 1 in 15 (V:H)) and fall to the north and east. In order to form more level building platforms, steep reinforced earth slopes of between 1 in 2 and 1 in 1.5 (V:H) have been constructed as shown on T+T Drawing 21854.0031–AHP5S3A–101.

Stage 3A is presently accessed from the existing Arran Drive.

1.3 Geological Setting

Published geological mapping and information indicates the Arrans Hill Precinct 5 area is underlain by East Coast Bays Formation (ECBF) materials. In addition to the ECBF materials, our investigations identified the presence of alluvial and colluvial materials on site along the stream margins.



Arrans Hill Precinct 5 site location

Figure 1 - Local Geology (from Edbrooke)

Summary descriptions of geological units in the Arrans Point area (after Kermode 1991) are as follows:

a East Coast Bays Formation

Alternating sandstone and mudstone with variable volcanic content (volcanic-poor lower in the sequence and mixed volcanic content higher) and interbedded volcaniclastic grit beds. These material typically show a well-developed weathering profile of clay, silt or sand depending on the parent lithology.

b Pleistocene Age Alluvium and Colluvium

Alluvium and Colluvium are generally observed on the lower slopes, along the edges of the tidal tributaries of the Orewa River - along the southern and eastern boundary of the site. In places, it is locally discontinuous or absent.

The alluvial deposits are typically very thinly to very thickly bedded, yellow-grey to orange-brown, angular to well rounded, mixed sizes (usually graded, coarse becoming fine upwards) of mud, sand and gravel, comprising rock fragments and weathered rock residue from the hinterland. They include some beds of black, humus-rich clay and white, pumice silt.

Colluvium closely resembles the undisturbed residual soil materials, comprising a mix of clayey silts and silts, but is often of lesser strength due to the deformation and disturbance that has occurred during transportation down-slope.

Geological cross-sections through the Arrans Hill Precinct 5 Stage 3A area, based on site investigations and observations during construction, are enclosed as Drawing Number 21854.0031–AHP5S3A–103 to –105 in Appendix A2.

Fill material placed across the site to form the final design profile typically comprised site-won East Coast Bays Formation materials.

2 Earthworks Operations

2.1 Plant

Bulk earthworks and civil works were undertaken by Hick Bros Civil Construction Ltd (Hicks). Various areas of soft and/or wet materials were encountered during the works and were undercut and replaced with engineered fill. Much of this undercut material was considered suitable for re-use as engineered fill if conditioned appropriately. Accordingly, mixing of the cohesive fill materials with lime/cement to facilitate fill placement and compaction was undertaken by Hiway Stabilizers Ltd (Hiway) under Hicks' control.

Various earthworks equipment was used to undertake the works, comprising motor scrapers, articulated dump trucks, tractors and discs, sheepsfoot compactors, padfoot rollers, and a number of 12 to 35 tonne excavators. This plant generally carried out all construction earthworks.

Specialist contractors and plant were brought on site for pavement construction. Certification of the pavement construction is beyond the scope of this report.

2.2 Construction Programme

Subdivisional earthworks commenced from February 2018 through to June 2018 under Hicks' control. Civil earthworks and construction for the residential Lots were also under Hicks' control and were undertaken progressively from May 2018 through to completion in September 2018.

Key Stage 3A earthworks components included:

a Stripping of vegetation, organic materials and topsoil to stockpile.

b Installation of subsoil drains.

c Cut to fill earthworks across the entire Stage 3A area as shown on the Woods Cut & Fill As–Built Plans (Woods Ref 37503–03A–110–AB to –112–AB) in Appendix A1.

d Construction of 2 No. Palisade Walls (PW6 and PW7) and 2 No. reinforced earth slopes (i.e. RE 6 and part of RE 7), as shown on T+T Drawing 21854.0031–AHP5S3A–101 in Appendix A2.

Key Stage 3A civil works components included:

a Minor cut to fill earthworks across parts of the site as part of final Lot development.

b Installation of roading and services.

The earthworks, undercuts and subsoil drainage as–built plans are included in Appendix A1 (Woods Drawings 37503–03A–100–AB, –110–AB to –112–AB, and –120–AB), and show the earthworks undertaken across the site.

2.3 Compaction Control

Compaction control criteria, consisting of maximum allowable air voids and minimum allowable shear strengths, were used for cohesive fill control. The Technical Specification included in our Geotechnical Investigation Report (Ref. [4],[5]) included the following requirement for the subdivisional earthworks:

Minimum Shear Strength and Maximum Air Voids Method

Minimum Undrained Shear Strength (Measured by insitu vane – IANZ calibrated)

General fills:

Average value not less than	140 kPa
Minimum single value	110 kPa

High Strength Structural fills (Undercuts & Reinforced Earth Fill Slopes):

Average value not less than	150 kPa
Minimum single value	120 kPa

Maximum Air Voids Percentage (as defined in NZS 4402:1986)

General fills:

Average value not more than	10%
Maximum single value	12%

High Strength Structural fills (Undercuts & Reinforced Earth Fill Slopes):

Average value not more than	8%
Maximum single value	10%

The average corrected shear strength value was determined over any ten consecutive tests.

Regular in situ density, strength and water content tests were carried out on the filling at, or in excess of, the frequency recommended by NZS 4431:1989 (Ref. [6]). Test results are contained in Appendix E.

Quality Control (QC) testing showed that the results for the filling were consistently meeting the required undrained shear strength, density and air voids criteria, demonstrating that the water content of placed fill was consistently at, or close to, optimum. To the best of our knowledge, any problems encountered were rectified, where required, by close monitoring of the selection of borrow materials, discing and remixing of the available soil types and minor reworking.

3 Geotechnical Development Works

3.1 Subsoil Drainage

A network of subsoil drains has been installed across Arrans Hill Precinct 5 during bulk earthworks as part of the reinforced earth slope construction.

Subsoil drains installed as part of reinforced earth slope construction comprised the following:

a 160mm diameter, Hiway grade, perforated Nexus pipes along the base of the rear of the reinforced soil block.

b SAP50 scoria over the top of the Nexus pipe and up the back face of the reinforced soil block, to within 2.0 metres of the ground surface (at time of construction).

c Bidim A19 geotextile filter-cloth over the top of the scoria prior to placement of the reinforced soil.

The reinforced earth slope drains were connected to the reticulated stormwater system or discharge into the swale drain along Grand Drive, as shown on the Woods Shear Key, Undercut and Subsoil Drain AsBuilt Plan (Woods Ref 37503–03A–120–AB) in Appendix A1 and on the T+T Drawing 21854.0031–AHP5S3A–101 in Appendix A2.

3.2 Palisade Walls

Palisade walls were identified as being required along a section of RE 7 (i.e. across Lots 37 to 47) to provide satisfactory factors of safety against instability for the finished development of Stage 3A.

2 No. palisade walls (i.e. PW6 and PW7) were constructed within Stage 3A during the bulk earthworks in the location shown on the T+T Drawing 21854.0031–AHP5S3A–101, included in Appendix A2. Palisade Wall 6 comprises 8m long 310UC97 steel piles installed at 2m centres encased in 600mm diameter concreted holes. Palisade Wall 7 comprises 6m long 250UC73 steel piles installed at 1.8m centres encased in 600mm diameter concreted holes. Drilling for the palisade wall pile bores was inspected and logged by an Engineering Geologist to check that the base of the piles had been extended sufficiently to the target depth.

Ground conditions exposed during palisade wall construction were generally as anticipated from the design stage of the development. The slope stability analysis results from the original design phase are discussed in Section 4.

3.3 Reinforced Earth Slopes

2 No. reinforced earth slopes (i.e. RE 6 and part of RE 7) were constructed during the bulk earthworks period within Stage 3A.

The reinforced earth slopes comprise horizontally laid biaxial geogrids placed at 0.5m (vertical) intervals within the engineered, compacted earth fill. The grids extend up to within 1.5 (vertical) metres of the slope crest. They have been placed at various lengths, starting at the face of the slope.

Typical cross–sections of the reinforced earth slopes are shown on T+T Drawings 21854.0031–AHP5S3A–110 to –112 in Appendix A2.

The placement of the geogrid allows steeper finished gradients than is possible with bulk fills, and will minimise risk of instability across the face of the slope, particularly where finished gradients across the slopes are up to 1 in 1.5 (V:H).

Construction of the slope comprised the following:

a placement and compaction of fill, or excavation within natural ground, to the required levels;

b placement of the geogrid, ensuring that the grid is held tightly in place;
c spreading of fill across the surface of the geogrid with lightweight plant;
d compaction and placement of further fill up to the level of the next grid layer.

The fill was placed and compacted beyond the limit of the final slope face and then trimmed back to ensure full compaction of the slope face was achieved.

As noted in Section 3.1, a drainage blanket was installed at the rear of the reinforced block of soil and comprises a minimum of 300mm thickness of SAP50 scoria, covered in Bidim A19 geotextile filtercloth and a cap of engineered cohesive fill 2m in thickness. A 160mm diameter Novaflo pipe at the base of the drainage blanket provides regular discharge outlets for any groundwater captured in the drainage blanket. These pipes are connected into the reticulated stormwater system (RE 6) or into the swale drain below Grand Drive (RE 7).

The slopes have been designed to accommodate surcharge of up to 10kPa distributed load at the crest of the slopes.

The slope faces will be subject to a planting covenant and building limitation zone preventing construction within this area. Protection of the geogrids from damage also precludes construction across the slope faces and immediately adjacent to the slope crest. Accordingly, a building restriction zone has been applied across the slopes (See Sections 5.3 and 6.6).

3.4 Undercuts

Undercuts (minimum 2m deep and 5m wide) were excavated below the toe of RE 6 and RE 7 to ensure a consistent subgrade. The undercut was replaced with engineered, compacted fill, placed in accordance with the bulk earthworks specification (Section 2.3 above).

In addition, 1m deep undercuts were excavated to expose more competent soils (minimum shear strength of 75kPa) across the Residential Lots and through the road alignments in Stage 3A due to exposure of some areas of unsuitable subgrade materials (i.e. soft and wet). The undercut was replaced with engineered, compacted fill, placed in accordance with the bulk earthworks specification (Section 2.3 above).

The extent of the undercut areas is shown on the Woods Shear Key, Undercut and Subsoil Drain AsBuilt Plan (Woods Ref 37503–03A–120–AB) in Appendix A1.

4 Stability Analyses

As noted in Section 1.1, slope stability analyses undertaken during the investigation stage of the project identified that shear keys were not required to achieve satisfactory factors of safety against slope instability for the finished development of Stage 3A.

Observations and monitoring were undertaken during bulk earthworks construction to confirm that the ground conditions exposed were consistent with the assumptions made in the stability analyses.

We are satisfied that the design stability analyses remain valid for the completed works on the following basis:

a the exposed ground conditions generally conform to those assumed for design;

b the as-built profiles match design levels;

c the earthworks monitoring shows compliance with specified criteria, upon which fill properties have been based.

5 Project Evaluation / Building Design Considerations

5.1 General

Ground conditions within the Arrans Hill Precinct 5 Stage 3A area straddle a range of "design conditions" including cut ground, filled ground, expansive soils and constructed slopes up to 1 in 1.5 (V:H). The following sections set out relevant geotechnical design issues.

5.2 Bearing capacity for building foundations

All filled and natural ground within the influence of conventional residential shallow strip and pad foundation loads is assessed as generally having a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011 (Ref. [8]). This corresponds to a factored (Ultimate Limit State) bearing capacity of 150kPa and working (Serviceability Limit State) bearing capacity of 100kPa.

Due to the presence of expansive soils, foundation conditions fall outside the definition of "good ground" contained in NZS 3604:2011 (Ref. [8]). In terms of AS 2870:2011 (Ref. [7]), the soils present are considered to lie within Site Class M (moderately expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm. Due allowance should be made for expansive soils, as discussed in Section 5.12.

Where a geotechnical ultimate bearing capacity greater than 300kPa is required to support any dwelling constructed outside the scope of NZS 3604:2011 (Ref. [8]), further specific site investigation and design of foundations will be required.

5.3 Building Limitation Zones – RE Slope

Identified steep slopes in the Stage 3A area have been constructed as reinforced earth fill structures with face gradients of between 1 in 1.5 and 1 in 2 (V:H). They are located in Lots 37 to 47 and Lots 156 to 163. Construction within the flatter parts of these Lots is intended, and a Building Restriction Zone ("No Build Zone") has been developed across the steeper sections of the Lots to ensure that the reinforcement of the slopes is not detrimentally affected by future development. The extent of the Building Limitation Zone associated with the RE slopes is shown on T+T Drawing 21854.0031–AHP5S3A–120 (Building Limitation Plan) in Appendix A2. Excavation, fill placement and/or construction within this zone is not permitted.

Vegetation on slopes that are 1 in 4 (V:H) or steeper is recommended to reduce the potential for shallow slope instability and to minimise surface erosion. Where gradients are 1 in 4 (V:H) or steeper, there is potential for minor shallow creep of the topsoil layer. However, such creep is considered unlikely to detrimentally affect the global stability of the slope.

Where slopes exceed gradients of 1 in 2 (V:H), "Enkamat" or "Geocells" have been anchored to the face of the RE Slope to function as a protective reinforcing layer for the topsoil and plant root system. This is shown on the Woods Reinforced Earth Batter & Slope Stabilisation Plan (Woods Ref 37503–03A–140–AB) in Appendix A1.

5.4 Settlement

From our inspections during earthworks operations, the results of compaction quality control testing, and post construction survey monitoring, we consider that differential settlement induced by self-weight of engineered fill should now be largely complete. Further settlements should be within normally accepted design tolerances of 25mm, as outlined in NZS 3604:2011 (Ref. [8]), with respect to conventional building development.

Monitoring points were installed across the top of the RE 7 following completion of the construction works. The monitoring commenced in November 2017 and has continued through until October 2018. The monitoring shows that while settlements of up to 11mm have occurred, there has been negligible movement since June 2018.

In order to minimise the risk of ground settlements exceeding 25 mm, NZS 3604:2011 (Ref. [8]) allows a maximum fill surcharge of 600 mm over the building platform during future development. Filling in excess of this thickness should be subject to specific foundation design and assessment.

5.5 Retaining walls

Due to the relatively shallow grades across most of the Stage 3A Lots, it is not anticipated that significant retaining walls will be required. However, if walls are required, then retaining wall design will be dependent on the site specific requirements.

For preliminary design we recommend the use of the following geotechnical design parameters:

$\gamma = 18$ kN/m^3,

$c' = 0$ kPa,

$\varnothing' = 30°$,

$K_a = 0.30$,

$K_p = 3.33$,

"Su" of 50kPa for the embedment soil (subject to confirmation during construction).

These values are based on level ground above and below the wall and will require appropriate amendment to allow for slope, traffic and other surcharges or toe slopes and the specific lot geometry and development requirements, as applicable.

All retaining walls should include a layer of free draining granular fill (with geotextile over the top) immediately behind the wall covered with a 0.3m thick (minimum) compacted clay fill cap, with intercepted groundwater seepage piped into the reticulated stormwater system.

Any walls greater than 1.5m retained height will require a geotechnical assessment, as a minimum, to check and confirm that the stability of the subject (or adjacent) Lot is not detrimentally affected.

5.6 Subsoil Drainage

Groundwater drainage was installed during bulk earthworks using Nexus drains covered in scoria and geotextile cloth to permanently handle ground water flows.

The extent of the subsoil drainage systems are shown on the Woods Shear Key, Undercut and Subsoil Drain AsBuilt Plan (Woods Ref 37503–03A–120–AB) in Appendix A1, and on T+T Drawing 21854.0031–AHP5S3A–102 in Appendix A2.

This drainage system is relatively deep and located so that it is unlikely to be encountered during future residential site development and is expected to be maintenance free. Any deep excavations should take account of the presence of these drains nonetheless. If a drain is encountered, damaged, or identified as defective, repairs should be observed by a Chartered Professional (Geotechnical) Engineer familiar with this report, and notified to Auckland Council.

5.7 Post Earthworks Investigations

Following the completion of earthworks operations, T+T have undertaken supplementary fieldwork to confirm the consistency of the natural subsoils and engineered fill. From the investigations, we confirm that the subsoils are considered to have a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011 (Ref. [8]). This corresponds to a factored (Ultimate Limit State) bearing capacity of 150kPa and working (Serviceability Limit State) bearing capacity of 100kPa. Associated borehole logs and site plan (T+T Drawing 21854.0031–AHP5S3A–121) are attached in Appendix E.

5.8 Stormwater

Public stormwater services have been installed within Arrans Hill Precinct 5 Stage 3A. Stormwater and runoff from roofs, decks and paved areas, together with discharges from future retaining wall drains and other subsoil drainage must be connected directly into the public stormwater drainage network.

5.9 Service lines

Trench backfill has been compacted to minimise potential for future settlements. However, where building envelopes lie adjacent to or across service lines, all foundations should extend and be founded below the 45 degree zone of influence line from pipe inverts. This requirement is to avoid excessive pipe surcharges, and to allow for future maintenance of the system without detrimentally affecting adjacent structures. Subject to approval from Auckland Council, foundations may extend and bridge over service lines provided specific foundation design is undertaken.

A copy of the Stormwater and Wastewater As–Built Plans (Woods Ref 37503–03A–300–AB to –302–AB and –400–AB to –402–AB) is included in Appendix A1.

5.10 Road subgrades

Based on the fill monitoring and site observations during development, filled and natural ground within the road and vehicle access Lots is considered generally suitable for the proposed residential pavements. Subgrade strength testing was carried out following excavation to formation levels along the road alignments. These subgrade test results were passed on to Woods for use in their pavement design. All road subgrades have been lime and cement stabilised to assist in pavement strengths, and to minimise the impact of expansive soils on road pavements.

For future road construction in other parts of the Arrans Hill Precinct 5 Stage 3A development, within natural ground, a design CBR of 2% is considered appropriate while, within engineered fill areas, a design CBR of 7% is appropriate.

5.11 Topsoil

Following completion of topsoil spreading and grassing, topsoil depths were measured in a representative number of the Lots and these are shown on T+T Drawing 21854.0031–AHP5S3A–122 attached in Appendix E. Due to variations in placement depths and earth worked surface levels, topsoil depths may vary from those recorded.

5.12 Expansive soils

Expansive soils (or "reactive soils" using Australian terminology) are clay soils that undergo appreciable volume change upon changes in moisture content. The reactivity and the typical range of movement that could be expected from soils underlying any given building site depend on the amount of clay present, clay mineral type, and proportion, depth and distribution of clay throughout the soil profile. Moisture changes tend to occur slowly in clays and produce swelling upon wetting and shrinkage upon drying.

Apart from seasonal moisture changes (wet winters / dry summers) other factors that can influence soil moisture content include:

a Influence of garden watering and site drainage;

b The presence of large trees (especially fast growing Australian species such as eucalyptus) close to building envelopes, and;

c Initial soil moisture conditions at construction time.

Visually, the surfaces of expansive soils are noted for developing extensive cracking during dry periods (especially late summer through autumn in Auckland) and can be locally identified by this feature when sites are excavated and left for a week or two to dry out. Further information on expansive soils is given in Appendices C and D of this report.

In order to assess for the presence of expansive soils within this stage of the development, representative soil samples were retrieved from near surface strata and tested by Geotechnics Ltd to determine soil shrinkage characteristics in accordance with AS 1289.7.1.1.

Based on the laboratory results (attached in Appendix E), the foundation soils on this stage of the subdivision lie outside the definition of 'good ground' as outlined in NZS 3604:2011 (Ref. [8]).

In terms of AS 2870:2011 (Ref. [7]), the soils present are considered to lie within Site Class M (moderately expansive) with characteristic surface movements anticipated to be in the range of 20mm to 40mm.

Accordingly, building foundations on this stage of the subdivision will need to be subject to specific foundation design by a Chartered Professional Engineer familiar with the contents of this report and responsible for design of structural elements (including foundations) of the building. Reference should be made to AS 2870:2011 (Ref. [7]) for assistance.

6 Statement of Professional Opinion as to the Suitability of Land for Building Development

I, Mr A.P. Stiles of Tonkin + Taylor Ltd, P O Box 5271, Wellesley St, Auckland, hereby confirm that:

6.1 I am a Chartered Professional Engineer experienced in the field of geotechnical engineering and an authorised representative of Tonkin + Taylor who was retained by WFH Properties Ltd as the Geotechnical Engineer on Arrans Hill Precinct 5 Stage 3A (comprising Residential Lots 37 to 47, 155 to 163 and 213 to 215, and Road Lot 902 inclusive) of the Millwater Residential Subdivision Development off Arran Drive in Silverdale. Inspection and observation of the works have been carried out during construction by either myself or staff acting under my direction.

6.2 The extents of investigations are described in Tonkin + Taylor Ltd Geotechnical Investigation Report for Arrans Hill Precinct 5 Ref. No. 21854.0031 dated December 2015. The conclusions and recommendations of those documents have been re-evaluated in the preparation of this report. Details of all earthworks control tests performed are enclosed (Appendix E).

6.3 The Contractor has confirmed that the work undertaken has been completed in accordance with the drawings, specifications and any variations issued and is consistent with the inspections and observations carried out by Tonkin + Taylor Ltd. Complete Construction Certificates have been provided by the Contractors and are presented in Appendix B. Tonkin + Taylor Ltd accepts no liability for any errors or omissions represented by those documents.

6.4 On the basis of our observations and inspections together with the information supplied by others, including the Contractor's Construction Certificates, it is my professional opinion, not to be construed as a guarantee that:

6.4.1 The earth fills shown on the attached Woods drawings, Project No 37503, Millwater, Arrans Hill Precinct 5 Stage 3A, Drawing Numbers 37503–03A–100–AB, –110–AB to –112–AB and –120–AB, have been generally placed in compliance with NZS 4431:1989 (Ref. ([6]).

6.4.2 The completed earthworks give due regard to land slope and foundation stability considerations.

6.5 **For Lots 37 to 47, 155 to 163 and 213 to 215 inclusive:**

6.5.1 Foundation design

The filled and natural ground within residential Lot boundaries is considered generally suitable for the erection thereon of light timber framed, flexibly clad residential buildings subject to clauses 6.5.2 to 6.5.6.

6.5.2 Bearing capacity

Foundation design for these Lots should limit geotechnical ultimate bearing capacity to 300 kPa (factored (ULS) 150 kPa, working (SLS) 100 kPa). This is as specified in NZS 3604:2011 (Ref. [8]).

6.5.3 Expansive soils

Due to the presence of expansive clay soils, foundation soils lie outside the definition of 'good ground' in NZS 3604:2011 (Ref. [8]). Soils are considered to lie in Site Class M (moderately expansive) as defined in AS 2870:2011 (Ref. [7]) with anticipated characteristic surface ground movements of 20mm to 40mm. Clause 6.5.3.1 of this Geotechnical Completion Report may be used for expansive soil foundation design on this subdivision:

6.5.3.1 Specific foundation design for expansive soils

Specific foundation design should be undertaken by a Chartered Professional Engineer familiar with the contents of this report and responsible for design of structural elements (including foundations) of the building.

The minimum specific design requirements set for expansive soils within this clause are:

i) Minimum foundation embedment of 600 mm following topsoil removal and benching of building platform areas to finished ground levels

ii) Four bar steel reinforcing cages should be used

iii) For buildings having brittle exterior cladding, for example brick veneer, stucco plaster, solid plaster, block work, styrofoam type cladding or sprayed plaster over harditex systems etc, the potential effects of seasonal ground movements need to be considered by the building designer.

The above minimum requirements within this clause may be superceded if individual engineers are able to demonstrate their specific design solutions are applicable to site soil conditions to the satisfaction of Auckland Council. Specific design may be undertaken by first principles or by reference to AS 2870:2011 (Ref. [7]), Section 4 and related documents.

6.5.4 Floor Slab Construction

Slab on grade construction is expected to be relatively straightforward across the subdivision, but problems can occur with slab construction on shrink/swell sensitive soils. In soils which become desiccated in summer, subsequent capillary moisture rise may cause dry soils to wet up and swell, causing slab uplift and building distress. Alternatively, construction during winter may result in subgrade soils with high moisture contents drying out through summer, with subsequent soil shrinkage and possible building deformation.

The structural engineer should take likely construction timeframes into account and confirm that their design and construction methodologies will accommodate the soil shrinkage or swelling that may occur.

The Contractor should ensure that the ground beneath the floor slab areas is suitably conditioned to ensure that the subgrade is neither too dry nor too wet prior to hardfill placement and concrete pouring to avoid undue shrink or swell movements.

6.5.5 Building maintenance - Owners responsibility

The owner is responsible for maintenance of the building and site and should be familiar with the performance and maintenance requirements set out in CSIRO sheet BTF18 Foundation Maintenance and Footing Performance: A Home Owners Guide. A copy of this sheet is included in Appendix D.

6.5.6 Retaining walls / Earthworks

No retaining wall construction in excess of 1.5 metres height and no earthworks involving fills in excess of 600mm depth should take place on these Lots unless endorsed by a suitable design undertaken by a Chartered Professional (Geotechnical)

Engineer familiar with the contents of this report and responsible for design of structural elements of the building.

6.6 **For Lots 37 to 47 and 156 to 163 inclusive:**

6.6.1 These Lots contain a "Building Line Limitation" relating to the reinforced earth slopes which forms the 1 in 1.5 to 1 in 2 (V:H) slopes along the Lot boundaries. The limitation zone is shown on T+T Drawing 21854.0031–AHP5S3A–120 in Appendix A2. Excavation, filling and/or construction within this zone is not to be undertaken, to ensure stability of the slopes is not compromised.

6.6.2 The presence of geogrids within the reinforced earth slopes is brought to the attention of future building and services designers. The topmost grid is located between 1 to 2 metres below the surface at the top of the slope, and does not generally extend more than 2 metres back from the crest of the slope. It is not expected that the grids will be encountered during future development of this Lot, however, the presence of the grids should be recognized. Any exposure and/or damage and subsequent repair to the grids during any future development must be observed and certified by a Chartered Professional Engineer (Geotechnical) familiar with the contents of this report.

Design of the reinforced earth slopes have assumed a maximum distributed load of 10kPa (dead plus live loads) up to the edge of the Building Limitation Line.

6.6.3 Any cut or fill walls greater than 1.5m retained height, or of any height within 2m of the building restriction lines shown on T+T Drawing 21854.0031–AHP5S3A–120 in Appendix A2, will require a geotechnical assessment, as a minimum, to ensure stability of the subject or adjacent Lot is not detrimentally affected.

6.6.4 Development outside of the Building Line Limitation zone may proceed in accordance with the recommendations outlined in Section 6.5.

6.7 Underfill (Subsoil) drainage

Underfill (Subsoil) drains have been installed during subdivisional development in the locations shown on the Woods Shear Key, Undercut and Subsoil Drain AsBuilt Plan (Woods Ref 37503–03A–120–AB) in Appendix A1, and on T+T Drawing 21854.0031–AHP5S3A–102 in Appendix A2. These drains are considered to be maintenance free. This drainage system is relatively deep and located so that it is unlikely to be encountered during future residential site development. Although future works are unlikely to encounter the drains, their location should be considered prior to designing deep foundations and, if damaged, repairs should be observed by a Chartered Professional (Geotechnical) Engineer familiar with this report, and notified to Auckland Council.

6.8 Stormwater and Sanitary Sewer Lines

Where building envelopes lie adjacent to or across service lines, all foundations should extend and be founded below the 45 degree zone of influence line extending from pipe inverts. This requirement is to avoid excessive pipe surcharges, and to allow for future maintenance of the system without detrimentally affecting adjacent structures. Subject to approval from Auckland Council, foundations may extend and bridge over service lines provided specific foundation design is undertaken. A copy of the stormwater and sanitary sewer as–built plans are included in Appendix A1.

6.9 Road and Access Lots

Based on the fill monitoring and site observations undertaken during site development, the filled and natural ground within Arrans Hill Precinct 5 Stage 3A is considered generally suitable for residential road and accessway construction. Scala penetrometer testing should be undertaken when road subgrades have been prepared to confirm subgrade strengths. Subject to such subgrade testing, for future road construction in other parts of the Arrans Hill Precinct 5 Stage 3A development, within natural ground, a design CBR of 2% is considered appropriate, while within engineered fill areas, a design CBR of 7% is appropriate.

6.10 Unexpected ground conditions

Our assessment is based on interpolation between borehole positions, site observations and periodic earthworks control visits. Local variations in ground conditions may occur. Although unlikely, unfavourable ground conditions may be encountered during site benching and footing excavations. It is important that we be contacted in this eventuality, or in the event that any variation in subsoil conditions from those described in the report are found. Design assistance is available as required to accommodate any unforeseen ground conditions present.

7 Applicability

This report has been prepared for the benefit of WFH Properties Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

It does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any dwelling, especially in cases where concrete blockwork and/or brick veneer or stucco plaster buildings are sited partly on fill or partly on natural ground, or where they are entirely sited on filling whose depth changes significantly across the building platform.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
James Lee	Andrew Stiles
Geotechnical Engineer	Project Director

JXXL
p:\21854\21854.0031 - arrans hill p5\gcr\stage 3a\jxxl.180808.ahp5s3a-gcr.docx

8 References

[1] Tonkin & Taylor Ltd., October 2001. *Stoney Block,* T+T Ref. 18214.

[2] Tonkin & Taylor Ltd., May 2001. *Silverdale Blocks, Silverdale, Geotechnical Issues – Future Medium Density Development,* T+T Ref. 18213.

[3] Tonkin & Taylor Ltd., November 2003. *Silverdale North and Orewa West Blocks, Silverdale, Geotechnical Issues – Future Medium Density Development,* T+T Ref. 20914.

[4] Tonkin & Taylor Ltd., March 2013. *Millwater – North South Link, North Bridge to Grand Drive, Geotechnical Investigation Report,* T+T Ref. 21854.012.

[5] Tonkin & Taylor Ltd., December 2015. *Millwater Subdivision Arrans Hill – Precinct 5 – Geotechnical Investigation Report,* T+T Ref. 21854.0031.

