REPORT

WFH PROPERTIES LTD

MILLWATER - PRECINCT 3 STAGE 2B
Geotechnical Completion Report

Report prepared for:

WFH PROPERTIES LTD

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

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February 2015

T&T Ref: 21854.008/2B

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Executive summary

Tonkin & Taylor Ltd were engaged by WFH Properties Ltd through Woods Ltd to monitor and provide earthworks certification for nineteen residential lots contained within Precinct 3, Stage 2B of the Millwater Subdivision in Silverdale. Stage 2B comprises residential Lots 1 to 24 and 26 to 34 inclusive, Reserve Lots 814 and 817 and Road Lot 901 (Pioneer Rise).

This 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 Tonkin & Taylor Ltd (T&T) and reported in:

- T&T Ref. No. 21854.008, Silverdale North Precinct Three, Geotechnical Investigation Report, dated June 2008.

Initial bulk earthworks across Precinct 3, Stage 2B, including shear key construction, were certified in the Precinct 3 Geotechnical Completion Report:

- T&T Ref. No. 21854.008, Millwater Precinct 3 Geotechnical Completion Report, dated March 2010.

Woods Ltd was responsible for undertaking the subdivision engineering design.

Current civil earthworks commenced on site in November 2014 and were completed by early February 2015, and comprised the following:

- Stripping of vegetation, organic materials and topsoil to stockpile;
- Minor cut to fill earthworks across parts of the site;
- Construction of a timber pole retaining walls (wall 1 on the Woods as-built drawings in Appendix A1);
- 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. Due to this classification, soils lie outside the definition of good ground within NZS 3604:2011. Building foundations will require either specific foundation design for expansive soils or foundation design in accordance with AS 2870:2011.

Subject to design issues outlined in Section 3 and 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(V) in 4(H). Foundation design should proceed in accordance with Clauses 5.5.1 to 5.5.6 of this report.

1 Introduction

Tonkin & Taylor Ltd (T&T) were engaged by WFH Properties Ltd through Woods Ltd to undertake earthworks compaction control and provide the geotechnical earthworks certification for the nineteen residential Lots of Precinct 3, Stage 2B, of the Millwater Subdivision in Silverdale North. Stage 2B comprises residential Lots 1 to 24 and 26 to 34 inclusive, Reserves Lot 814 and 817, and Road Lots 900 (Gruet Greens) and 901 (Pioneer Rise), as shown on Woods Final Contour As-built Plans (Drawing 33302-2B-AB-100 in Appendix A1).

Site investigations for the subdivision were undertaken by Tonkin & Taylor and reported in:

- T&T Ref. No. 21854.008, Silverdale North Precinct Three, Geotechnical Investigation Report, dated June 2008;

Initial bulk earthworks across Precinct 3, Stage 2B were undertaken between 2008 and 2010 and have been certified in the Precinct 3 Geotechnical Completion Report:

- T&T Ref. No. 21854.008, Millwater Precinct Three Geotechnical Completion Report, dated March 2010.

The investigation report noted the presence of existing instability comprising landsliding, soil creep and shallow slope movement. These features were stabilised, and/or undercut and replaced with engineered fill, during development works.

Compaction control in terms of minimum shear strengths and maximum air voids was recommended and 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:

- Review of geotechnical investigation and completion reporting for the site;
- Monitoring and certification of earthworks operations;
- Assessment of soils for expansive conditions in accordance with AS 2870:2011[1];
- Certification of completed Lots for residential development in accordance with NZS 3604:2011[2].

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

1.1 Description of Subdivision

The Millwater subdivision is situated to the north of the Silverdale Township, and west of the proposed 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 the recently constructed Millwater Parkway. The original site comprised a mix of farm properties and associated dwellings and existing residential developments.

The Precinct 3, Stage 2B area of the Millwater subdivision is located within what is known as Precinct 3 in the Silverdale North Structure Plan. Precinct 3 is bound to the east by the Millwater Parkway and an existing stream, to the north by Bankside Road, to the west by Manuel Road and

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[1] AS 2870:2011: Residential Slabs & Footings

[2] NZS 3604:2011: Timber Framed Buildings

to the south by existing pasture. An existing residence (the Stoney property) is located in the northwest corner of the Precinct. The site is shown on the as-built plans included in Appendix A1.

Stage 2B is located in the southwest corner of the Precinct 3 area, bound to the north by Precinct 3, Stage 1, the east and south-east by Precinct 3 Stage 2A, the south by existing pasture and the west by Manual Road.

Pre-development gradients within the Stage 2B area were gentle to moderate with an overall fall to the southeast. A number of slip debris lobes and areas of instability had been identified within the investigation report and were remediated during bulk earthworks operations.

Post-development gradients within the Stage 2B area are gentle (1 in 5 to 1 in 18 (V:H)) and generally fall to the southeast. In order to form more level building platforms, several timber pole retaining walls have been constructed along some Lot boundaries.

Stage 2B will be accessed from the existing Bonair Crescent or Manual Road.

2 Earthworks Operations

2.1 Plant

Initial bulk earthworks were undertaken by Hick Bros Civil Construction Ltd. More recent civil works have been completed by Hopper Construction Ltd (HCL). Various earthworks equipment was used to undertake the works, comprising D6 and D8 bulldozers and scoops, motor scrapers, tractors and discs, sheepsfoot compactors, padfoot rollers, and a number of 20 to 35 tonne excavators. This plant generally carried out all construction earthworks.

Specialist contractors and plant were brought on site for retaining wall and pavement construction.

2.2 Construction Programme

Initial bulk earthworks commenced from April 2008 through to February 2010 under Hick Bros control. These earthworks have previously been certified in the Geotechnical Completion Report for Precinct 3 (T&T Ref. 21854.008, dated March 2010). Relevant drawings from this bulk earthworks Geotechnical Completion Report are included in Appendix A, which show finished ground levels at the completion of bulk earthworks. Final earthworks and civil construction works for the residential Lots of Stage 2B were under HCL's control and were undertaken progressively from October 2014 and were generally completed by February 2015.

Key Stage 2B civil earthworks components included:

- Stripping of vegetation, organic materials and topsoil to stockpile;
- Minor cut to fill earthworks across parts of the site;
- Construction of three timber pole retaining walls (walls 3, 5 and 6);
- Installation of roading and services.

During the initial earthworks in the 2008 to 2010 earthworks seasons, maximum cut depth from the original bulk earthworked surface within Stage 2B was approximately 4 metres with fill heights from the original surface of up to 15 metres. Subsequent to the Precinct 3 bulk earthworks, the adjacent Manual Road alignment has been lowered as part of the Precinct 7 works. This has resulted in additional cuts of up to 3 metres depth along the northern boundary of Lots 4 to 12 in Precinct 3 Stage 2B. Additional earthworks during civils construction within the Stage 2B area have been limited to Lot regrading following construction of timber pole retaining walls, predominantly involving cuts across the rear of Lots 10 to 24.

Drawings prepared by Woods, showing the as -built contours, the cut/fill areas and depths and subsoil drainage systems are attached in Appendix A1. We note that two sets of As-Built Plans have been presented. The original plans (Woods Drawings 2010) show the bulk earthworks undertaken in the 2008 to 2010 seasons, while the second set of plans (Woods Drawings 2014) show the final civil earthworks undertaken in the 2014 season. The 2014 set of as-builts shows the total bulk earthworks (cuts and fills from original surface) for the Stage 2B Lots also.

Substantial underfill drainage was installed during the original earthworks across the stage, as shown on the Woods 2010 as-built plans in Appendix A1 (Drawing P3-GCR-103-UC CFC).

In order to provide for gentler finished gradients across Stage 2B, a timber pole retaining wall (Wall 1 on the Woods As-builts) was constructed during the recent civil earthworks operations. There is also an existing timber pole retaining wall (Wall 3) on the southern boundary of Lots 26 to 34. The location of the timber pole retaining walls is shown on the Woods 2014 As-Builts in Appendix A1, as well as on Drawing T&T Drawing 21854.008-RW-01 in Appendix A2. Long

sections for retaining walls 1 and 3 are shown in T&T Drawings 21854.008-RW-04 and 21854.008-RW-05 in Appendix A2. Typical retaining wall construction details are presented in T&T Drawing 21854.008-RW-07.

2.3 Compaction Control

Compaction control criteria consisting of maximum allowable air voids and minimum allowable shear strengths were used for fill control. The fill specification outlined below was used for subdivisional earthworks. Specification details were as follows:

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

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

General fills:

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

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. Test results have previously been presented in the Precinct 3 Geotechnical Completion Report (T&T Ref. No. 21854.008, dated March 2010).

Control testing showed that the results for the filling were consistently meeting the required undrained shear strength 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 by close monitoring of the selection of borrow materials, discing and remixing of the available soil types and minor reworking where required.

3 Geotechnical Development Works

3.1 Subsoil Drainage

A network of subsoil drains has been installed across Stage 2B during the original bulk earthworks.

The drains comprised 600mm to 1 metre wide trenches, excavated to either 1 metre below the soil / rock interface, or 5 to 6 metres depth, and filled with:

- 160mm diameter, Hiway grade, perforated Novaflo pipes along the base of the trench;
- SAP50 scoria to within 1 metre of the cut/finished ground surface (at time of construction);
- Bidim A19 geotextile filtercloth over the top of the scoria;
- Compacted, engineered fill within the top metre of the trench.

The drain pipes were connected to either the reticulated stormwater system or appropriate surface discharge points. Where discharge points are not into stormwater manholes, they have had a concrete collar installed to protect them from future damage.

The subsoil drainage system is shown on the Woods as-built plan P3-GCR-103-UF CFC in Appendix A1.

3.2 Retaining Walls

A timber pole retaining wall (Retaining Wall 1) has been constructed during the recent Stage 2B civil earthworks. The walls were built from October 2014 through December 2014, with regular visits by an engineer from Tonkin & Taylor during construction to check that the works were generally in accordance with the design drawings and specifications.

Tonkin & Taylor project staff undertook observations of each foundation excavation (i.e. bored pile shaft), prior to placement of the timber piles and concrete, to confirm that the assumed design shear strength of 50kPa was available. In all cases the in-situ shear strength test results confirmed that the minimum allowable criteria had been met.

T&T checked pile embedment depths, pile hole diameters and undertook observations of the timber piles and lagging used in the wall construction to confirm they met the requirements of the design. A certificate has been provided by the Contractor's supplier (TTT) certifying the H5 treatment levels of the timber delivered to site for use in the wall construction.

Following concreting of the piles, timber lagging was installed along the rear of the wall, in accordance with the design. A 110 mm diameter perforated Novaflo pipe was run behind the wall along the base of the excavation and connected to the stormwater system, to discharge any captured groundwater. A layer of "SAP50" drainage scoria was placed against the rear face of the wall. A layer of geotextile filter cloth was placed over top of the SAP50 scoria, prior to placement of a clay and topsoil cap to seal off the SAP50 from surface water infiltration in accordance with the design.

Following completion of the wall, a 1.3m high, powder coated 'pool type' fence was constructed along the top of the wall.

Design drawings for the timber pole retaining walls are presented in Appendix A2.

4 Project Evaluation / Building Design Considerations

Ground conditions within Precinct 3, Stage 2B straddle a range of "design conditions" including cut ground, filled ground, expansive soils and slopes at, or steeper than, 1 in 3. The following sections set out relevant design issues.

4.1 Bearing capacity for building foundations

All filled and natural ground within the influence of conventional residential shallow strip and pad foundation loads generally has a geotechnical ultimate bearing capacity of 300kPa, as required by NZS 3604:2011. This corresponds to a factored (Ultimate Limit State) bearing capacity of 150kPa and working 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. In terms of AS 2870:2011, the soils present are considered to lie within Site Class M (moderately expansive) with characteristic surface movements anticipated to be in the range 20mm to 40mm. Due allowance should be made for expansive soils, as discussed in Section 4.10.

Where an ultimate bearing capacity greater than 300kPa is required to support any dwelling constructed outside the scope of NZS 3604:2011, further specific site investigation and design of foundations will be required.

4.2 Settlement

On the basis of our inspections of the fill and compaction quality control testing, differential settlements induced by self-weight of the engineered fill should now be largely complete. Further settlements should be within normally accepted design tolerances with respect to conventional residential building development.

In order to minimise the risk of ground settlements exceeding 20 to 25 mm, NZS 3604:2011 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.

4.3 Retaining walls

It is not anticipated that significant additional retaining walls will be required due to the shallow grades across most of the Stage 2A Lots. However, if low walls are required (e.g. up to 1.5m retained height), 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:

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

$c' = 0kPa$

$\varnothing' = 30°$,

$K_a = 0.30$,

$K_p = 3.33$,

"Su" for the embedment soil of 50kPa (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, as applicable.

All retaining walls should include a layer of free draining granular fill immediately behind the wall covered with a 0.3m thick (minimum) clay 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 ensure stability of the subject or adjacent Lot is not detrimentally affected.

The existing timber pole retaining walls constructed within the Precinct 3 Stage 2B area are shown on the Woods "Finished Contours" As Built Plan (Ref 33302-2B-AB-100), as well as on the "Retaining Wall" As Built Plan (Ref 33302-2B-AB-150). These walls have been designed to accommodate a maximum 5kPa surcharge, although development immediately behind/above the walls is likely to be precluded by Council planning rules. The presence of these walls should be taken into account in any proposed works downslope of the walls, specifically to ensure that any proposed cuts do not undermine the base of the wall. In general, earthworks should be limited to no closer than 1.5m from the toe of the walls. The design plan and long section of the walls is also included in Appendix A2 for reference.

For clarity, ALL Lots within Stage 2B will need to consider the presence of the existing retaining walls during site development.

- Timber wall #1 – Lots 1 to 24 inclusive
- Timber wall #3 – Lots 26 to 34 inclusive

4.4 Subsoil drainage

Following gully muckouts during the initial bulk earthworks, groundwater drainage was accomplished by installation of Novaflo drains covered in a minimum thickness of 500mm of SAP50 scoria, which was then covered in geotextile cloth, to handle ground water flows.

The subsoil drainage system is shown on the appended underfill and drainage as-built plans, provided by Woods (P3-GCR-102-CFC in Appendix A1).

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

Subsoil drains have also been installed behind the timber pole retaining walls. The Retaining Wall As Built plan shows the discharge locations for these drains.

4.5 Natural subsoils

Following the completion of earthworks operations, T&T have undertaken additional site investigations comprising hand augered boreholes to determine the consistency of the subsoils across the stage (both natural and fill. The subsoils are considered to have an ultimate bearing capacity of 300 kPa (150 kPa factored (ULS), 100 kPa working). Associated borehole logs and site plans are attached in Appendix E.

4.6 Stormwater

Public stormwater services have been installed within the Precinct 3, Stage 2B area and the Woods plans of these are included in Appendix A1 (Woods Ref. 33302-2B-AB-300 to -303). Stormwater and runoff from roofs, decks and paved areas, together with discharges from

retaining wall drains and other subsoil drains should be connected directly into the public stormwater drainage network.

4.7 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.

Any disturbance of service lines in the future should be remediated to ensure the drains operation is not compromised.

A copy of the stormwater and sanitary sewer as-built plans (Woods Ref 33302-2A-AB-300 to -303 and 500 respectively) is included in Appendix A1.

4.8 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 stabilised to assist in pavement strengths, and to minimise the impact of expansive soils on road pavements. Within natural (unstabilised) ground, a design CBR of 2% is considered appropriate, while within unstabilised filled areas, a design CBR of 7% is appropriate.

4.9 Topsoil

Following completion of topsoil spreading and grassing, topsoil depths were measured in each of the Lots and these are shown on T&T Drawing 21854.008-2B-102 attached in Appendix E. Due to variations in placement depths and earth worked surface levels, topsoil depths may vary from those recorded.

4.10 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 depends 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:

- Influence of garden watering and site drainage;
- The presence of large trees (especially fast growing Australian species such as eucalyptus) close to building envelopes, and;
- Initial soil moisture conditions at construction time.

Visually, 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 on this stage of the development, representative soil samples were retrieved from near surface strata and tested in our laboratory 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. In terms of AS 2870:2011, the soils present are considered to lie within Site Class M (moderately expansive) with characteristic surface movements anticipated to be in the range of 20 mm to 40 mm.

Accordingly, building foundations and floor slabs on this 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 for assistance.

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

I, Mr C.J. Freer of Tonkin & Taylor Ltd, P O Box 5271, Wellesley St, Auckland, hereby confirm that:

5.1 I am a Chartered Professional Engineer experienced in the field of geotechnical engineering and was retained by WFH Properties Ltd as the Geotechnical Engineer on Precinct 3, Stage 2B comprising residential Lots 1 to 24 and 26 to 34 inclusive, reserve Lots 814 and 817 and Road Lots 900 (Gruet Greens) and 901 (Pioneer Rise) of the Millwater Residential Subdivision Development off the Millwater Parkway in Silverdale. Inspection and observation of the works have been carried out during construction by either myself or staff acting under my direction.

5.2 The extents of preliminary investigations are described in Tonkin & Taylor Ltd report Ref No. 21854.008, dated June 2008. Bulk earthworks certification of the broader Precinct 3 area was provided in the T&T Geotechnical Completion Report Ref. 21854.008, dated March 2010. The conclusions and recommendations of those documents have been re-evaluated in the preparation of this report.