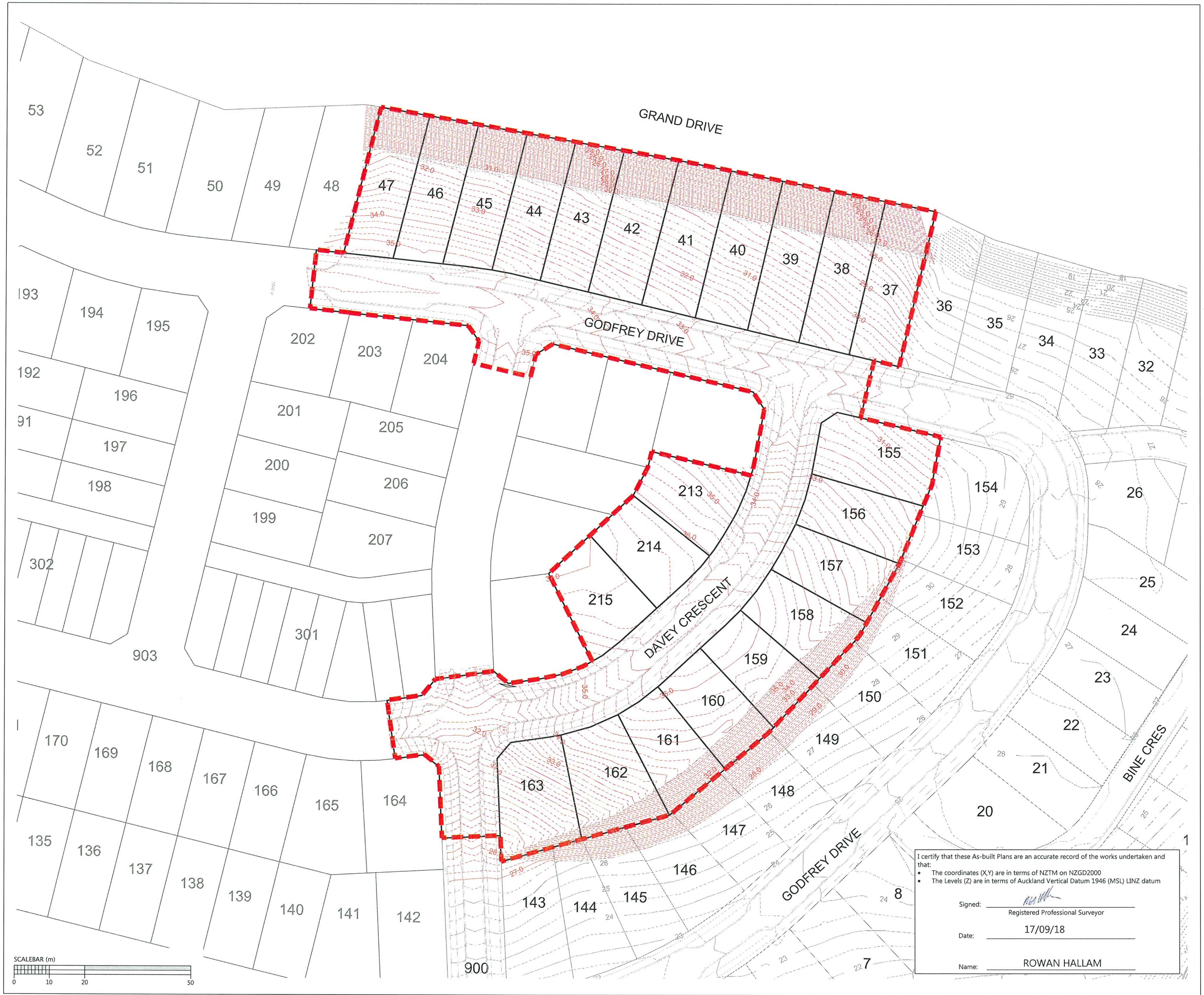
[6] New Zealand Standards, 1989. *NZS 4431:1989 Code of Practice for Earth Fill for Residential Development.*

[7] Standards Australia, 2011. *AS 2870:2011 Residential slabs and footings.*

[8] New Zealand Standards, 2011. *NZS 3604:2011 Timber Framed Buildings.*

Appendix A1: Woods Drawings

37503–03A–100–AB	Final Contour AsBuilt Plan
37503–03A–110–AB	Cut & Fill As–Built – Original to Lowest Surface
37503–03A–111–AB	Cut & Fill As–Built – Lowest to Final Surface
37503–03A–112–AB	Cut & Fill As–Built – Original to Final Surface
37503–03A–120–AB	Shear Key, Undercut and Subsoil Drain AsBuilt Plan
37503–03A–140–AB	Reinforced Earth Batter & Slope Stabilisation Plan
37503–03A–300–AB to –302–AB	Stormwater As–Built Plans
37503–03A–400–AB to –402–AB	Wastewater As–Built Plans



I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ____________________
Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM

WOODS
EST.1970

NOTES

1. NEW CONTOURS ARE AT 0.25m INTERVALS

LEGEND

───	CONTOURS MAJOR
- - -	CONTOURS MINOR
───	EXISTING CONTOURS MAJOR
- - -	EXISTING CONTOURS MINOR
▬ ▬ ▬	STAGE BOUNDARIES
───	LOT BOUNDARIES

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	17/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	MB	
DRAWN	KR	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

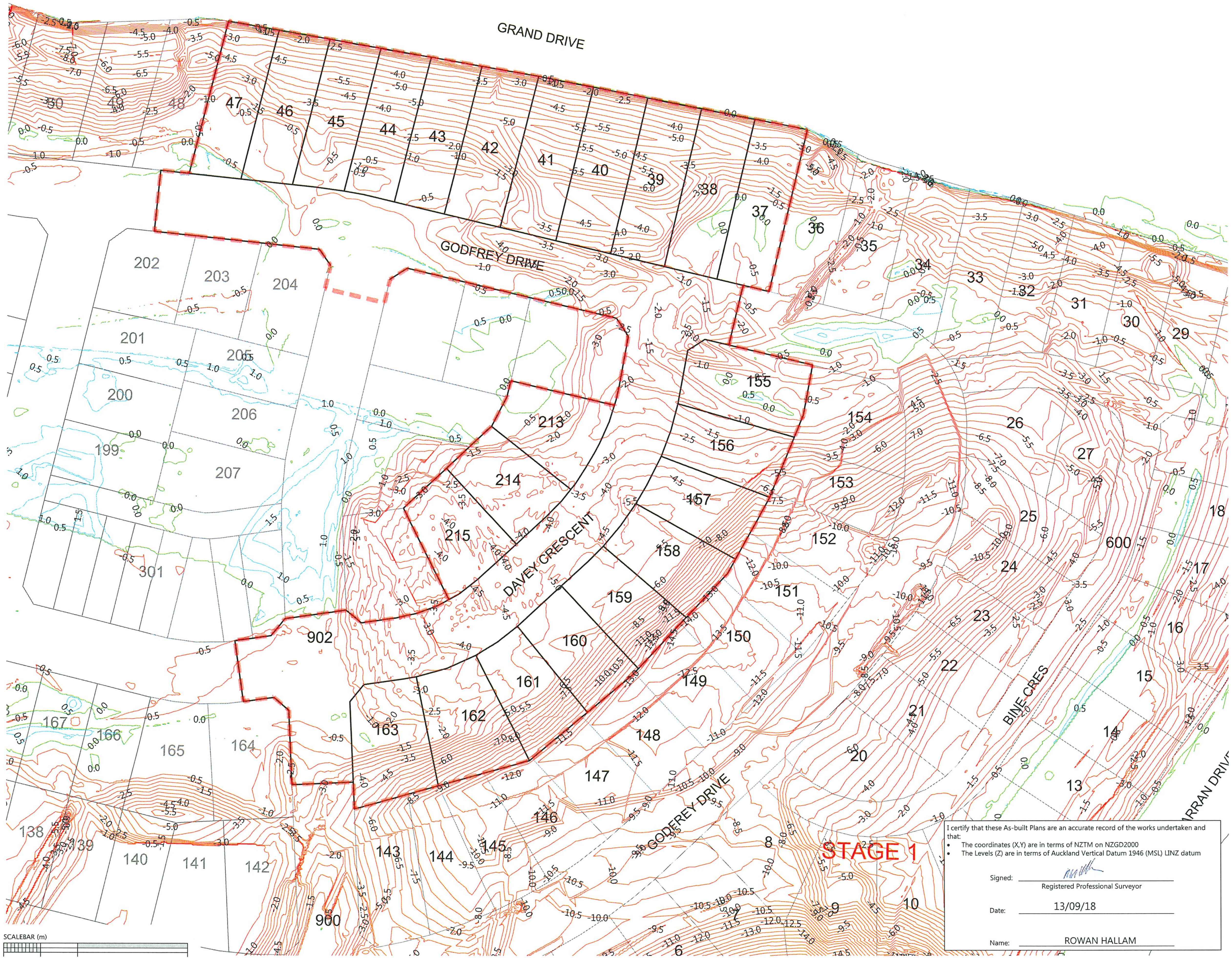
N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

FINAL CONTOUR
ASBUILT PLAN
SHEET 1 OF 1
(SLC - 66650)

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-100-AB	



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- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: Registered Professional Surveyor

Date: 13/09/18

Name: ROWAN HALLAM

WOODS
Est.1970

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

—	ZERO CONTOUR
—	CUT CONTOUR
—	FILL CONTOUR
- -	STAGE BOUNDARIES
—	LOT BOUNDARIES

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	10/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	T&T	
DRAWN	KR	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

N

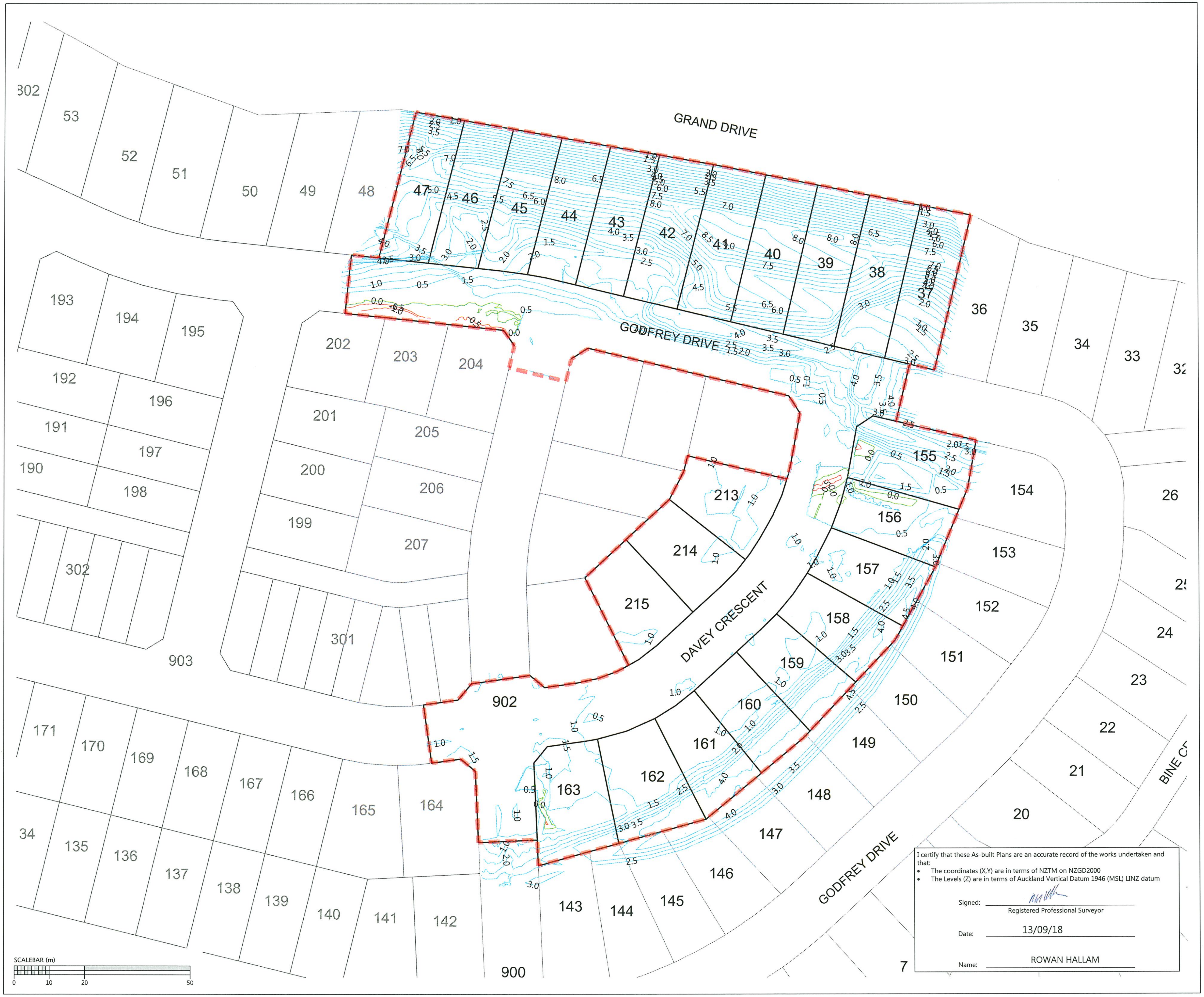
WFH PROPERTIES

MILLWATER PRECINCT 5 OREWA WEST STAGE 3A

CUT & FILL AS-BUILT ORIGINAL TO LOWEST SURFACE (SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-110-AB	

Document No. K:\37503 - ARRAN HILL PRECINCT 5 STAGE 3\DRAWINGS\SURV\AS-BUILT\3A\37503-03A-110-AB-CUT FILL CONTOURS.DWG



WOODS
EST.1970

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

- ZERO CONTOUR
- CUT CONTOUR
- FILL CONTOUR
- STAGE BOUNDARIES
- LOT BOUNDARIES

I certify that these As-built Plans are an accurate record of the works undertaken and that:

- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed:
Registered Professional Surveyor

Date: 13/09/18

Name: ROWAN HALLAM

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	10/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	MB	
DRAWN	KR	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

CUT & FILL AS-BUILT
LOWEST TO FINAL SURFACE
(SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-111-AB	

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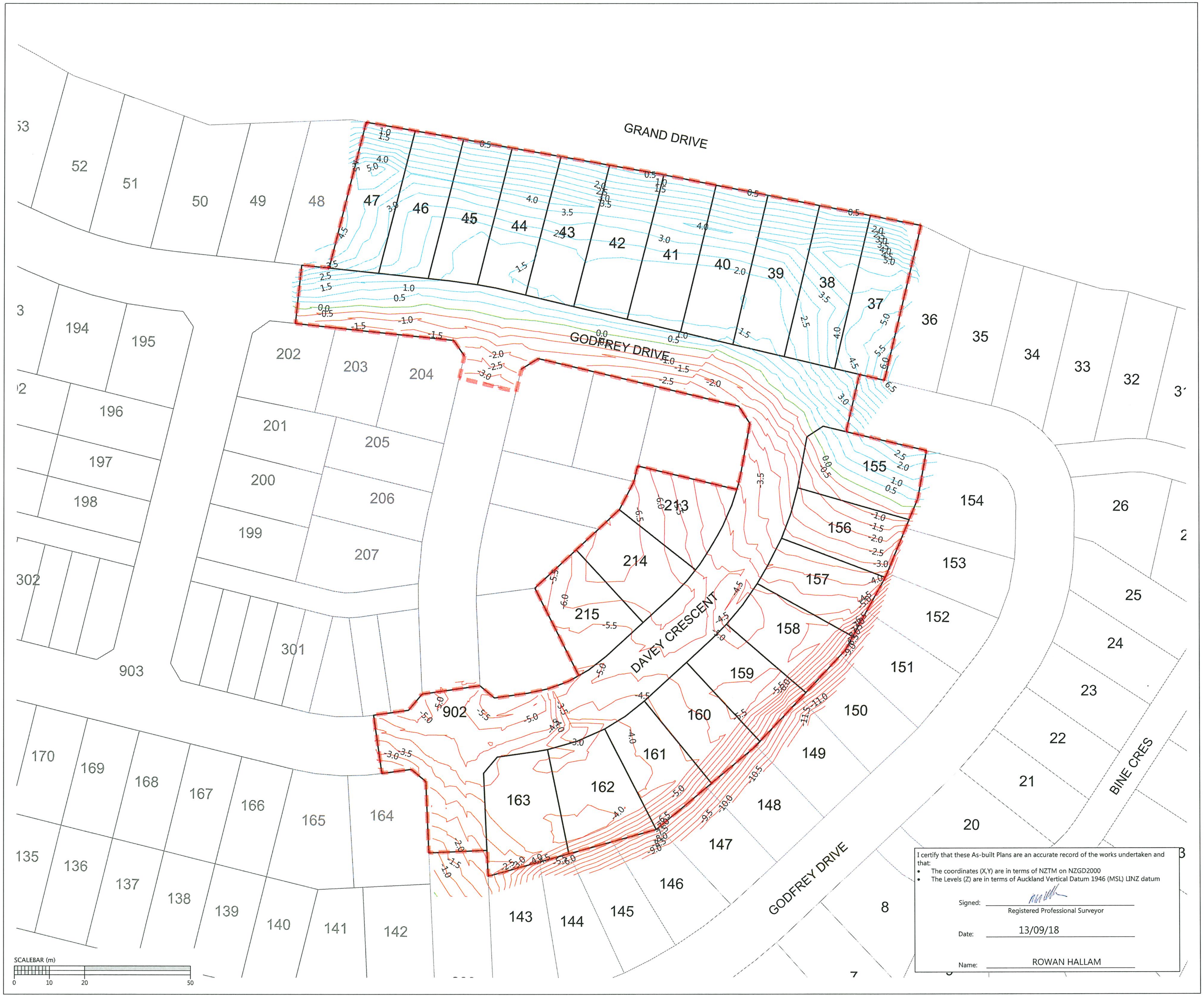

I certify that these As-built Plans are an accurate record of the works undertaken and that:

- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ____________________

Registered Professional Surveyor

Date: 13/09/18

Name: ROWAN HALLAM

WOODS
EST.1970

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

🟩	ZERO CONTOUR
🟥	CUT CONTOUR
🟦	FILL CONTOUR
🟥 - -	STAGE BOUNDARIES
■	LOT BOUNDARIES

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	10/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	MB	
DRAWN	KR	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

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WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

CUT & FILL AS-BUILT
ORIGINAL TO FINAL SURFACE
(SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-112-AB	

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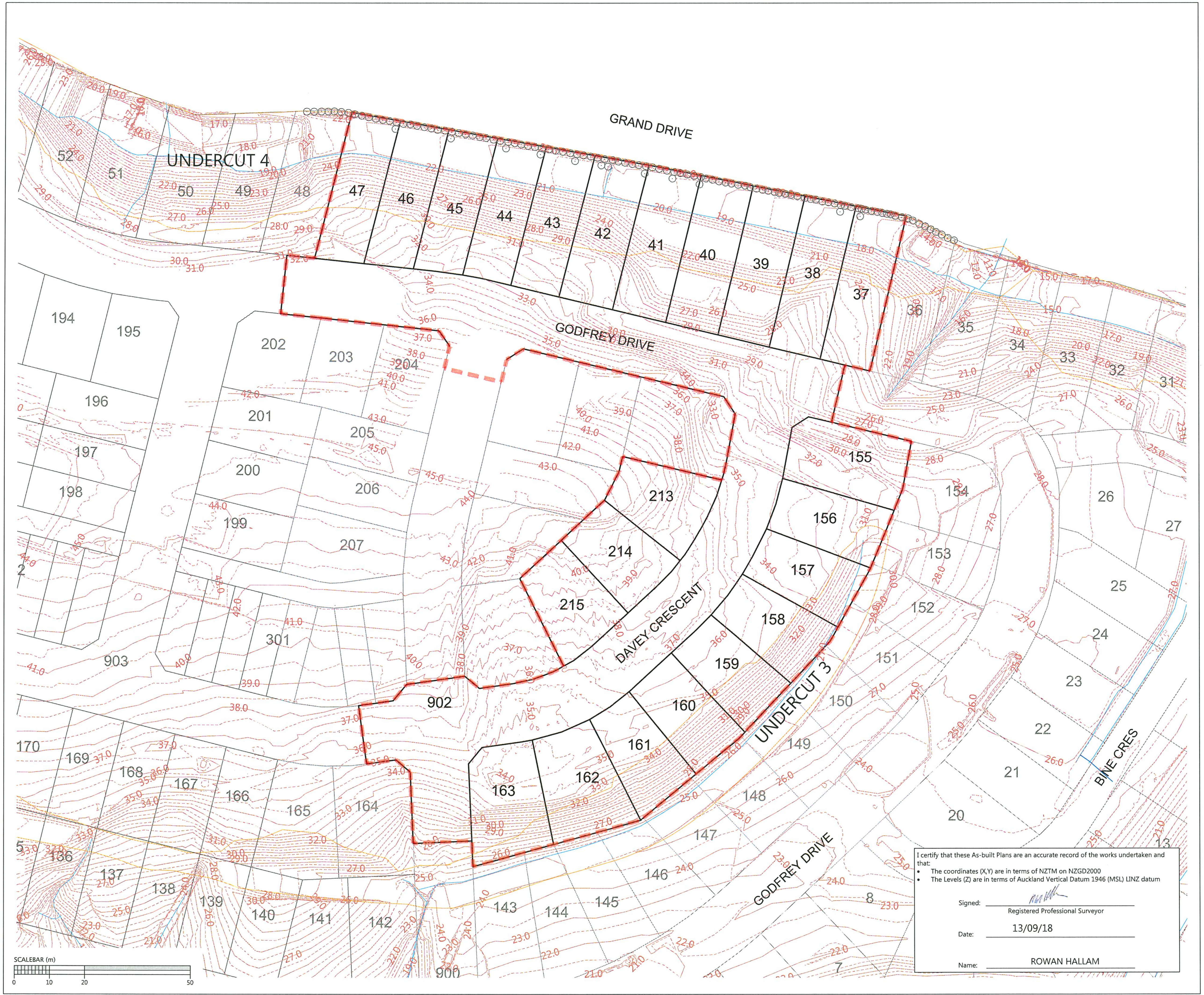

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- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______________________
Registered Professional Surveyor

Date: 13/09/18

Name: ROWAN HALLAM

WOODS
EST.1970

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS
2. SUBSOIL DATA SUPPLIED BY CONTRACTOR

LEGEND

―	NOVACOIL SUBSOIL DRAINS
―	UPVC SUBSOIL DRAINS
―	EXISTING STORMWATER DRAINAGE
-·-·-	NEW STORMWATER DRAINAGE
— —	STAGE BOUNDARIES
―	LOT BOUNDARIES
- - -	CONTOURS
▭	SHEAR KEY & UNDERCUT AREAS
○	PALISADE WALL PILE AT BOTTOM OF SHEARKEY

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	10/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	T&T	
DRAWN	KR	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

SHEAR KEY, UNDERCUT
AND SUBSOIL DRAIN ASBUILT
SHEET 1 OF 1
(SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-120-AB	

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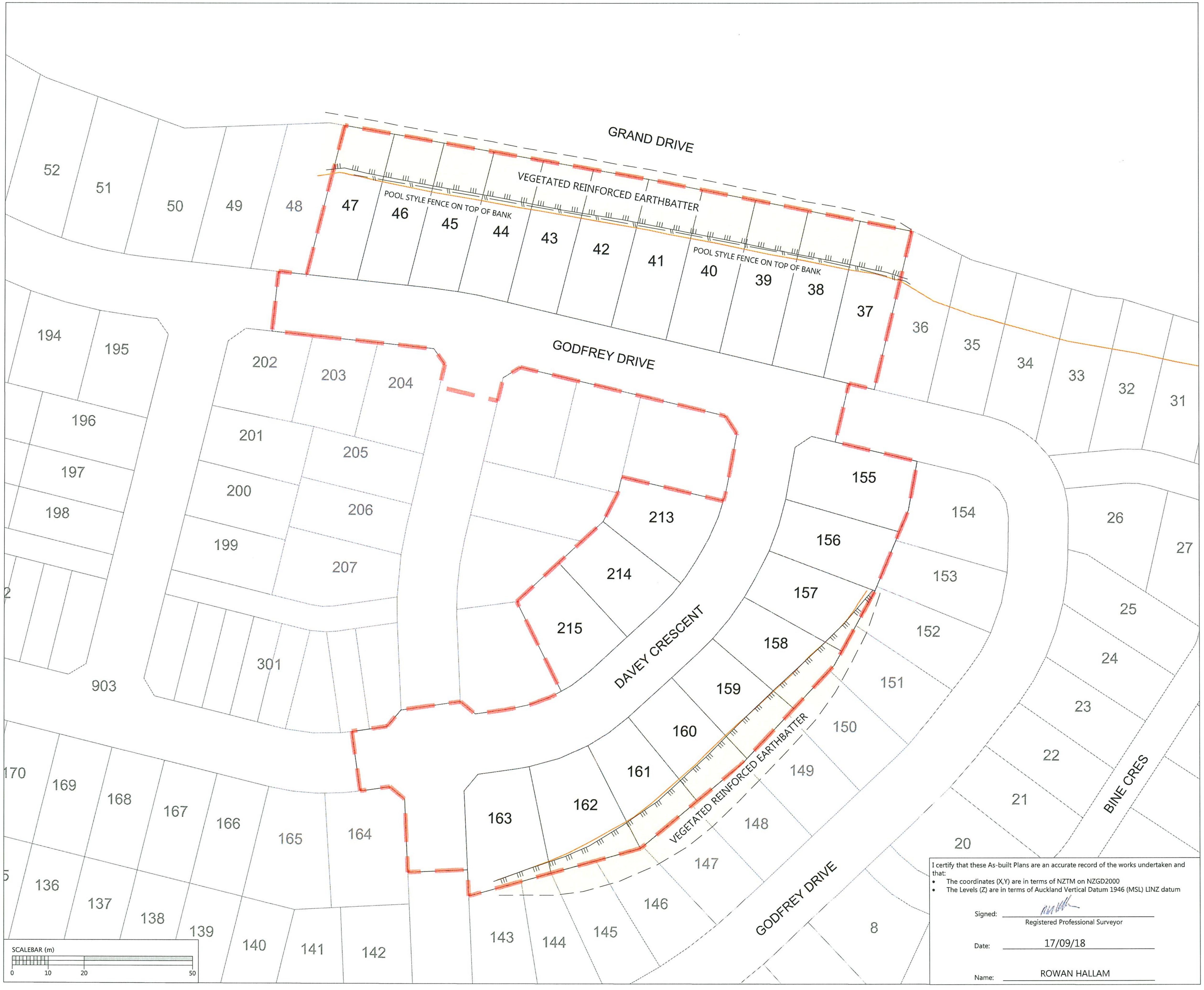

I certify that these As-built Plans are an accurate record of the works undertaken and that:

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- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM

WOODS
EST.1970

LEGEND:

———	BOUNDARY
———	DEADMAN
▭	SLOPE STABILISATION DEVICE
—‖‖—	TOP OF BANK
— —	BOTTOM OF BANK
—\\—	FENCE

NOTES:

1. *DEADMAN LOCATION PROVIDED BY CONTRACTOR. LOT OWNER TO LOCATE AND PROTECT DEADMAN POSITION PRIOR TO ANY WORKS.*
2. *THE DIMENSIONS PROVIDED ARE A BEST FIT APPROXIMATION BASED ON LOCATIONS PROVIDED BY THE CONTRACTOR.*

DISCLAIMER:
THIS DRAWING IS INTENDED TO BE SOLELY USED AS THE BASE DATA FOR THE PURPOSES OF THE CLIENT. WOODS ACCEPT NO RESPONSIBILITY FOR ANY SUBSEQUENT WORKS CARRIED OUT IN THIS AREA.

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	17/09/18

SURVEYED	CONTRACTOR	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	T&T	
DRAWN	KH	
CHECKED	KR	
APPROVED	RH	WOODS.CO.NZ

N

WFH
PROPERTIES

MILLWATER PRECINCT 5 OREWA WEST STAGE 3A

REINFORCED EARTH BATTER & SLOPE STABILISATION PLAN

STATUS	INFORMATION	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37003-03A-140-AB	

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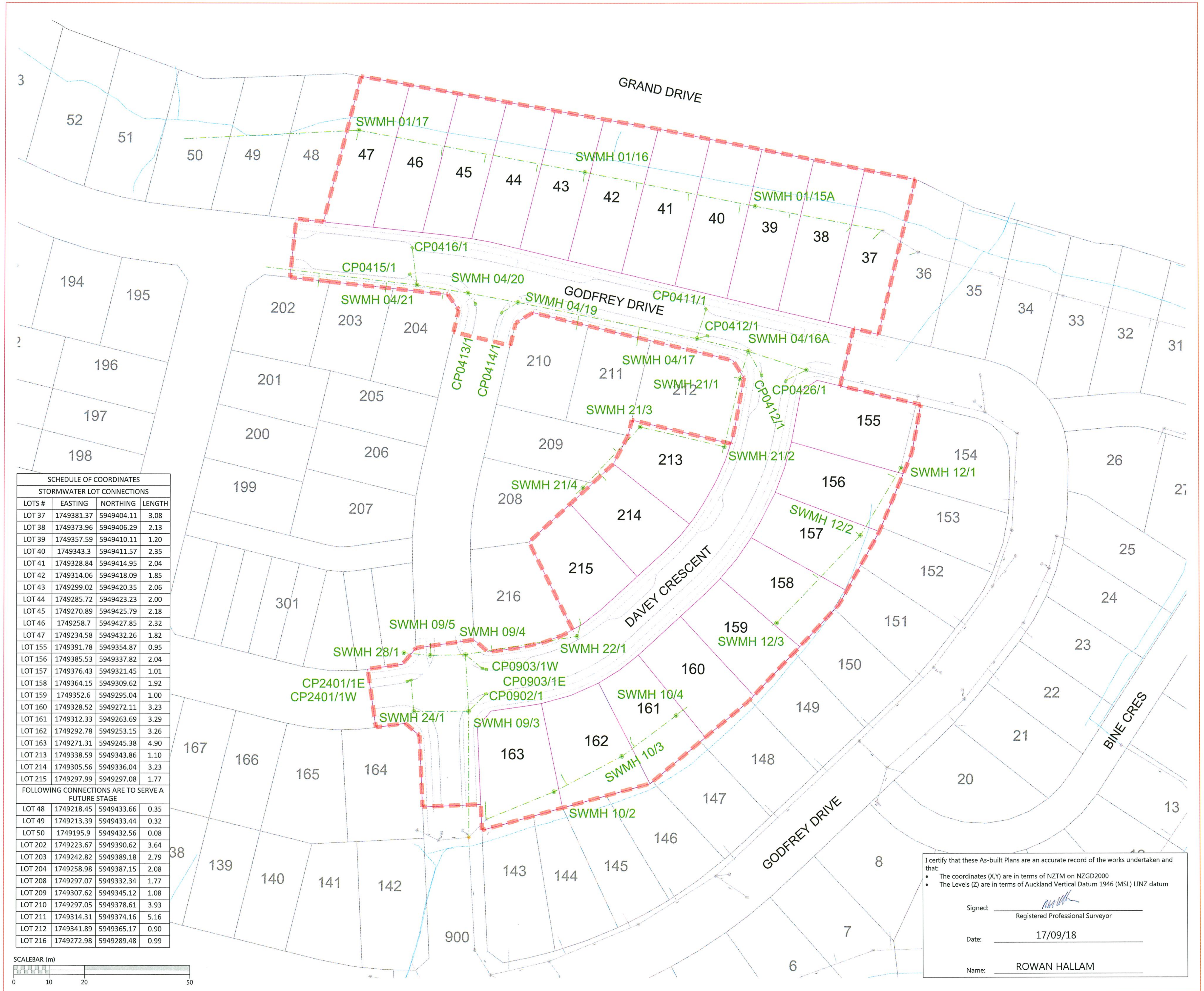

SCHEDULE OF COORDINATES			
STORMWATER LOT CONNECTIONS			
LOTS #	EASTING	NORTHING	LENGTH
LOT 37	1749381.37	5949404.11	3.08
LOT 38	1749373.96	5949406.29	2.13
LOT 39	1749357.59	5949410.11	1.20
LOT 40	1749343.3	5949411.57	2.35
LOT 41	1749328.84	5949414.95	2.04
LOT 42	1749314.06	5949418.09	1.85
LOT 43	1749299.02	5949420.35	2.06
LOT 44	1749285.72	5949423.23	2.00
LOT 45	1749270.89	5949425.79	2.18
LOT 46	1749258.7	5949427.85	2.32
LOT 47	1749234.58	5949432.26	1.82
LOT 155	1749391.78	5949354.87	0.95
LOT 156	1749385.53	5949337.82	2.04
LOT 157	1749376.43	5949321.45	1.01
LOT 158	1749364.15	5949309.62	1.92
LOT 159	1749352.6	5949295.04	1.00
LOT 160	1749328.52	5949272.11	3.23
LOT 161	1749312.33	5949263.69	3.29
LOT 162	1749292.78	5949253.15	3.26
LOT 163	1749271.31	5949245.38	4.90
LOT 213	1749338.59	5949343.86	1.10
LOT 214	1749305.56	5949336.04	3.23
LOT 215	1749297.99	5949297.08	1.77
FOLLOWING CONNECTIONS ARE TO SERVE A FUTURE STAGE			
LOT 48	1749218.45	5949433.66	0.35
LOT 49	1749213.39	5949433.44	0.32
LOT 50	1749195.9	5949432.56	0.08
LOT 202	1749223.67	5949390.62	3.64
LOT 203	1749242.82	5949389.18	2.79
LOT 204	1749258.98	5949387.15	2.08
LOT 208	1749297.07	5949332.34	1.77
LOT 209	1749307.62	5949345.12	1.08
LOT 210	1749297.05	5949378.61	3.93
LOT 211	1749314.31	5949374.16	5.16
LOT 212	1749341.89	5949365.17	0.90
LOT 216	1749272.98	5949289.48	0.99

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- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: ______ Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM

WOODS
Est.1970

LEGEND

STORMWATER MANHOLE	◉
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
NEW STORMWATER	— · —
EXISTING STORMWATER	——
SUBSOIL DRAINAGE	——
STAGE BOUNDARY	▬ ▬ ▬

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
2. ALL PIPE BEDDING COMPLIES WITH AC STANDARDS
3. ALL CESSPIT LEADS AND PIPES UNDER THE ROAD AND CARRIDGEWAYS ARE REINFORCED CONCRETE PIPES CLASS 4 (Z) RRJ. ALL OTHER PIPELINES ARE REINFORCED CONCRETE CLASS 2 (X) RRJ UNLESS OTHERWISE NOTED.
4. ALL PIPE CROSSINGS UNDER ROADS AND ACCESSWAYS HAVE BEEN HARDFILL BACKFILLED.
5. ALL SW 100mm DIA. RAMPED RISERS HAVE BEEN EXTENDED AND CAPPED OFF 1.0m BELOW THE FINISHED GROUND SURFACE.
6. ALL PRIVATE DRAINAGE CONNECTIONS ARE 100mmø.
7. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED AND CONTRACTOR RECEIVED DATA.