5.3 The Contractor shall confirm 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 Certificates-Construction have been provided by the Contractors and are presented in Appendix B.

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

5.4.1 The earth fills shown on the attached Woods drawings, Project No 33302, Millwater, Precinct 3, Stage 2B, Drawing Number 33302-2B-AB-120, have been generally placed in compliance with NZS 4431:1989.

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

5.5 For Lots 1 to 24 and 26 to 34 inclusive:

5.5.1 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 not requiring specific design in terms of NZS 3604:2011 and related documents subject to clauses 5.5.2 to 5.5.6.

5.5.2 Bearing capacity

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

5.5.3 Expansive soils

Foundation soils lie outside the definition of 'good ground' in NZS 3604:2011 due to the presence of expansive clay soils. Soils are considered to lie in Site Class M (moderately expansive) as defined in AS 2870:2011 with anticipated characteristic

surface ground movements of 20mm to 40mm. Clause 5.5.3.1 may be used for expansive soil foundation design in this subdivision:

5.5.3.1 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 such as 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 superseded 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, Section 4 and related documents.

5.5.4 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.

5.5.5 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.

5.5.6 Retaining walls / Earthworks

No retaining wall construction in excess of 1.5 metres height and no earthworks involving fills or unsupported cuts 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.

Where existing walls are located on property boundaries, consideration shall be given to the potential impacts on these walls of any additional proposed cuts, fills, surcharges or new walls.

5.6 Underfill (Subsoil) drainage

Underfill (Subsoil) drains have been installed during subdivisional development in the locations shown on the Woods Undercut Surface As-Built Plan (P3-GCR-103-UC CFC) in Appendix A1. These drains are considered to be maintenance free for the design life of the 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.

5.7 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 A (Woods Ref 33302-01-AB-300 to -303 and 33301-01-AB-500).

5.8 Road and Access Lots

Based on the fill monitoring and site observations undertaken during site development, the filled and natural ground within Precinct 3, Stage 1 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, within natural ground a design CBR of 2% is recommended, while within filled ground a design CBR of 7% should be available.

5.9 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 highly 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.

6 Applicability

The professional opinion contained within this report is furnished to 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

Environmental and Engineering Consultants

Report prepared by:

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Andrew Linton

Senior Geotechnical Engineer

Authorised for Tonkin & Taylor by:

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Chris Freer

Project Director

Andrew Linton

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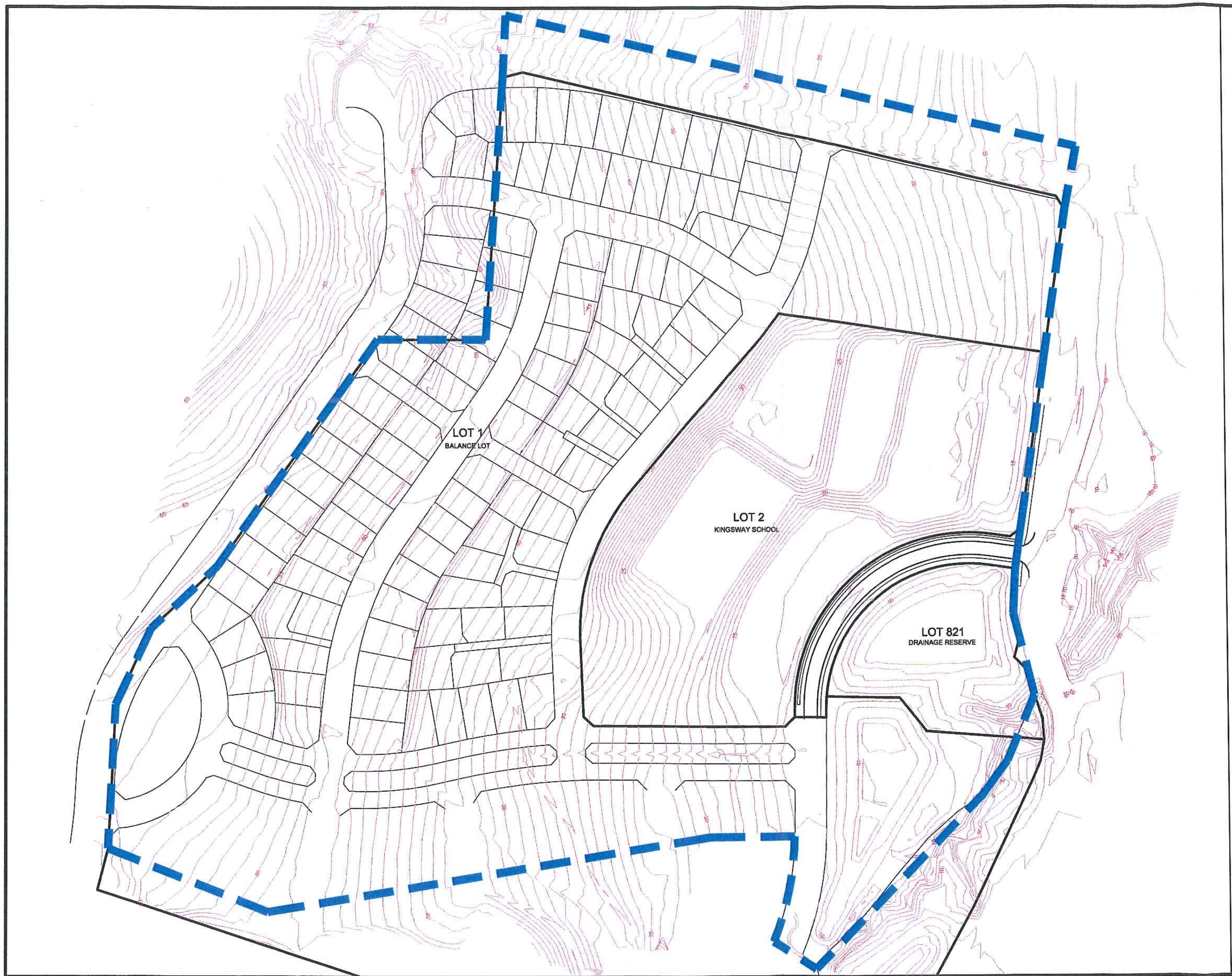
Appendix A1: Woods Drawings

WOODS DRAWINGS (2010)

- P3-GCR-101-FC — Final Contours
- P3-GCR-102-CFC — Cut Fill Contours from Original Surface
- P3-GCR-103-UC CFC — Cut fill contours including undercuts
- P3-GCR-104-AUC — Plan showing all undercut areas

WOODS DRAWINGS (2015)

- 33302-2B-AB-100 — Final Contour Plan
- 33302-2B-AB-120 — Original Surface – Earthwork Surface, Cut/Fill Contour Plan
- 33302-2B-AB-121 — Earthwork Surface – Final Surface, Cut/Fill Contour Plan
- 33302-2B-AB-150 to -152 — Retaining Wall As-Built Plans
- 33302-2B-AB-300 to 303 — Stormwater As-Built Plans
- 33302-2B-AB-500 — Sanitary Sewer As-Built Plan



NOTES

1. CONTOURS ARE AT 1.0m INTERVALS

NORTH

LEGEND

PRECINCT 3 GCR EXTENTS

CERTIFICATION

I, Jamie Alistair Whyte, LICENSED CADASTRAL SURVEYOR, HEREBY CERTIFY THE ACCURACY OF THIS AS–BUILT INFORMATION.

SIGNED........................ LICENSED CADASTRAL SURVEYOR

DATE....18/2/2010....

NOTES

1. HEIGHTS ARE IN TERMS OF AUCKLAND DATUM 1946
2. COORDINATES ARE IN TERMS OF NZGD2000 MOUNT EDEN CIRCUIT
3. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.

LATEST REVISION DETAILS	NAME	DATE
1. FOR ASBUILT	JAW	FEB 2010

CLIENT: WFH PROPERTIES

MILLWATER

PRECINCT 3
FINAL EARTHWORKS CONTOURS
ASBUILT PLAN
RODNEY DISTRICT COUNCIL

WOODS
Engineers. Surveyors. Planners.

PO BOX 6752, WELLESLEY ST, AUCKLAND 1141
BLDG 3, LEVEL 4, 666 GREAT SOUTH ROAD, PENROSE
PHONE +64 9 571 2470 FAX +64 9 571 3405 WWW.WOODS.CO.NZ

DESIGNED: WOODS		ASBUILT	
CHECKED:		DRAWN: JAW	
APPROVED:		SURVEYED: WOODS	
JOB NUMBER: 33300		SCALE: 1:1250 @ A1 1:2500 @ A3	
ISSUED: FEB 2010			
DWG. NO. P3-GCR-101-FC		REV. 1	

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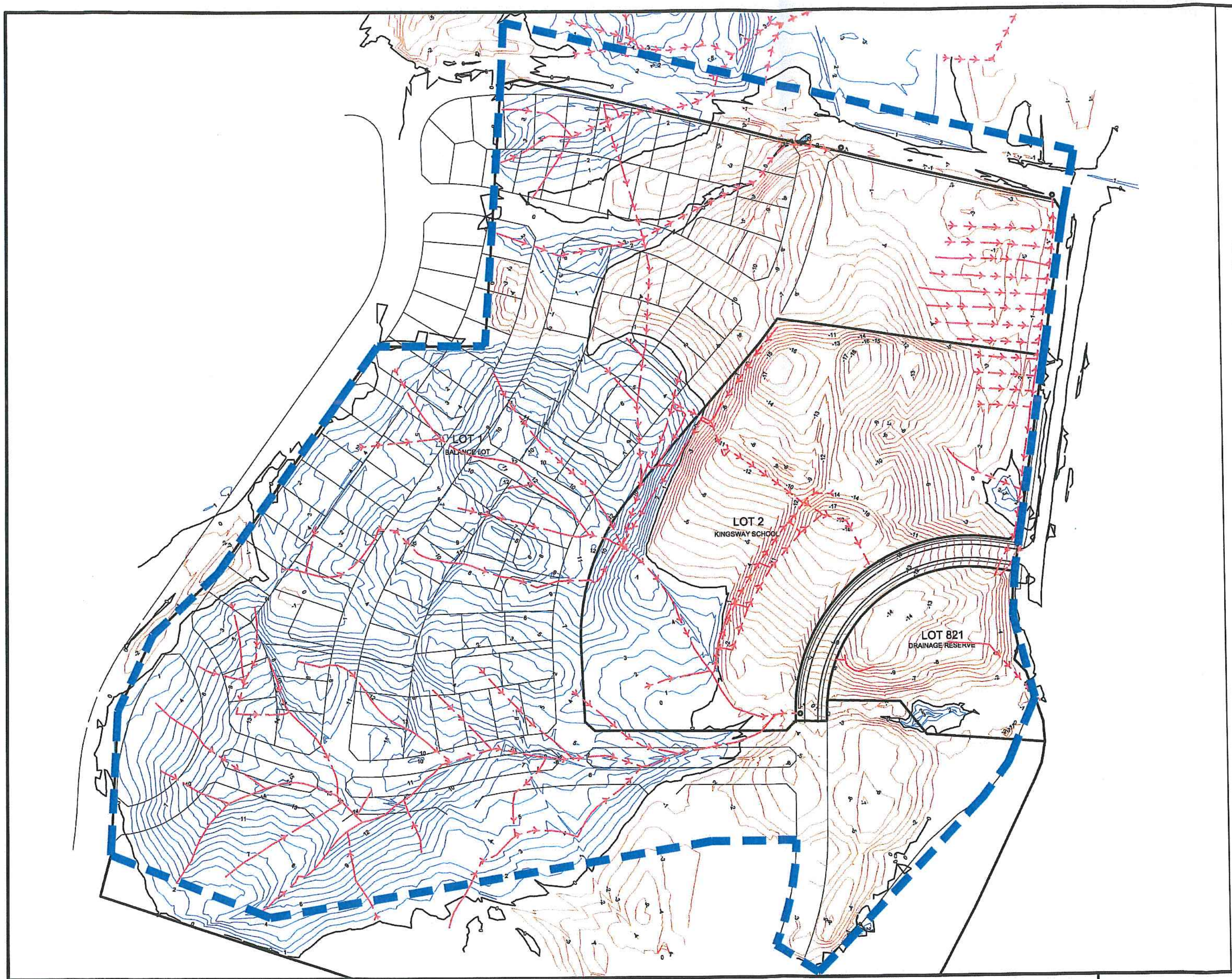


NORTH

NOTES

1. CONTOURS ARE AT 1.0m INTERVALS

LEGEND

- P3 GCR EXTENTS
- FILL CONTOURS
- CUT CONTOURS
- ZERO CONTOURS
- UNDERFILL DRAINS

CERTIFICATION

I, Jamie Alistair Whyte, LICENSED CADASTRAL SURVEYOR, HEREBY CERTIFY THE ACCURACY OF THIS AS-BUILT INFORMATION.

SIGNED........[signature]........ LICENSED CADASTRAL SURVEYOR

DATE 18/2/2010

NOTES

1. HEIGHTS ARE IN TERMS OF AUCKLAND DATUM 1946
2. COORDINATES ARE IN TERMS OF NZGD2000 MOUNT EDEN CIRCUIT
3. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.

LATEST REVISION DETAILS	NAME	DATE
1. FOR ASBUILT	JAW	FEB 2010

CLIENT: WFH PROPERTIES

MILLWATER

PRECINCT 3

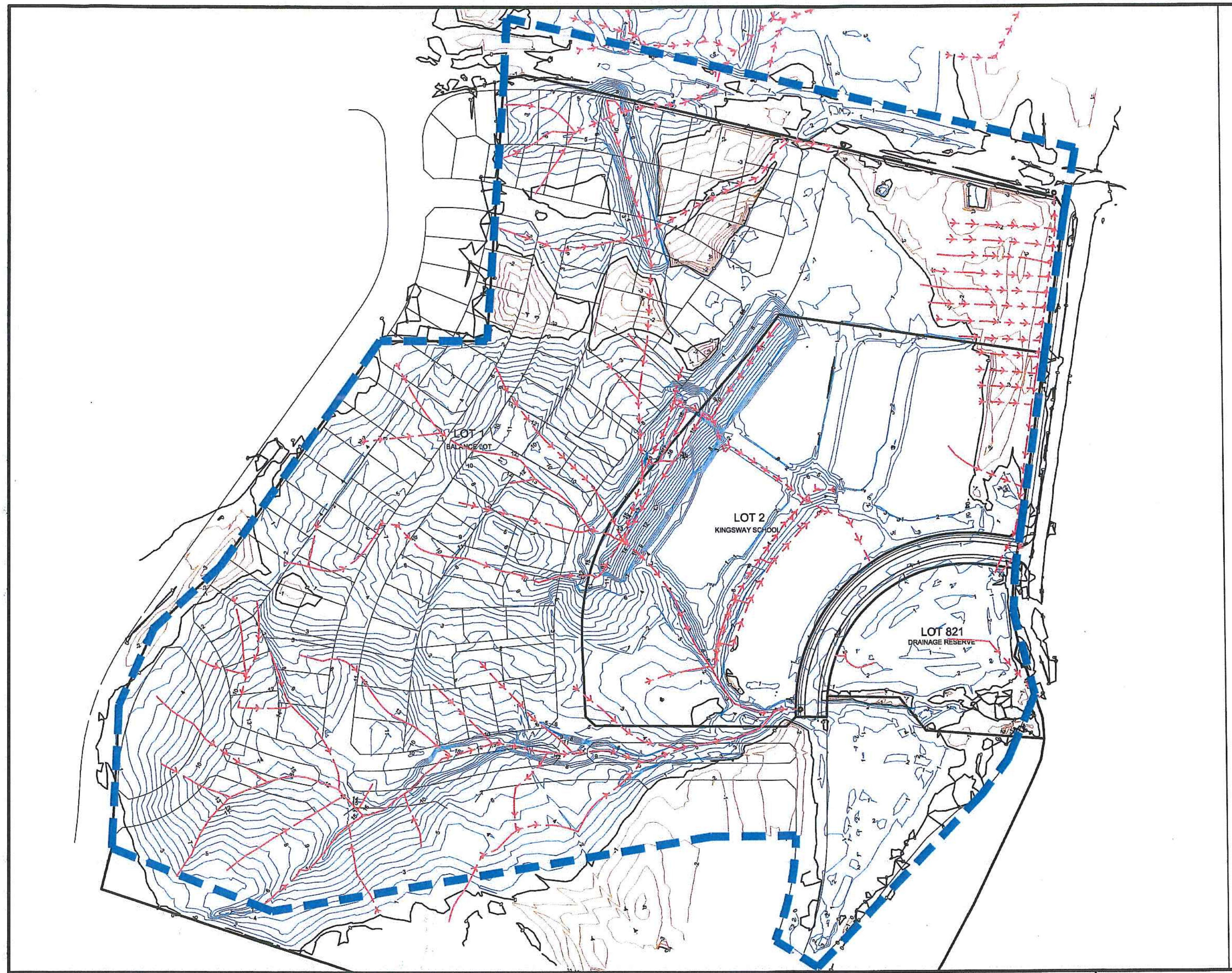
CUT/FILL CONTOURS - ORIGINAL SURFACE TO FINAL EARTHWORKS SURFACE

ASBUILT PLAN

RODNEY DISTRICT COUNCIL

WOODS
Engineers. Surveyors. Planners.
PO BOX 6752, WELLESLEY ST, AUCKLAND 1141
BLDG 3, LEVEL 4, 666 GREAT SOUTH ROAD, PENROSE
PHONE +64 9 571 2470 FAX +64 9 571 3405 WWW.WOODS.CO.NZ

DESIGNED: WOODS		AS BUILT	
CHECKED:		DRAWN: JAW	
APPROVED:		SURVEYED: WOODS	
JOB NUMBER: 33300		SCALE: 1:1250 @ A1 1:2500 @ A3	
ISSUED: FEB 2010			
DWG. NO. P3-GCR-102-CFC		REV. 1	



NOTES

1. CONTOURS ARE AT 1.0m INTERVALS

NORTH

LEGEND

- P3 GCR EXTENTS
- FILL CONTOURS
- CUT CONTOURS
- ZERO CONTOURS
- UNDERFILL DRAINS

CERTIFICATION

I, Jamie Alistair Whyte, LICENSED CADASTRAL SURVEYOR, HEREBY CERTIFY THE ACCURACY OF THIS AS-BUILT INFORMATION.