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	17/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	AF	
DRAWN	KH	
CHECKED	KR	
APPROVED	RH	WOODS.CO.NZ

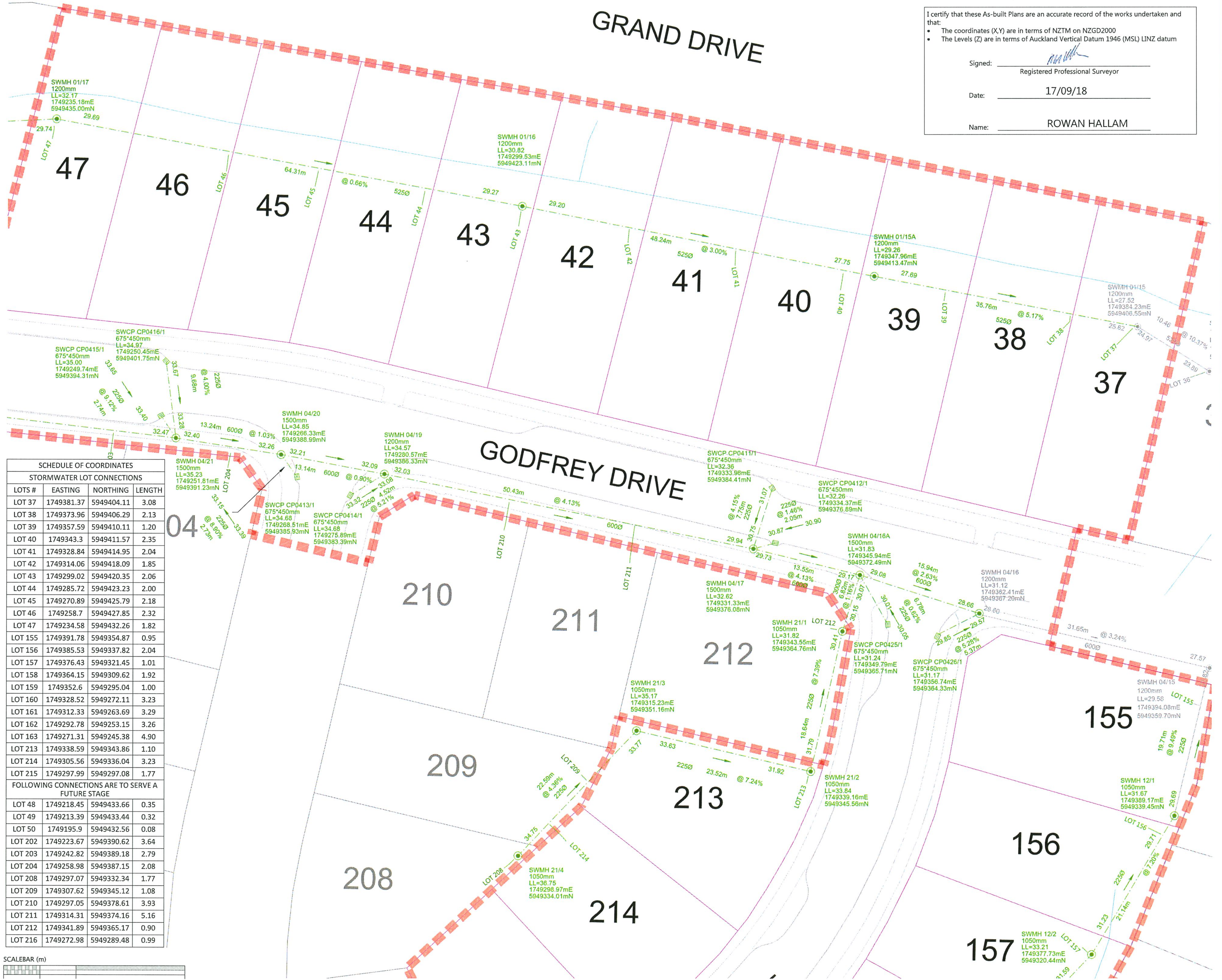
N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

STORMWATER AS-BUILT
OVERALL LAYOUT
SHEET 1 OF 3
(SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-300-AB	



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Signed: Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM

SCHEDULE OF COORDINATES			
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LOT 155	1749391.78	5949354.87	0.95
LOT 156	1749385.53	5949337.82	2.04
LOT 157	1749376.43	5949321.45	1.01
LOT 158	1749364.15	5949309.62	1.92
LOT 159	1749352.6	5949295.04	1.00
LOT 160	1749328.52	5949272.11	3.23
LOT 161	1749312.33	5949263.69	3.29
LOT 162	1749292.78	5949253.15	3.26
LOT 163	1749271.31	5949245.38	4.90
LOT 213	1749338.59	5949343.86	1.10
LOT 214	1749305.56	5949336.04	3.23
LOT 215	1749297.99	5949297.08	1.77
FOLLOWING CONNECTIONS ARE TO SERVE A FUTURE STAGE			
LOT 48	1749218.45	5949433.66	0.35
LOT 49	1749213.39	5949433.44	0.32
LOT 50	1749195.9	5949432.56	0.08
LOT 202	1749223.67	5949390.62	3.64
LOT 203	1749242.82	5949389.18	2.79
LOT 204	1749258.98	5949387.15	2.08
LOT 208	1749297.07	5949332.34	1.77
LOT 209	1749307.62	5949345.12	1.08
LOT 210	1749297.05	5949378.61	3.93
LOT 211	1749314.31	5949374.16	5.16
LOT 212	1749341.89	5949365.17	0.90
LOT 216	1749272.98	5949289.48	0.99

SCALEBAR (m)

0 5 10 25

WOODS
EST.1970

LEGEND

STORMWATER MANHOLE	◉
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
NEW STORMWATER	— · — · —
EXISTING STORMWATER	- - - - -
SUBSOIL DRAINAGE	——
STAGE BOUNDARY	▬ ▬ ▬ ▬ ▬ ▬

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
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4. ALL PIPE CROSSINGS UNDER ROADS AND ACCESSWAYS HAVE BEEN HARDFILL BACKFILLED.
5. ALL SW 100mm DIA. RAMPED RISERS HAVE BEEN EXTENDED AND CAPPED OFF 1.0m BELOW THE FINISHED GROUND SURFACE.
6. ALL PRIVATE DRAINAGE CONNECTIONS ARE 100mmø.
7. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED DATA AND CONTRACTOR RECEIVED DATA.

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	17/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	AF	
DRAWN	KH	
CHECKED	KR	
APPROVED	RH	WOODS.CO.NZ

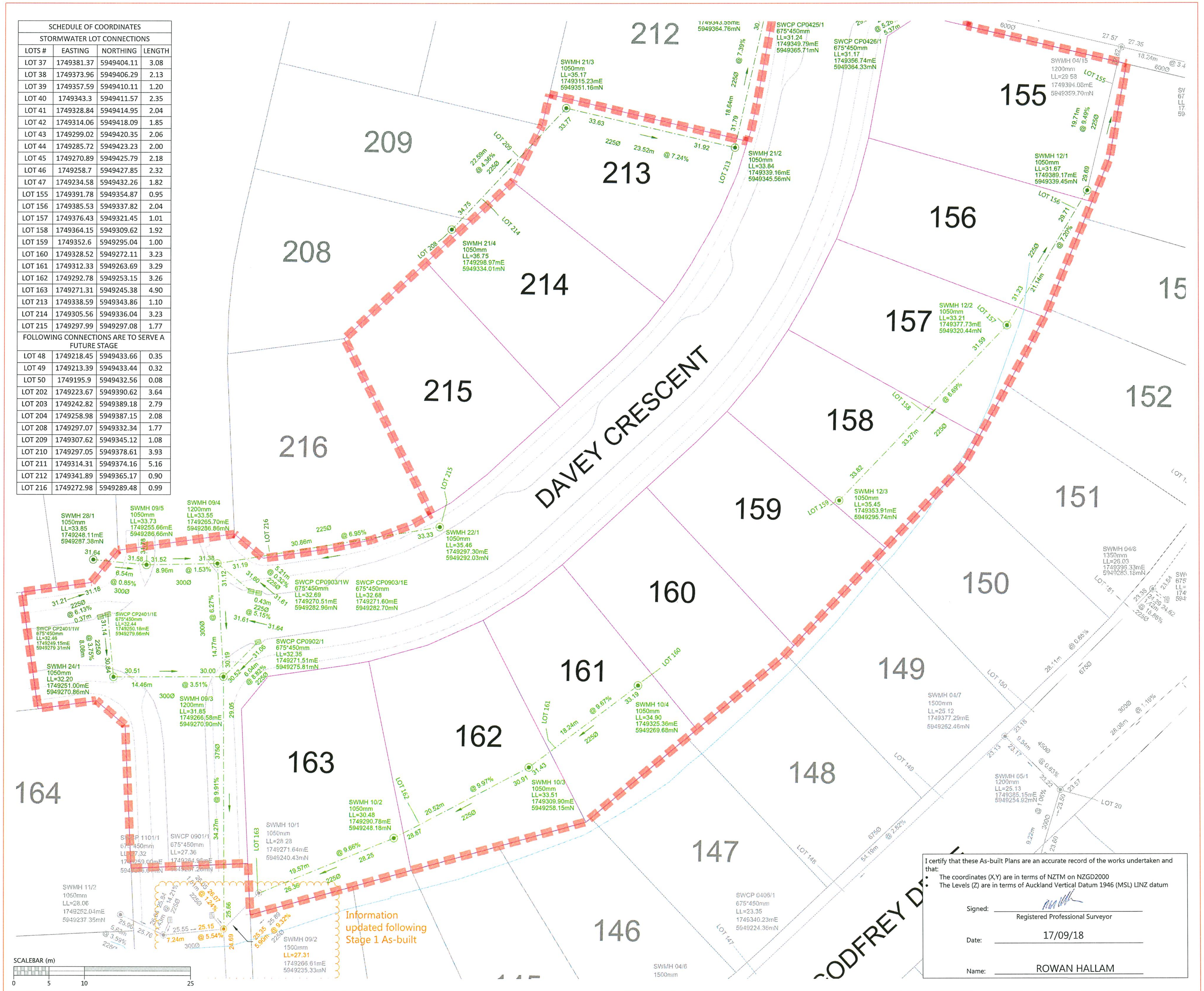
WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

STORMWATER AS-BUILT
SHEET 2 OF 3
(SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:500 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-301-AB	

SCHEDULE OF COORDINATES			
STORMWATER LOT CONNECTIONS			
LOTS #	EASTING	NORTHING	LENGTH
LOT 37	1749381.37	5949404.11	3.08
LOT 38	1749373.96	5949406.29	2.13
LOT 39	1749357.59	5949410.11	1.20
LOT 40	1749343.3	5949411.57	2.35
LOT 41	1749328.84	5949414.95	2.04
LOT 42	1749314.06	5949418.09	1.85
LOT 43	1749299.02	5949420.35	2.06
LOT 44	1749285.72	5949423.23	2.00
LOT 45	1749270.89	5949425.79	2.18
LOT 46	1749258.7	5949427.85	2.32
LOT 47	1749234.58	5949432.26	1.82
LOT 155	1749391.78	5949354.87	0.95
LOT 156	1749385.53	5949337.82	2.04
LOT 157	1749376.43	5949321.45	1.01
LOT 158	1749364.15	5949309.62	1.92
LOT 159	1749352.6	5949295.04	1.00
LOT 160	1749328.52	5949272.11	3.23
LOT 161	1749312.33	5949263.69	3.29
LOT 162	1749292.78	5949253.15	3.26
LOT 163	1749271.31	5949245.38	4.90
LOT 213	1749338.59	5949343.86	1.10
LOT 214	1749305.56	5949336.04	3.23
LOT 215	1749297.99	5949297.08	1.77
FOLLOWING CONNECTIONS ARE TO SERVE A FUTURE STAGE			
LOT 48	1749218.45	5949433.66	0.35
LOT 49	1749213.39	5949433.44	0.32
LOT 50	1749195.9	5949432.56	0.08
LOT 202	1749223.67	5949390.62	3.64
LOT 203	1749242.82	5949389.18	2.79
LOT 204	1749258.98	5949387.15	2.08
LOT 208	1749297.07	5949332.34	1.77
LOT 209	1749307.62	5949345.12	1.08
LOT 210	1749297.05	5949378.61	3.93
LOT 211	1749314.31	5949374.16	5.16
LOT 212	1749341.89	5949365.17	0.90
LOT 216	1749272.98	5949289.48	0.99



I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed:

Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM

WOODS
EST.1970

LEGEND

STORMWATER MANHOLE	◉
STORMWATER CESSPIT	▤
STORMWATER DOUBLE CESSPIT	▤▤
NEW STORMWATER	— · —
EXISTING STORMWATER	— —
SUBSOIL DRAINAGE	——
STAGE BOUNDARY	▬ ▬ ▬

NOTES

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7. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
8. ASBUILT DATA HAS BEEN SOURCED FROM A COMBINATION OF WOODS SURVEY MEASURED DATA AND CONTRACTOR RECEIVED DATA.

REVISION DETAILS		BY	DATE
1	ISSUED FOR INFORMATION	KR	17/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	AF	
DRAWN	KH	
CHECKED	KR	
APPROVED	RH	WOODS.CO.NZ

N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

STORMWATER AS-BUILT
SHEET 3 OF 3
(SLC-66650)

STATUS	AS-BUILT	REV
SCALE	1:500 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-302-AB	

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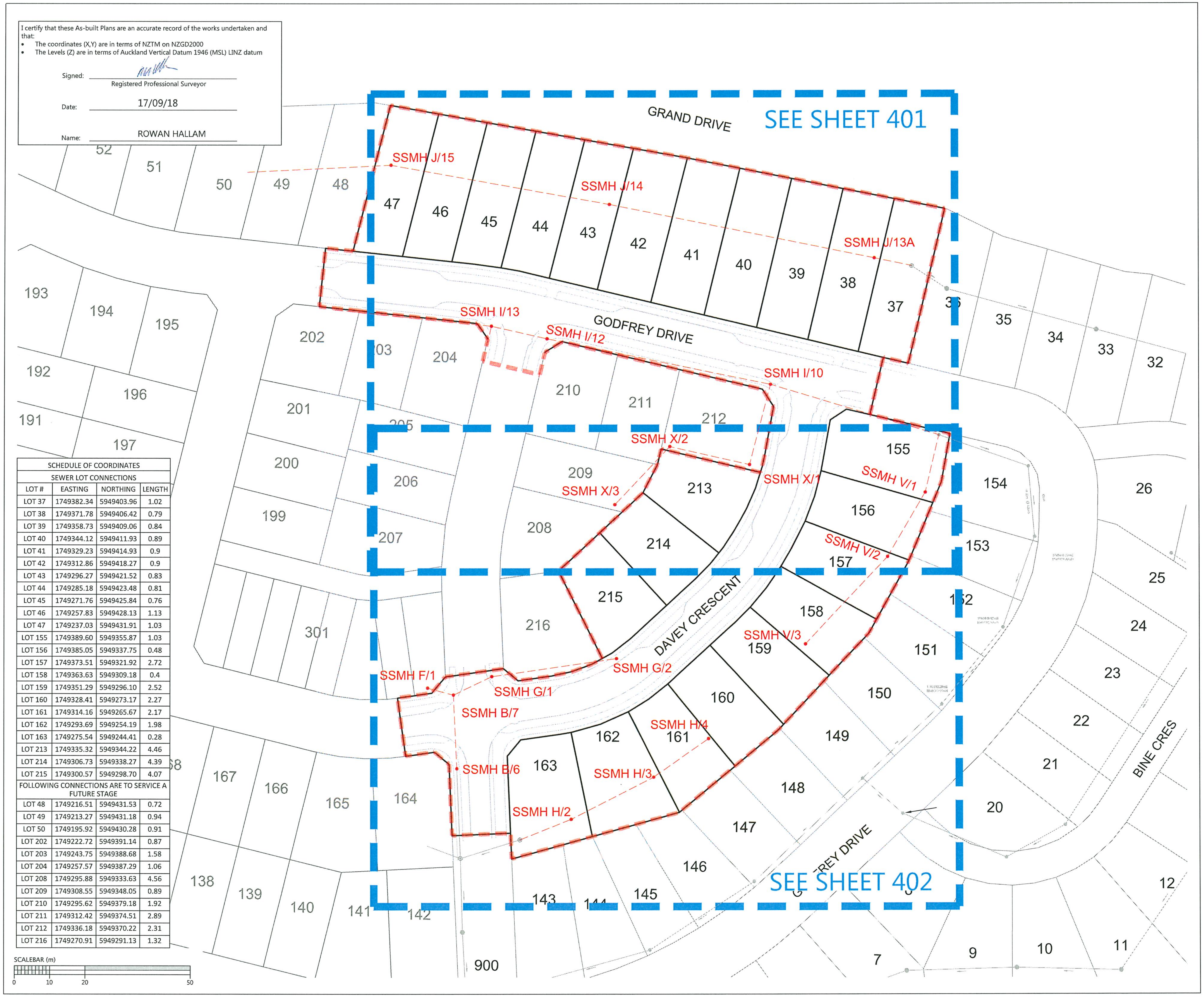
Signed: Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM



SCHEDULE OF COORDINATES			
SEWER LOT CONNECTIONS			
LOT #	EASTING	NORTHING	LENGTH
LOT 37	1749382.34	5949403.96	1.02
LOT 38	1749371.78	5949406.42	0.79
LOT 39	1749358.73	5949409.06	0.84
LOT 40	1749344.12	5949411.93	0.89
LOT 41	1749329.23	5949414.93	0.9
LOT 42	1749312.86	5949418.27	0.9
LOT 43	1749296.27	5949421.52	0.83
LOT 44	1749285.18	5949423.48	0.81
LOT 45	1749271.76	5949425.84	0.76
LOT 46	1749257.83	5949428.13	1.13
LOT 47	1749237.03	5949431.91	1.03
LOT 155	1749389.60	5949355.87	1.03
LOT 156	1749385.05	5949337.75	0.48
LOT 157	1749373.51	5949321.92	2.72
LOT 158	1749363.63	5949309.18	0.4
LOT 159	1749351.29	5949296.10	2.52
LOT 160	1749328.41	5949273.17	2.27
LOT 161	1749314.16	5949265.67	2.17
LOT 162	1749293.69	5949254.19	1.98
LOT 163	1749275.54	5949244.41	0.28
LOT 213	1749335.32	5949344.22	4.46
LOT 214	1749306.73	5949338.27	4.39
LOT 215	1749300.57	5949298.70	4.07
FOLLOWING CONNECTIONS ARE TO SERVICE A FUTURE STAGE			
LOT 48	1749216.51	5949431.53	0.72
LOT 49	1749213.27	5949431.18	0.94
LOT 50	1749195.92	5949430.28	0.91
LOT 202	1749222.72	5949391.14	0.87
LOT 203	1749243.75	5949388.68	1.58
LOT 204	1749257.57	5949387.29	1.06
LOT 208	1749295.88	5949333.63	4.56
LOT 209	1749308.55	5949348.05	0.89
LOT 210	1749295.62	5949379.18	1.92
LOT 211	1749312.42	5949374.51	2.89
LOT 212	1749336.18	5949370.22	2.31
LOT 216	1749270.91	5949291.13	1.32

SCALEBAR (m)

0 10 20 50

WOODS
EST.1970

LEGEND

NEW SANITARY SEWER MANHOLE	◉
NEW SANITARY SEWER	– – –
EXISTING SANITARY SEWER	———
STAGE BOUNDARY	▬ ▬ ▬

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AUCKLAND COUNCIL & WATERCARE SERVICES LTD STANDARDS FOR ENGINEERING DESIGN AND CONSTRUCTION.
2. ALL SANITARY SEWER LINES ARE 150mmØ uPVC CLASS SN16 UNLESS STATED OTHERWISE.
3. ALL PIPE BEDDING COMPLIES WITH WATERCARE STANDARDS.
4. ALL PIPE CROSSINGS UNDER ROADS AND ACCESSWAYS HAVE BEEN HARDFILL BACKFILLED.
5. ALL PRIVATE LOT CONNECTIONS ARE 100mmØ
6. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.
7. ALL PIPE AND MH DIAMETERS ARE INTERNAL, AND SHOWN IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
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REVISION DETAILS		BY	DATE
1	ISSEUD FOR INFORMATION	KR	17/09/18

SURVEYED	WOODS	WOODS Ltd LEVEL 1 BUILDING B, 8 NUGENT STREET, GRAFTON AUCKLAND 1023 09 308 9229
DESIGNED	AF	
DRAWN	KH	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

N

WFH PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

WASTEWATER AS-BUILT
OVERALL LAYOUT
SHEET 1 OF 3
(SLC-66650)

STATUS	AS BUILT	REV
SCALE	1:1000 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-400-AB	

Document No. K:\37503 - ARRAN HILL PRECINCT 5 STAGE 3\DRAWINGS\SURV\AS-BUILT\3A\37503-03A-400-AB-SEWER.DWG

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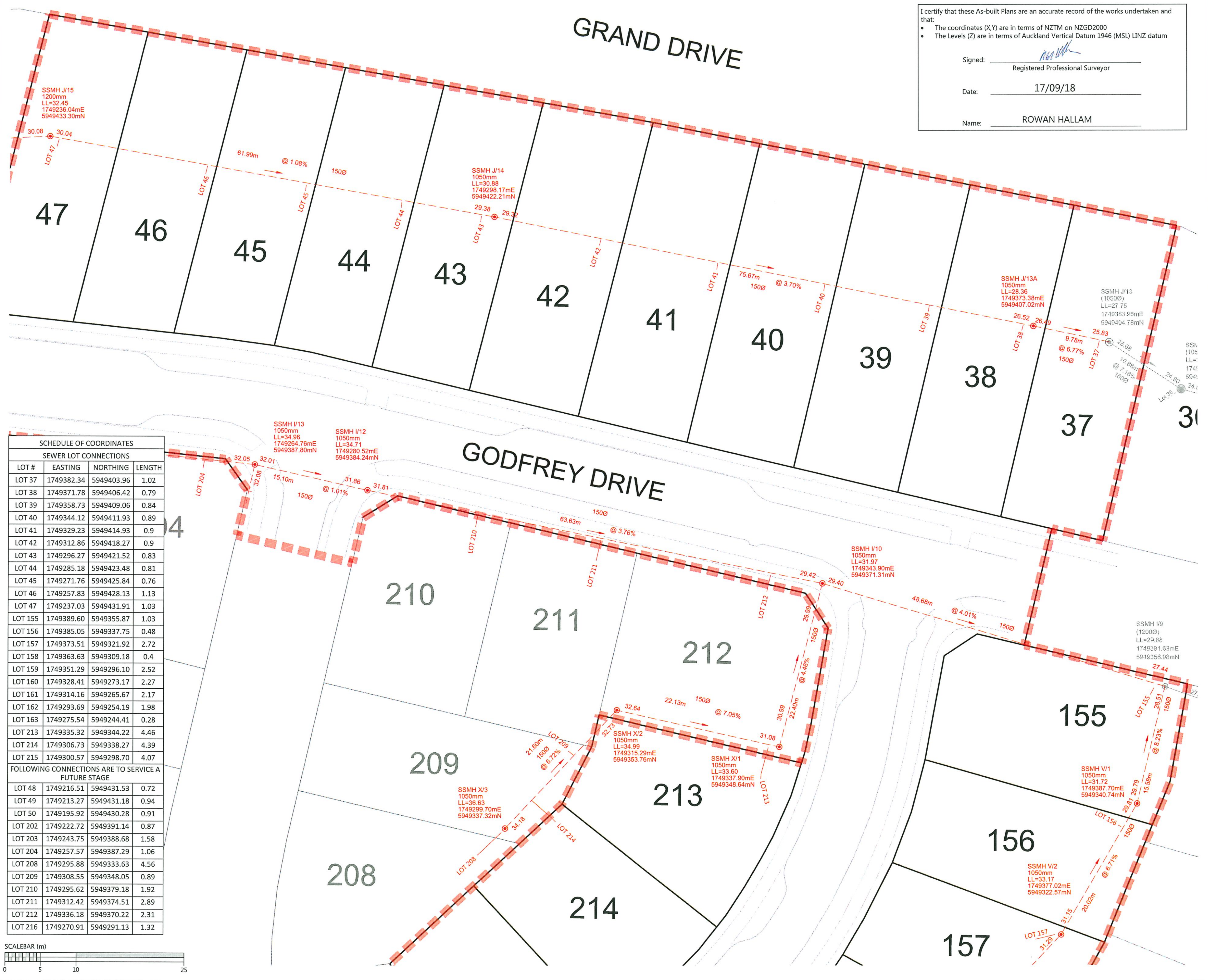
Signed: RH
Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM



SCHEDULE OF COORDINATES			
SEWER LOT CONNECTIONS			
LOT #	EASTING	NORTHING	LENGTH
LOT 37	1749382.34	5949403.96	1.02
LOT 38	1749371.78	5949406.42	0.79
LOT 39	1749358.73	5949409.06	0.84
LOT 40	1749344.12	5949411.93	0.89
LOT 41	1749329.23	5949414.93	0.9
LOT 42	1749312.86	5949418.27	0.9
LOT 43	1749296.27	5949421.52	0.83
LOT 44	1749285.18	5949423.48	0.81
LOT 45	1749271.76	5949425.84	0.76
LOT 46	1749257.83	5949428.13	1.13
LOT 47	1749237.03	5949431.91	1.03
LOT 155	1749389.60	5949355.87	1.03
LOT 156	1749385.05	5949337.75	0.48
LOT 157	1749373.51	5949321.92	2.72
LOT 158	1749363.63	5949309.18	0.4
LOT 159	1749351.29	5949296.10	2.52
LOT 160	1749328.41	5949273.17	2.27
LOT 161	1749314.16	5949265.67	2.17
LOT 162	1749293.69	5949254.19	1.98
LOT 163	1749275.54	5949244.41	0.28
LOT 213	1749335.32	5949344.22	4.46
LOT 214	1749306.73	5949338.27	4.39
LOT 215	1749300.57	5949298.70	4.07
FOLLOWING CONNECTIONS ARE TO SERVICE A FUTURE STAGE			
LOT 48	1749216.51	5949431.53	0.72
LOT 49	1749213.27	5949431.18	0.94
LOT 50	1749195.92	5949430.28	0.91
LOT 202	1749222.72	5949391.14	0.87
LOT 203	1749243.75	5949388.68	1.58
LOT 204	1749257.57	5949387.29	1.06
LOT 208	1749295.88	5949333.63	4.56
LOT 209	1749308.55	5949348.05	0.89
LOT 210	1749295.62	5949379.18	1.92
LOT 211	1749312.42	5949374.51	2.89
LOT 212	1749336.18	5949370.22	2.31
LOT 216	1749270.91	5949291.13	1.32

SCALEBAR (m)
0 5 10 25

WOODS
EST.1970

LEGEND

NEW SANITARY SEWER MANHOLE	◉
NEW SANITARY SEWER	– – – –
EXISTING SANITARY SEWER	———
STAGE BOUNDARY	▬ ▬ ▬

NOTES

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DESIGNED	AF	
DRAWN	KH	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