SIGNED.......[signature]....... LICENSED CADASTRAL SURVEYOR

DATE.........22/2/2010.........

NOTES

1. HEIGHTS ARE IN TERMS OF AUCKLAND DATUM 1946
2. COORDINATES ARE IN TERMS OF NZGD2000 MOUNT EDEN CIRCUIT
3. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.

LATEST REVISION DETAILS	NAME	DATE
1. FOR ASBUILT	JAW	FEB 2010

CLIENT: WFH PROPERTIES

MILLWATER

PRECINCT 3

CUT/FILL CONTOURS - UNDERCUT SURFACE TO FINAL EARTHWORKS SURFACE

ASBUILT PLAN

RODNEY DISTRICT COUNCIL

WOODS
Engineers. Surveyors. Planners.
PO BOX 6752, WELLESLEY ST, AUCKLAND 1141
BLDG 3, LEVEL 4, 666 GREAT SOUTH ROAD, PENROSE
PHONE +64 9 571 2470 FAX +64 9 571 3405 WWW.WOODS.CO.NZ

DESIGNED: WOODS		AS BUILT	
CHECKED:		DRAWN: JAW	
APPROVED:		SURVEYED: WOODS	
JOB NUMBER: 33300		SCALE: 1:1250 @ A1 1:2500 @ A3	
ISSUED: FEB 2010			
DWG. NO. P3-GCR-103-UC CFC		REV. 1	

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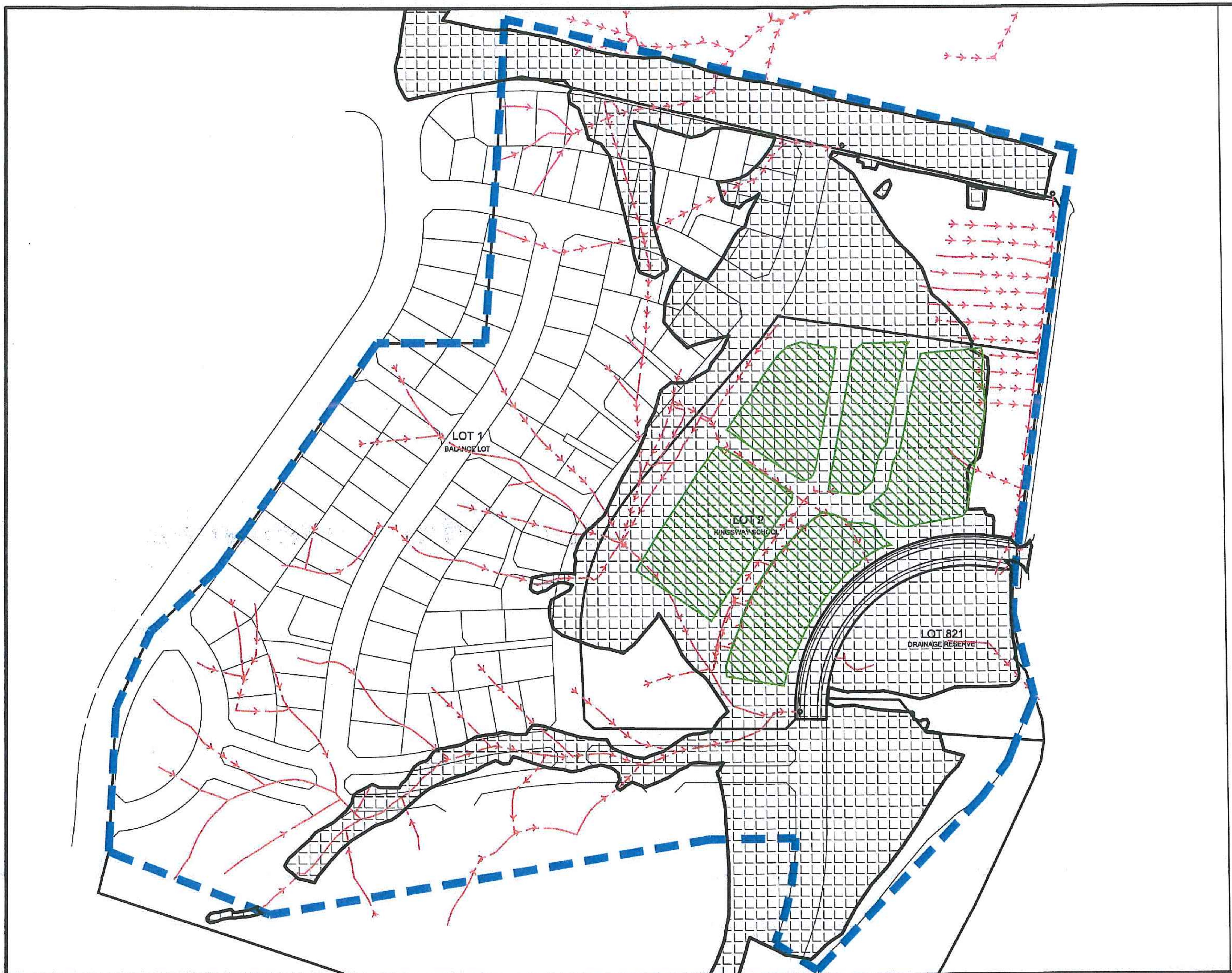

LEGEND

- UNDERCUT AREAS
- HOED AREAS (150mm UNDERCUT & REPLACED, 300mm HOED)
- UNDERFILL DRAINS

CERTIFICATION

I, Jamie Alistair Whyte LICENSED CADASTRAL SURVEYOR, HEREBY CERTIFY THE ACCURACY OF THIS AS-BUILT INFORMATION.

SIGNED .... LICENSED CADASTRAL SURVEYOR

DATE 23/2/2010

NOTES

1. HEIGHTS ARE IN TERMS OF AUCKLAND DATUM 1946
2. COORDINATES ARE IN TERMS OF NZGD2000 MOUNT EDEN CIRCUIT
3. LOT BOUNDARIES ARE SUBJECT TO FINAL SURVEY.

LATEST REVISION DETAILS	NAME	DATE
1. FOR ASBUILT	JAW	FEB 2010

CLIENT: WFH PROPERTIES

MILLWATER

PRECINCT 3
AREAS OF UNDERCUT
ASBUILT PLAN
RODNEY DISTRICT COUNCIL

WOODS
Engineers. Surveyors. Planners.

PO BOX 6752, WELLESLEY ST, AUCKLAND 1141
BLDG 3, LEVEL 4, 666 GREAT SOUTH ROAD, PENROSE
PHONE +64 9 571 2470 FAX +64 9 571 3405 WWW.WOODS.CO.NZ

DESIGNED: WOODS		AS BUILT	
CHECKED:		DRAWN: JAW	
APPROVED:		SURVEYED: WOODS	
JOB NUMBER: 33300		SCALE: 1:1250 @ A1 1:2500 @ A3	
ISSUED: FEB 2010			
DWG. NO. P3-GCR-104-AUC		REV. 1	

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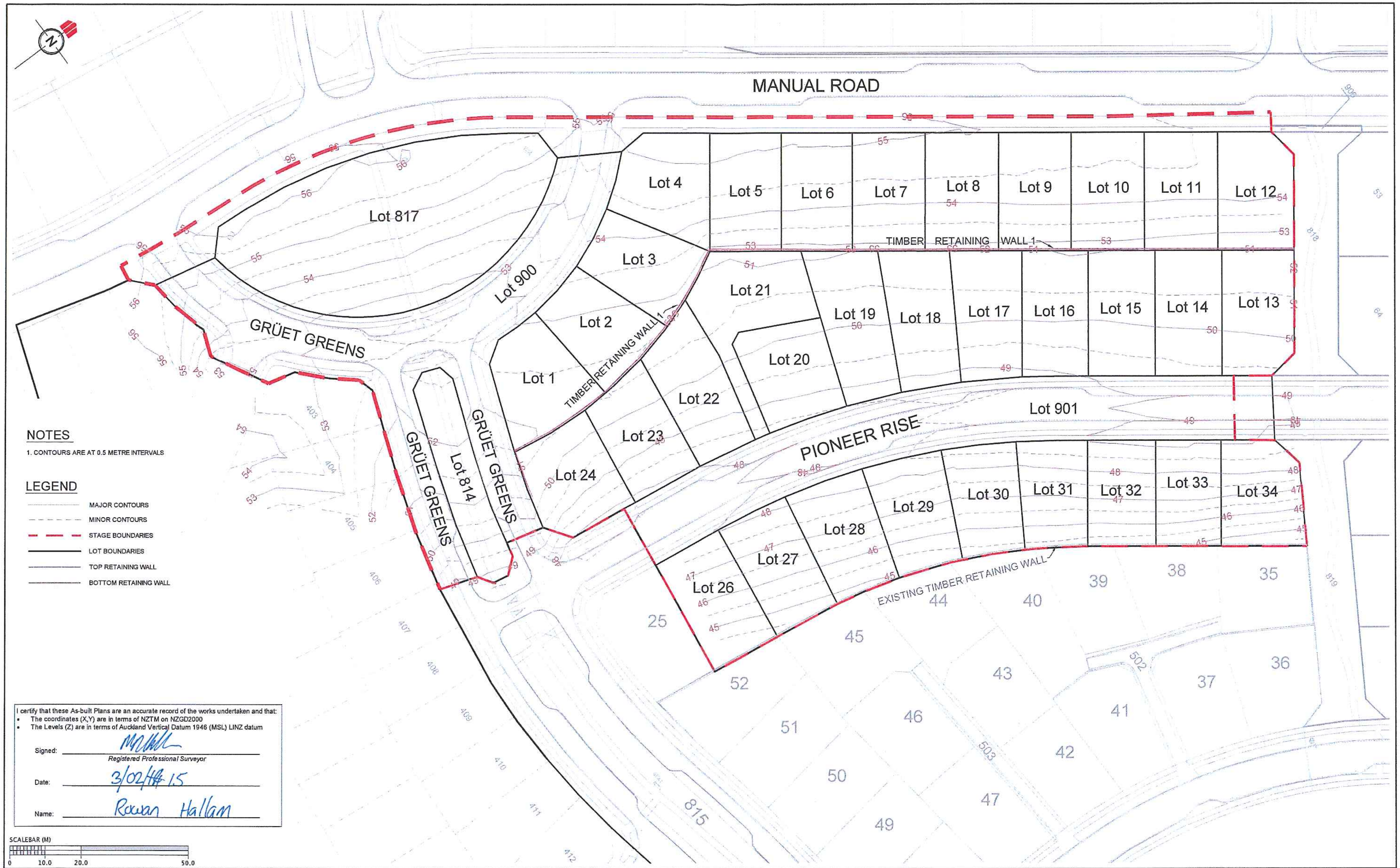

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

- MAJOR CONTOURS
- MINOR CONTOURS
- STAGE BOUNDARIES
- LOT BOUNDARIES
- TOP RETAINING WALL
- BOTTOM RETAINING WALL

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: [signature]
Registered Professional Surveyor

Date: 3/02/~~14~~ 15

Name: Rowan Hallam

SCALEBAR (M)
0 10.0 20.0 50.0

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	29/01/15

CLIENT: WFH PROPERTIES

MILLWATER – PRECINCT 3 STAGE 2B

ASBUILT FINAL CONTOUR PLAN

AUCKLAND COUNCIL

WOODS Engineers. Surveyors. Planners.

DESIGNED:			ASBUILT
CHECKED:		DRAWN:	RM
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33302-P3-2B	SCALE:	1:1000 @ A3
ISSUED:	JAN 2015		
DWG. NO.	33302-2B-AB-100	REV.	1

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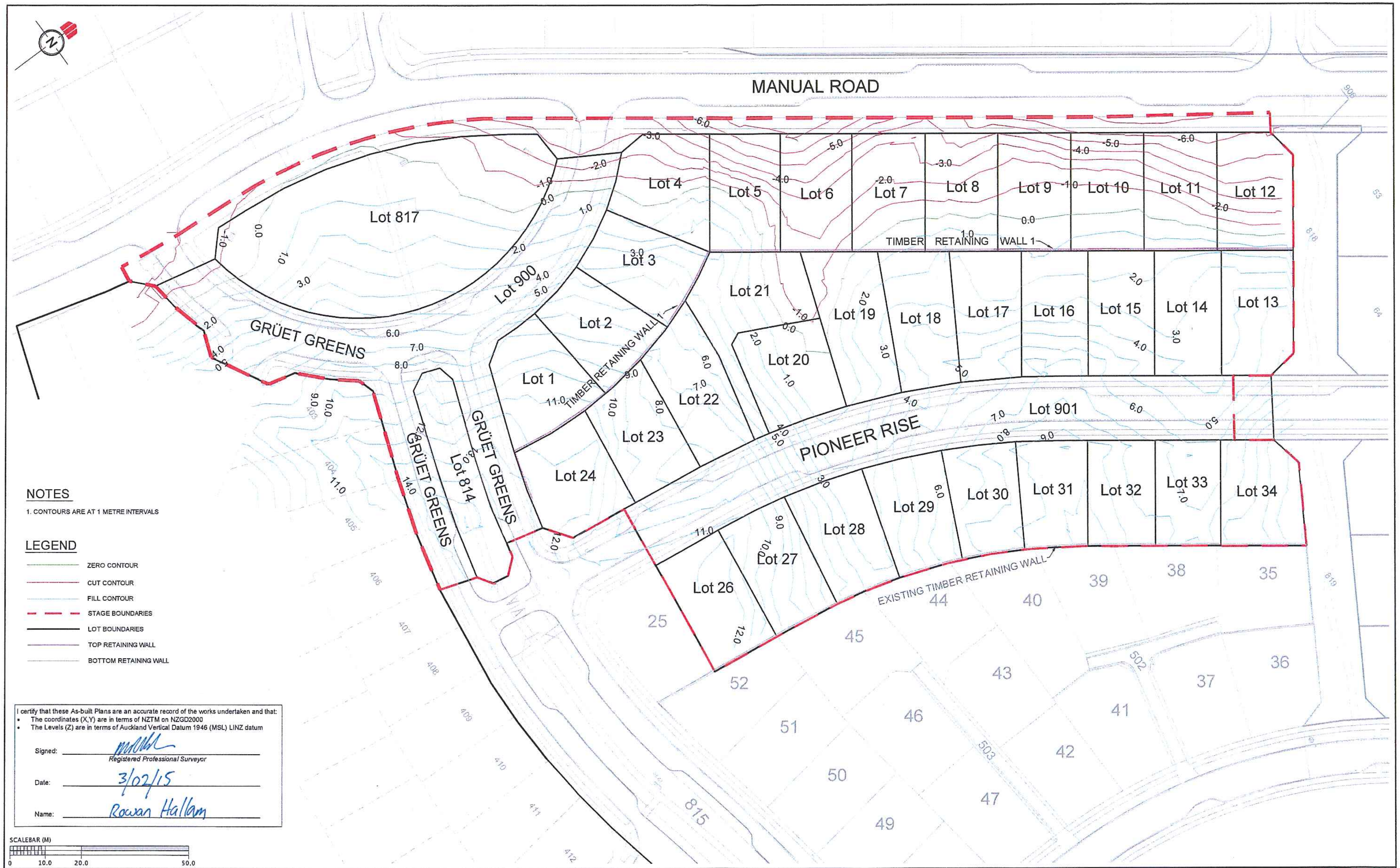

NOTES

1. CONTOURS ARE AT 1 METRE INTERVALS

LEGEND

- ZERO CONTOUR
- CUT CONTOUR
- FILL CONTOUR
- STAGE BOUNDARIES
- LOT BOUNDARIES
- TOP RETAINING WALL
- BOTTOM RETAINING WALL

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: [signature]
Registered Professional Surveyor

Date: 3/02/15

Name: Rowan Hallam

SCALEBAR (M)
0 10.0 20.0 50.0

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	29/01/15

CLIENT: WFH PROPERTIES

MILLWATER - PRECINCT 3 STAGE 2B

ASBUILT - ORIGINAL SURFACE - EARTHWORK SURFACE, CUT/FILL CONTOUR PLAN

AUCKLAND COUNCIL

WOODS Engineers. Surveyors. Planners.

ISSUED FOR INFORMATION

DESIGNED:		DRAWN:	RM
CHECKED:		SURVEYED:	WOODS
APPROVED:			
JOB NUMBER:	33302-P3-2B	SCALE:	1:1000 @ A3
ISSUED:	JAN 2015		
DWG. NO.	33302-2B-AB-120	REV.	1

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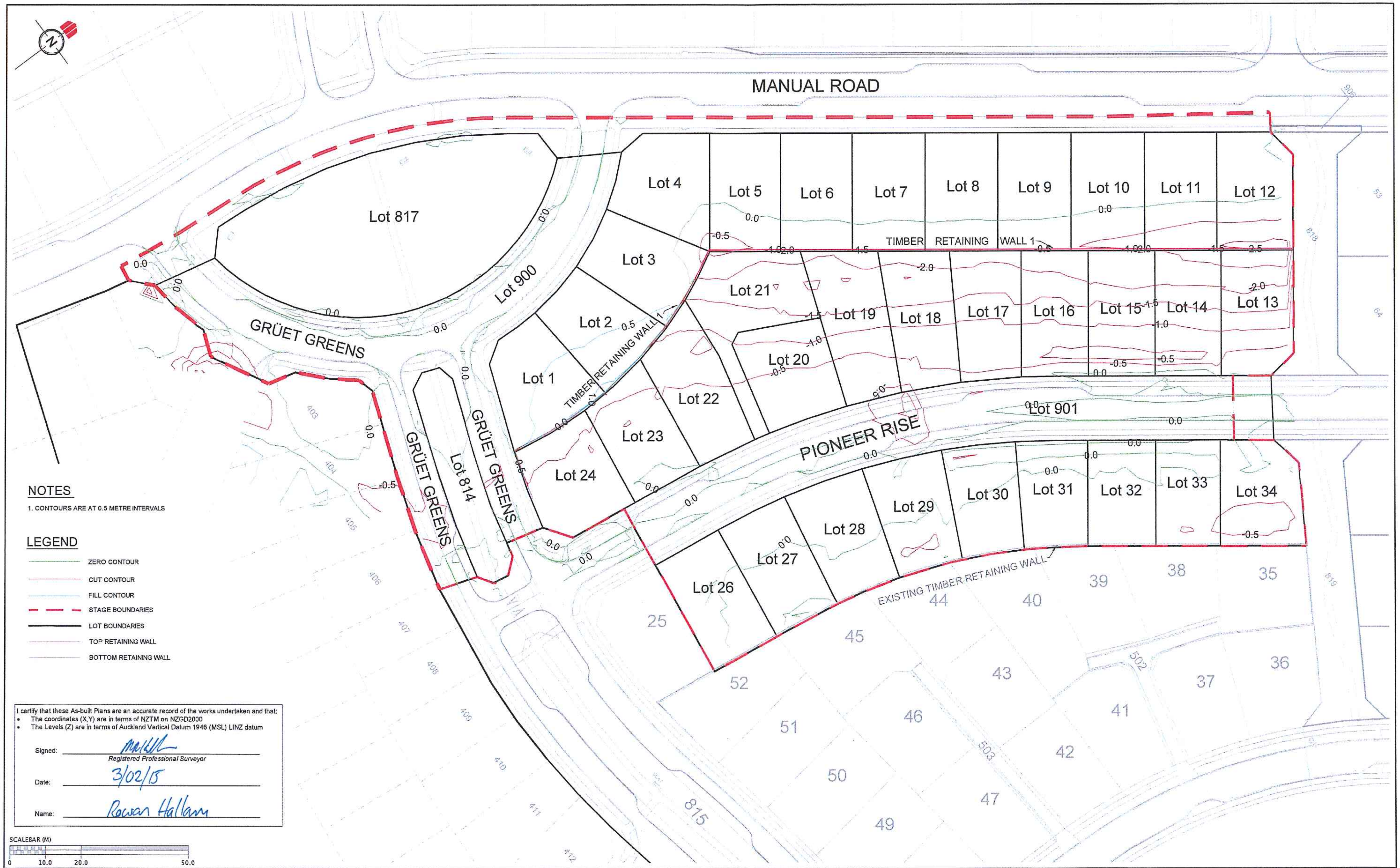

NOTES

1. CONTOURS ARE AT 0.5 METRE INTERVALS

LEGEND

- ZERO CONTOUR
- CUT CONTOUR
- FILL CONTOUR
- STAGE BOUNDARIES
- LOT BOUNDARIES
- TOP RETAINING WALL
- BOTTOM RETAINING WALL

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: [signature]
Registered Professional Surveyor

Date: 3/02/15

Name: Rowan Hallam

SCALEBAR (M)
0 10.0 20.0 50.0

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	29/01/15

CLIENT: WFH PROPERTIES

MILLWATER - PRECINCT 3 STAGE 2B

ASBUILT - EARTHWORK SURFACE - FINAL SURFACE, CUT/FILL CONTOUR PLAN

AUCKLAND COUNCIL

WOODS Engineers. Surveyors. Planners.

DESIGNED:		ASBUILT	
CHECKED:		DRAWN:	RM
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33302-P3-2B	SCALE:	1:1000 @ A3
ISSUED:			
DWG. NO.	33302-2B-AB-121	REV.	1

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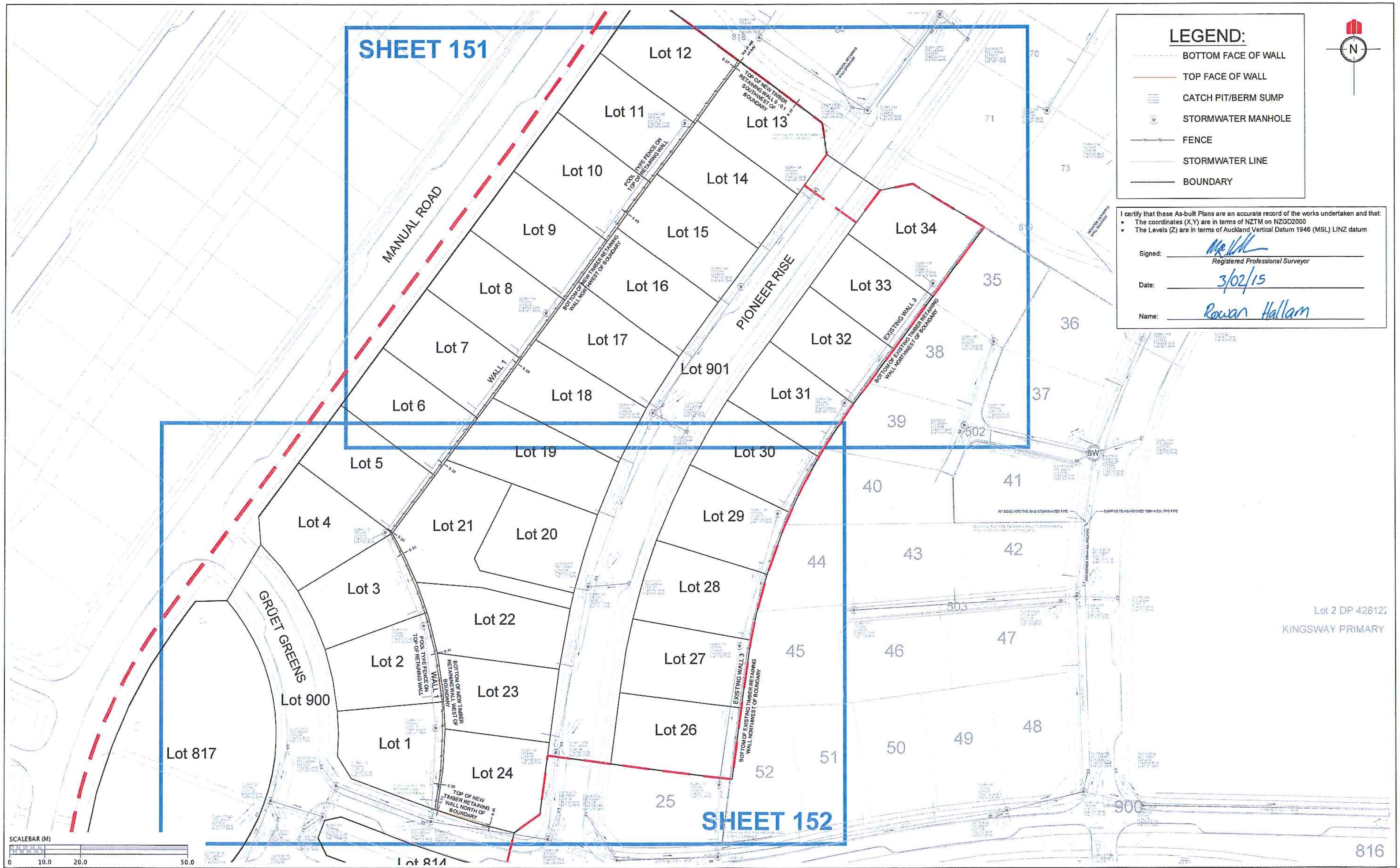

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	28/01/15

CLIENT:

MILLWATER – PRECINCT 3 – STAGE 2B

RETAINING WALL ASBUILT PLAN

AUCKLAND COUNCIL

WOODS
Engineers. Surveyors. Planners.

DESIGNED:		ASBUILT	
CHECKED:		DRAWN:	AC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33302-P3-2B	SCALE:	1:1000@ A3
ISSUED:	JAN 2015		
DWG. NO.	33302-2B-AB-150	REV.	1

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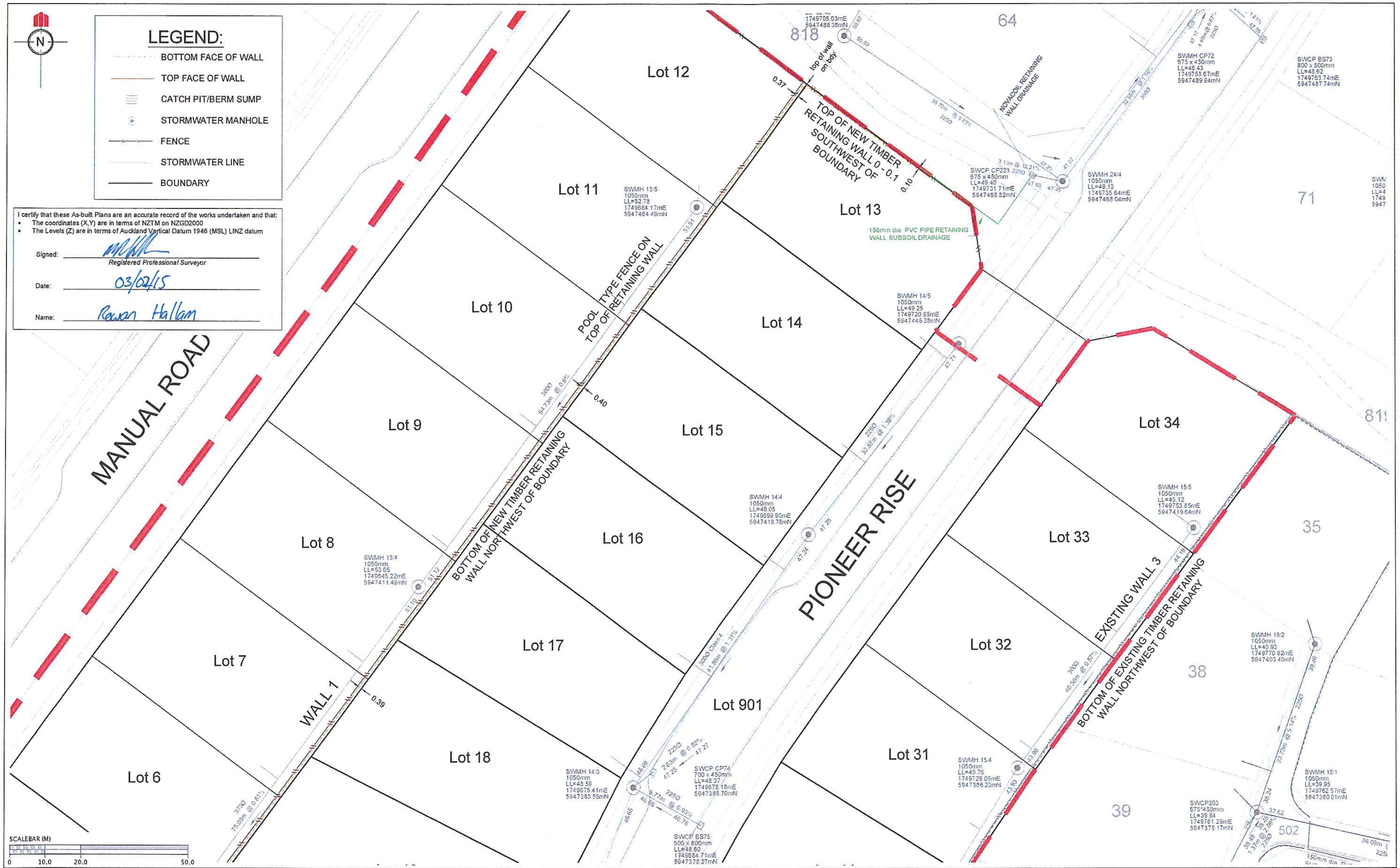

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	28/01/15

CLIENT:

MILLWATER - PRECINCT 3 - STAGE 2B

RETAINING WALL ASBUILT PLAN
SHEET 1 OF 2

AUCKLAND COUNCIL

WOODS
Engineers. Surveyors. Planners.

DESIGNED:			ASBUILT
CHECKED:		DRAWN:	AC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33302-P3-2B	SCALE:	1:500@ A3
ISSUED:	JAN 2015		
DWG. NO.	33302-2B-AB-151	REV.	1

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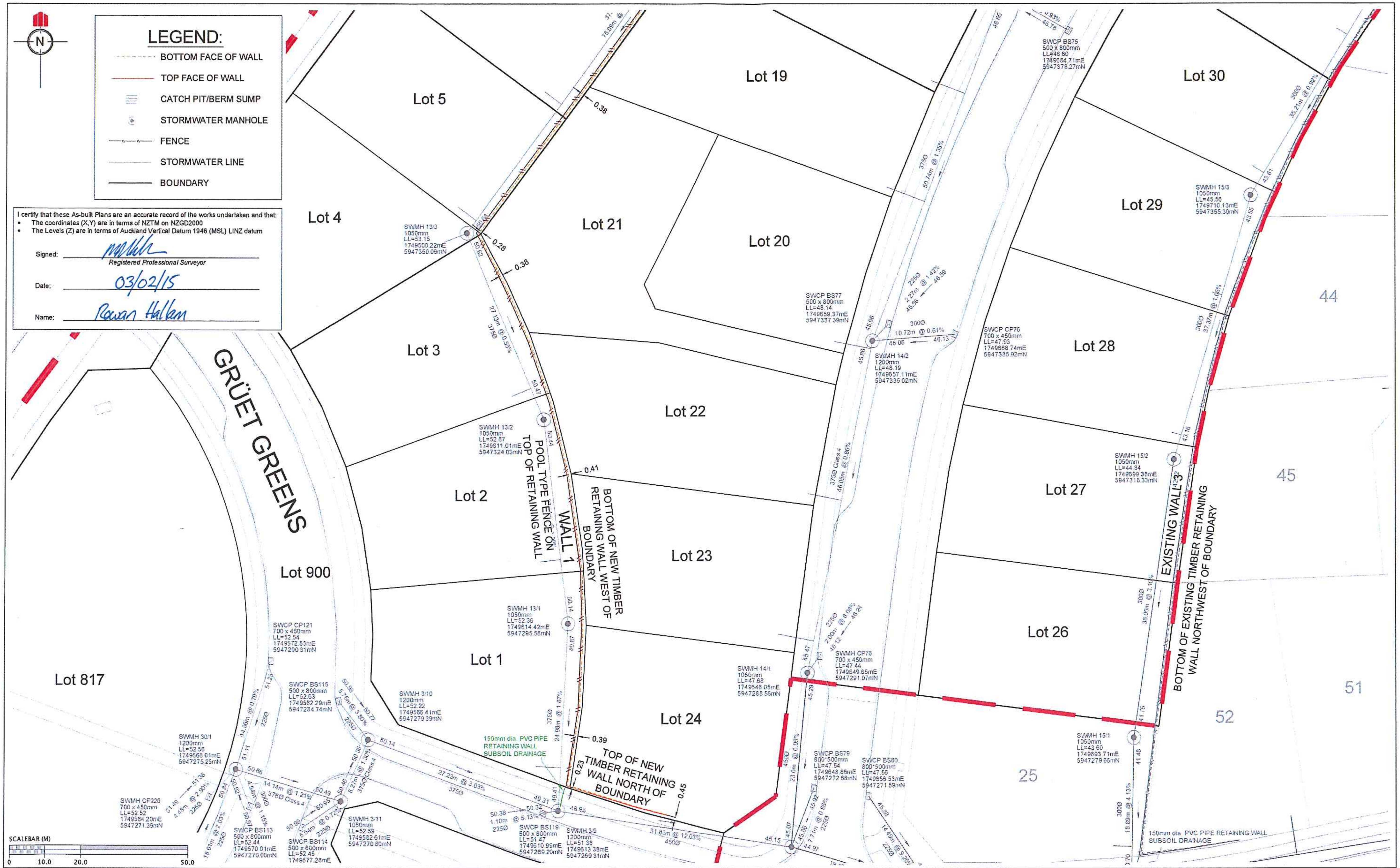

I certify that these As-built Plans are an accurate record of the works undertaken and that:
- The coordinates (X,Y) are in terms of NZTM on NZGD2000
- The Levels (Z) are in terms of Auckland Vertical Datum 1946 (MSL) LINZ datum

Signed: [signature]
Registered Professional Surveyor

Date: 03/02/15

Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	28/01/15

CLIENT:

MILLWATER – PRECINCT 3 – STAGE 2A

RETAINING WALL ASBUILT PLAN
SHEET 2 OF 2

AUCKLAND COUNCIL

WOODS
Engineers. Surveyors. Planners.