WASTEWATER AS-BUILT
SHEET 2 OF 3
(SLC-66650)

STATUS	AS BUILT	REV
SCALE	1:500 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-401-AB	

Document No. K:\37503 - ARRAN HILL PRECINCT 5 STAGE 3\DRAWINGS\SURV\AS-BUILT\3A\37503-03A-400-AB-SEWER.DWG

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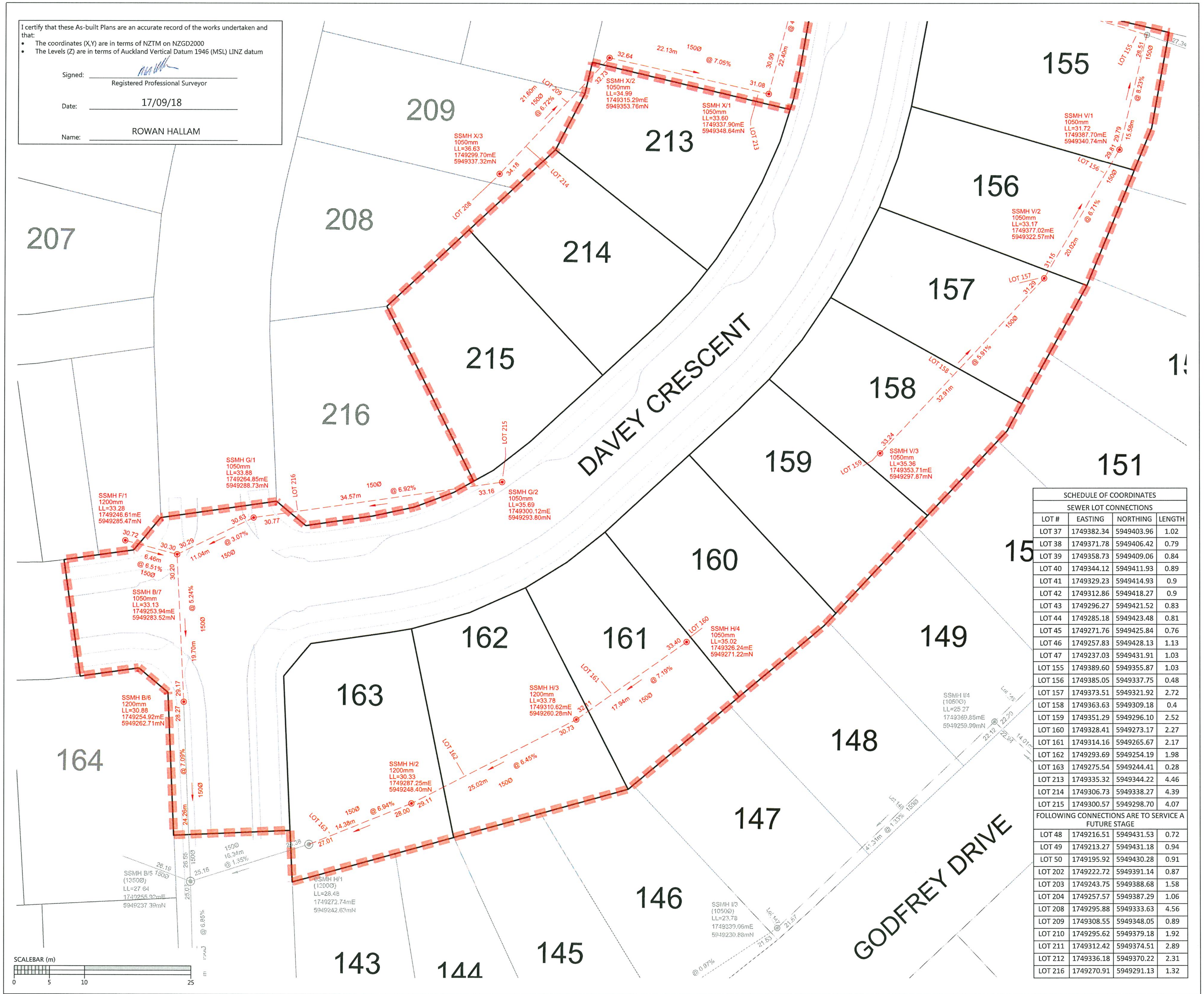
Signed: ____________
Registered Professional Surveyor

Date: 17/09/18

Name: ROWAN HALLAM



SCHEDULE OF COORDINATES			
SEWER LOT CONNECTIONS			
LOT #	EASTING	NORTHING	LENGTH
LOT 37	1749382.34	5949403.96	1.02
LOT 38	1749371.78	5949406.42	0.79
LOT 39	1749358.73	5949409.06	0.84
LOT 40	1749344.12	5949411.93	0.89
LOT 41	1749329.23	5949414.93	0.9
LOT 42	1749312.86	5949418.27	0.9
LOT 43	1749296.27	5949421.52	0.83
LOT 44	1749285.18	5949423.48	0.81
LOT 45	1749271.76	5949425.84	0.76
LOT 46	1749257.83	5949428.13	1.13
LOT 47	1749237.03	5949431.91	1.03
LOT 155	1749389.60	5949355.87	1.03
LOT 156	1749385.05	5949337.75	0.48
LOT 157	1749373.51	5949321.92	2.72
LOT 158	1749363.63	5949309.18	0.4
LOT 159	1749351.29	5949296.10	2.52
LOT 160	1749328.41	5949273.17	2.27
LOT 161	1749314.16	5949265.67	2.17
LOT 162	1749293.69	5949254.19	1.98
LOT 163	1749275.54	5949244.41	0.28
LOT 213	1749335.32	5949344.22	4.46
LOT 214	1749306.73	5949338.27	4.39
LOT 215	1749300.57	5949298.70	4.07
FOLLOWING CONNECTIONS ARE TO SERVICE A FUTURE STAGE			
LOT 48	1749216.51	5949431.53	0.72
LOT 49	1749213.27	5949431.18	0.94
LOT 50	1749195.92	5949430.28	0.91
LOT 202	1749222.72	5949391.14	0.87
LOT 203	1749243.75	5949388.68	1.58
LOT 204	1749257.57	5949387.29	1.06
LOT 208	1749295.88	5949333.63	4.56
LOT 209	1749308.55	5949348.05	0.89
LOT 210	1749295.62	5949379.18	1.92
LOT 211	1749312.42	5949374.51	2.89
LOT 212	1749336.18	5949370.22	2.31
LOT 216	1749270.91	5949291.13	1.32

WOODS
EST.1970

LEGEND

NEW SANITARY SEWER MANHOLE	◉
NEW SANITARY SEWER	– – – –
EXISTING SANITARY SEWER	——
STAGE BOUNDARY	▬ ▬ ▬

NOTES

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REVISION DETAILS		BY	DATE
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DESIGNED	AF	
DRAWN	KH	
CHECKED	AF	
APPROVED	RH	WOODS.CO.NZ

N

WFH
PROPERTIES

MILLWATER PRECINCT 5
OREWA WEST
STAGE 3A

WASTEWATER AS-BUILT
SHEET 3 OF 3
(SLC-66650)

STATUS	AS BUILT	REV
SCALE	1:500 @ A3	1
COUNCIL	AUCKLAND COUNCIL	
DWG NO	37503-03A-402-AB	

Document No. K:\37503 - ARRAN HILL PRECINCT 5 STAGE 3\DRAWINGS\SURV\AS-BUILT\3A\37503-03A-400-AB-SEWER.DWG

Appendix A2: T+T Drawings

21854.0031–AHP5S3A–100	Drawing List and Site Location Plan
21854.0031–AHP5S3A–101	Geotechnical Works Plan
21854.0031–AHP5S3A–102	Geotechnical Works Subsoil Drain Plan
21854.0031–AHP5S3A–103	Geological Cross Sections 1 & 2
21854.0031–AHP5S3A–104	Geological Cross Sections 3 & 4
21854.0031–AHP5S3A–105	Geological Cross Sections 5 & 6
21854.0031–AHP5S3A–110	RE Slope 6 – Typical Section
21854.0031–AHP5S3A–111	RE Slope 7 – Typical Section (Sheet 1 of 2)
21854.0031–AHP5S3A–112	RE Slope 7 – Typical Section (Sheet 2 of 2)
21854.0031–AHP5S3A–120	Building Limitation Plan

WFH PROPERTIES LTD
MILLWATER - ARRANS HILL
PRECINCT 5 STAGE 3A
COMPLETION REPORT ISSUE

DRAWING	Rev	Title
GENERAL		
● 21854.0031-AHP5S3A-100	1	DRAWING LIST AND LOCATION PLAN
● 21854.0031-AHP5S3A-101	1	GEOTECHNICAL WORKS PLAN
● 21854.0031-AHP5S3A-102	1	GEOTECHNICAL WORKS SUBSOIL DRAIN PLAN
● 21854.0031-AHP5S3A-103	1	GEOLOGICAL CROSS SECTIONS 1 & 2
● 21854.0031-AHP5S3A-104	1	GEOLOGICAL CROSS SECTIONS 3 & 4
● 21854.0031-AHP5S3A-105	1	GEOLOGICAL CROSS SECTIONS 5 & 6
● 21854.0031-AHP5S3A-110	1	RE SLOPE 6 - TYPICAL SECTION
● 21854.0031-AHP5S3A-111	1	RE SLOPE 7 - TYPICAL SECTION (SHEET 1 OF 2)
● 21854.0031-AHP5S3A-112	1	RE SLOPE 7 - TYPICAL SECTION (SHEET 2 OF 2)
● 21854.0031-AHP5S3A-120	1	BUILDING LIMITATION PLAN
● 21854.0031-AHP5S3A-121	1	POST EARTHWORKS INVESTIGATION PLAN
● 21854.0031-AHP5S3A-122	1	TOPSOIL DEPTHS PLAN
● 21854.0031-AHP5S3A-123	1	EARTHWORKS TESTING LOCATION PLAN

LOCATION PLAN
SCALE 1:10,000

● Denotes drawing this issue: 9/10/2018

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REV	DESCRIPTION	CAD	CHK	DATE
1	COMPLETION REPORT ISSUE	JC		

DESIGNED	JXXL	Sep.18
DRAWN	JC	Sep.18
DESIGN CHECKED		
DRAWING CHECKED		

DRAWING STATUS
COMPLETION REPORT

NOT FOR CONSTRUCTION
THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED
APPROVED DATE

CLIENT WFH PROPERTIES LTD
PROJECT MILLWATER - ARRANS HILL
TITLE PRECINCT 5 STAGE 3A
DRAWING LIST AND LOCATION PLAN
SCALE (A3) 1:10,000 **DWG No.** 21854.0031-AHP5S3A-100 **REV** 1

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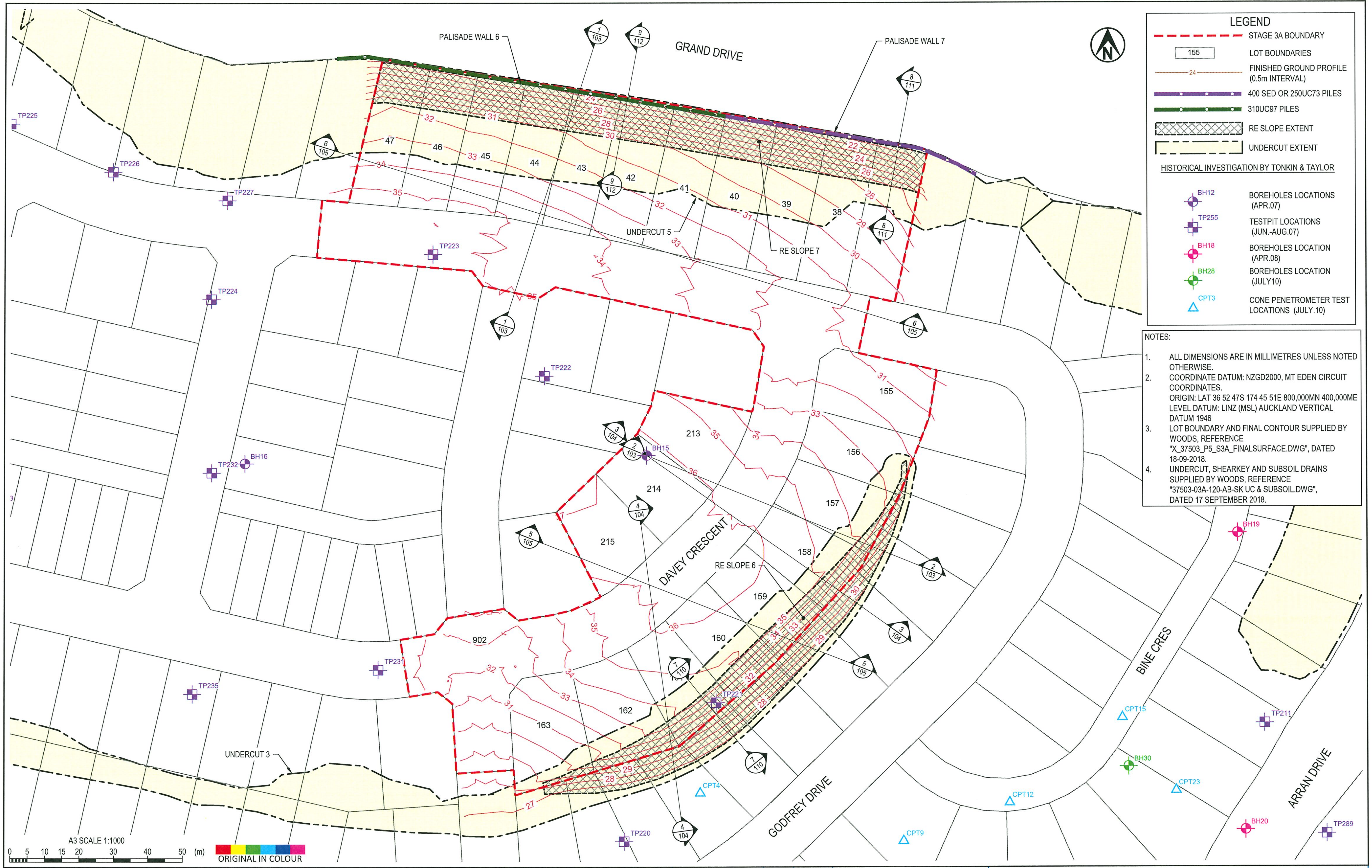

LEGEND

🟥	STAGE 3A BOUNDARY
155	LOT BOUNDARIES
24	FINISHED GROUND PROFILE (0.5m INTERVAL)
🟪	400 SED OR 250UC73 PILES
🟩	310UC97 PILES
▨	RE SLOPE EXTENT
☐	UNDERCUT EXTENT

HISTORICAL INVESTIGATION BY TONKIN & TAYLOR

BH12	BOREHOLES LOCATIONS (APR.07)
TP255	TESTPIT LOCATIONS (JUN.-AUG.07)
BH18	BOREHOLES LOCATION (APR.08)
BH28	BOREHOLES LOCATION (JULY10)
CPT3	CONE PENETROMETER TEST LOCATIONS (JULY.10)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, MT EDEN CIRCUIT COORDINATES.
   ORIGIN: LAT 36 52 47S 174 45 51E 800,000MN 400,000ME
   LEVEL DATUM: LINZ (MSL) AUCKLAND VERTICAL DATUM 1946
3. LOT BOUNDARY AND FINAL CONTOUR SUPPLIED BY WOODS, REFERENCE "X_37503_P5_S3A_FINALSURFACE.DWG", DATED 18-09-2018.
4. UNDERCUT, SHEARKEY AND SUBSOIL DRAINS SUPPLIED BY WOODS, REFERENCE "37503-03A-120-AB-SK UC & SUBSOIL.DWG", DATED 17 SEPTEMBER 2018.

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DRAWING CHECKED		

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CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
GEOTECHNICAL WORKS PLAN
SCALE (A3) 1:1000   DWG No. 21854.0031-AHP5S3A-101   REV 1

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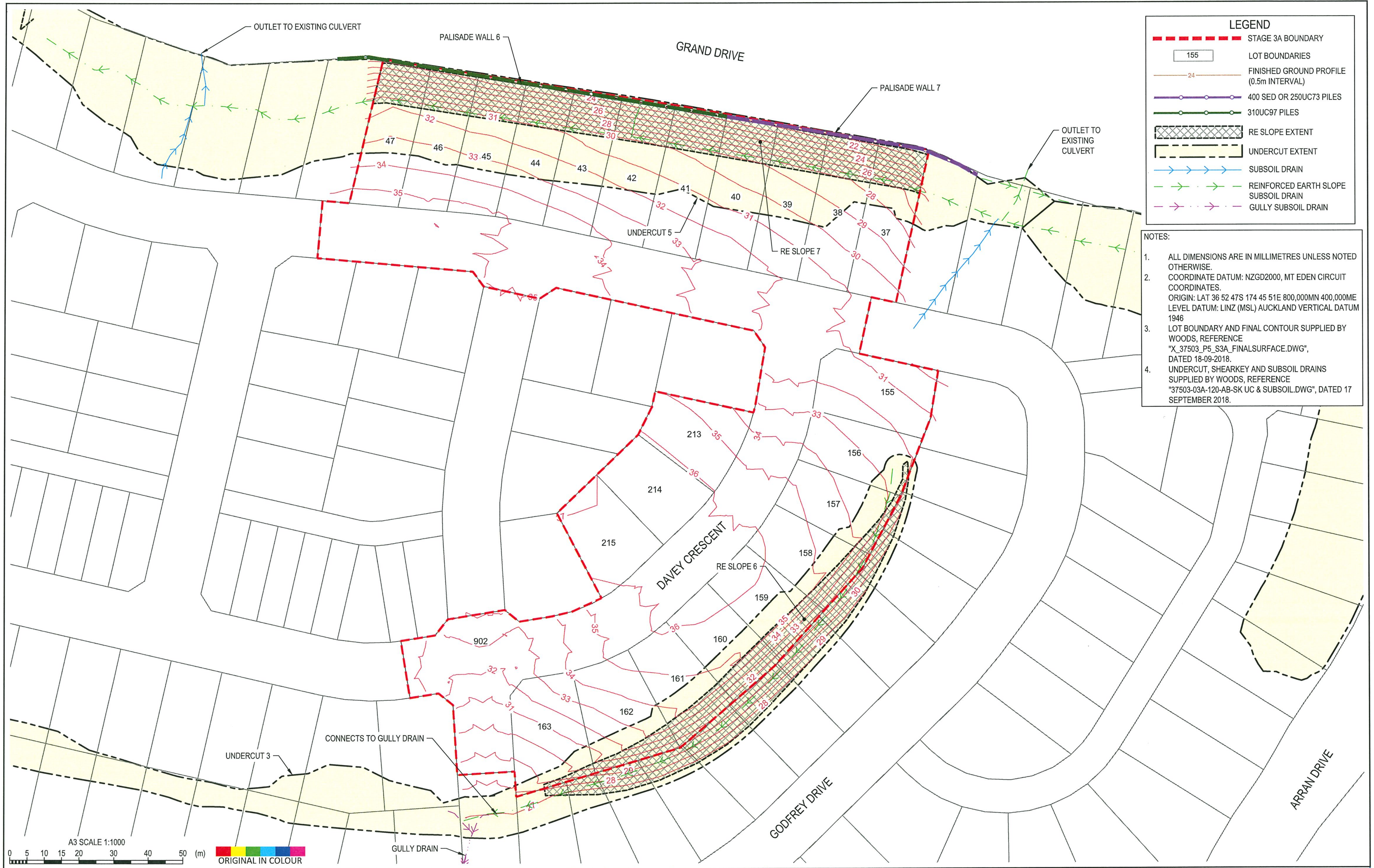

LEGEND

- STAGE 3A BOUNDARY
- 155 LOT BOUNDARIES
- 24 FINISHED GROUND PROFILE (0.5m INTERVAL)
- 400 SED OR 250UC73 PILES
- 310UC97 PILES
- RE SLOPE EXTENT
- UNDERCUT EXTENT
- SUBSOIL DRAIN
- REINFORCED EARTH SLOPE SUBSOIL DRAIN
- GULLY SUBSOIL DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, MT EDEN CIRCUIT COORDINATES.
   ORIGIN: LAT 36 52 47S 174 45 51E 800,000MN 400,000ME
   LEVEL DATUM: LINZ (MSL) AUCKLAND VERTICAL DATUM 1946
3. LOT BOUNDARY AND FINAL CONTOUR SUPPLIED BY WOODS, REFERENCE "X_37503_P5_S3A_FINALSURFACE.DWG", DATED 18-09-2018.
4. UNDERCUT, SHEARKEY AND SUBSOIL DRAINS SUPPLIED BY WOODS, REFERENCE "37503-03A-120-AB-SK UC & SUBSOIL.DWG", DATED 17 SEPTEMBER 2018.

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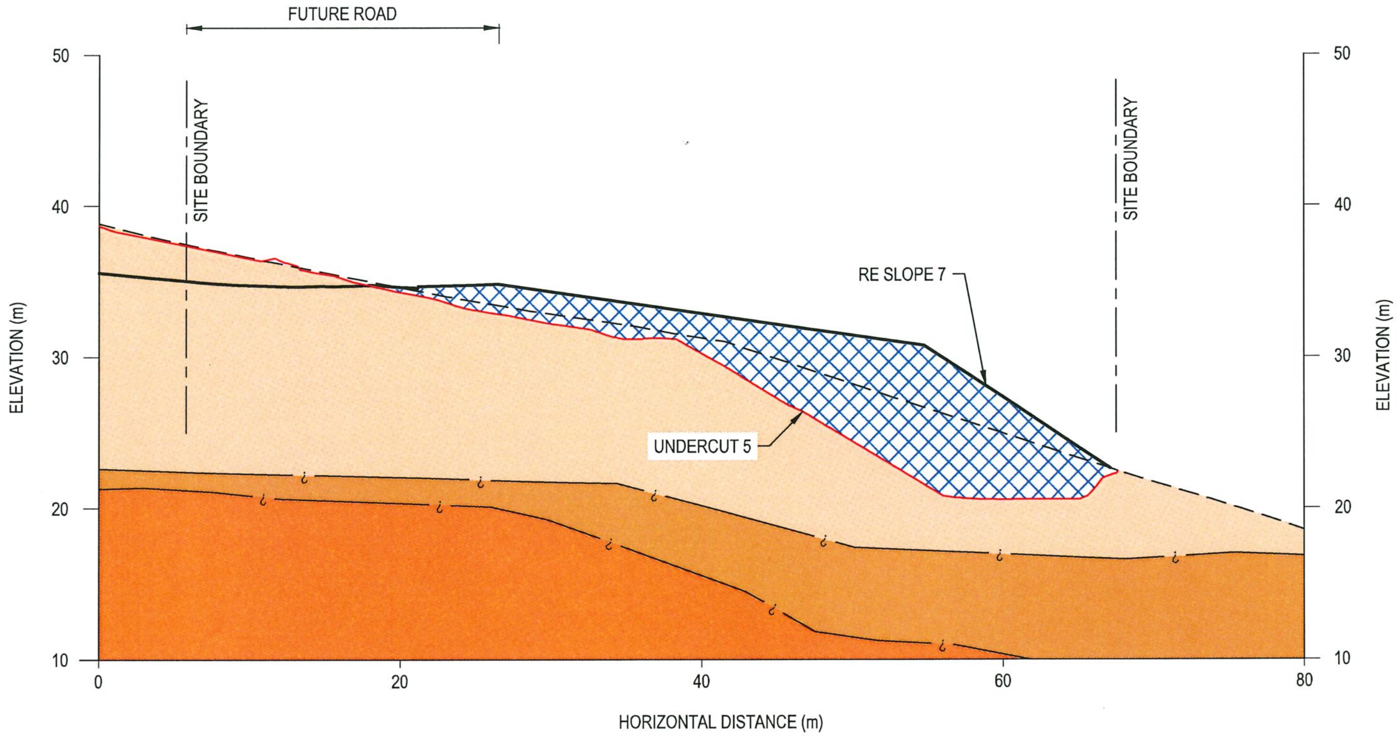
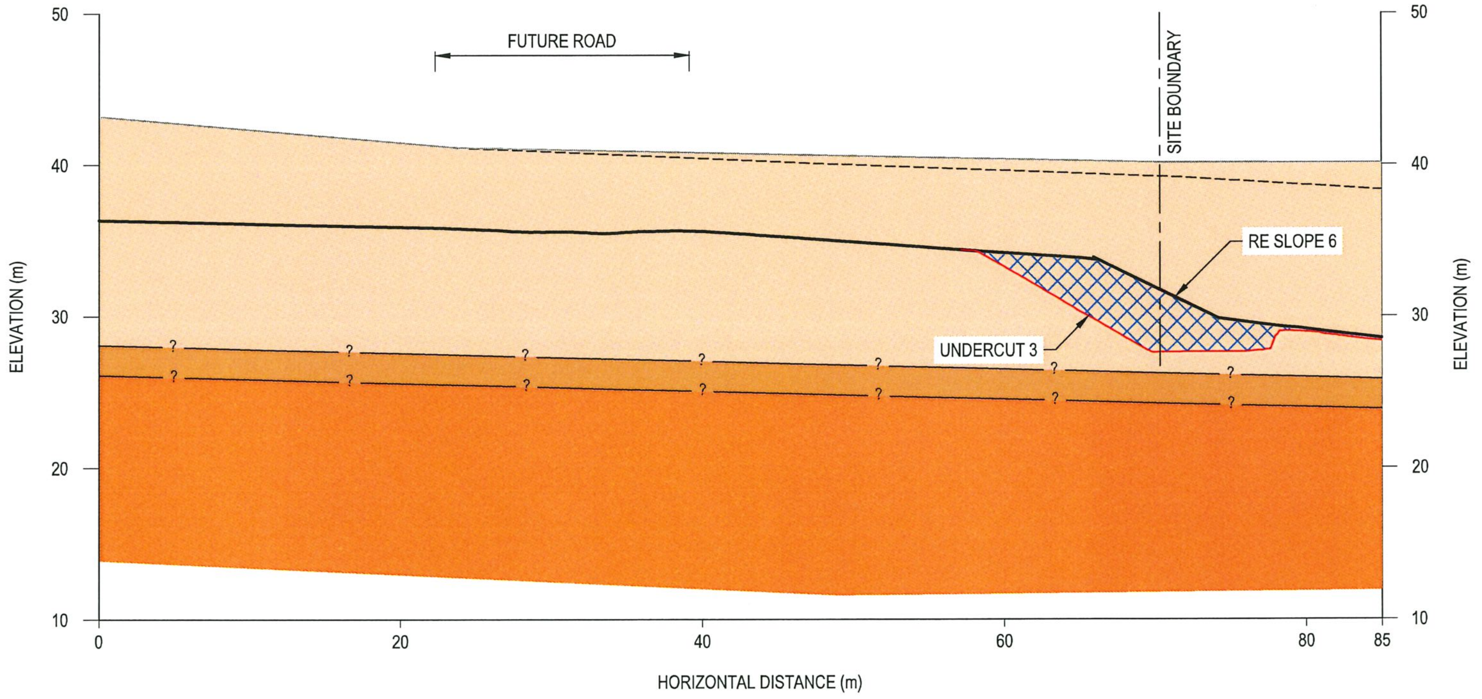
APPROVED DATE

CLIENT WFH PROPERTIES LTD
PROJECT MILLWATER - ARRANS HILL
TITLE PRECINCT 5 STAGE 3A
GEOTECHNICAL WORKS SUBSOIL DRAIN PLAN

SCALE (A3) 1:1000 DWG No. 21854.0031-AHP5S3A-102 REV 1



SECTION 1/101
SCALE 1:500



SECTION 2/101
SCALE 1:500

LEGEND

- ——— ORIGINAL GROUND PROFILE
- - - - - GROUND PROFILE PRIOR TO PRECINCT 5 COMMENCEMENT
- ━━━ FINAL GROUND PROFILE
- — ? — GEOLOGICAL CONTACT
- ▨ ENGINEERED FILL
- ■ RESIDUAL-WEATHERED ECBF
- ■ HIGHLY WEATHERED ECBF
- ■ SLIGHTLY WEATHERED ECBF

NOTE:

1. ALL GEOLOGICAL BOUNDARIES ARE APPROXIMATE AND INFERRED FROM POINT LOCATION DATA.

A3 SCALE 1:500
0 5 10 15 20 25 (m)

ORIGINAL IN COLOUR

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REV	DESCRIPTION	CAD	CHK	DATE
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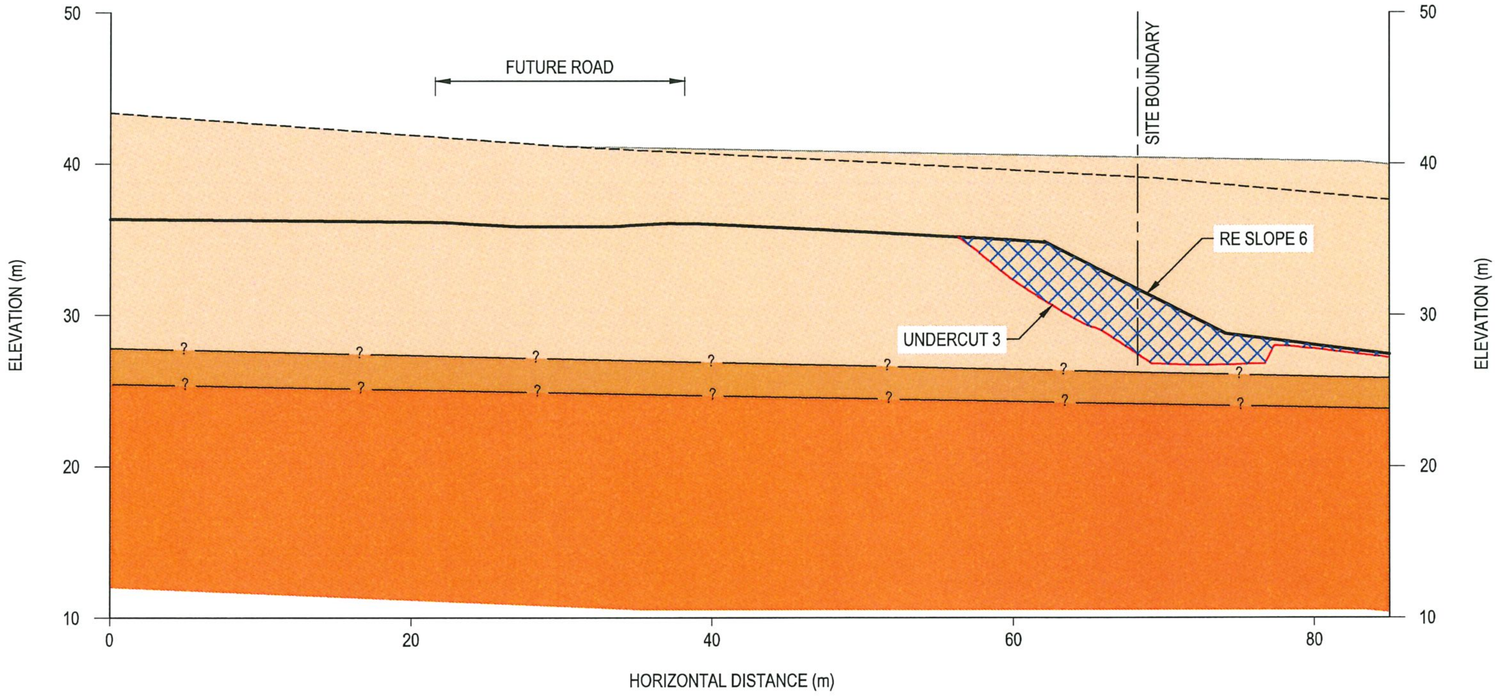
APPROVED   DATE