DESIGNED:		ASBUILT	
CHECKED:		DRAWN:	AC
APPROVED:		SURVEYED:	WOODS
JOB NUMBER:	33302-P3-2A	SCALE:	1:500@ A3
ISSUED:	NOV 2014		
DWG. NO.	33302-2A-AB-152	REV.	1

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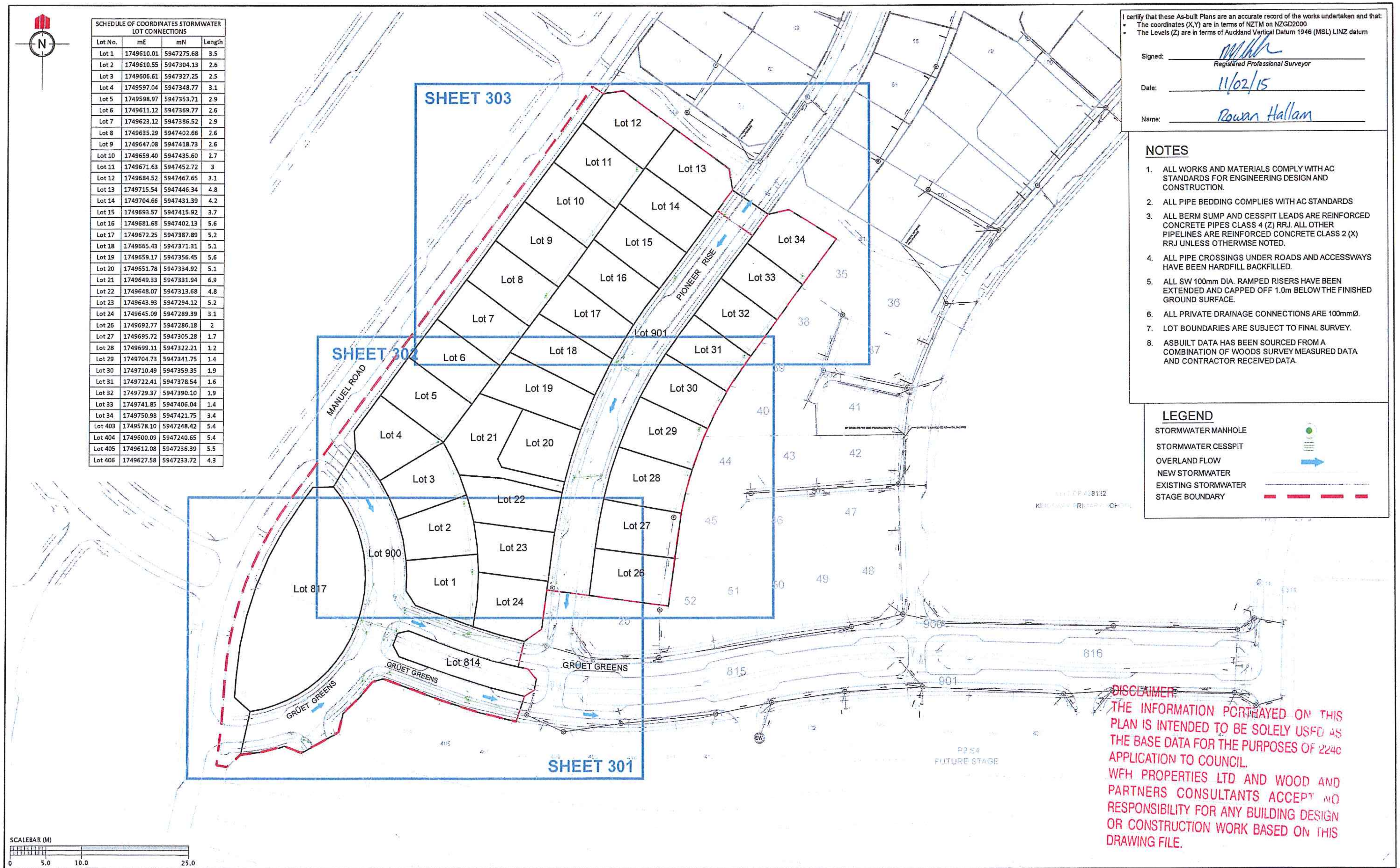
SCHEDULE OF COORDINATES STORMWATER LOT CONNECTIONS			
Lot No.	mE	mN	Length
Lot 1	1749610.01	5947275.68	3.5
Lot 2	1749610.55	5947304.13	2.6
Lot 3	1749606.61	5947327.25	2.5
Lot 4	1749597.04	5947348.77	3.1
Lot 5	1749598.97	5947353.71	2.9
Lot 6	1749611.12	5947369.77	2.6
Lot 7	1749623.12	5947386.52	2.9
Lot 8	1749635.29	5947402.66	2.6
Lot 9	1749647.08	5947418.73	2.6
Lot 10	1749659.40	5947435.60	2.7
Lot 11	1749671.63	5947452.72	3
Lot 12	1749684.52	5947467.65	3.1
Lot 13	1749715.54	5947446.34	4.8
Lot 14	1749704.66	5947431.39	4.2
Lot 15	1749693.57	5947415.92	3.7
Lot 16	1749681.68	5947402.13	5.6
Lot 17	1749672.25	5947387.89	5.2
Lot 18	1749665.43	5947371.31	5.1
Lot 19	1749659.17	5947356.45	5.6
Lot 20	1749651.78	5947334.92	5.1
Lot 21	1749649.33	5947331.94	6.9
Lot 22	1749648.07	5947313.68	4.8
Lot 23	1749643.93	5947294.12	5.2
Lot 24	1749645.09	5947289.39	3.1
Lot 26	1749692.77	5947286.18	2
Lot 27	1749695.72	5947305.28	1.7
Lot 28	1749699.11	5947322.21	1.2
Lot 29	1749704.73	5947341.75	1.4
Lot 30	1749710.49	5947359.35	1.9
Lot 31	1749722.41	5947378.54	1.6
Lot 32	1749729.37	5947390.10	1.9
Lot 33	1749741.85	5947406.04	1.4
Lot 34	1749750.98	5947421.75	3.4
Lot 403	1749578.10	5947248.42	5.4
Lot 404	1749600.09	5947240.65	5.4
Lot 405	1749612.08	5947236.39	5.5
Lot 406	1749627.58	5947233.72	4.3



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: [signature] Registered Professional Surveyor

Date: 11/02/15

Name: Rowan Hallam

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 BERM SUMP AND CESSPIT LEADS 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 DATA AND CONTRACTOR RECEIVED DATA.

LEGEND

STORMWATER MANHOLE
STORMWATER CESSPIT
OVERLAND FLOW
NEW STORMWATER
EXISTING STORMWATER
STAGE BOUNDARY

DISCLAIMER:
THE INFORMATION PORTRAYED ON THIS PLAN IS INTENDED TO BE SOLELY USED AS THE BASE DATA FOR THE PURPOSES OF 224c APPLICATION TO COUNCIL.
WFH PROPERTIES LTD AND WOOD AND PARTNERS CONSULTANTS ACCEPT NO RESPONSIBILITY FOR ANY BUILDING DESIGN OR CONSTRUCTION WORK BASED ON THIS DRAWING FILE.

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	11/02/15

CLIENT: WFH PROPERTIES

MILLWATER - PRECINCT 3 - STAGE 2B

STORMWATER ASBUILT PLAN
SHEET 1 OF 4

AUCKLAND COUNCIL

WOODS Engineers. Surveyors. Planners.

DESIGNED:	ASBUILT
CHECKED:	DRAWN: BY SM
APPROVED:	SURVEYED: SM RM JL JR
JOB NUMBER: 33302-2B	SCALE: 1:1500 @ A3
ISSUED: JAN 2015	
DWG. NO. 33302-2B-AB-300	REV. 1

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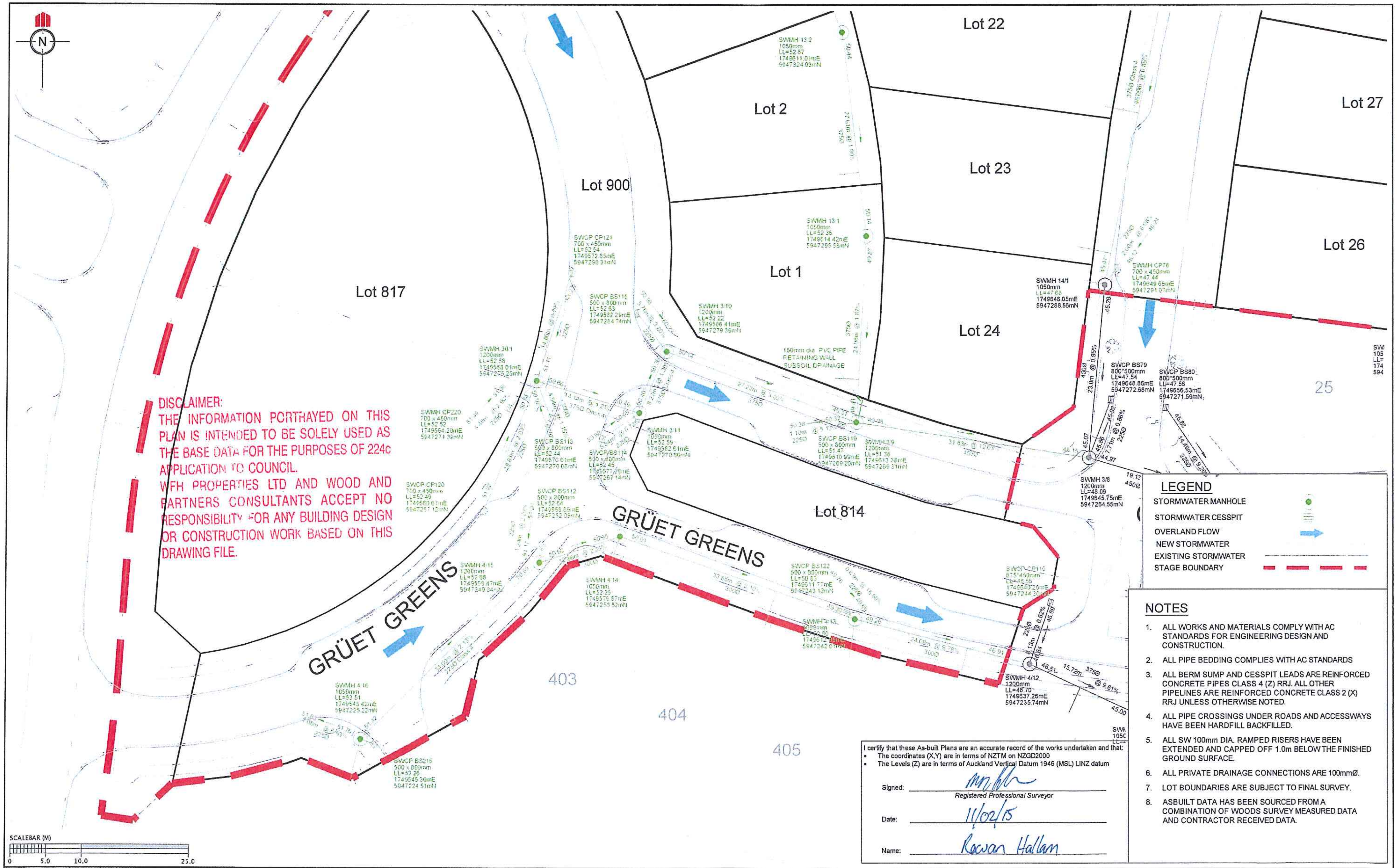

I certify that these As-built Plans are an accurate record of the works undertaken and that:

- 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: [signature]
Registered Professional Surveyor

Date: 11/02/15

Name: Rowan Hallam

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 BERM SUMP AND CESSPIT LEADS 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 DATA AND CONTRACTOR RECEIVED DATA.

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	11/02/15

CLIENT: WFH PROPERTIES

MILLWATER – PRECINCT 3 – STAGE 2B

STORMWATER ASBUILT PLAN
SHEET 2 OF 4

AUCKLAND COUNCIL

WOODS
Engineers. Surveyors. Planners.

DESIGNED:			ASBUILT
CHECKED:		DRAWN:	BY SM
APPROVED:		SURVEYED:	SM RM JL JR
JOB NUMBER:	33302-2B	SCALE:	1:500 @ A3
ISSUED:	JAN 2015		
DWG. NO.	33302-2B-AB-301	REV.	1

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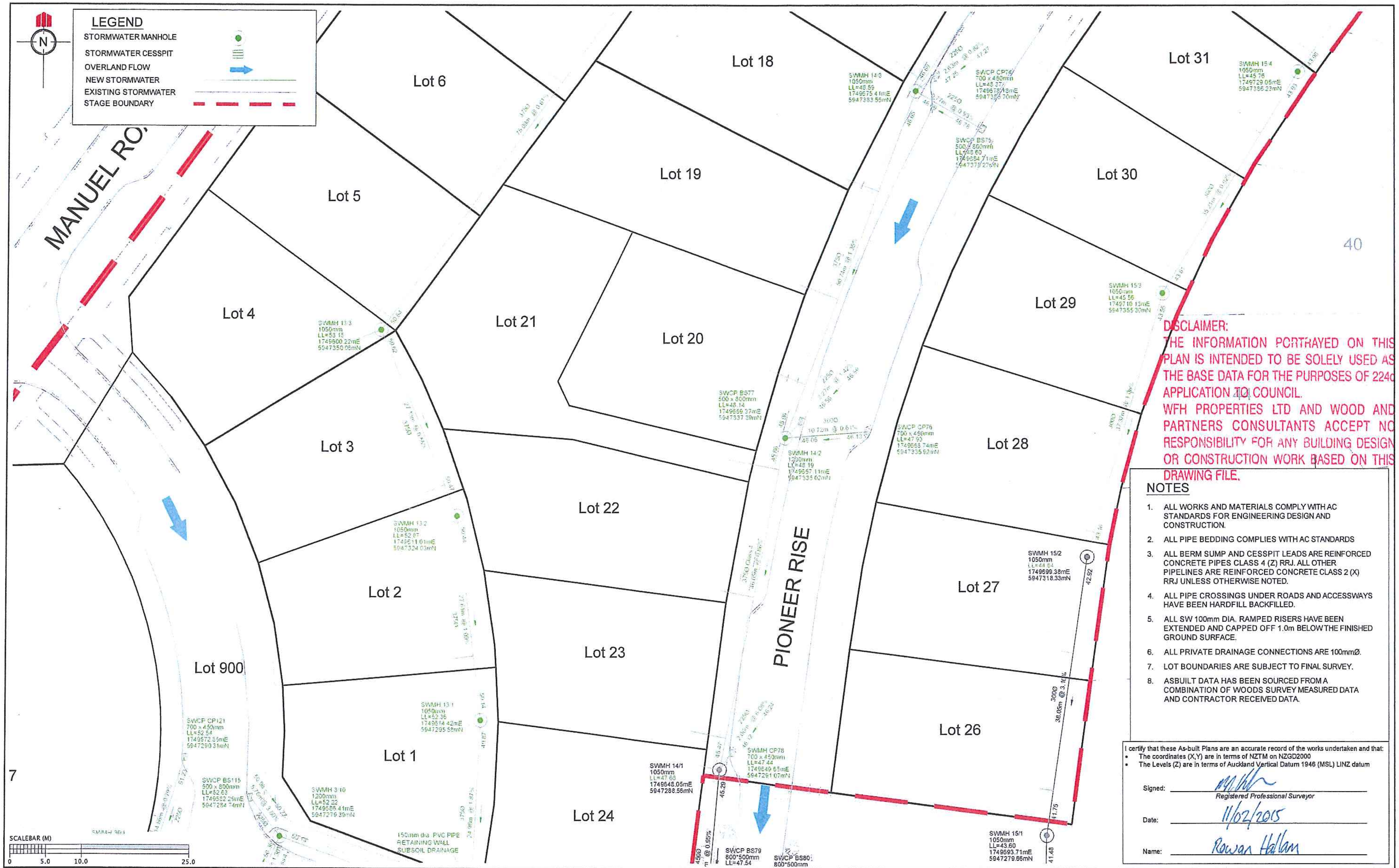


LEGEND

- STORMWATER MANHOLE
- STORMWATER CESSPIT
- OVERLAND FLOW
- NEW STORMWATER
- EXISTING STORMWATER
- STAGE BOUNDARY

DISCLAIMER:
THE INFORMATION PORTRAYED ON THIS PLAN IS INTENDED TO BE SOLELY USED AS THE BASE DATA FOR THE PURPOSES OF 224c APPLICATION TO COUNCIL.
WFH PROPERTIES LTD AND WOOD AND PARTNERS CONSULTANTS ACCEPT NO RESPONSIBILITY FOR ANY BUILDING DESIGN OR CONSTRUCTION WORK BASED ON THIS DRAWING FILE.

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 BERM SUMP AND CESSPIT LEADS 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 DATA AND CONTRACTOR RECEIVED DATA.

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: [signature]
Registered Professional Surveyor
Date: 11/02/2015
Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	11/02/15

CLIENT: WFH PROPERTIES

MILLWATER – PRECINCT 3 – STAGE 2B

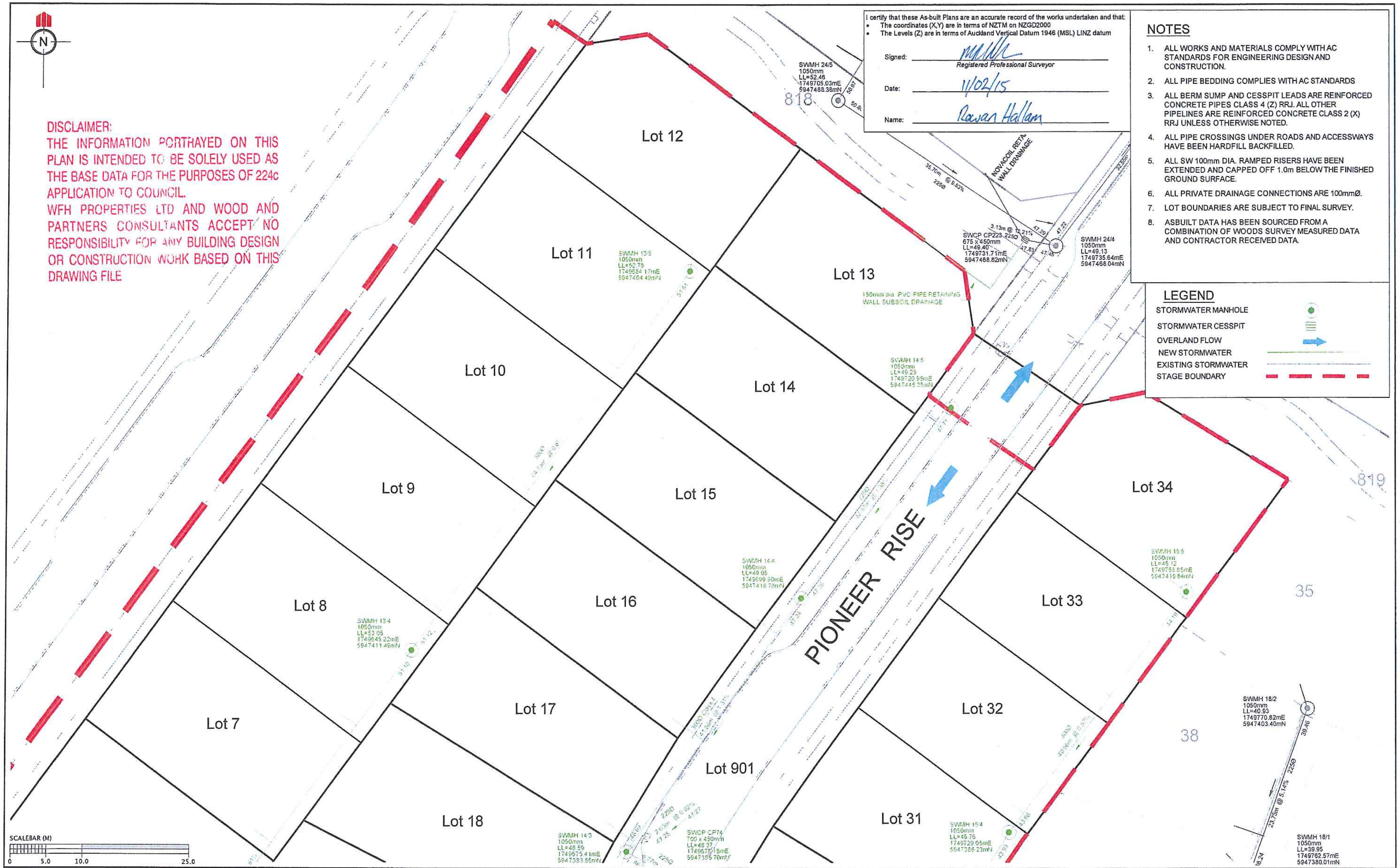
STORMWATER ASBUILT PLAN
SHEET 3 OF 4

AUCKLAND COUNCIL

WOODS Engineers. Surveyors. Planners.

DESIGNED:	ASBUILT
CHECKED:	DRAWN: BY SM
APPROVED:	SURVEYED: SM RM JL JR
JOB NUMBER: 33302-2B	SCALE: 1:500 @ A3
ISSUED: JAN 2015	
DWG. NO. 33302-2B-AB-302	REV. 1

K:\33302 Millwater Precinct 3 Stage 2\Project Data\Acad Drawings\Survey\As-Builts\Stage 2B\33302-2B-ASB-300 P3 Stormwater-asbuilt.dwg, 11/02/2015 2:19:07 p.m.



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: [signature] Registered Professional Surveyor

Date: 11/02/15

Name: Rowan Hallam

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 BERM SUMP AND CESSPIT LEADS 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 DATA AND CONTRACTOR RECEIVED DATA.

LEGEND

- STORMWATER MANHOLE
- STORMWATER CESSPIT
- OVERLAND FLOW
- NEW STORMWATER
- EXISTING STORMWATER
- STAGE BOUNDARY

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	11/02/15

CLIENT: WFH PROPERTIES

MILLWATER – PRECINCT 3 – STAGE 2B

STORMWATER ASBUILT PLAN
SHEET 4 OF 4

AUCKLAND COUNCIL

WOODS Engineers. Surveyors. Planners.

DESIGNED:	ASBUILT
CHECKED:	DRAWN: BY SM
APPROVED:	SURVEYED: SM RM JL JR
JOB NUMBER: 33302-2B	SCALE: 1:500 @ A3
ISSUED: JAN 2015	
DWG. NO. 33302-2B-AB-303	REV. 1

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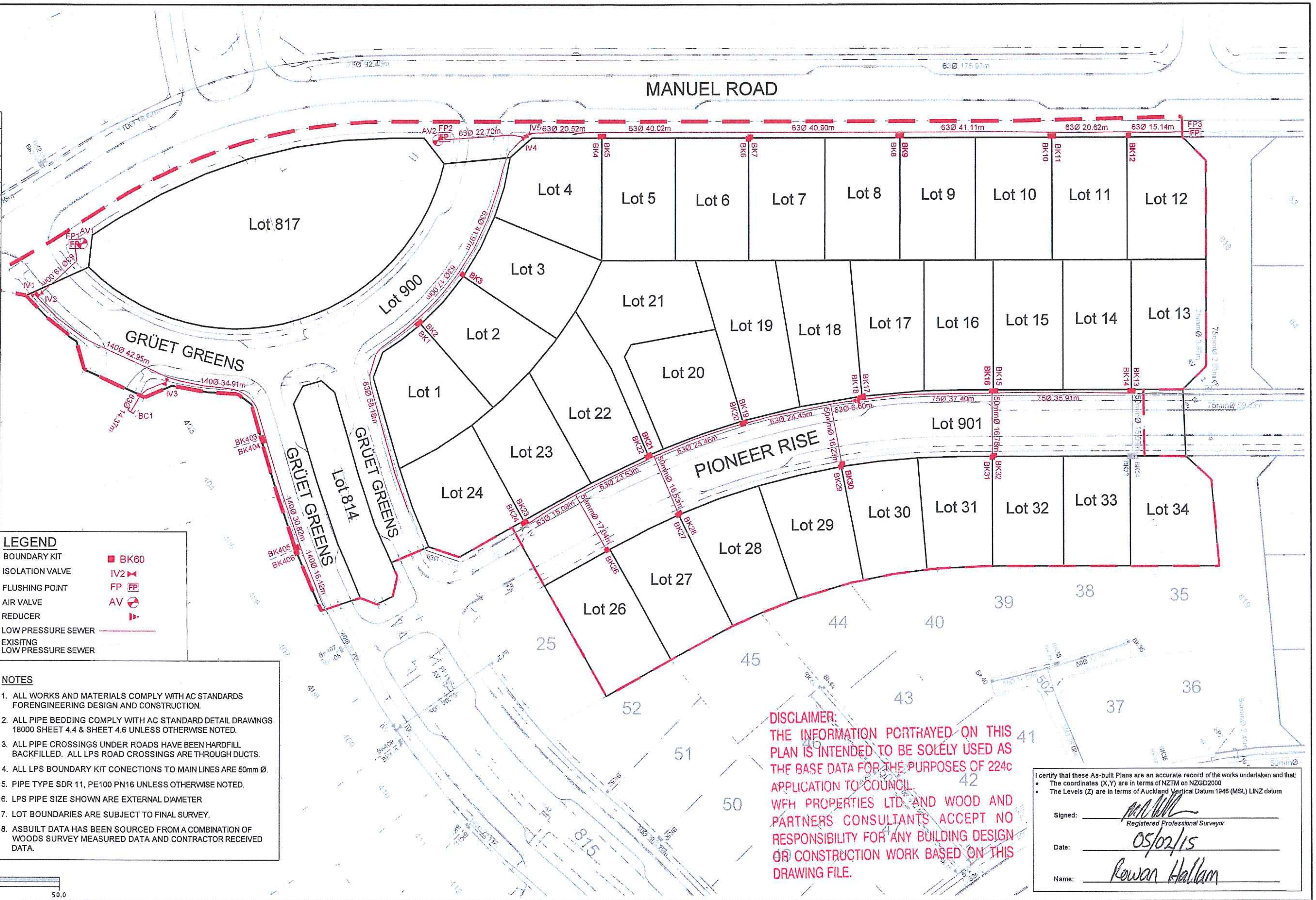
SCHEDULE OF COORDINATES		
WASTE WATER FEATURES		
	mE	mN
BK1	1749586.28	5947299.74
BK2	1749586.21	5947300.65
BK3	1749582.71	5947317.57
BK4	1749575.06	5947369.59
BK5	1749575.59	5947370.36
BK6	1749599.07	5947401.61
BK7	1749599.55	5947402.33
BK8	1749623.24	5947434.65
BK9	1749623.70	5947435.36
BK10	1749647.78	5947467.57
BK11	1749648.31	5947468.25
BK12	1749660.40	5947484.73
BK13	1749716.35	5947444.76
BK14	1749715.82	5947444.04
BK15	1749694.03	5947414.75
BK16	1749693.55	5947414.00
BK17	1749674.17	5947385.22
BK18	1749673.76	5947384.40
BK19	1749660.40	5947355.37
BK20	1749659.94	5947354.63
BK21	1749652.24	5947329.36
BK22	1749652.01	5947328.51
BK23	1749646.66	5947291.90
BK24	1749646.60	5947291.05
BK26	1749665.77	5947304.86
BK27	1749669.38	5947325.77
BK28	1749669.60	5947326.64
BK29	1749685.07	5947368.98
BK30	1749685.49	5947369.73
BK31	1749707.34	5947403.43
BK32	1749707.84	5947404.15
BK403	1749586.01	5947247.75
BK404	1749586.88	5947247.52
BK405	1749615.26	5947237.81
BK406	1749616.10	5947237.47



LEGEND

BOUNDARY KIT	BK60
ISOLATION VALVE	IV2
FLUSHING POINT	FP
AIR VALVE	AV
REDUCER	
LOW PRESSURE SEWER	
EXISITNG LOW PRESSURE SEWER	

SCHEDULE OF COORDINATES		
FLUSH PITS		
	mE	mN
FP1	1749513.73	5947237.63
FP2	1749549.93	5947335.42
FP3	1749670.63	5947499.65
AIR VALVES		
	mE	mN
AV1	1749514.67	5947239.37
AV2	1749549.58	5947333.53
INSPECTION VALVES		
	mE	mN
IV1	1749518.04	5947220.97
IV2	1749518.97	5947222.11
IV3	1749558.20	5947235.47
IV4	1749563.23	5947353.23
IV5	1749563.12	5947354.14

NOTES

1. ALL WORKS AND MATERIALS COMPLY WITH AC STANDARDS FORENGINEERING DESIGN AND CONSTRUCTION.
2. ALL PIPE BEDDING COMPLY WITH AC STANDARD DETAIL DRAWINGS 18000 SHEET 4.4 & SHEET 4.6 UNLESS OTHERWISE NOTED.
3. ALL PIPE CROSSINGS UNDER ROADS HAVE BEEN HARDFILL BACKFILLED. ALL LPS ROAD CROSSINGS ARE THROUGH DUCTS.
4. ALL LPS BOUNDARY KIT CONECTIONS TO MAIN LINES ARE 50mm Ø.
5. PIPE TYPE SDR 11, PE100 PN16 UNLESS OTHERWISE NOTED.
6. LPS PIPE SIZE SHOWN ARE EXTERNAL DIAMETER
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.

SCALEBAR (M)
0 10.0 20.0 50.0

DISCLAIMER:
THE INFORMATION PORTRAYED ON THIS PLAN IS INTENDED TO BE SOLELY USED AS THE BASE DATA FOR THE PURPOSES OF 224c APPLICATION TO COUNCIL.
WFH PROPERTIES LTD AND WOOD AND PARTNERS CONSULTANTS ACCEPT NO RESPONSIBILITY FOR ANY BUILDING DESIGN OR CONSTRUCTION WORK BASED ON THIS DRAWING FILE.

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: [signature]
Registered Professional Surveyor
Date: 05/02/15
Name: Rowan Hallam

REVISION DETAILS	NAME	DATE
1. DRAWING ISSUED	AC	03/02/15

CLIENT: WFH PROPERTIES

MILLWATER – PRECINCT 3 STAGE 2B

SANITARY SEWER OVERALL LAYOUT PLAN
LOW PRESSURE

AUCKLAND COUNCIL

WOODS
Engineers. Surveyors. Planners.

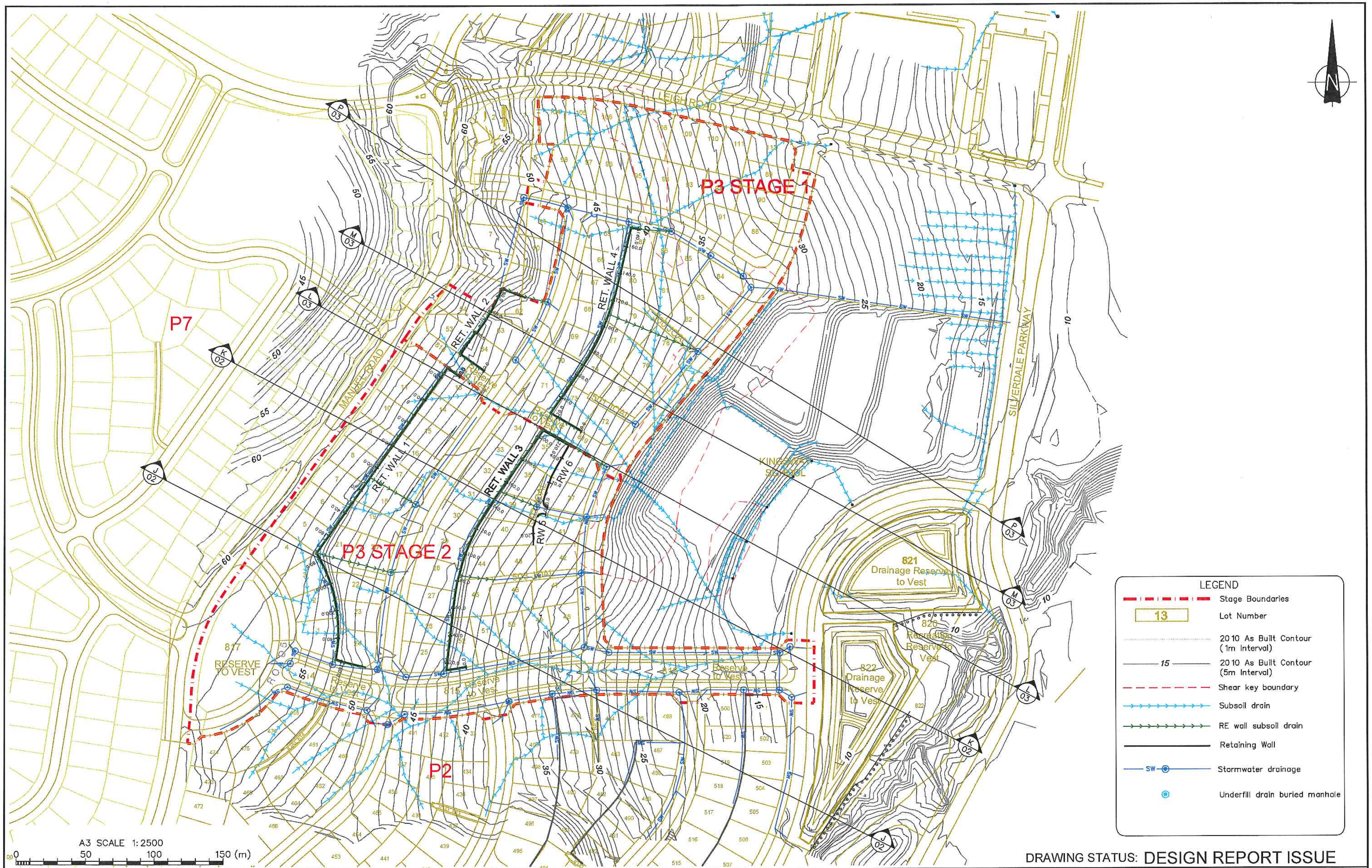
DESIGNED:	ASBUILT
CHECKED:	DRAWN: AC
APPROVED:	SURVEYED: WOODS
JOB NUMBER: 33302-2B	SCALE: 1:1000 @ A3
ISSUED: JAN 2015	
DWG. NO. 33302-2B-AB-500	REV. 1

K:\33302 Millwater Precinct 3 Stage 2\Project Data\Acad Drawings\Survey\As-Builts\Stage 2B\33302-2B-ASB-500 P3 Wastewater asbuilt.dwg, 5/02/2015 1:45:19 p.m.