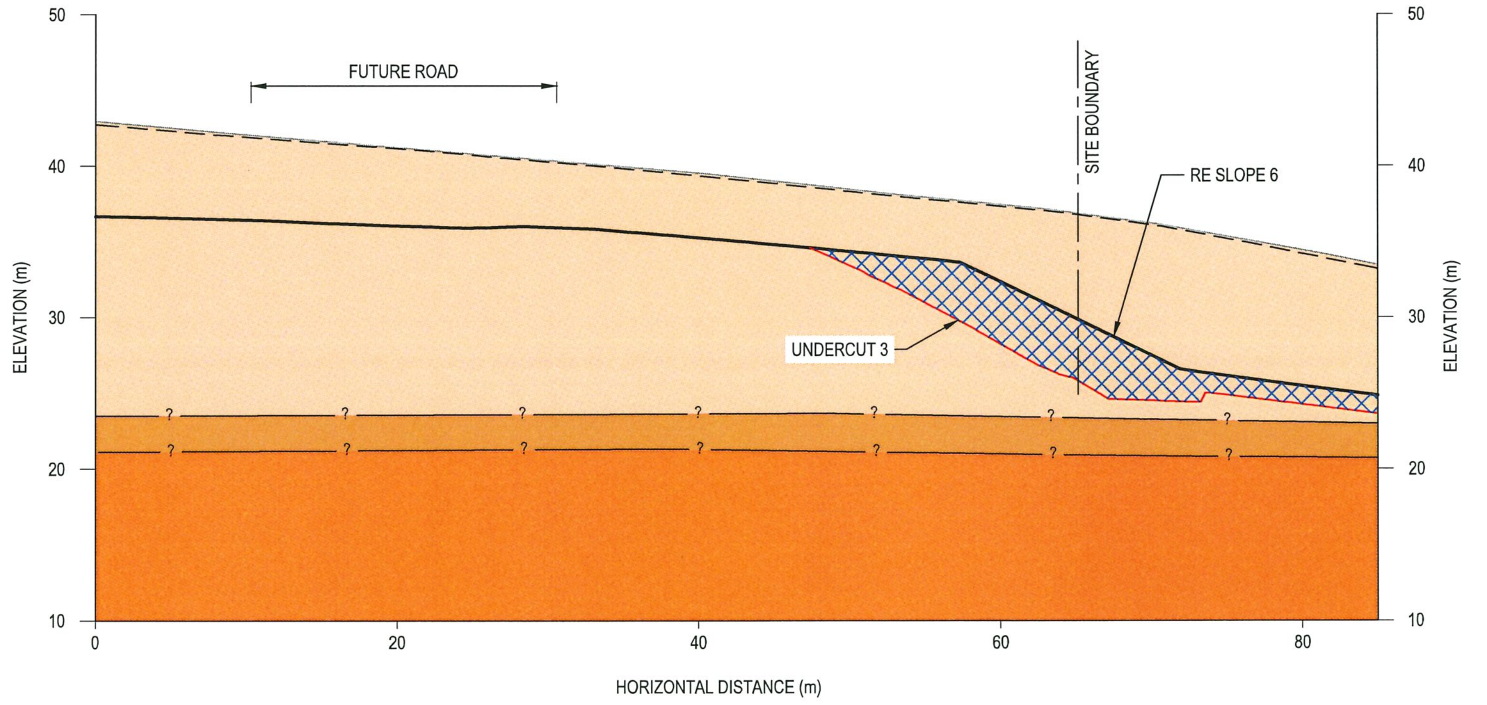
CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
GEOLOGICAL CROSS SECTIONS 1 & 2
SCALE (A3) 1:500   DWG No. 21854.0031-AHP5S3A-103   REV 1



SECTION 3/101
SCALE 1:500

LEGEND

————	ORIGINAL GROUND PROFILE
- - - - -	GROUND PROFILE PRIOR TO PRECINCT 5 COMMENCEMENT
━━━━	FINAL GROUND PROFILE
—— ? ——	GEOLOGICAL CONTACT
▨	ENGINEERED FILL
🟧	RESIDUAL-WEATHERED ECBF
🟧	HIGHLY WEATHERED ECBF
🟧	SLIGHTLY WEATHERED ECBF



SECTION 4/101
SCALE 1:500

NOTE:

1. ALL GEOLOGICAL BOUNDARIES ARE APPROXIMATE AND INFERRED FROM POINT LOCATION DATA.

A3 SCALE 1:500
0 5 10 15 20 25 (m)

ORIGINAL IN COLOUR

REV	DESCRIPTION	CAD	CHK	DATE
1	COMPLETION REPORT ISSUE	JC		

DESIGNED	JXXL	Sep.18
DRAWN	JC	Sep.18
DESIGN CHECKED		
DRAWING CHECKED		

DRAWING STATUS
COMPLETION REPORT

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APPROVED DATE

CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
GEOLOGICAL CROSS SECTIONS 3 & 4
SCALE (A3) 1:500 DWG No. 21854.0031-AHP5S3A-104 REV 1

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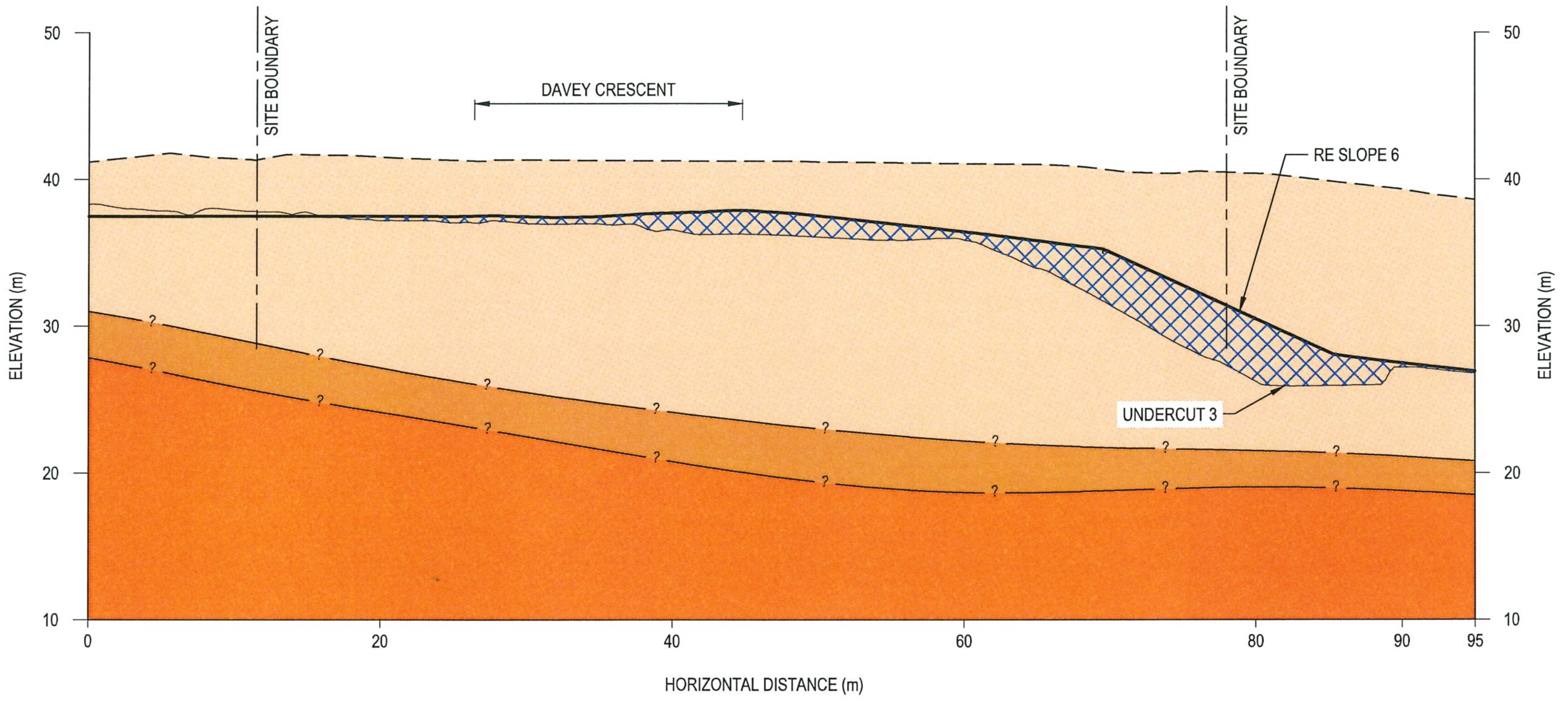
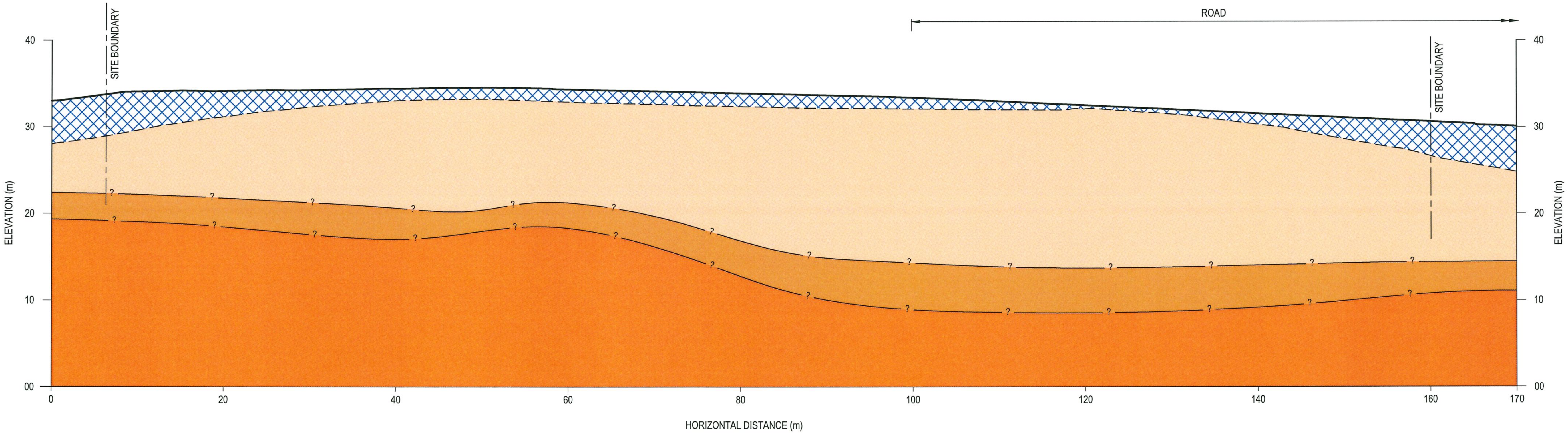


SECTION 5/101
SCALE 1: 500

LEGEND

- ORIGINAL GROUND PROFILE
- GROUND PROFILE PRIOR TO PRECINCT 5 COMMENCEMENT
- FINAL GROUND PROFILE
- ? GEOLOGICAL CONTACT
- ▨ ENGINEERED FILL
- RESIDUAL-WEATHERED ECBF
- HIGHLY WEATHERED ECBF
- SLIGHTLY WEATHERED ECBF



SECTION 6/101
SCALE 1: 500

NOTE:

1. ALL GEOLOGICAL BOUNDARIES ARE APPROXIMATE AND INFERRED FROM POINT LOCATION DATA.

A3 SCALE 1:500

0 5 10 15 20 25 (m)

ORIGINAL IN COLOUR

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DRAWING CHECKED		
APPROVED		DATE

DRAWING STATUS
COMPLETION REPORT

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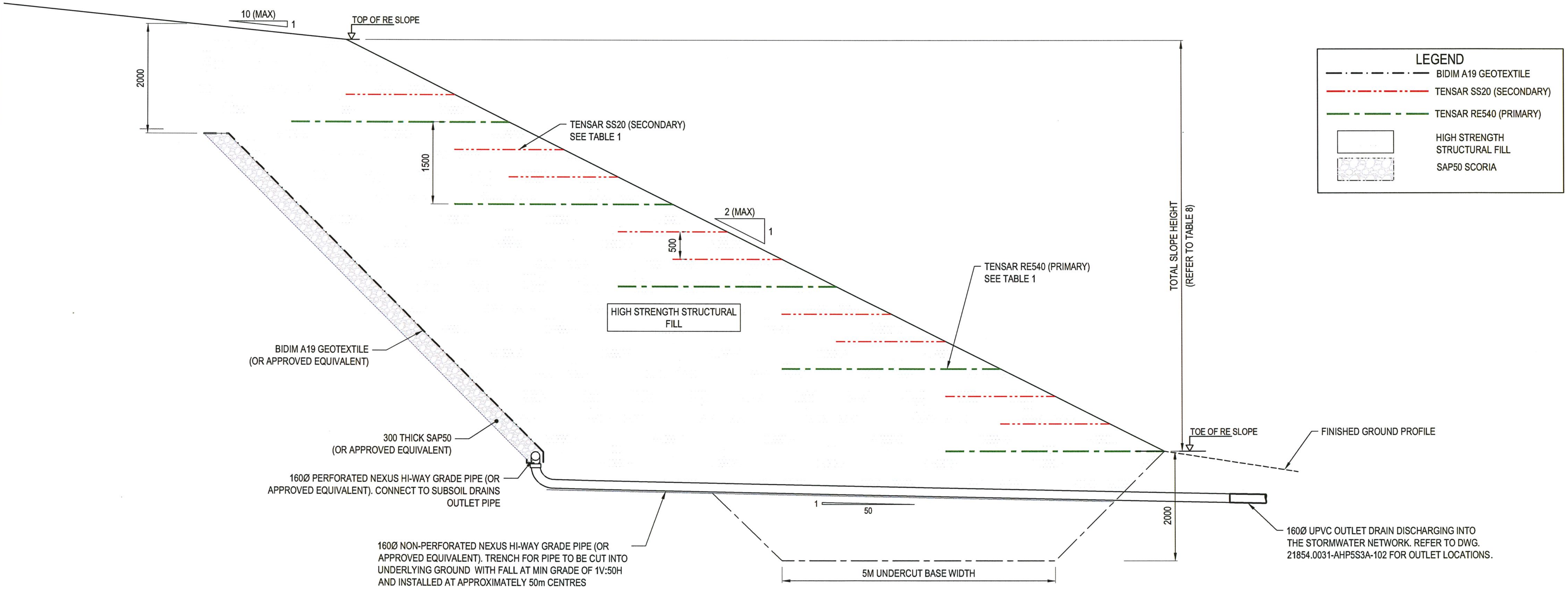
CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
GEOLOGICAL CROSS SECTIONS 5 & 6
SCALE (A3) 1:500
DWG No. 21854.0031-AHP5S3A-105
REV 1

TABLE 1: REINFORCEMENT DETAIL FOR RE SLOPES 4, 5 AND 6

WALL TYPE	MAXIMUM TOTAL SLOPE HEIGHT (m)	MAX SLOPE	MAX FORWARD SLOPE	MAX BACK SLOPE	GEOGRID REQUIREMENTS		
					GEOGRID TYPE	GEOGRID LENGTH (m)	MAX VERTICAL SPACING (m)
RE SLOPES 6	H ≤ 8	1V:2H	1V:10H	1V:10H	TENSAR RE540	4.0	1.5
					TENSAR SS20	2.0	0.5

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. WALL SETOUT AS PROVIDED BY WOODS AND CONFIRMED ON SITE BY THE ENGINEER.
3. SEE DWG.21854.0031-AHP5S3A-101 FOR RE SLOPE 6 PLAN.



SECTION 7/101 RE SLOPE 6 TYPICAL DETAILS
SCALE 1:75

A3 SCALE 1:75
0 1 2 3 4 (m)

ORIGINAL IN COLOUR

REV	DESCRIPTION	CAD	CHK	DATE	APPROVED	DATE
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DRAWING STATUS
COMPLETION REPORT

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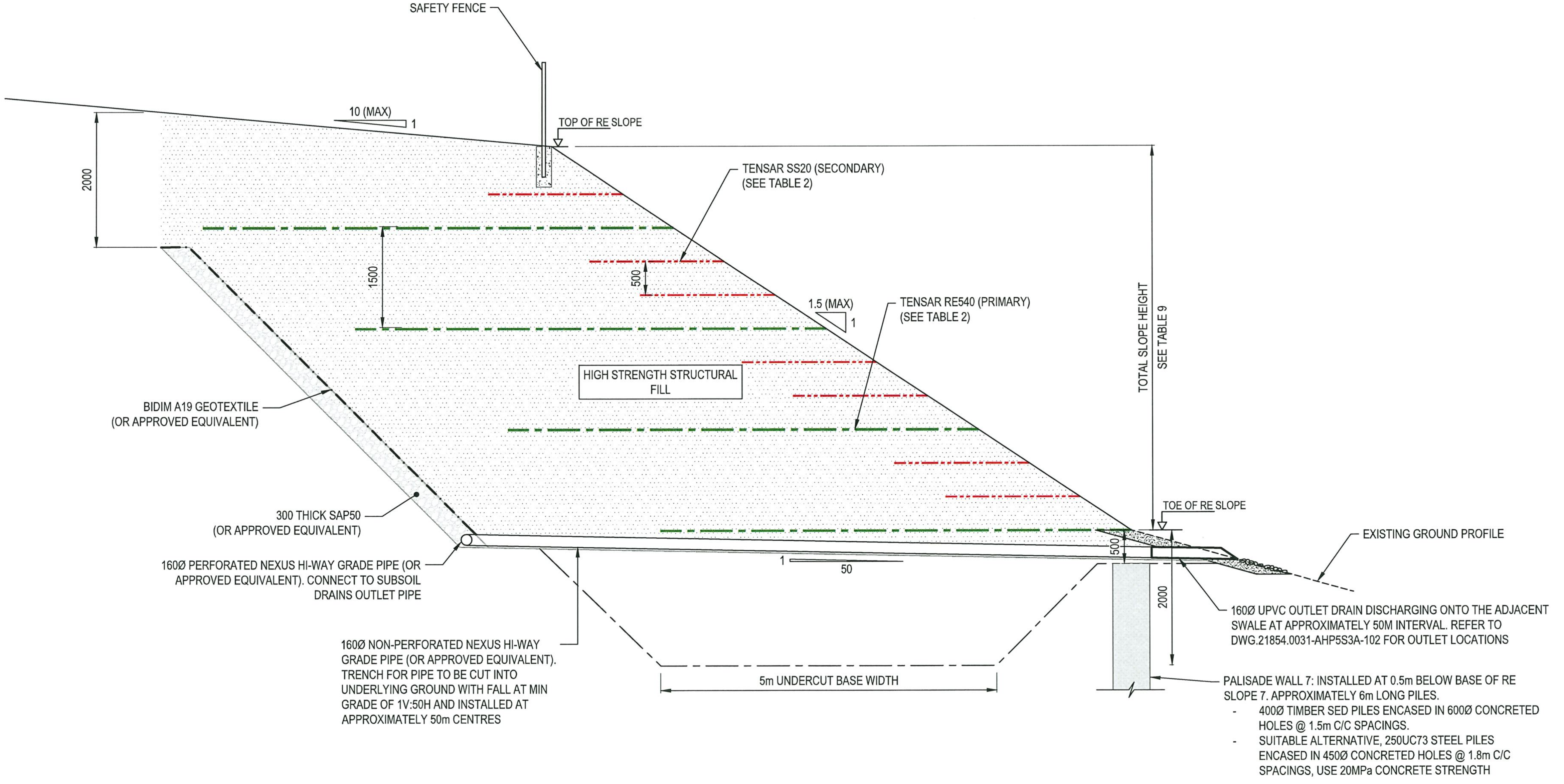
CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
RE SLOPE 6 - TYPICAL SECTION
SCALE (A3) 1:75 DWG No. 21854.0031-AHP5S3A-110 REV 1

TABLE 2: REINFORCEMENT DETAIL FOR RE SLOPE 7

WALL TYPE	MAXIMUM TOTAL SLOPE HEIGHT (m)	MAX SLOPE	MAX BACK SLOPE	GEOGRID REQUIREMENTS		
				GEOGRID TYPE	GEOGRID LENGTH (m)	MAX VERTICAL SPACING (m)
RE SLOPE 7	H ≤ 5	1V:1.5H	1V:10H	TENSAR RE540	4.0	1.5
				TENSAR SS20	2.0	0.5
	5 < H ≤ 7	1V:1.5H	1V:10H	TENSAR RE540	7.0	1.5
				TENSAR SS20	2.0	0.5
	7 < H ≤ 9	1V:1.5H	1V:10H	TENSAR RE540	11.0	1.5
				TENSAR SS20	2.0	0.5
	9 < H ≤ 11	1V:1.5H	1V:10H	TENSAR RE540	14.0	1.5
				TENSAR SS20	2.0	0.5

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. WALL SETOUT AS PROVIDED BY WOODS AND CONFIRMED ON SITE BY THE ENGINEER.
3. SEE DWG.21854.0031-AHP5S3A-101 FOR RE SLOPE 7 PLAN.

LEGEND
- —·—·— BIDIM A19 GEOTEXTILE
- —·—·— TENSAR SS20 (SECONDARY)
- —·—·— TENSAR RE540 (PRIMARY)
- ▨ HIGH STRENGTH STRUCTURAL FILL
- ▨ SAP50 SCORIA



SECTION 8/101 RE SLOPE 7 WITH PALISADE WALL 7
SCALE 1: 75

A3 SCALE 1:75
0 1 2 3 4 (m)

ORIGINAL IN COLOUR

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COMPLETION REPORT

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CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
RE SLOPE 7 - TYPICAL SECTION (SHEET 1 OF 2)
SCALE (A3) 1:75
DWG No. 21854.0031-AHP5S3A-111
REV 1

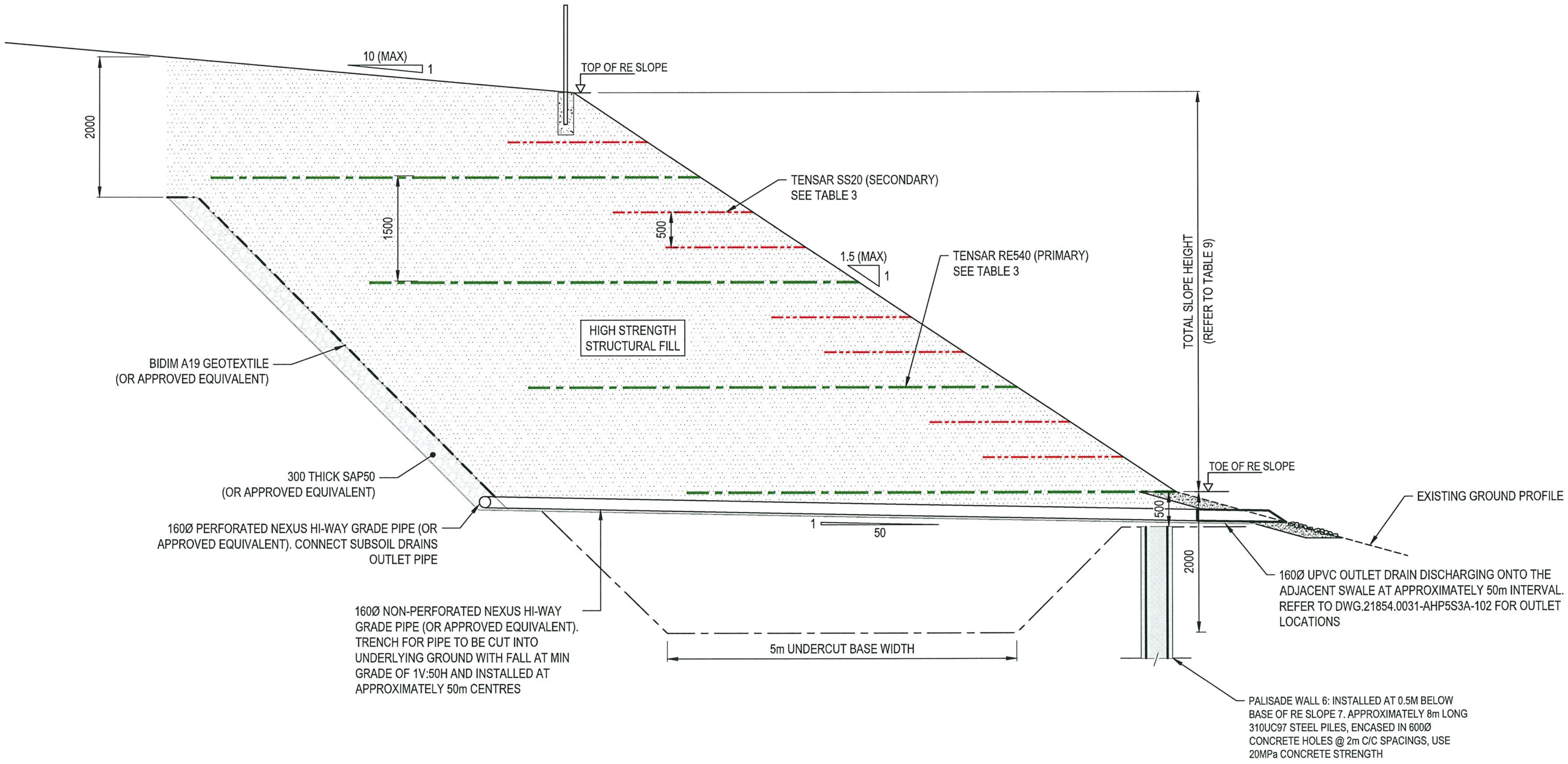
TABLE 3: REINFORCEMENT DETAIL FOR RE SLOPE 7

WALL TYPE	MAXIMUM TOTAL SLOPE HEIGHT (m)	MAX SLOPE	MAX BACK SLOPE	GEOGRID REQUIREMENTS		
				GEOGRID TYPE	GEOGRID LENGTH (m)	MAX VERTICAL SPACING (m)
RE SLOPES 7	H ≤ 5	1V:1.5H	1V:10H	TENSAR RE540	4.0	1.5
				TENSAR SS20	2.0	0.5
	5 < H ≤ 7	1V:1.5H	1V:10H	TENSAR RE540	7.0	1.5
				TENSAR SS20	2.0	0.5
	7 < H ≤ 9	1V:1.5H	1V:10H	TENSAR RE540	11.0	1.5
				TENSAR SS20	2.0	0.5
	9 < H ≤ 11	1V:1.5H	1V:10H	TENSAR RE540	14.0	1.5
				TENSAR SS20	2.0	0.5

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. WALL SETOUT AS PROVIDED BY WOODS AND CONFIRMED ON SITE BY THE ENGINEER.
3. SEE DWG.21854.0031-AHP5S3A-101 FOR RE SLOPE 7 PLAN.