Appendix A2: T&T Drawings

T&T DRAWINGS (2013)

- **21854.008 – RW - 01** **Stage 1 & 2 Retaining Walls – Layout Plan**
- **21854.008 – RW - 02** **Geological Cross Sections J and K**
- **21854.008 – RW - 04** **Retaining Wall 1 – Long Section**
- **21854.008 – RW - 05** **Retaining Wall 3 – Long Section**
- **21854.008 – RW - 07** **Retaining Walls – Typical Details**



DRAWING STATUS: DESIGN REPORT ISSUE

0	Design Report Issue	
REVISION DESCRIPTION	BY	DATE

DESIGNED :	CCD	Apr. 13
DRAWN :	JATG	Apr. 13
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.008-RW-01.dwg		
APPROVED : NOT FOR CONSTRUCTION		

This drawing is not to be used for construction purposes unless signed as approved

NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. 2010 As-built earthworks contour supplied by WOODS, reference data "Pond 4B drain info for AA.dwg"
3. 2010 As-built Shear and Subsoil drain key supplied by WOODS, reference data "P3-SHEAR KEY UNDERCUTS 3D TRIANGLES.dwg"
4. Lot boundary, Stormwater lines and proposed retaining wall 1 to 6 location supplied by WOODS, reference data "base_MILLWATER_P3.dwg", dated Feb 2012

REFERENCE :

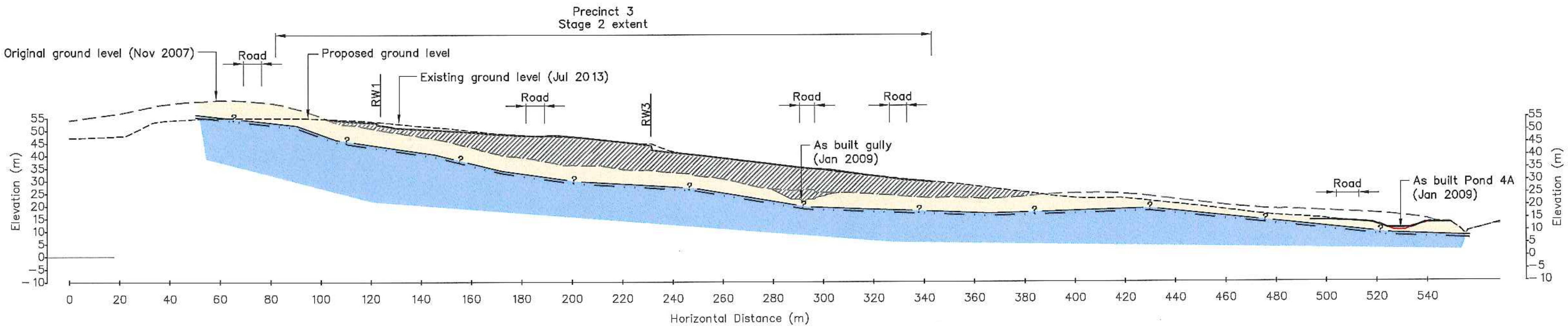
Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

CLIENT, PROJECT
WFH PROPERTIES
MILLWATER PRECINCT 3

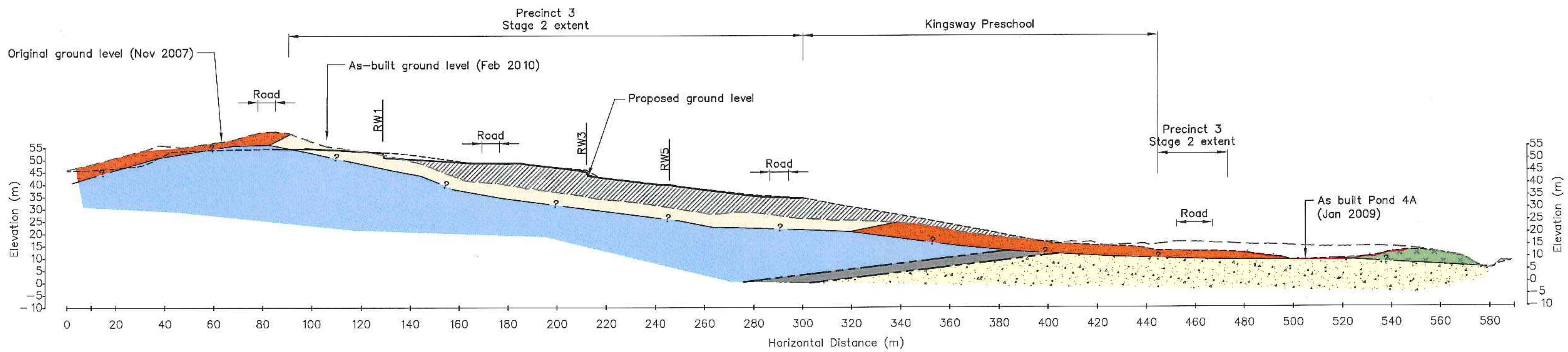
TITLE
STAGE 1 & 2 RETAINING WALLS
Layout Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1:2500	21854.008-RW-01	0

L:\21854\21854.008 - Precinct 3\WorkingMaterial\CAD\GCR CAD\21854.008-RW-01.dwg, 01, 26/06/2013 9:31:38 a.m., jatg, 1:1



SECTION J/01
SCALE 1:2000



SECTION K/01
SCALE 1:2000

LEGEND

- Original ground Level
- 2010 As-built ground level
- Proposed ground level
- Inferred geological boundary
- Fault Zone
- Engineered fill
- Colluvium
- Alluvium
- Softened Northland Allochthon
- Northland Allochthon
- ECBF

SCALE 1:2000 (A3)
0 20 40 60 80 100 (m)

ORIGINAL IN COLOUR

DRAWING STATUS: CONSTRUCTION ISSUE

REV	DESCRIPTION	BY	DATE
A	Construction Issue	AJL	12.12.13
1	Design Report Issue	AJL	1.09.13

DESIGNED :	CCD	May.13
DRAWN :	JATG	May.13
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\21854.008-RW-02_03.dwg		
APPROVED :		/ /

This drawing is not to be used for construction purposes unless signed as approved

NOTES :
1. All dimensions are in millimetres unless noted otherwise.
2. 2010 As-built earthworks contour supplied by WOODS, reference data "Pond 4B drain info for AA.dwg"
3. 2010 As-built Shear and Subsoil drain key supplied by WOODS, reference data "P3-SHEAR KEY UNDERCUTS 3D TRIANGLES.dwg"
4. Proposed ground level and proposed retaining wall 1 to 6 location supplied by WOODS, reference data "millwater P3 Base_25 July 2013 2.dwg", dated July 2013

REFERENCE :

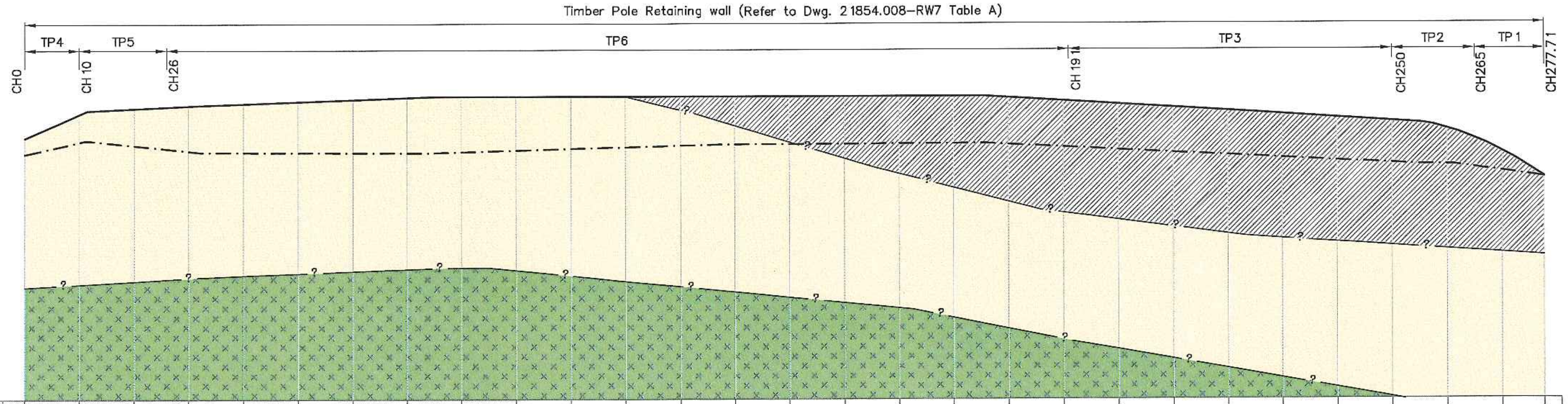
Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

CLIENT, PROJECT
WFH PROPERTIES
MILLWATER PRECINCT 3

TITLE
STAGE 1 & 2 RETAINING WALLS
Geological Section (Sheet 1 of 2)

SCALES (AT A3 SIZE) 1: 2000
DWG. No. 21854.008-RW-02
REV. A

L:\21854\21854.008 - Precinct 3\WorkingMaterial\CAD\21854.008-RW-02_03.dwg, 02, 3/9/2015 12:33:17 PM, jatg, 1:1

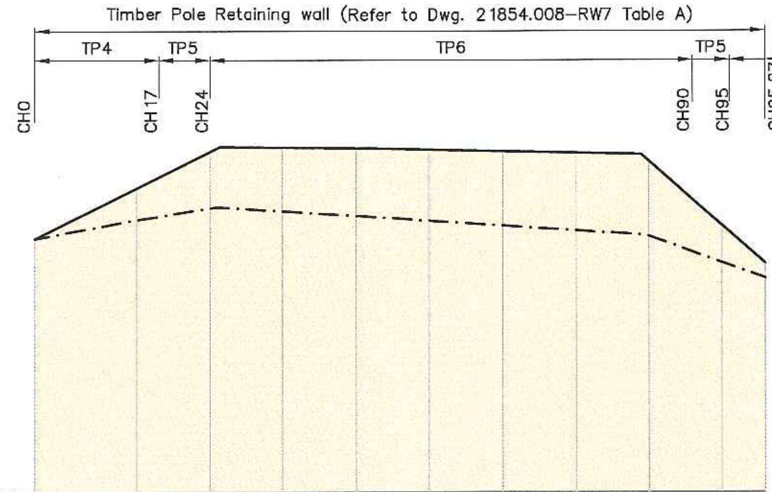


DATUM R.L. = 42.00

BOTTOM OF RETAINING	50.92	51.37	51.24	51.04	50.99	50.99	50.98	50.97	51.00	51.06	51.11	51.17	51.22	51.27	51.28	51.28	51.29	51.30	51.26	51.16	51.06	50.96	50.86	50.76	50.66	50.55	50.50	50.26	50.05
RETAINED HEIGHT	0.58	1.01	1.34	1.64	1.76	1.84	1.92	2	2	1.94	1.89	1.83	1.78	1.73	1.72	1.72	1.71	1.7	1.69	1.67	1.65	1.63	1.61	1.58	1.55	1.52	1.3	0.72	0
TOP OF RETAINING	51.51	52.38	52.58	52.68	52.76	52.83	52.90	52.97	53.00	53.00	53.00	53.00	53.00	53.00	53.00	53.00	53.00	53.00	52.95	52.83	52.70	52.58	52.46	52.34	52.20	52.07	51.79	50.97	50.05
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	277.71

WALL 1 LONGITUDINAL SECTION

SCALE 1: 1000 (H), 1: 200 (V)



DATUM R.L. = 43.00

BOTTOM OF RETAINING	50.11	50.43	50.74	50.66	50.53	50.39	50.26	50.13	49.98	49.25	
RETAINED HEIGHT		0.87	1.53	1.73	1.84	1.94	2.02	2.11	2.03	1	
TOP OF RETAINING		51.29	52.28	52.39	52.37	52.33	52.28	52.24	52.00	50.26	49.23
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	95.87

WALL 2 LONGITUDINAL SECTION

SCALE 1: 1000 (H), 1: 200 (V)

LEGEND
- Top of retaining wall
- Bottom of retaining wall
- ? Inferred geological boundary
- Engineered fill
- Colluvium
- Alluvium

SCALE 1: 1000 (H)
0 10 20 30 40 50 (m)

SCALE 1: 200 (V)
0 2 4 6 8 10 (m)

I:\21854\21854.008 - precinct 3\workingmaterial\CAD\GCR CAD\21854.008-RW-04_06.dwg, 04, 26/06/2013 9:26:55 a.m., jatg, 1:1

DRAWING STATUS: DESIGN REPORT ISSUE

0	Design Report Issue		
REVISION DESCRIPTION		BY	DATE

DESIGNED : CCD May. 13
DRAWN : JATG May. 13
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\21854.008–RW–04_06.dwg
APPROVED :
NOT FOR CONSTRUCTION
This drawing is not to be used for construction purposes unless signed as approved

NOTES :
1. All dimensions are in millimetres unless noted otherwise.
2. Retaining wall Section taken from WOODS drawing, reference data "millwater P3 Ret Walls 2.dwg", dated June 2013

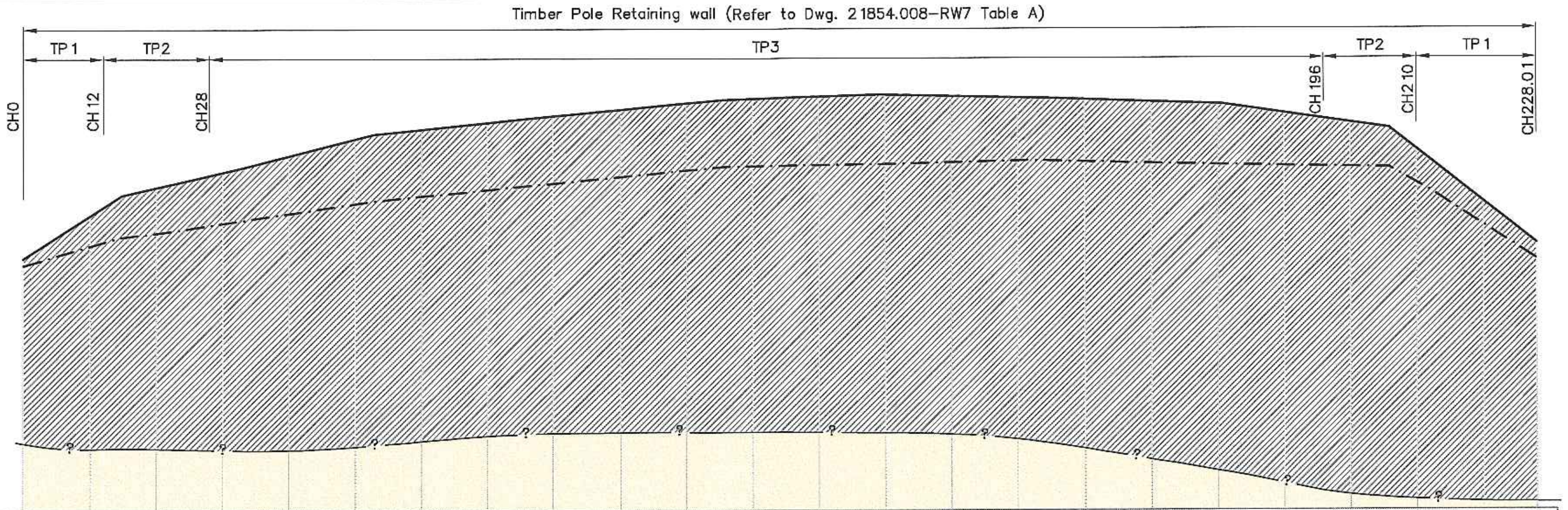
REFERENCE :