LEGEND

—·—·—·—	BIDIM A19 GEOTEXTILE
—··—··—	TENSAR SS20 (SECONDARY)
— · — · —	TENSAR RE540 (PRIMARY)
▨	HIGH STRENGTH STRUCTURAL FILL
▨	SAP50 SCORIA



SECTION 9/101 RE SLOPE 7 WITH PALISADE WALL 6
SCALE 1: 75

A3 SCALE 1:75
0 1 2 3 4 (m)

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COMPLETION REPORT

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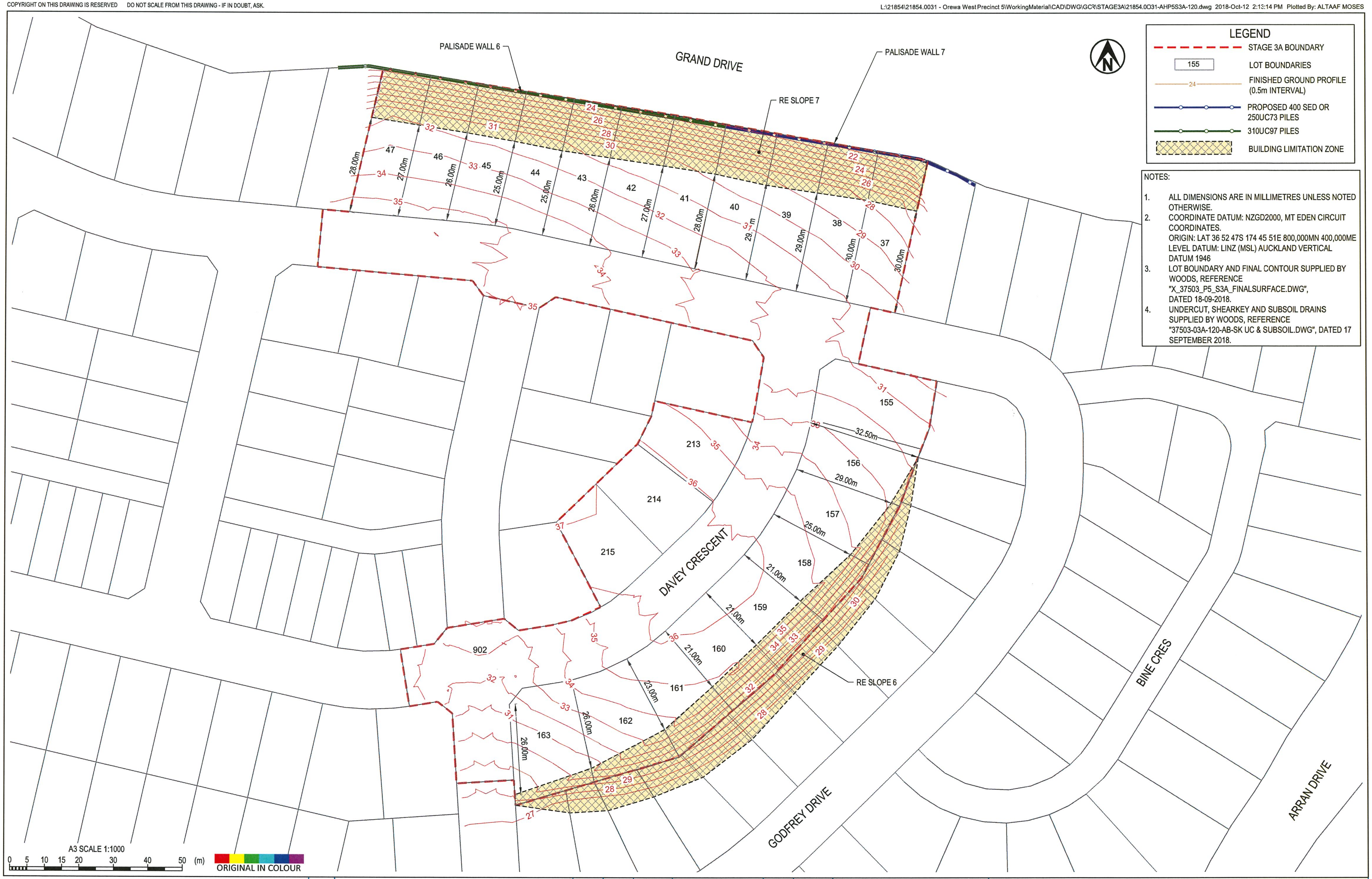
CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
RE SLOPE 7 - TYPICAL SECTION (SHEET 2 OF 2)
SCALE (A3) 1:75   DWG No. 21854.0031-AHP5S3A-112   REV 1



LEGEND

🟥 - - - -	STAGE 3A BOUNDARY
155	LOT BOUNDARIES
24	FINISHED GROUND PROFILE (0.5m INTERVAL)
●─●	PROPOSED 400 SED OR 250UC73 PILES
●─●	310UC97 PILES
▨	BUILDING LIMITATION ZONE

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, MT EDEN CIRCUIT COORDINATES.
   ORIGIN: LAT 36 52 47S 174 45 51E 800,000MN 400,000ME
   LEVEL DATUM: LINZ (MSL) AUCKLAND VERTICAL DATUM 1946
3. LOT BOUNDARY AND FINAL CONTOUR SUPPLIED BY WOODS, REFERENCE "X_37503_P5_S3A_FINALSURFACE.DWG", DATED 18-09-2018.
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CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
BUILDING LIMITATION PLAN
SCALE (A3) 1:1000   DWG No. 21854.0031-AHP5S3A-120   REV 1

Appendix B: Contractors Certificates

- Hick Bros Civil Construction Ltd – Producer Statement PS3 – Precinct 5 Stage 3A Earthworks Contract
- Hick Bros Civil Construction Ltd – Producer Statement PS3 – Precinct 5 Stage 3A Civils Contract
- ICB Retaining and Construction Ltd – Producer Statement 3 (Palisade Wall 6 Construction)
- ICB Retaining and Construction Ltd – Producer Statement 3 (Palisade Wall 7 Construction)
- North Harbour Fencing Ltd – Producer Statement 3 (RE Slope 7 Fence)

PS3 - FORM OF PRODUCER STATEMENT- CONSTRUCTION

ISSUED BY: HICK BROS CIVIL CONSTRUCTION LIMITED

TO: WFH Development Ltd

IN RESPECT OF: Precinct 5 Stage 3A Earthworks
AT: 157 Grand Drive, Orewa

HICK BROS CIVIL CONSTRUCTION LTD has contracted to WFH Development Ltd to carry out and complete certain building works in accordance with a contract, titled Precinct 5 Stage 3A Earthworks ("the contract")

I JAMES BILKEY a duly authorized representative of HICK BROS CIVIL CONSTRUCTION LIMITED believe on reasonable grounds that HICK BROS CIVIL CONSTRUCTION LIMITED has carried out and completed all of the contract works in in accordance with the contract.

Date: 29th August 2018

(Signature of Authorized Agent on behalf of)

HICK BROS CIVIL CONSTRUCTION LIMITED
(Contractor)

42 FORGE ROAD, SILVERDALE
(Address)

PS3 - FORM OF PRODUCER STATEMENT- CONSTRUCTION

ISSUED BY: HICK BROS CIVIL CONSTRUCTION LIMITED

TO: WFH Development Ltd

IN RESPECT OF: Precinct 5 Stage 3A Civils
AT: 157 Grand Drive, Orewa

HICK BROS CIVIL CONSTRUCTION LTD has contracted to WFH Development Ltd to carry out and complete certain building works in accordance with a contract, titled Precinct 5 Stage 3A Civils ("the contract")

I JAMES BILKEY a duly authorized representative of HICK BROS CIVIL CONSTRUCTION LIMITED believe on reasonable grounds that HICK BROS CIVIL CONSTRUCTION LIMITED has carried out and completed all of the contract works in in accordance with the contract.

Date: 29th August 2018

Bilkey

(Signature of Authorized Agent on behalf of)

HICK BROS CIVIL CONSTRUCTION LIMITED
(Contractor)

42 FORGE ROAD, SILVERDALE
(Address)

SIXTH SCHEDULE

(NZS 3910:2003)

FORM OF PRODUCER STATEMENT CONSTRUCTION

ISSUED BY **ICB Retaining & Construction Limited**
(Contractor)

TO **Hicks Bros Civil Contractors Ltd**
(Principal)

IN RESPECT OF **Palisade Wall no.6**
(Description of Contract Works)

AT **Millwater Subdivision, Arran Hill, Precinct 5, Orewa West**
(Address)

ICB Retaining & Construction Ltd
(Contractor)

has contracted to **Hicks Bros Civil Contractors Ltd**
(Principal)

to carry out and complete certain building works in accordance with a contract, titled

Palisade Wall no.6 *(The Contract)*
(The Project)

I, ***Chris Burke*** a duly authorised
(Duly Authorised Agent)

representative of **ICB Retaining & Construction Limited**
(Contractor)

Believe on reasonable grounds that **ICB Retaining & Construction Limited**
(Contractor)

has carried out and completed:
☑ All ☐ Part only as specified in the attached particulars of the building works in accordance with the Building Consent No. and any Authorised Instruction / Variations that have been issued during the course of the work.

(Signature of Authorised Agent on Behalf of)

16 October 2018
(Date)

ICB Retaining & Construction Limited
(Contractor)

13 Volkner Place, Rosedale, Auckland 0632
(Address)

SIXTH SCHEDULE

(NZS 3910:2003)

FORM OF PRODUCER STATEMENT CONSTRUCTION

ISSUED BY **ICB Retaining & Construction Limited**
(Contractor)

TO **Hicks Bros Civil Contractors Ltd**
(Principal)

IN RESPECT OF **Palisade Wall no.7**
(Description of Contract Works)

AT **Millwater Subdivision, Arran Hill, Precinct 5, Orewa West**
(Address)

ICB Retaining & Construction Ltd
(Contractor)

has contracted to **Hicks Bros Civil Contractors Ltd**
(Principal)

to carry out and complete certain building works in accordance with a contract, titled

Palisade Wall no.7 *(The Contract)*
(The Project)

I, ***Chris Burke*** a duly authorised
(Duly Authorised Agent)

representative of **ICB Retaining & Construction Limited**
(Contractor)

Believe on reasonable grounds that **ICB Retaining & Construction Limited**
(Contractor)

has carried out and completed:

☑ All ☐ Part only as specified in the attached particulars of the building works in accordance with the Building Consent No. and any Authorised Instruction / Variations that have been issued during the course of the work.

(Signature of Authorised Agent on Behalf of)

16 October 2018
(Date)

ICB Retaining & Construction Limited
(Contractor)

13 Volkner Place, Rosedale, Auckland 0632
(Address)

FORM OF PRODUCER STATEMENT PS3 – CONSTRUCTION

At project completion, this form shall be completed by the building contractor and supplied to the Engineer.

ISSUED BY: NORTH HARBOUR FENCING
(Building Contractor)

TO: HICK BROS CIVIL
(Owner/Principal)

IN RESPECT OF: FENCING TO TOP OF WALL
(Description of Contract Works)

AT: OREWA WEST PRECINCT 5 STAGE 39 RE WALL 07
(Address)

T/A:.. **BUILDING CONSENT No:**................
(Territorial Authority / Building Consent Authority)

The above Building Contractor has contracted to the above Owner/Principal to carry out and complete certain building works in accordance with the contract, titled

.... ("the contract")
(Title of building contract)

I ROY HERBERT a duly authorised representative of the
(Builder's Authorised Agent)

above building contractor, believe on reasonable grounds that the above building contractor has carried out and completed

☐All ☐Part only as specified in the attached particulars

of the building works in accordance with the contract.

....
(Signature of Authorised Agent on behalf of the Building Contractor)

29. 8. 2018
(Date)

20 A MANGA RD
SILVERDALE
(Address)

This producer statement is confirmation by the builder(s) that they have carried out the building work in accordance with the drawings, specifications (and site amendments) that are part of the contract / building consent documents.

Work covered by this statement should have been supervised and checked by suitably qualified trades-persons.

The Engineer requires this producer statement and a copy of the T/A's building consent conditions, to confirm that items of the contract that he has not personally examined, have in fact been built according to the documents, so that the Engineer may issue appropriate documents to the T/A for it to release the Code Compliance Certificate.

20393-1

Appendix C: NZS 3604:2011 Expansive Soils (Extract)

NZS 3604:2011 Expansive Soils (Extract)

Expansive soils tend to be moderately to highly plastic clays that undergo appreciable volume change upon changes in moisture content. Technically, they are defined in NZS 3604:2011 as those soils having a liquid limit of more than 50% and a linear shrinkage of more than 15%. Where soils are quite silty or sandy, shrink and swell is less of a problem, due to the lower clay contents.

Building damage resulting from expansive soil movement can range from relatively minor brick veneer cracking and internal cracking on wall corners and wall ceiling corners with attendant door and windows jamming, through to extensive cracking of foundation block framework, extensive internal visual cracking and significant warping of building frames. Damage is dependent on building construction and materials and is rarely of structural concern.

NZS 3604:2011 "Timber Framed Buildings" defines good ground as follows:

"Any soil or rock capable of permanently withstanding an ultimate bearing capacity of 300 kPa (i.e. an allowable bearing pressure of 100 kPa using a factor of safety of 3.0), but excludes:

a) *Potentially compressible ground such as topsoil, soft soils such as clay which can be moulded easily in the fingers, and uncompacted loose gravel which contains obvious voids;*

b) *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 in accordance with NZS 4402 Test 2.6, and*

c) *Any ground which could forseeably experience movement of 25 mm or greater for any reason including one or a combination of: land instability, ground creep, subsidence, seasonal swelling and shrinking, frost heave, changing ground water level, erosion, dissolution of soil in water, and effects of tree roots."*

Foundations on expansive soils are outside the scope of NZS 3604:2011 as an acceptable solution to the New Zealand Building Code (NZBC). Specific engineering design of foundation elements is involved where expansive soils are present with a recommendation that AS 2870:2011 is used for building design. While not mandatory, AS 2870 designs will allow for a non-specific design foundation to be used without resorting to further ongoing investigation or design.

This geotechnical completion report has classified the soils present on this subdivision to be in Site Class M as per the requirements of AS 2870:2011. Descriptions of the various site classes, together with characteristic surface ground movements are outlined below.

Allowing for some correlation with NZS 3604, the various site classes applicable to NZ conditions are considered to be:

Characteristic Surface Movements	Site Class	Description
a) 20 mm (Note NZS 3604:2011 assumes movement of 25 mm as part of underlying design.	Class A (sand) and/or Class S (Silts) Equivalent to NZS 3604:2011 "Good Ground" sites	Poor to slightly expansive
b) 20 mm – 40 mm	Class M	Moderately expansive
c) 40 mm – 60 mm	Class H1	Highly expansive
d) 60 mm – 75mm	Class H2	Highly expansive
e) > 75 mm	Class E	Extremely expansive

AS 2870 uses a range of factors to assess characteristic soil movement including:

i. Building distress due to ground movement visible on adjacent structures,

ii. Known soil properties and site specific testing to determine the shrink / swell index of a soil (Test 7.1.1 in AS 1289 – Methods of Testing Soils for Engineering Purposes).

AS 2870 is based on defining soil types into various hazard classes based on expected surface movement and depth of desiccation that could occur. It then applies various foundation designs and embedment depths based on the form of building construction (slab on ground, strip footing, stiffened raft, stiffened slab with deep edge beams, etc). AS2870 uses more reinforcing steel than NZ designs generally would to create stiffer foundations that are better able to tolerate ground movement.

The Australian approach also regards expansive soil to a considerable extent being a home owner maintenance issue and significant emphasis is put into ensuring that people understand the influence that trees and dry summers etc may have on foundation performance. See Appendix D.

Appendix D: CSIRO – BTF18 – Foundation Maintenance and Footing Performance: A Homeowners Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

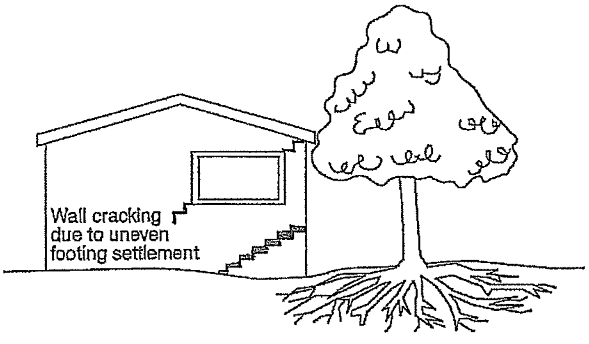
Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

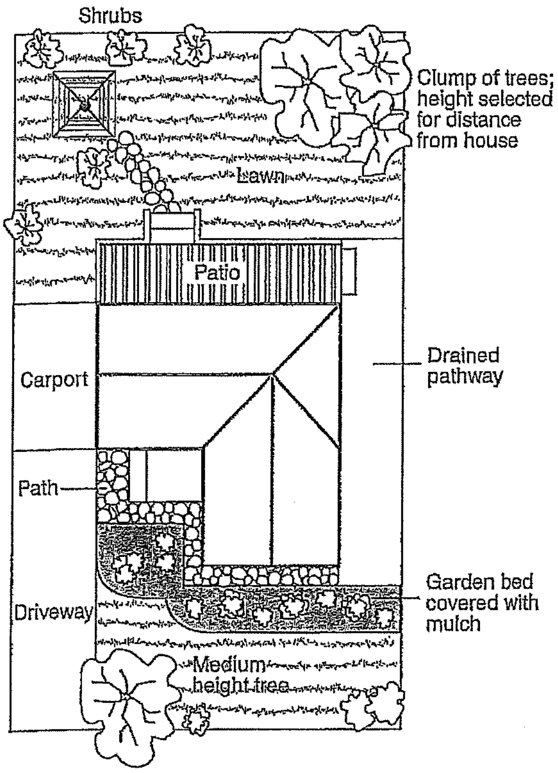
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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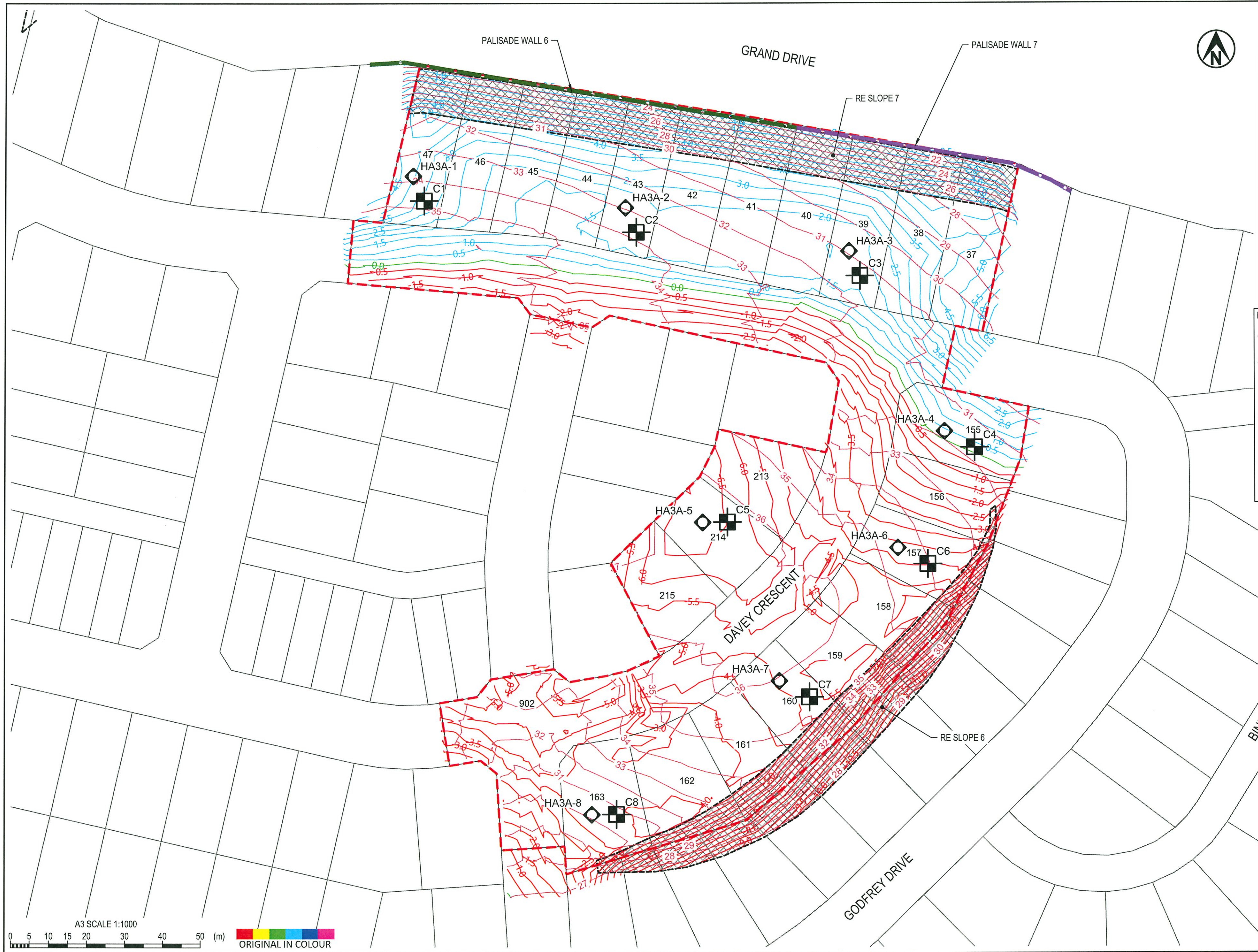
Appendix E: Test Results

21854.0031–AHP5S3A–121	Post Earthworks Investigation Plan
21854.0031–AHP5S3A–122	Topsoil Depths Plan
21854.0031–AHP5S3A–123	Earthworks Testing Location Plan

- Soil Expansion Test Results
- Post Earthworks Investigation Borehole Logs HA3A-1 to HA3A-8
- Earthworks Test Results

L:\21854\21854.0031 - Orewa West Precinct 5\WorkingMaterial\CAD\DWG\GCR\STAGE3A\21854.0031-AHP5S3A-121.dwg 2018-Oct-09 9:40:20 AM Plotted By: JONALD CASTRO



LEGEND

🟥 - - -	STAGE 3A BOUNDARY
155	LOT BOUNDARIES
—24—	FINISHED GROUND PROFILE (0.5m INTERVAL)
—○—○—	PROPOSED 400 SED OR 250UC73 PILES
—○—○—	310UC97 PILES
▨	RE SLOPE EXTENT
—2.0—	FILL CONTOURS
—0.0—	ZERO CONTOURS
—-2.0—	CUT CONTOURS
C3	EXPANSIVE SOIL TEST SAMPLES @ 0.5M AND 1.0M DEPTH
◇ HA03	HAND AUGER TO 3M DEPTH (FULLY LOGGED)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, MT EDEN CIRCUIT COORDINATES.
   ORIGIN: LAT 36 52 47S 174 45 51E 800,000MN 400,000ME
   LEVEL DATUM: LINZ (MSL) AUCKLAND VERTICAL DATUM 1946
3. LOT BOUNDARY AND FINAL CONTOUR SUPPLIED BY WOODS, REFERENCE "X_37503_P5_S3A_FINALSURFACE.DWG", DATED 18-09-2018.
4. UNDERCUT, SHEARKEY AND SUBSOIL DRAINS SUPPLIED BY WOODS, REFERENCE "37503-03A-120-AB-SK UC & SUBSOIL.DWG", DATED 17 SEPTEMBER 2018.

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REV	DESCRIPTION	CAD	CHK	DATE
1	COMPLETION REPORT ISSUE	JC		

DESIGNED	JXXL	Sep.18
DRAWN	JC	Sep.18
DESIGN CHECKED		
DRAWING CHECKED		

DRAWING STATUS
COMPLETION REPORT

NOT FOR CONSTRUCTION

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED

APPROVED   DATE

CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
POST EARTHWORKS INVESTIGATION PLAN
SCALE (A3) 1:1000   DWG No. 21854.0031-AHP5S3A-121   REV 1

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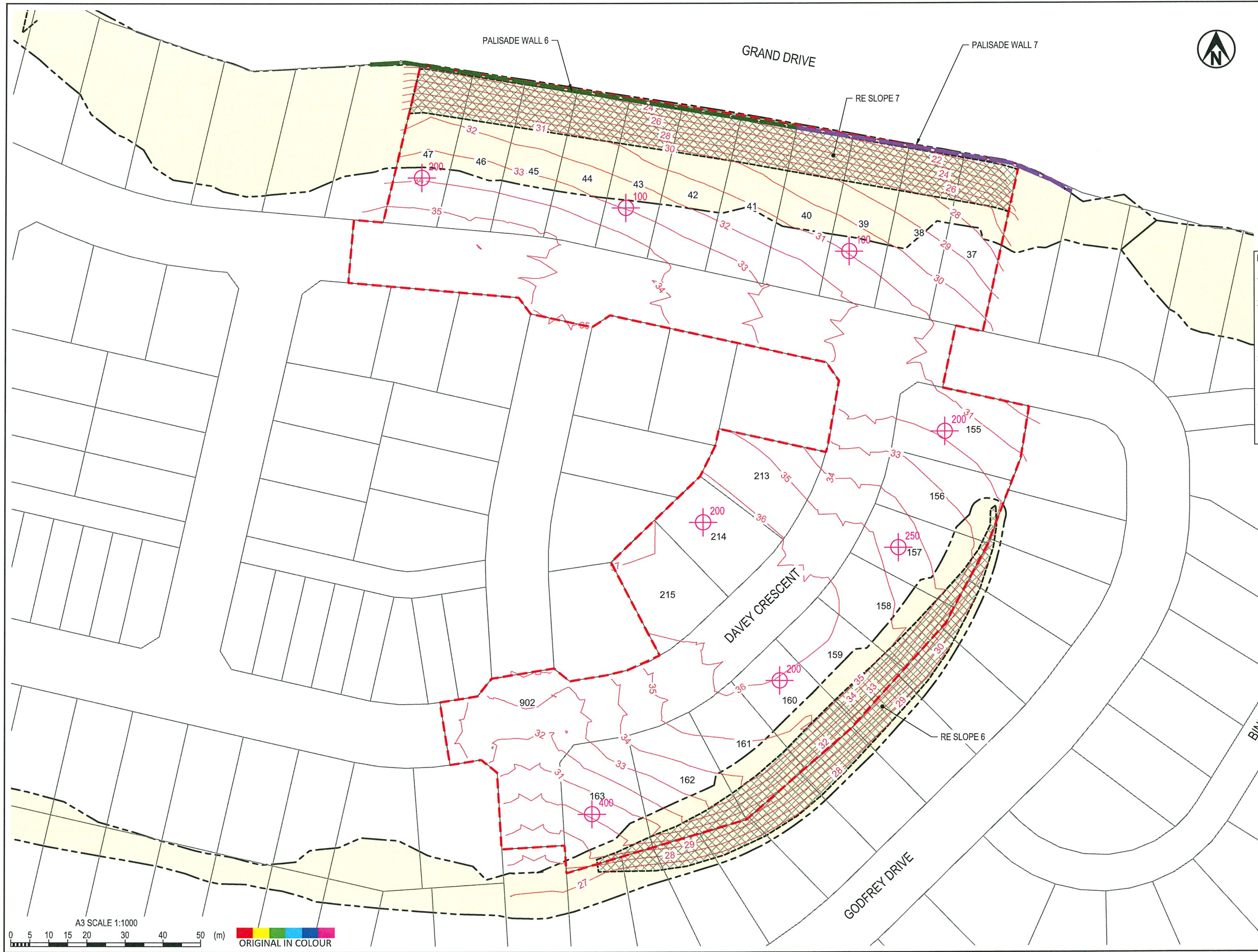

LEGEND

- STAGE 3A BOUNDARY
- 155 LOT BOUNDARIES
- FINISHED GROUND PROFILE (0.5m INTERVAL)
- PROPOSED 400 SED OR 250UC73 PILES
- 310UC97 PILES
- ▨ RE SLOPE EXTENT
- UNDERCUT EXTENT
- 200 TOPSOIL DEPTH (mm) TAKEN AT CENTRE OF EACH LOT

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, MT EDEN CIRCUIT COORDINATES.
   ORIGIN: LAT 36 52 47S 174 45 51E 800,000MN 400,000ME
   LEVEL DATUM: LINZ (MSL) AUCKLAND VERTICAL DATUM 1946
3. LOT BOUNDARY AND FINAL CONTOUR SUPPLIED BY WOODS, REFERENCE "X_37503_P5_S3A_FINALSURFACE.DWG", DATED 18-09-2018.
4. UNDERCUT, SHEARKEY AND SUBSOIL DRAINS SUPPLIED BY WOODS, REFERENCE "37503-03A-120-AB-SK UC & SUBSOIL.DWG", DATED 17 SEPTEMBER 2018.

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REV	DESCRIPTION	CAD	CHK	DATE
1	COMPLETION REPORT ISSUE	JC		

DESIGNED	JXXL	Sep.18
DRAWN	JC	Sep.18
DESIGN CHECKED		
DRAWING CHECKED		

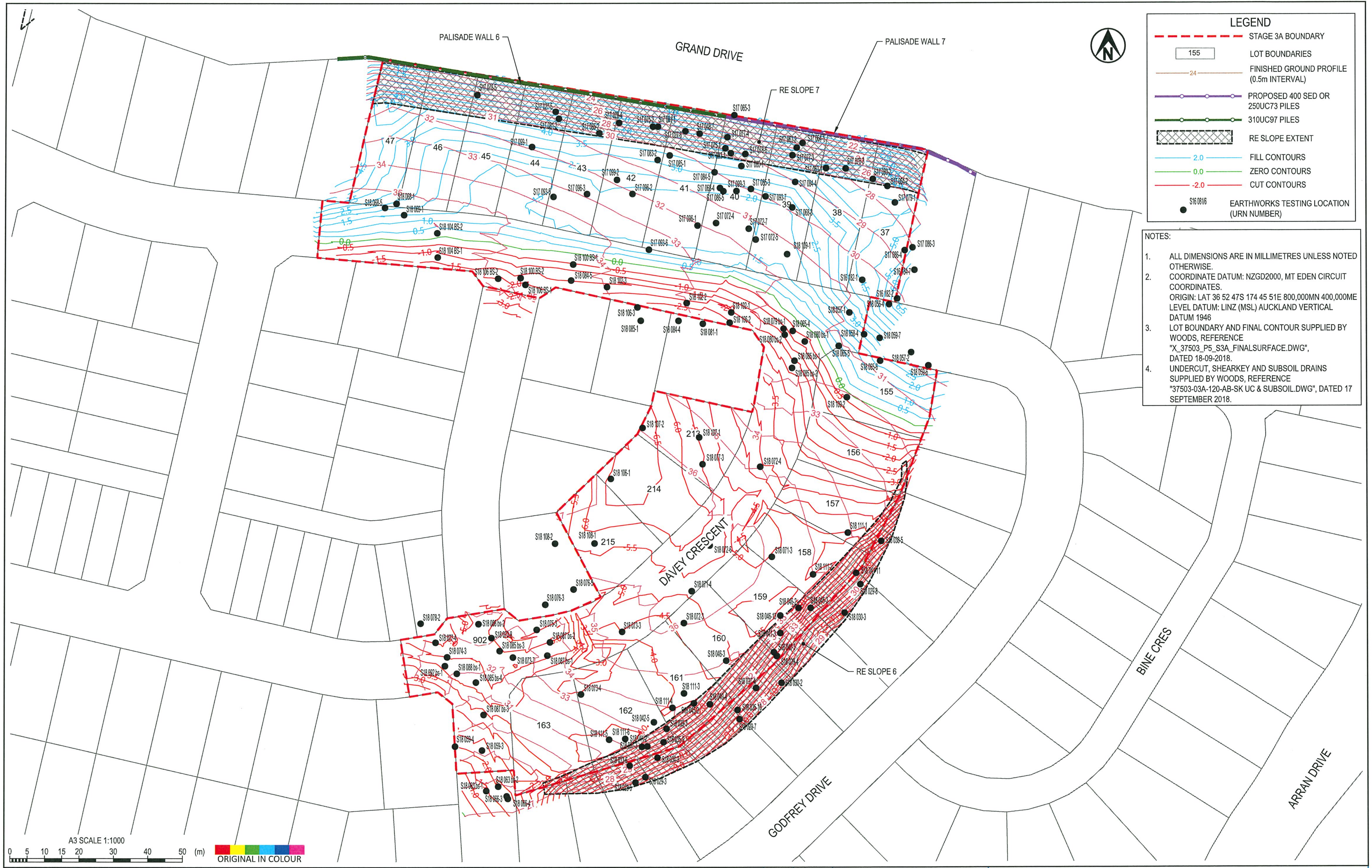
DRAWING STATUS
COMPLETION REPORT

NOT FOR CONSTRUCTION

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED

APPROVED   DATE

CLIENT **WFH PROPERTIES LTD**
PROJECT **MILLWATER - ARRANS HILL**
TITLE PRECINCT 5 STAGE 3A
TOPSOIL DEPTHS PLAN
SCALE (A3) 1:1000   DWG No. 21854.0031-AHP5S3A-122   REV 1



LEGEND

▬ ▬	STAGE 3A BOUNDARY
155	LOT BOUNDARIES
24	FINISHED GROUND PROFILE (0.5m INTERVAL)
○—○	PROPOSED 400 SED OR 250UC73 PILES
○—○	310UC97 PILES
▨	RE SLOPE EXTENT
2.0	FILL CONTOURS
0.0	ZERO CONTOURS
-2.0	CUT CONTOURS
● S16 081/6	EARTHWORKS TESTING LOCATION (URN NUMBER)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, MT EDEN CIRCUIT COORDINATES. ORIGIN: LAT 36 52 47S 174 45 51E 800,000MN 400,000ME LEVEL DATUM: LINZ (MSL) AUCKLAND VERTICAL DATUM 1946
3. LOT BOUNDARY AND FINAL CONTOUR SUPPLIED BY WOODS, REFERENCE "X_37503_P5_S3A_FINALSURFACE.DWG", DATED 18-09-2018.
4. UNDERCUT, SHEARKEY AND SUBSOIL DRAINS SUPPLIED BY WOODS, REFERENCE "37503-03A-120-AB-SK UC & SUBSOIL.DWG", DATED 17 SEPTEMBER 2018.

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REV	DESCRIPTION	CAD	CHK	DATE
1	COMPLETION REPORT ISSUE	JC		

DESIGNED	JXXL	Sep.18
DRAWN	JC	Sep.18
DESIGN CHECKED		
DRAWING CHECKED		

DRAWING STATUS
COMPLETION REPORT

NOT FOR CONSTRUCTION

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED

APPROVED   DATE

CLIENT WFH PROPERTIES LTD
PROJECT MILLWATER - ARRANS HILL
TITLE PRECINCT 5 STAGE 3A
EARTHWORKS TESTING LOCATION PLAN
SCALE (A3) 1:1000   DWG No. 21854.0031-AHP5S3A-123   REV 1

GEOTECHNICS

Our Ref: 1008182.0.0.0/Rep 1
Customer Ref: 21854.0031
11 September 2018

Tonkin & Taylor
PO Box 5271, Wellesley Street,
Auckland 1141

Attention: Mr James Lee

Dear James

Millwater, Orewa West - Precinct 5 - Stage 3A

Laboratory Test Report

Samples from the above mentioned site have been tested as received according to your instructions. Test results are included in this report.

Samples were destroyed during testing.

Please reproduce this report in full when transmitting to others or including in internal reports.

If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of this page.

GEOTECHNICS LTD

Report prepared by:

Sim Tirunahari
I am the author of this
document
2018.09.11 08:02:37 +12'00'

....
Sim Tirunahari
Soils Laboratory Manager
Approved Signatory

Authorised for Geotechnics by:

Steven Anderson

....
Steven Anderson
Project Director

Report checked by:

Steven Anderson

....
Steven Anderson
Operations & Technical Manager

This document consists of 3 pages.
11-Sep-18
t:\geotechnicsgroup\projects\1008182\issueddocuments\20180911.millwater_ p5_stage 3a.st.final.rep1.docx

GEOTECHNICS
Ground Floor, 19 Morgan Street, Newmarket, Auckland 1023
PO Box 9360, Newmarket, Auckland 1149
p 64 9 356 3510
www.geotechnics.co.nz

Site: **Millwater, Orewa West - Precinct 5, Stage 3A**

Your Job No: 21854.0031
Our Job No: 1008182.0.0.0

Test Method Used: **AS 1289.7.1.1 - 2003 Determination of the Shrink - Swell Index**

SUMMARY OF SHRINK - SWELL TEST RESULTS

HA No.:			1	1	2	2	3	3	4	4
DEPTH		(m)	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		(kPa)	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	33.7	31.6	36.9	35.8	41.2	34.8	36.0	40.2
	Bulk Density	(t/m³)	1.85	1.77	1.73	1.68	1.70	1.82	1.71	1.73
	Dry Density	(t/m³)	1.38	1.34	1.26	1.24	1.2	1.35	1.26	1.23
	Final Water Content	(%)	34.9	33.1	39.0	37.9	43.3	36.6	37.4	41.7
	Swelling Strain	(%)	0.06	0.05	-0.02	0.02	-0.04	-0.02	0.03	0.07
SHRINKAGE TEST	Final Water Content	(%)	12.1	20.5	21.8	14.5	21.7	15.9	22.0	24.3
	Shrinkage Strain	(%)	1.5	3.2	1.5	2.3	3.5	1.6	3.3	4.6
	Inert Material Estimate in the Soil Specimen	(%)	0	0	0	0	0	0	0	0
	Soil Crumbling During Shrinkage		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Cracking of the Shrinkage Specimen		Major	Major	Minor	Moderate	Moderate	Moderate	Moderate	Moderate
SHRINK - SWELL INDEX		(%)	**0.9**	**1.8**	**0.8**	**1.3**	**2.0**	**0.9**	**1.8**	**2.6**

Remarks: The test results are IANZ accredited.

Entered by: JK Date: 11/09/2018 Checked by: ST Date: 11/09/2018

GEOTECHNICS
Ground Floor, 19 Morgan Street, Newmarket, Auckland 1023
PO Box 9360, Newmarket, Auckland 1149
p 64 9 356 3510
www.geotechnics.co.nz

Site: Millwater, Orewa West - Precinct 5, Stage 3A

Your Job No: 21854.0031
Our Job No: 1008182.0.0.0

Test Method Used: **AS 1289.7.1.1 - 2003 Determination of the Shrink - Swell Index**

SUMMARY OF SHRINK - SWELL TEST RESULTS

HA No.:			**5**	**5**	**6**	**6**	**7**	**7**	**8**	**8**
DEPTH		**(m)**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		**(kPa)**	**55**	**55**	**55**	**55**	**55**	**55**	**55**	**55**
SWELL TEST	Initial Water Content	(%)	41.6	36.1	37.2	27.1	35.6	43.1	30.8	37.2
	Bulk Density	(t/m³)	1.66	1.73	1.65	1.91	1.73	1.69	1.70	1.63
	Dry Density	(t/m³)	1.17	1.27	1.20	1.50	1.28	1.18	1.30	1.19
	Final Water Content	(%)	42.8	37.7	39.2	28.7	37.4	44.2	32.8	39.3
	Swelling Strain	(%)	0.03	-0.03	0.13	0.08	0.04	0.04	0.03	0.02
SHRINKAGE TEST	Final Water Content	(%)	19.8	16.7	21.5	17.1	24.5	33.1	24.5	25.5
	Shrinkage Strain	(%)	1.8	0.7	2.0	1.0	1.2	1.7	1.5	1.1
	Inert Material Estimate in the Soil Specimen	(%)	0	0	0	0	0	0	0	0
	Soil Crumbling During Shrinkage		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Cracking of the Shrinkage Specimen		Minor	Minor	Moderate	Minor	Moderate	Moderate	Moderate	Moderate
SHRINK - SWELL INDEX		**(%)**	**1.0**	**0.4**	**1.2**	**0.6**	**0.7**	**1.0**	**0.8**	**0.6**

Remarks: The test results are IANZ accredited.

Entered by: JK Date: 11/09/2018 Checked by: ST Date: 11/09/2018

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **HA3A-1**
SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5
LOCATION: Arran Drive, Millwater
JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000) 5949422.72 mN 1749234.22 mE
R.L.: 33.70m
DATUM: NZVD2016
DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:
HOLE STARTED: 03/08/2018
HOLE FINISHED: 03/08/2018
DRILLED BY: GEOTECHNICS
LOGGED BY: RBE
CHECKED: AGRA

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	TESTS	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION Description and Additional Observations
Topsoil		M	VSt	SILT, some clay, low plasticity, moist, dark brown
Fill	● 158/80 kPa			SILT, some clay, low to no plasticity, moist, pinkish and yellowish brown
	● >224 kPa ● >224 kPa ● 157/75 kPa		VSt-H	SILT, non plastic, moist, pinkish and yellowish brown with grey inclusions and fragments of weathered sandstone *0.90m:* low plasticity, yellowish brown pink and brown *1.00m:* non plastic *1.20m:* abundant grey inclusions
	● 157/78 kPa ● 167/64 kPa		VSt	clayey SILT, low plasticity, moist, yellowish brown and pink with some brown inclusions *1.70m:* inclusions of grey sandstone *2.05m:* solid refusal on ?gravel inclusion
				2.05m: Refusal

COMMENTS:

Hole Depth
2.05m

Scale 1:20

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **HA3A-2**

SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5

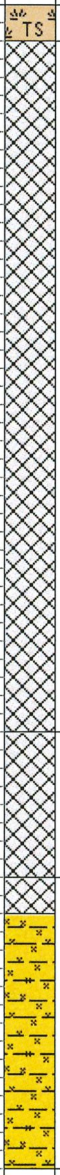
LOCATION: Arran Drive, Millwater

JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000)	5949414.23 mN 1749288.64 mE	DRILL TYPE: 50mm hand auger	HOLE STARTED: 03/08/2018
		DRILL METHOD: HA	HOLE FINISHED: 03/08/2018
R.L.:	32.80m		DRILLED BY: GEOTECHNICS
DATUM:	NZVD2016	DRILL FLUID:	LOGGED BY: RBE CHECKED: AGRA

GEOLOGICAL

ENGINEERING DESCRIPTION



GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (cm) 20 60 200 600 2000	Description and Additional Observations
Fill										TS	M	VSt-H				SILT, some clay, low plasticity, moist, dark brown
						● UTP ● UTP ● UTP ● UTP ● UTP ● UTP		32 31	0.5 1.0 1.5		D-M	H				SILT, non plastic, dry to moist, pinkish brown, minor grey inclusions
						● UTP			2.0		D					sandy SILT, non plastic, dry, light greyish white and brown, minor grey sandstone inclusions *2.20m:* gravelly, very difficult to penetrate
						● 118/87 kPa					M	VSt				clayey SILT, low plasticity, moist, grey and brown
Residual Soil						● 163/75 kPa ● 157/77 kPa		30	2.5 3.0							clayey SILT, medium plasticity, moist, light grey mottled yellowish brown
								29	3.5							3.2m: Target depth

COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

BoreLog - 31/08/2018 2:11:37 p.m. - Produced with Core-GS by GeRoc

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **HA3A-3**

SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5	LOCATION: Arran Drive, Millwater	JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000) 5949402.60 mN 1749348.55 mE

R.L.: 30.50m

DATUM: NZVD2016

DRILL TYPE: 50mm hand auger

DRILL METHOD: HA

DRILL FLUID:

HOLE STARTED: 03/08/2018

HOLE FINISHED: 03/08/2018

DRILLED BY: GEOTECHNICS

LOGGED BY: RBE

CHECKED: AGRA

GEOLOGICAL

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.

FLUID LOSS (%) 25 50 75 | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | RL (m) | DEPTH (m)

ENGINEERING DESCRIPTION

GRAPHIC LOG | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (cm) 20 60 200 600 2000 | Description and Additional Observations

Fill

Tests	RL (m)	Depth (m)
116/38 kPa		
	30	0.5
>224 kPa		
UTP		
		1.0
>224 kPa		
>224 kPa	29	1.5
UTP		
		2.0
UTP		
147/91 kPa		
	28	2.5
>224 kPa		
208/119 kPa		3.0
	27	3.5

Graphic log	Moisture condition	Strength/density classification	Description and Additional Observations
TS	M	VSt	clayey SILT, low plasticity, moist, dark brown
	D-M	VSt-H	SILT non plastic, moist, yellowish orange brown *0.50m:* low plasticity with inclusions of brown topsoil *0.55m:* yellowish brown mottled pinkish red *1.30m:* grey inclusions *1.40m:* dry, friable, reddish brown and yellowish brown *2.00m:* abundant grey inclusions and minor sandstone gravel
	M	VSt	clayey SILT, low to medium plasticity, moist, yellowish brown mottled reddish brown, with grey inclusions
		H	SILT, non plastic, moist, minor gravel, brown and yellowish brown *3.10m:* minor clay

3.2m: Target depth

COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

BoreLog - 31/08/2018 2:11:37 p.m. - Produced with Core-GS by GeRoc

Tonkin+Taylor

BOREHOLE LOG

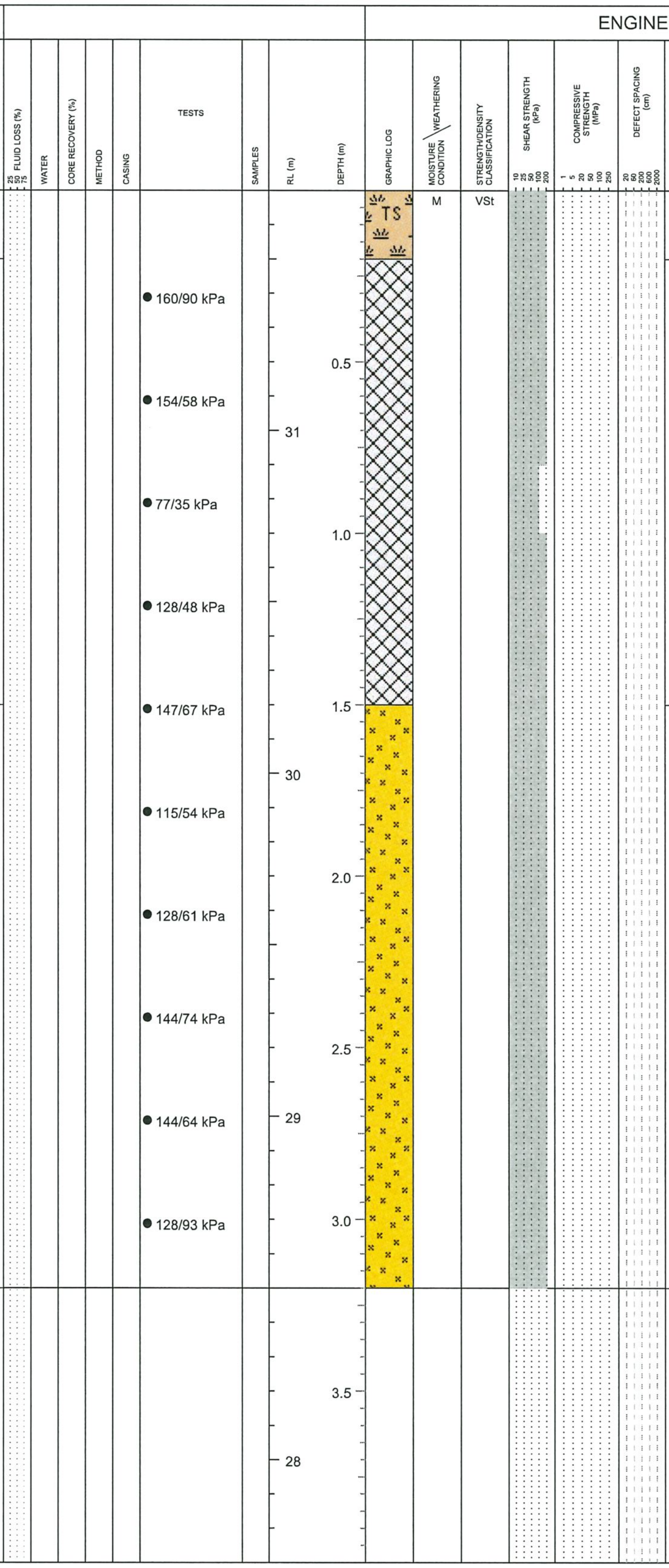
BOREHOLE No.: **HA3A-4**

SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5
LOCATION: Arran Drive, Millwater
JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000) 5949349.65 mN 1749372.76 mE
R.L.: 31.70m
DATUM: NZVD2016
DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:
HOLE STARTED: 06/08/2018
HOLE FINISHED: 06/08/2018
DRILLED BY: GEOTECHNICS
LOGGED BY: AGRA
CHECKED: AGRA

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION Description and Additional Observations
Topsoil	M	VSt	SILT, non plastic, moist, dark brown
Fill			SILT, trace clay, non plastic, moist, yellowish brown mottled white
Residual Soil			SILT, some clay, low to no plasticity, moist, yellowish brown mottled white *1.70m:* non plastic, trace clay *3.00m:* white mottled orange and pink
			3.2m: Target depth



COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **HA3A-5**

SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5
LOCATION: Arran Drive, Millwater
JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000) 5949322.10 mN 1749316.30 mE
R.L.: 37.50m
DATUM: NZVD2016

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 03/08/2018
HOLE FINISHED: 03/08/2018
DRILLED BY: GEOTECHNICS
LOGGED BY: RBE
CHECKED: AGRA

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	GRAPHIC LOG	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (cm) 20 60 200 600 2000	ENGINEERING DESCRIPTION Description and Additional Observations
Fill										TS	M	VSt-H				clayey SILT, low plasticity, moist, dark brown
						● >224 kPa ● 221/75 kPa		37	0.5		D-M	H				SILT, non plastic, dry to moist, minor sand, light orange brown
						● UTP			1.0		M					gravelly SILT, non plastic, moist, brown
Residual Soil						● 161/39 kPa ● 141/45 kPa ● 141/33 kPa		36	1.5 2.0			VSt				SILT, non plastic, moist, yellowish brown mottled orange brown *1.40m:* moist to wet, light yellowish brown to light brown *2.00m:* trace sand
						● 131/32 kPa ● 138/33 kPa ● 132/35 kPa ● 141/35 kPa		35	2.5 3.0		M-W					sandy SILT, non plastic, moist, light brown *2.90m:* wet, light yellowish brown
								34	3.5							3.2m: Target depth

COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **HA3A-6**
SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5
LOCATION: Arran Drive, Millwater
JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000) 5949317.26 mN
1749365.26 mE
R.L.: 33.40m
DATUM: NZVD2016

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 06/08/2018
HOLE FINISHED: 06/08/2018
DRILLED BY: GEOTECHNICS
LOGGED BY: RBE
CHECKED: AGRA

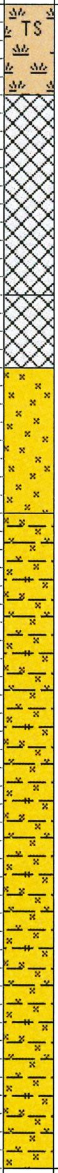
GEOLOGICAL

GEOLOGICAL UNIT,
GENERIC NAME,
ORIGIN,
MATERIAL COMPOSITION.

ENGINEERING DESCRIPTION

Columns: 25 50 75 FLUID LOSS (%) | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (cm) 20 60 200 600 2000 | Description and Additional Observations

RL (m): 33, 32, 31, 30
DEPTH (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5



GEOLOGICAL	TESTS	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	Description and Additional Observations
Fill		M	VSt	clayey SILT, medium plasticity, moist, dark brown
	● 163/48 kPa ● 144/54 kPa		VSt-H	SILT, non plastic, moist, pinkish brown, and clayey SILT, low plasticity, moist, light yellowish brown
	● UTP		H	SILT non plastic, moist, light reddish brown
Residual Soil	● UTP			SILT, non plastic, moist, yellowish brown mottled light greyish white
	● 58/23 kPa ● 72/22 kPa ● 86/26 kPa ● 83/32 kPa ● 74/29 kPa ● 93/26 kPa		St	clayey SILT, low plasticity, moist, pink *1.90m:* low plasticity, yellowish brown and pink *2.80m:* low to no plasticity, moist to wet, light brown
				3.2m: Target depth

COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: **HA3A-7**

SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5
LOCATION: Arran Drive, Millwater
JOB No.: 21854.0031 - 2018

CO-ORDINATES: 5949277.76 mN
(NZTM2000) 1749327.26 mE
R.L.: 35.60m
DATUM: NZVD2016

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 06/08/2018
HOLE FINISHED: 06/08/2018
DRILLED BY: GEOTECHNICS
LOGGED BY: RBE
CHECKED: AGRA

GEOLOGICAL

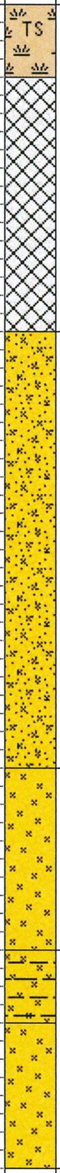
ENGINEERING DESCRIPTION

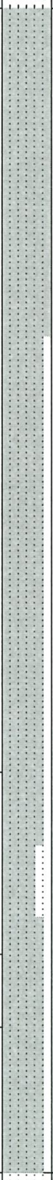
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.

FLUID LOSS (%) 25 50 75 | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (cm) 20 60 200 600 2000 | Description and Additional Observations

Tests:
- ● >224 kPa
- ● 198/75 kPa
- ● UTP
- ● 179/35 kPa
- ● 157/26 kPa
- ● 195/23 kPa
- ● 135/27 kPa
- ● 64/22 kPa
- ● 125/35 kPa
- ● UTP
- ● 141/35 kPa

RL (m)	DEPTH (m)
35	0.5
34	1.0
33	1.5
32	2.0
	2.5
	3.0
	3.5





Geological	Moisture	Strength	Description and Additional Observations
Fill	M	VSt-H	clayey SILT, low to medium plasticity, moist, dark brown
			SILT non plastic, moist, pinkish and yellowish brown
Residual Soil	D-M		sandy SILT, non plastic, dry to moist, light brown *1.20m:* moist *1.70m:* light greyish brown
	M-W	St-VSt	SILT, non plastic, moist to wet, light greyish brown
	M	VSt	clayey SILT, low plasticity, moist, light brown
		VSt-H	SILT, non plastic, moist, orange brown *3.00m:* grey *3.05m:* cemented rusty brown, difficult to auger *3.15m:* wet, orange brown

3.2m: Target depth

COMMENTS:

Hole Depth
3.2m

Scale 1:20

Rev.: A

BoreLog - 31/08/2018 2:11:37 p.m. - Produced with Core-GS by GeRoc

Tonkin+Taylor

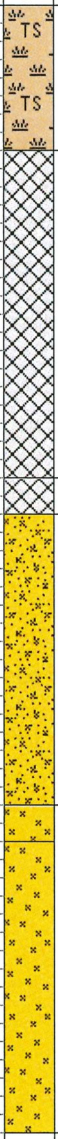
BOREHOLE LOG

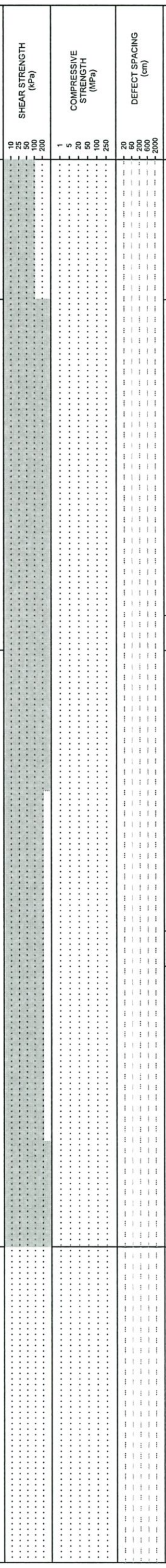
BOREHOLE No.: **HA3A-8**
SHEET: 1 OF 1

PROJECT: Millwater - Arrans Hill Precinct 5
LOCATION: Arran Drive, Millwater
JOB No.: 21854.0031 - 2018

CO-ORDINATES: (NZTM2000) 5949250.23 mN 1749276.01 mE
R.L.: 29.90m
DATUM: NZVD2016
DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:
HOLE STARTED: 06/08/2018
HOLE FINISHED: 06/08/2018
DRILLED BY: GEOTECHNICS
LOGGED BY: AGRA
CHECKED: AGRA

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MATERIAL COMPOSITION.	FLUID LOSS (%) 25 50 75	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	RL (m)	DEPTH (m)	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION Description and Additional Observations
Topsoil						● 54/22 kPa				M	St	SILT, non plastic, moist, dark brown
Fill						● >224 kPa ● >224 kPa ● 138/65 kPa		29	0.5 1.0	D-M	H	SILT, minor sand, friable, dry to moist, yellowish brown *0.70m:* trace gravel
										M		SILT, trace clay, non plastic, moist, yellowish brown
Residual Soil		◄				● UTP ● 131/32 kPa ● 119/22 kPa		28	1.5 2.0	D-M	VSt-H	sandy SILT, friable, dry to moist, yellowish brown *1.70m:* moist
										M		SILT non plastic, moist light grey
						● 141/38 kPa ● 176/29 kPa ● UTP		27	2.5 3.0			SILT non plastic, moist, yellowish brown with reddish brown rusty inclusions *3.00m:* band of rusty oxides
								26	3.5			3.1m: Target depth





COMMENTS:

Hole Depth
3.1m

Scale 1:20

Rev.: A

GEOTECHNICS
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Job: P5 Silverdale Arran's Hill
Earth Works
Client: Tonkin & Taylor
T&T Job #: 21854.0037

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

Job # 614089.040/1
Entered By: TA/CBEN/ELHO
Checked By:
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URN	New No.	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m^3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate) Test 1	Test 2	Test 3	Test 4	Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
S16 182-1		2659868.397	6511101.295	26.311	North Gully	TA	9/12/2016	1.91 1.91	1.55 1.55	23.5 23.5	2.7 2.7	6.2 6.2	214	214	214	214	214		P	
S16 182-2		2659878.434	6511095.705	24.314	North Gully	TA	9/12/2016	1.92 1.90	1.45 1.43	32.8 32.8	2.7 2.7	0.0 0.3	214	214	214	214	214		P	
S16 184-7		2659883.628	6511103.879	23.572	North Gully	TA	12/12/2016	1.94 1.93	1.50 1.49	29.4 29.4	2.7 2.7	0.4 1.2	174	171	191	199	184		P	
S17 027-5		2659780.547	6511151.756	22.667	N Shear Key	CBEN	10/02/2017	1.88 1.86	1.48 1.46	27.1 27.1	2.7 2.7	5.1 6.1	214	214	214	214	214		P	
S17 027-6		2659818.128	6511145.303	21.055	N Shear Key	CBEN	10/02/2017	1.89 1.89	1.47 1.47	28.7 28.7	2.7 2.7	3.3 3.7	214	214	199	199	207		P	
S17 028-4		2659798.9	6511148.1	22.55	N Shear Key	CBEN	13/02/2017	1.88 1.89	1.42 1.42	33.0 33.0	2.7 2.7	0.8 0.6	153	165	165	202	171		P	
S17 048-7		2659822.24	6511144.501	22.277	N RE Wall	CBEN	17/03/2017	1.94 1.94	1.52 1.52	27.5 27.5	2.7 2.7	1.7 2.0	214	214	214	214	214		P	
S17 063-1		2659858.609	6511133.775	22.007	N RE Wall	CBEN	7/04/2017	1.82 1.84	1.39 1.40	31.6 31.6	2.7 2.7	4.8 3.9	153	183	214	214	191		P	
S17 063-2		2659850.25	6511139.869	22.002	N RE Wall	CBEN	7/04/2017	1.80 1.81	1.36 1.36	32.4 32.4	2.7 2.7	5.4 5.3	214	214	214	214	214		P	
S17 064-1		2659851.991	6511141.201	22.138	N RE Wall	CBEN	10/04/2017	1.87 1.88	1.42 1.42	32.3 32.3	2.7 2.7	1.8 1.5	214	160	214	214	201		P	
S17 064-2		2659876.291	6511128.183	22.207	N RE Wall	CBEN	10/04/2017	1.86 1.88	1.41 1.42	32.4 32.4	2.7 2.7	2.4 1.6	214	214	206	214	212		P	
S17 065-3		2659832.407	6511149.613	22.02	N RE Wall	CBEN	11/04/2017	1.87 1.89	1.40 1.41	33.4 33.4	2.7 2.7	1.4 0.4	183	214	183	208	197		P	
S17 068-3		2659848.566	6511122.615	24.334	N RE Wall	CMO	21/04/2017	1.79 1.78	1.35 1.36	32.3 30.6	2.7 2.7	6.2 7.8	214	214	214	214	214		P	
S17 068-4		2659827.781	6511128.732	24.751	N RE Wall	CMO	21/04/2017	1.87 1.87	1.41 1.40	32.9 33.7	2.7 2.7	1.6 1.1	199	196	214	214	206		P	
S17 072-4		2659826.428	6511118.624	26.976	N RE Wall	CMO	27/04/2017	1.91 1.91	1.51 1.49	26.4 28.0	2.7 2.7	4.1 3.0	214	214	183	168	195		P	
S17 072-5		2659837.82	6511113.596	27.073	N RE Wall	CMO	27/04/2017	1.87 1.84	1.41 1.37	32.4 34.6	2.7 2.7	1.9 2.1	214	214	214	214	214		P	
S17 072-7		2659835.907	6511116.789	27.853	Pond W of Shear Key 1	CMO	27/04/2017	1.85 1.84	1.44 1.42	28.3 29.4	2.7 2.7	5.8 5.5	214	214	214	214	214		P	
S17 075-1		2659829.59	6511140.1	23.218	N RE Wall	CMO	3/05/2017	1.88 1.88	1.47 1.46	27.8 28.8	2.7 2.7	4.6 3.9	214	214	214	214	214		P	
S17 075-2		2659808.75	6511146.8	23.19	N RE Wall	CMO	3/05/2017	1.91 1.90	1.49 1.44	28.6 32.0	2.7 2.7	2.5 0.6	186	180	200	209	194		P	
S17 076-3		2659864.26	6511133.5	23.784	N RE Wall	CMO	4/05/2017	1.90 1.90	1.48 1.51	28.5 26.2	2.7 2.7	3.1 4.8	214	214	214	214	214		P	
S17 077-3		2659848.96	6511137.68	23.93	N RE Wall	CMO	8/05/2017	1.85 1.85	1.42 1.41	30.4 31.4	2.7 2.7	4.3 3.6	214	168	171	188	185		P	
S17 077-4		2659830.27	6511143.3	24.838	N RE Wall	CMO	8/05/2017	1.79 1.78	1.36 1.31	31.5 36.1	2.7 2.7	6.7 4.3	183	214	214	205	204		P	
S17 078-5		2659757.96	6511157.03	25.06	N RE Wall	CMO	9/05/2017	1.76 1.77	1.32 1.29	33.3 37.2	2.7 2.7	7.1 4.2	168	214	214	191	197		P	
S17 078-6		2659835.34	6511138.33	24.885	S Butress	CMO	9/05/2017	1.86 1.86	1.37 1.39	36.0 33.5	2.7 2.7	0.1 1.7	176	183	214	214	197		P	
S17 079-1		2659878.429	6511123.394	25.42	N RE Wall	TA	10/05/2017	1.88 1.87	1.43 1.44	31.8 30.2	2.7 2.7	1.8 3.4	176	214	214	214	205		P	
S17 080-1		2659834.136	6511134.909	25.664	N RE Wall	TA	15/05/2017	1.88 1.89	1.40 1.41	33.6 33.6	2.7 2.7	0.8 0.3	199	214	214	191	205		P	
S17 080-2		2659872.105	6511130.299	25.782	N RE Wall	TA	15/05/2017	1.85 1.85	1.38 1.38	34.1 34.1	2.7 2.7	1.6 1.9	214	214	214	214	214		P	
S17 081-1		2659810.214	6511146.788	26.439	N RE Wall	TA	16/05/2017	1.82 1.81	1.35 1.34	34.9 34.9	2.7 2.7	3.0 3.4	168	183	214	214	195		P	
S17 081-2		2659781.449	6511149.696	26.355	N RE Wall	TA	16/05/2017	1.81 1.80	1.32 1.31	37.3 37.3	2.7 2.7	1.9 2.7	214	214	214	214	214		P	

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Job: P5 Silverdale Arran's Hill
Earth Works

Client: Tonkin & Taylor
T&T Job #: 21854.0037

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

Job # **614089.040/1**
Entered By: TA/CBEN/ELHO
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URN	New No.	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m³)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate)				Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
													Test 1	Test 2	Test 3	Test 4				
S17 083-1		2659831.158	6511138.687	27.398	N RE Wall	TA	23/05/2017	1.80	1.34	34.9	2.7	3.8	186	214	179	214	198		P	
		2659831.158	6511138.687					1.81	1.34	34.9	2.7	3.6								
S17 083-2		2659809.874	6511137.156	27.231	N RE Wall	TA	23/05/2017	1.89	1.43	32.3	2.7	0.9	206	183	214	214	204		P	
								1.81	1.37	32.3	2.7	5.0								
S17 084-4		2659849.588	6511129.981	27.695	N RE Wall	TA	24/05/2017	1.88	1.41	33.3	2.7	0.9	214	214	214	214	214		P	
								1.88	1.41	33.3	2.7	0.9								
S17 084-5		2659826.326	6511133.275	27.627	N RE Wall	TA	24/05/2017	1.80	1.32	36.0	2.7	3.4	214	214	214	214	214		P	
								1.80	1.33	36.0	2.7	3.1								
S17 085-1		2659813.425	6511138.414	28.379	N RE Wall	TA	25/05/2017	1.80	1.36	33.0	2.7	5.0	199	214	214	199	207		P	
								1.82	1.37	33.0	2.7	4.3								
S17 085-2		2659793.041	6511145.285	28.764	N RE Wall	TA	25/05/2017	1.85	1.33	38.5	2.7	0.0	183	199	214	214	203		P	
								1.84	1.33	38.5	2.7	0.0								
S17 085-3		2659836.776	6511128.231	28.692	N RE Wall	TA	25/05/2017	1.75	1.25	39.9	2.7	3.6	153	168	176	214	178		P	
								1.76	1.25	39.9	2.7	3.5								
S17 086-3		2659883.223	6511110.332	27.338	N RE Wall	CBEN	26/05/2017	1.78	1.30	36.9	2.7	4.0	157	160	168	189	169		P	
								1.77	1.29	36.9	2.7	4.4								
S17 086-4		2659880.943	6511109.614	24.323	N RE Wall	CBEN	26/05/2017	1.82	1.31	38.9	2.7	0.6	214	183	175	214	197		P	
								1.81	1.30	38.9	2.7	1.1								
S17 086-5		2659828.752	6511127.777	29.465	N RE Wall	CBEN	26/05/2017	1.79	1.27	41.3	2.7	0.9	214	176	183	183	189		P	
								1.78	1.26	41.3	2.7	1.2								
S17 093-5		2659779.394	6511127.236	31.743	N RE Wall	CBEN	12/06/2017	1.81	1.33	36.1	2.7	2.6	153	168	145	199	166		P	
								1.80	1.32	36.1	2.7	3.2								
S17 093-6		2659806.819	6511111.371	31.118	N RE Wall	CBEN	12/06/2017	1.82	1.34	35.5	2.7	2.6	199	199	153	161	178		P	
								1.82	1.34	35.5	2.7	2.7								
S17 093-7		2659840.893	6511125.983	29.685	N RE Wall	CBEN	12/06/2017	1.83	1.36	33.9	2.7	3.3	161	145	171	199	169		P	
								1.83	1.37	33.9	2.7	3.1								
S17 096-1		2659821.042	6511118.032	31.101	N RE Wall	CBEN	15/06/2017	1.76	1.25	40.6	2.7	2.6	214	214	214	214	214		P	
								1.76	1.25	40.6	2.7	2.8								
S17 096-2		2659802.362	6511127.531	31.803	N RE Wall	CBEN	15/06/2017	1.77	1.28	38.4	2.7	3.8	199	206	214	214	208		P	
								1.75	1.27	38.4	2.7	4.4								
S17 096-3		2659789.092	6511127.8	31.987	N RE Wall	CBEN	15/06/2017	1.81	1.27	42.0	2.7	0.0	214	214	214	214	214		P	
								1.81	1.27	42.0	2.7	0.0								
S17 099-1		2659773.532	6511141.732	32.037	N RE Wall	CBEN	20/06/2017	1.87	1.44	29.9	2.7	3.9	214	214	214	214	214		P	
								1.86	1.43	29.9	2.7	4.3								
S17 099-2		2659797.932	6511131.699	34.624	N RE Wall	CBEN	20/06/2017	1.86	1.36	36.3	2.7	0.0	214	214	214	214	214		P	
								1.84	1.35	36.3	2.7	0.9								
S17 099-3		2659832.556	6511127.745	30.568	N RE Wall	CBEN	20/06/2017	1.91	1.48	29.4	2.7	1.8	214	214	214	214	214		P	
								1.89	1.46	29.4	2.7	3.0								
S18 028-5		2659799.643	6510957.845	25.463	Undercut 3	ELHO	20/02/2018	1.82	1.39	30.8	2.7	5.4	204	204	204	204	204		P	
								1.83	1.40	30.8	2.7	5.1								
S18 029-3		2659802.551	6510959.358	26.165	Undercut 3	ELHO	21/02/2018	1.83	1.42	29.3	2.7	5.9	204	204	204	204	204		P	
								1.84	1.42	29.3	2.7	5.8								
S18 029-7		2659830.161	6510975.471	26.225	Undercut 3	ELHO	21/02/2018	1.93	1.48	30.1	2.7	0.6	204	204	204	204	204		P	
								1.94	1.49	30.1	2.7	0.0								
S18 029-8		2659865.875	6511013.561	27.736	Undercut 3	ELHO	21/02/2018	1.85	1.42	30.7	2.7	4.1	204	204	204	204	204		P	
								1.85	1.42	30.7	2.7	4.0								
S18 030-2		2659842.486	6510985.681	26.97	Undercut 3	ELHO	22/02/2018	1.81	1.36	32.8	2.7	4.8	204	204	204	204	204		P	
								1.82	1.37	32.8	2.7	4.4								
S18 030-3		2659861.128	6511005.462	27.563	Undercut 3	ELHO	22/02/2018	1.82	1.38	32.5	2.7	4.4	204	204	204	204	204		P	
								1.81	1.37	32.5	2.7	4.9								
S18 033-6		2659798.075	6510962.759	27.004	RE Wall 6	ELHO	27/02/2018	1.78	1.34	32.9	2.7	6.2	204	204	204	204	204		P	
								1.78	1.34	32.9	2.7	6.1								
S18 034-3		2659806.196	6510964.862	27.781	RE Wall 6	ELHO	28/02/2018	1.78	1.34	33.2	2.7	6.1	204	204	204	204	204		P	
								1.80	1.35	33.2	2.7	4.9								
S18 035-9		2659808.033	6510969.348	28.181	RE Wall 6	ELHO	1/03/2018	1.81	1.35	34.4	2.7	3.5	204	204	204	204	204		P	
								1.81	1.35	34.4	2.7	3.7								
S18 035-10		2659829.67	6510978.173	28.655	RE Wall 6	ELHO	1/03/2018	1.81	1.34	34.6	2.7	3.7	204	204	204	204	204		P	
								1.81	1.35	34.6	2.7	3.6								

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Job: P5 Silverdale Arran's Hill
Earth Works
Client: Tonkin & Taylor
T&T Job #: 21854.0037
Job # 614089.040/1
Entered By: TA/CBEN/ELHO
Checked By:
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NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

URN	New No.	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m³)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate)				Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
													Test 1	Test 2	Test 3	Test 4				
S18 037-3		2659801.762	6510968.089	30.197	RE Wall 6	ELHO	5/03/2018	1.74	1.28	36.8	2.7	5.8	204	204	204	204	204		P	
								1.74	1.27	36.8	2.7	6.3								
S18 037-4		2659835.114	6510984.342	26.427	RE Wall 6	ELHO	5/03/2018	1.75	1.30	34.6	2.7	7.1	204	204	204	204	204		P	
								1.75	1.30	34.6	2.7	6.8								
S18 038-5		2659872.199	6511025.889	30.443	RE Wall 6	ELHO	6/03/2018	1.84	1.43	29.2	2.7	5.6	204	204	204	204	204		P	
								1.84	1.42	29.2	2.7	5.8								
S18 039-3		2659808.972	6510973.222	31.2	RE Wall 6	ELHO	7/03/2018	1.80	1.38	30.3	2.7	6.9	204	204	204	204	204		P	
								1.79	1.38	30.3	2.7	7.3								
S18 039-4		2659841.29	6510993.359	29.118	RE Wall 6	ELHO	7/03/2018	1.80	1.38	30.0	2.7	7.4	204	204	204	204	204		P	
								1.81	1.39	30.0	2.7	6.8								
S18 040-3		2659840.433	6510994.555	31.249	RE Wall 6	ELHO	8/03/2018	1.84	1.39	31.8	2.7	4.1	204	204	204	204	204		P	
								1.84	1.39	31.8	2.7	4.0								
S18 040-4		2659821.662	6510979.956	31.406	RE Wall 6	ELHO	8/03/2018	1.82	1.39	31.7	2.7	4.8	204	204	204	204	204		P	
								1.84	1.40	31.7	2.7	3.9								
S18 041-2		2659803.324	6510968.183	31.308	RE Wall 6	ELHO	9/03/2018	1.80	1.39	30.1	2.7	7.0	204	204	204	204	204		P	
								1.80	1.39	30.1	2.7	6.9								
S18 041-3		2659842.415	6510999.987	29.932	RE Wall 6	ELHO	9/03/2018	1.81	1.40	29.8	2.7	6.6	204	204	204	204	204		P	
								1.80	1.39	29.8	2.7	7.4								
S18 041-11		2659864.712	6511016.875	31.968	RE Wall 6	ELHO	9/03/2018	1.85	1.42	30.3	2.7	4.5	204	204	204	204	204		P	
								1.85	1.42	30.3	2.7	4.4								
S18 042-5		2659805.376	6510975.153	32.406	RE Wall 6	ELHO	12/03/2018	1.86	1.49	25.0	2.7	7.6	204	204	204	204	204		P	
								1.86	1.49	25.0	2.7	7.8								
S18 045-2		2659817.05	6510980.315	32.966	RE Wall 6	ELHO	15/03/2018	1.87	1.45	28.7	2.7	4.6	204	204	204	204	204		P	
								1.86	1.44	28.7	2.7	5.0								
S18 045-3		2659851.391	6511007.071	33.256	RE Wall 6	ELHO	15/03/2018	1.85	1.44	28.9	2.7	5.3	204	204	204	204	204		P	
								1.86	1.44	28.9	2.7	4.8								
S18 046-2		2659847.863	6511007.122	34.314	RE Wall 6	ELHO	16/03/2018	1.84	1.39	32.4	2.7	3.7	204	204	204	204	204		P	
								1.83	1.39	32.4	2.7	3.8								
S18 046-3		2659826.633	6510992.413	34.103	RE Wall 6	ELHO	16/03/2018	1.82	1.37	33.3	2.7	3.8	204	204	204	204	204		P	
								1.83	1.37	33.3	2.7	3.4								
S18 046-13		2659842.535	6511005.05	34.67	RE Wall 6	ELHO	16/03/2018	1.82	1.38	31.6	2.7	5.0	204	204	204	204	204		P	
								1.83	1.39	31.6	2.7	4.3								
S18 056-4		2659876.029	6511094.103	27.39	N Pond Stage 1	CBEN	4/04/2018	1.79	1.39	29.3	2.7	7.9	204	204	204	204	204		P	
								1.79	1.38	29.3	2.7	8.3								
S18 057-1		2659864.435	6511091.988	28.478	N Pond Stage 1	CBEN	5/04/2018	1.84	1.40	30.9	2.7	4.7	204	204	204	204	204		P	
								1.85	1.41	30.9	2.7	4.0								
S18 057-2		2659882.14	6511080.137	27.735	N Pond Stage 1	CBEN	5/04/2018	1.84	1.41	30.6	2.7	4.6	204	204	204	204	204		P	
								1.84	1.41	30.6	2.7	4.5								
S18 058-4		2659868.558	6511085.605	29.168	N Pond Stage 1	CBEN	6/04/2018	1.84	1.41	30.6	2.7	4.8	204	204	204	204	204		P	
								1.83	1.40	30.6	2.7	5.0								
S18 059-3		2659755.482	6510968.02	29.01	Undercut above Rd 2	CBEN	9/04/2018	1.84	1.39	32.2	2.7	3.5	160	160	175	204	175		P	
								1.86	1.40	32.2	2.7	2.8								
S18 059-4		2659747.704	6510969.321	29.982	Undercut above Rd 2	CBEN	9/04/2018	1.88	1.41	33.8	2.7	0.4	204	204	204	204	204		P	
								1.89	1.41	33.8	2.7	0.1								
S18 059-6		2659887.036	6511076.246	29.74	N Pond Stage 1	CBEN	9/04/2018	1.80	1.37	31.4	2.7	6.2	204	204	204	204	204		P	
								1.80	1.37	31.4	2.7	6.3								
S18 059-7		2659873.08	6511084.425	30.445	N Pond Stage 1	CBEN	9/04/2018	1.80	1.38	31.1	2.7	6.3	204	204	204	204	204		P	
								1.81	1.38	31.1	2.7	5.9								
S18 068-1		2659733.912	6511126.196	32.424	RE Wall 7	SABY	26/04/2018	1.83	1.39	32.0	2.7	4.4	140	146	175	204	166		P	
								1.83	1.37	33.3	2.7	3.7								
S18 068-5		2659730.548	6511125.082	34.427	RE Wall 7	SABY	26/04/2018	1.71	1.17	46.7	2.7	2.4	204	204	204	204	204		P	
								1.72	1.20	43.0	2.7	4.0								
S18 069-1		2659736.016	6511122.877	34.984	RE Wall 7	SABY	27/04/2018	1.82	1.35	34.5	2.7	3.2	146	160	204	175	171		P	
								1.81	1.35	34.0	2.7	4.1								
S18 071-3		2659840.477	6511022.005	35.316	Undercut above wall 6	ELHO	3/05/2018	1.78	1.34	32.3	2.7	6.9	204	204	204	204	204		P	
								1.77	1.33	32.3	2.7	7.5								
S18 071-4		2659817.114	6511012.611	35.93	Undercut above wall 6	ELHO	3/05/2018	1.82	1.37	33.0	2.7	4.1	204	204	204	204	204		P	
								1.83	1.37	33.0	2.7	3.8								

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Job: P5 Silverdale Arran's Hill
Earth Works
Client: Tonkin & Taylor
T&T Job #: 21854.0037
NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.1 Direct Transmission Mode
NZGS August 2001 Guidelines for hand held shear vane test.

Job # 614089.040/1
Entered By: TA/CBEN/ELHO
Checked By:
Page of

URN	New No.	Easting	Northing	RL	Location	Tech.	Date	Nuclear Wet Density (t/m^3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa) (UTP = Unable to penetrate)				Average Shear Strength (kPa)	Re - Test (Y)	pass / fail Specification > 140 kPa and < 10 % Air Voids)	Comments These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.
													Test 1	Test 2	Test 3	Test 4				
S18 072-3		2659814.7	6511003.474	35.712	Undercut above wall 6	ELHO	4/05/2018	1.77 1.77	1.32 1.32	33.6 33.6	2.7 2.7	6.4 6.6	204	204	204	204	204		P	
S18 072-4		2659837.709	6511048.077	34.687	Undercut above wall 6	ELHO	4/05/2018	1.74 1.75	1.27 1.28	36.9 36.9	2.7 2.7	6.2 5.5	175	175	160	204	179		P	
S18 072-6		2659822.574	6511025.682	36.346	Undercut above wall 6	ELHO	4/05/2018	1.73 1.73	1.23 1.23	40.5 40.5	2.7 2.7	4.5 4.6	175	175	190	190	183		P	
S18 073-3		2659796.692	6511001.361	35.67	Undercut above wall 6	ELHO	7/05/2018	1.81 1.81	1.35 1.34	34.7 34.7	2.7 2.7	3.4 3.8	190	190	204	160	186		P	
S18 073-4		2659784.377	6510983.599	33.86	Undercut above wall 6	ELHO	7/05/2018	1.77 1.76	1.30 1.29	36.5 36.5	2.7 2.7	4.7 5.3	190	204	204	204	201		P	
S18 073-7		2659765.001	6510994.639	32.177	Undercut above wall 6	ELHO	7/05/2018	1.74 1.74	1.28 1.29	35.6 35.6	2.7 2.7	6.7 6.6	204	204	204	204	204		P	
S18 073-8		2659758.869	6511000.372	32.651	Undercut above wall 6	ELHO	7/05/2018	1.79 1.80	1.32 1.33	35.8 35.8	2.7 2.7	3.8 3.3	204	204	204	204	204		P	
S18 074-3		2659745.952	6510995.112	33.013	Undercut above wall 6	ELHO	8/05/2018	1.79 1.78	1.32 1.31	35.3 35.3	2.7 2.7	4.5 5.1	204	204	204	204	204		P	
S18 075-3		2659772.037	6511002.451	33.527	Undercut above wall 6	ELHO	9/05/2018	1.85 1.86	1.39 1.40	33.0 33.0	2.7 2.7	2.8 2.0	204	204	204	204	204		P	
S18 076-3		2659774.636	6511009.644	34.587	Undercut above wall 6	ELHO	10/05/2018	1.85 1.87	1.46 1.47	27.2 27.2	2.7 2.7	6.4 5.4	204	204	204	204	204		P	
S18 076-5		2659782.893	6511013.892	35.757	Undercut above wall 6	ELHO	10/05/2018	1.89 1.90	1.39 1.40	35.7 35.7	2.7 2.7	0.0 0.0	140	160	204	204	177		P	
S18 077-3		2659821.043	6511049.162	35.202	Undercut above wall 6	ELHO	11/05/2018	1.85 1.83	1.41 1.39	31.3 31.3	2.7 2.7	3.9 4.8	140	160	160	175	159		P	
S18 077-4		2659742.676	6510999.366	33.19	Undercut above wall 6	ELHO	11/05/2018	1.84 1.84	1.40 1.40	31.0 31.0	2.7 2.7	4.6 4.4	204	204	204	204	204		P	
S18 078-2		2659738.498	6511004.974	34.007	Undercut above wall 6	ELHO	15/05/2018	1.84 1.84	1.41 1.41	30.0 30.0	2.7 2.7	5.2 5.4	204	204	204	204	204		P	
S18 081-1		2659822.013	6511089.67	32.13	undercut end of rd 4	ELHO	21/05/2018	1.79 1.78	1.29 1.28	39.0 39.0	2.7 2.7	1.9 2.6	140	140	175	204	165		P	
S18 084-4		2659814.984	6511090.657	33.044	undercut end of rd 4	ELHO	29/05/2018	1.79 1.79	1.31 1.32	36.3 36.3	2.7 2.7	3.8 3.6	204	146	146	160	164		P	
S18 084-5		2659784.029	6511102.983	34.011	undercut end of rd 4	ELHO	29/05/2018	1.78 1.79	1.31 1.32	35.9 35.9	2.7 2.7	4.3 4.0	204	146	160	160	168		P	
S18 085-1		2659804.043	6511090.924	32.799	undercut end of rd 4	ELHO	30/05/2018	1.80 1.80	1.38 1.38	30.6 30.6	2.7 2.7	6.8 6.8	148	162	162	207	170		P	
S18 106-1		2659794.319	6511045.538	36.375	Super Lot	CBEN	4/07/2018	1.76 1.74	1.25 1.24	40.5 40.5	2.7 2.7	3.1 4.2	162	148	148	162	155		P	
S18 107-1		2659820.201	6511056.951	35.087	Super Lot	CBEN	5/07/2018	1.74 1.74	1.28 1.28	36.1 36.1	2.7 2.7	6.7 6.3	142	148	133	162	146		P	
S18 107-2		2659803.887	6511060.041	35.583	Super Lot	CBEN	5/07/2018	1.76 1.76	1.31 1.30	34.9 34.9	2.7 2.7	6.1 6.2	148	148	177	162	159		P	
S18 108-1		2659789.195	6511026.986	36.416	Super Lot	CBEN	6/07/2018	1.72 1.73	1.24 1.24	38.8 38.8	2.7 2.7	6.0 5.8	121	145	162	148	144		P	
S18 108-2		2659777.82	6511027.208	36.214	Super Lot	CBEN	6/07/2018	1.73 1.72	1.28 1.27	35.4 35.4	2.7 2.7	7.4 7.7	142	142	133	148	141		P	

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Job: Silverdale
Site: Arrans Hill P5 Civil
Job # 021854.031

Form #	
Result Rev N	0
Entered By:	CBEN
Checked By:	ELHO

NZS 4407:1991 Field water content and field dry density using a nuclear densometer
Test 4.2.2 Backscatter Mode
ASTM D5874-02 Determination of Impact Value (IV) of soil.

URN	Tech.	Date	Location	Material Type	Layer	Easting	Northing	RL	Nuclear Wet Density (t/m^3)	Nuclear Dry Density (t/m^3)	Nuclear water content (%)	Solid Density (t/m^3) measured/-assumed	Maximum Dry Density (MDD) Std/Hvl/Vib (t/m^3)	Percentage maximum Dry Density MDD (%)	Impact Value (IV)	Nuclear Wet Density (t/m3)	Oven Dry Density (t/m3)	Oven Moisture content (%)	Solid Density (t/m3) assumed	Oven Calculated Air Voids (%)	Shear Strength (kPa)	Pass / Fail	Retest (Y)	Comments **These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.**
S18 063 bs-1	CBEN	17/04/2018	SS B/5-H/1	MAP65	500mm above pipe	2659756.461	6510956.308	26.213	2.29	2.14	6.7	2.72	2.24	95.7%	26							P		Waiting on GPS Data Conversion
S18 063 bs-2	CBEN	17/04/2018	SS B/5-H/1	MAP65	1m above pipe	2659759.966	6510957.514	27.24	2.34	2.19	6.9	2.72	2.24	97.8%	26							P		Waiting on GPS Data Conversion
S18 065-4	ELHO	20/04/2018	SS I/9-I/10	Clayey Silt	Surface	2659847.952	6511087.008	31.067								1.97	1.50	31.1	2.7	0.0	204	P		
																1.97	1.51	31.1	2.7	0.0	204	P		
S18 065-5	ELHO	20/04/2018	SW 4/15-4/16	Clayey Silt	Surface	2659861.198	6511082.415	30.49								1.79	1.29	38.9	2.7	2.2	204	P		
																1.78	1.28	38.9	2.7	2.6	204	P		
S18 065-6	ELHO	20/04/2018	SS I/8-I/9	Clayey Silt	Surface	2659873.068	6511077.885	30.108								1.81	1.36	33.1	2.7	4.6	204	P		
																1.79	1.34	33.1	2.7	5.8	204	P		
S18 066-3	ELHO	23/04/2018	SW 09/2-10/1	Clayey Silt	Surface	2659762.378	6510954.694	25.924								1.78	1.37	30.5	2.7	7.7	105	P		
																1.78	1.36	30.5	2.7	7.9	105	P		
S18 066-4	ELHO	23/04/2018	SW 09/2-10/1	Clayey Silt	Surface	2659762.693	6510953.939	26.456								1.78	1.35	31.6	2.7	7.1	105	P		
																1.78	1.35	31.6	2.7	7.2	105	P		
S18 079 bs-1	ELHO	16/05/2018	SW 4/46-4/16a	MAP65	Final Lift	2659845.266	6511087.724	31.081	2.27	2.13	6.7	2.72	2.24	95.1%	32							P		
S18 080 bs-1	ELHO	18/05/2018	SS I/9-I/10	MAP65	Final Lift	2659851.375	6511083.909	30.202	2.42	2.30	5.1	2.72	2.24	102.7%	35							P		
S18 080 bs-2	ELHO	18/05/2018	SS I/9-I/10	MAP65	Final Lift	2659845.569	6511085.993	30.525	2.36	2.24	5.5	2.72	2.24	99.9%	36							P		
S18 085 bs-1	ELHO	30/05/2018	Water	MAP65	Final Lift	2659848.262	6511078.435	30.841	2.41	2.25	7.5	2.72	2.24	100.2%	28							P		
S18 085 bs-2	ELHO	30/05/2018	Gas	MAP65	Final Lift	2659847.493	6511076.382	30.987	2.42	2.23	8.2	2.72	2.24	99.6%	28							P		
S18 085 bs-3	ELHO	30/05/2018	SW 24/1-9/3	MAP65	Final Lift	2659761.195	6510996.58	32.246	2.24	2.13	5.4	2.72	2.24	95.0%	25							P		
S18 085 bs-4	ELHO	30/05/2018	SW 9/3-9/4	MAP65	Final Lift	2659754.105	6510987.672	31.278	2.30	2.18	5.6	2.72	2.24	97.3%	26							P		
S18 087 bs-1	ELHO	31/05/2018	Gas 9/3-9/4 SW	MAP65	Final Lift	2659774.901	6510995.009	32.948	2.37	2.17	9.1	2.72	2.24	96.8%	25							P		
S18 087 bs-2	ELHO	31/05/2018	Power 9/3-9/4 SW	MAP65	Final Lift	2659775.737	6510998.799	32.894	2.38	2.16	10.2	2.72	2.24	96.6%	26							P		
S18 087 bs-3	ELHO	31/05/2018	Power 24/1-9/3 SW	MAP65	Final Lift	2659756.153	6510978.31	29.93	2.35	2.15	8.9	2.72	2.24	96.2%	26							P		
S18 088 bs-1	ELHO	1/06/2018	SW 24/1 crossing	MAP65	Final Lift	2659748.635	6510990.319	31.367	2.34	2.22	5.6	2.72	2.24	99.0%	25							P		
S18 088 bs-2	ELHO	1/06/2018	SW 9/5-9/4	MAP65	Final Lift	2659755.188	6511004.444	32.83	2.26	2.13	6.1	2.72	2.24	95.1%	26							P		
S18 100 BS-1	CBEN	27/06/2018	Service Crossing	MAP65	Surface	2659784.698	6511107.568	5.556	2.24	2.13	5.3	2.72	2.24	95.1%	25							P		
S18 100 BS-2	CBEN	27/06/2018	MH 4/19-4/20	MAP65	Surface	2659769.466	6511104.015	5.556	2.26	2.15	5.4	2.72	2.24	95.9%	26							P		
S18 102-1	CBEN	29/06/2018	MH 4/16-4/17	Clayey Silt	Surface	2659830.334	6511092.746	5.557								1.74	1.32	32.3	2.7	8.6	207	P		
																1.74	1.31	32.3	2.7	8.9	207	P		
S18 102-2	CBEN	29/06/2018	MH 4/17-4/19	Clayey Silt	Surface	2659817.463	6511095.723	5.557								1.78	1.30	36.7	2.7	4.2	142	P		
																1.77	1.29	36.7	2.7	4.6	207	P		
S18 102-3	CBEN	29/06/2018	MH 4/19-4/20	Clayey Silt	Surface	2659794.349	6511100.881	5.556								1.76	1.29	36.2	2.7	5.4	148	P		
																1.75	1.28	36.2	2.7	6.1	162	P		
S18 104 BS-1	CBEN	3/07/2018	MH 4/20 Drain Crossing	MAP65	Surface	2659745.561	6511110.467	34.75	2.26	2.16	4.2	2.72	2.24	96.6%	28							P		
S18 104 BS-2	CBEN	3/07/2018	MH 4/20 Drain Crossing	MAP65	Surface	2659745.599	6511117.466	34.672	2.29	2.19	4.6	2.72	2.24	97.8%	27							P		
S18 106 BS-1	CBEN	4/07/2018	MH I/12-I/13	MAP65	Surface	2659770.823	6511102.02	34.017	2.25	2.16	4.3	2.72	2.24	96.3%	30							P		
S18 106 BS-2	CBEN	4/07/2018	MH I/12-I/13	MAP65	Surface	2659762.962	6511103.957	34.26	2.22	2.13	4.2	2.72	2.24	95.1%	28							P		
S18 106-2	CBEN	4/07/2018	MH I/10-I/12	Clayey Silt	Surface	2659829.769	6511089.796	31.95								1.77	1.28	37.9	2.7	4.0	148	P		
																1.78	1.29	37.9	2.7	3.2	177	P		
S18 106-3	CBEN	4/07/2018	MH I/10-I/12	Clayey Silt	Surface	2659803.111	6511094.796	33.498								1.76	1.32	34.0	2.7	6.5	192	P		
																1.77	1.32	34.0	2.7	6.1	148	P		
S18 109-1	CBEN	12/07/2018	Decan Lot 39/38	Clayey Silt	Surface	2659846.774	6511109.19	31.066								1.82	1.37	32.6	2.7	4.5	162	P		
																1.81	1.37	32.6	2.7	4.8	177	P		
S18 109-2	CBEN	12/07/2018	Decan Lot 155	Clayey Silt	Surface	2659863.147	6511067.594	31.628								1.84	1.41	31.0	2.7	4.3	148	P		
																1.84	1.41	31.0	2.7	4.3	142	P		
S18 111-1	CBEN	19/07/2018	12/2 - 12/3	Clayey Silt	Surface	2659862.566	6511028.489	33.256								1.81	1.36	33.2	2.7	4.7	162	P		
																1.82	1.37	33.2	2.7	3.9	148	P		
S18 111-2	CBEN	19/07/2018	V/2 - V/3	Clayey Silt	Surface	2659852.311	6511016.691	34.174								1.82	1.36	33.8	2.7	3.8	148	P		
																1.82	1.36	33.8	2.7	3.8	162	P		
S18 111-3	CBEN	19/07/2018	10/4 - 10/3	Clayey Silt	Surface	2659814.254	6510983.266	34.407								1.81	1.35	34.3	2.7	3.7	148	P		
																1.81	1.35	34.3	2.7	3.7	207	P		
S18 111-4	CBEN	19/07/2018	H/4 - H/3	Clayey Silt	Surface	2659810.836	6510979.184	33.886								1.81	1.36	32.4	2.7	5.3	177	P		
																1.81	1.37	32.4	2.7	5.1	148	P		
S18 111-5	CBEN	19/07/2018	10/3 - 10/2	Clayey Silt	Surface	2659792.249	6510970.412	31.674								1.81	1.33	36.3	2.7	2.6	148	P		
																1.83	1.34	36.3	2.7	1.8	207	P		
S18 111-6	CBEN	19/07/2018	H/3 - H/2	Clayey Silt	Surface	2659796.918	6510970.545	32.321								1.80	1.33	34.7	2.7	4.4	177	P		
																1.79	1.33	34.7	2.7	4.9	192	P		

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