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

CLIENT, PROJECT
WFH PROPERTIES
MILLWATER PRECINCT 3

TITLE
STAGE 1 & 2 RETAINING WALLS
Retaining Walls Longsection (Sheet 1 of 3)

SCALES (AT A3 SIZE) AS SHOWN
DWG. No. 21854.008–RW–04
REV. 0

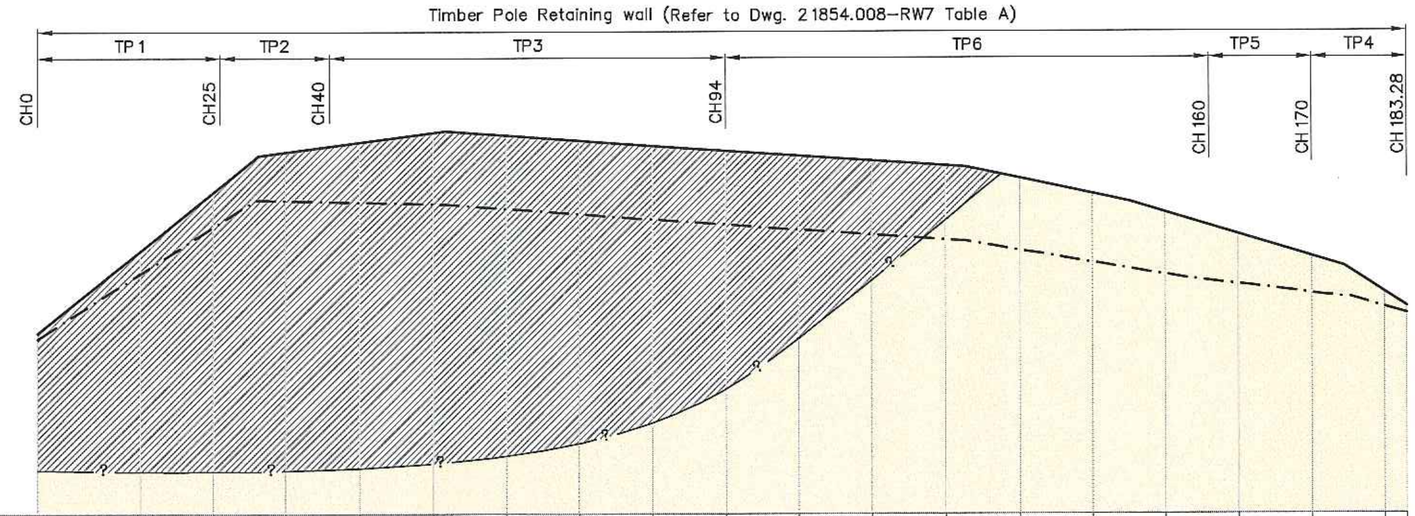


DATUM R.L. = 33.00

BOTTOM OF RETAINING		40.95	41.34	41.63	41.92	42.21	42.44	42.63	42.82	43.01	43.20	43.32	43.35	43.39	43.43	43.48	43.45	43.40	43.35	43.32	43.29	42.83	41.55	
RETAINED HEIGHT		0.91	1.37	1.53	1.73	1.94	2	2	2.01	2	2	2.01	2.05	2.07	1.98	1.89	1.86	1.84	1.82	1.58	1.33	0.98	0.7	
TOP OF RETAINING	40.58	41.86	42.71	43.16	43.65	44.16	44.44	44.63	44.83	45.01	45.20	45.34	45.40	45.46	45.41	45.37	45.31	45.24	45.17	44.90	44.62	43.81	42.25	41.00
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	228.01

WALL 3 LONGITUDINAL SECTION

SCALE 1: 1000 (H), 1: 200 (V)



LEGEND
- Top of retaining wall
- Bottom of retaining wall
- ? Inferred geological boundary
- Engineered fill
- Colluvium

SCALE 1: 1000 (H)
0 10 20 30 40 50 (m)

SCALE 1: 200 (V)
0 2 4 6 8 10 (m)

DATUM R.L. = 35.00

BOTTOM OF RETAINING		41.55	42.82	43.54	43.50	43.45	43.32	43.17	43.01	42.88	42.74	42.60	42.46	42.18	41.84	41.51	41.24	41.00	40.61	40.43
RETAINED HEIGHT		0.61	0.94	1.32	1.63	1.94	2	2	2	2.01	2.01	2.01	2.02	1.96	1.87	1.69	1.36	1	0.41	
TOP OF RETAINING		42.17	43.76	44.86	45.13	45.39	45.31	45.17	45.02	44.88	44.75	44.61	44.48	44.13	43.71	43.20	42.60	42.00	41.02	
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	183.28

WALL 4 LONGITUDINAL SECTION

SCALE 1: 1000 (H), 1: 200 (V)

I:\21854\21854.008 - precinct 3\workingmaterial\CAD\GCR CAD\21854.008-RW-04_06.dwg, 05, 26/06/2013 9:26:55 a.m., jatg, 1:1

DRAWING STATUS: DESIGN REPORT ISSUE

REVISION	DESCRIPTION	BY	DATE
0	Design Report Issue		

DESIGNED : CCD May.13
DRAWN : JATG May.13
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\21854.008-RW-04_06.dwg
APPROVED :
NOT FOR CONSTRUCTION
This drawing is not to be used for construction purposes unless signed as approved

NOTES :
1. All dimensions are in millimetres unless noted otherwise.

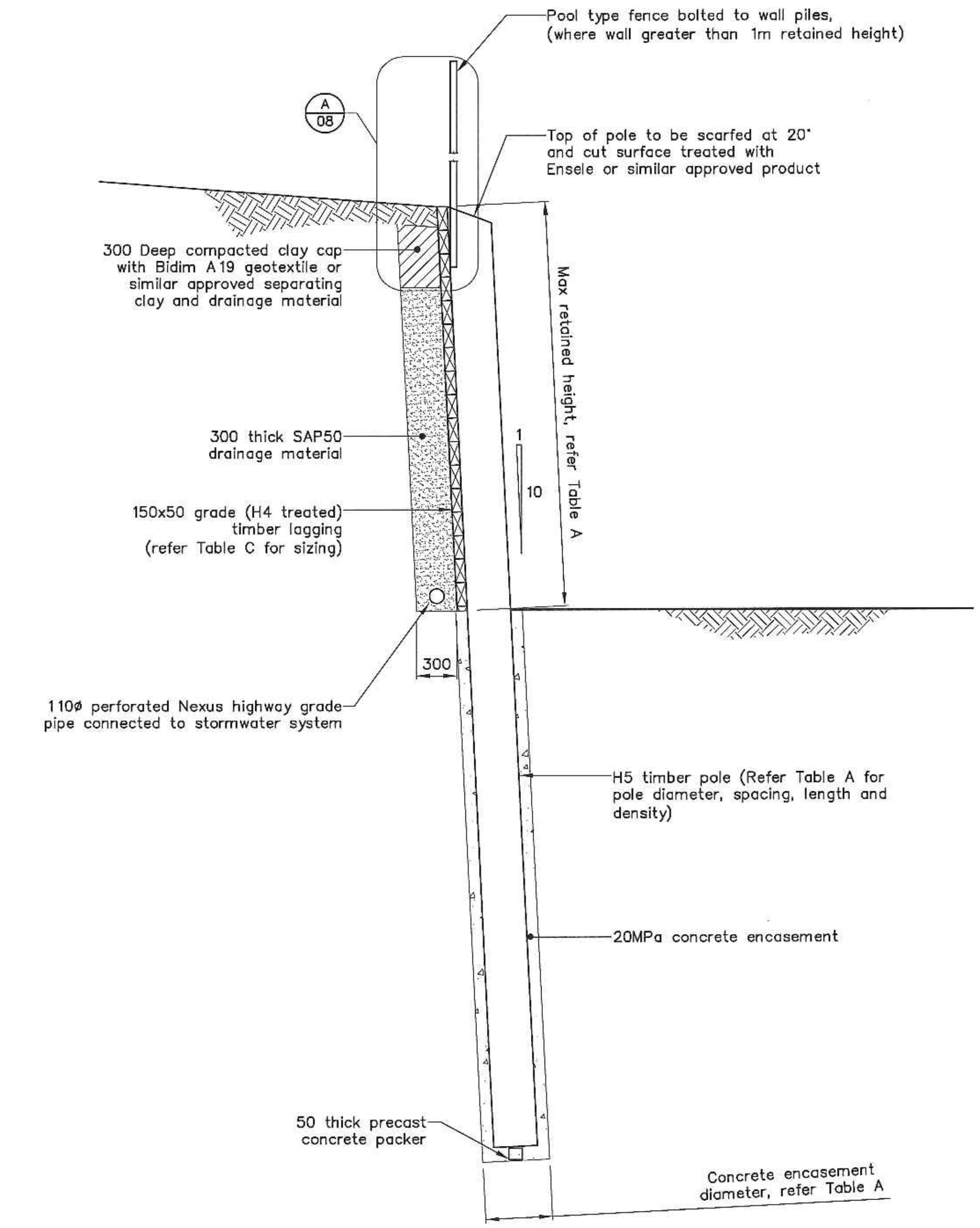
REFERENCE :

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

CLIENT, PROJECT
WFH PROPERTIES
MILLWATER PRECINCT 3

TITLE
STAGE 1 & 2 RETAINING WALLS
Retaining Walls Longsection (Sheet 2 of 3)

SCALES (AT A3 SIZE) AS SHOWN
DWG. No. 21854.008-RW-05
REV. 0



TYPICAL DETAIL – TIMBER POLE RETAINING WALL (TP)

SCALE 1:50

Refer to table A

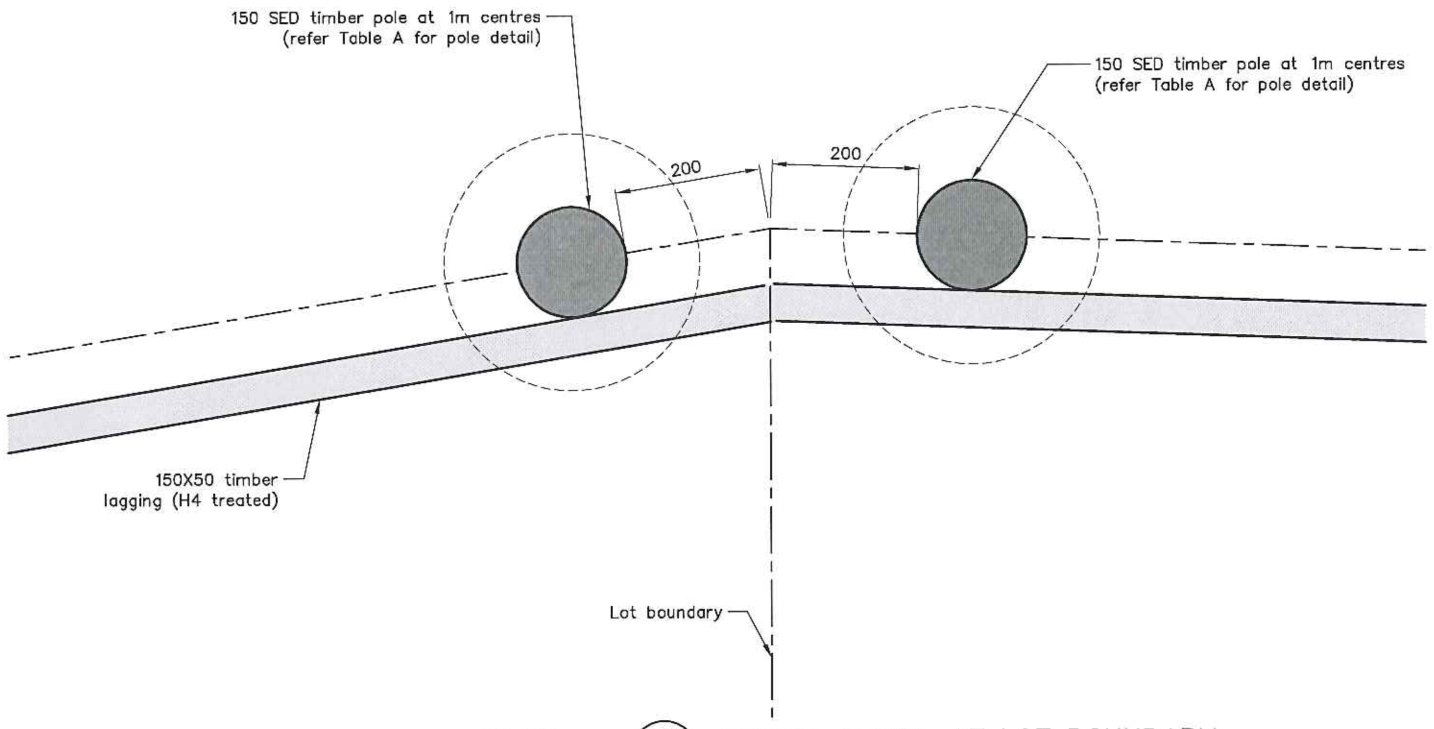
A3 SCALE 1:25

0 0.5 1.0 1.5 (m)

TABLE A: TIMBER POLE DETAIL TABLE

Timber Wall Type	Pole Details							Foundation Material type
	Retained height (m)	Min. embedment (m)	Pole Length (m)	Pole Size (SED mm dia)	Pole Density	Pole Spacing (m)	Min Concrete Encasement Diameter (mm)	
TP1	0 – 1.0	1.1	2.1	150	High	1.0	300	Engineered Fill
TP2	1.0 – 1.5	2.1	3.6	200	High	1.0	350	
TP3	1.5 – 2.0	3.4	5.4	250	High	1.0	400	
TP4	0 – 1.0	2.0	3.0	150	High	1.0	300	Colluvium
TP5	1.0 – 1.5	3.9	5.4	225	High	1.0	375	
TP6	1.5 – 2.0	5.0	7.0	300	High	1.0	450	

NOTE
1. All poles shall be sourced from the same region and documentation shall be provided supporting this
2. For each pole size, 10% of all poles shall be tested in accordance with the specification.



DETAIL A/536 TYPICAL DETAIL AT LOT BOUNDARY

SCALE 1:10

A3 SCALE 1: 10

0 0.1 0.2 0.3 0.4 0.5 (m)

DRAWING STATUS: DESIGN REPORT ISSUE

0	Design Report Issue	
REVISION	DESCRIPTION	BY	DATE

DESIGNED : CCD May.13
DRAWN : JATG May.13
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\21854.008–RW–07_08.dwg
APPROVED :
NOT FOR CONSTRUCTION
This drawing is not to be used for construction purposes unless signed as approved

NOTES :
1. All dimensions are in millimetres unless noted otherwise.
2. Wall setout to be provided by WOODS
3. Small end diameter to be placed at top of wall.
4. All cut surfaces to be treated with ensile or similar approved timber sealant.

REFERENCE :

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

CLIENT, PROJECT
WFH PROPERTIES
MILLWATER PRECINCT 3
TITLE
STAGE 1 & 2 RETAINING WALLS
Typical Timber Pole Retaining Wall Detail
SCALES (AT A3 SIZE) AS SHOWN
DWG. No. 21854.008–RW–07
REV. 0

I:\21854\21854.008 - precinct 3\workingmaterial\CAD\GCR CAD\21854.008-RW-07_08.dwg, 07, 26/06/2013 9:26:59 a.m., jatg, 1:1

Appendix B: Contractors Certificates

- **Hopper Construction Ltd (Civil Earthworks)**

NZS 3910:2013 Conditions of contract for building and civil engineering construction

Schedule 6 – Form of Producer Statement – Construction

ISSUED BY	**HOPPER CONSTRUCTION ltd**	*(Contractor)*
TO	**WFH PROPERTIES ltd**	*(Principal)*
IN RESPECT OF	**PRECINCT 3 STAGE 2B CONTRACT 33302-01**	*(Description of Contract Works)*
AT	**MILLWATER, SILVERDALE**	*(Address)*

Hopper Construction Ltd *(Contractor)* has contracted to **WFH Properties Ltd** *(Principal)* to carry out and complete certain building works in accordance with a Contract titled **33302-01 Precinct 3 Stage 2B** ('the Contract')

I GUY JONES *(Duly Authorised Agent)* a duly authorised representative of
HOPPER CONSTRUCTION LTD *(Contractor)* believe on reasonable grounds that
HOPPER CONSTRUCTION LTD *(Contractor)* has carried out and completed:

☑ All

☐ Part only as specified in the attached particulars of the contract works in accordance with the Contract

GUY JONES
Manager / Director
Hopper Construction Ltd

(Signature of Authorised Agent on behalf of)

Date 3/2/15

HOPPER CONSTRUCTION LTD

(Contractor)

17 FORGE RD, SILVERDALE

(Address)

Appendix C: NZS 3604:2011 Expansive Soils

NZS 3604:2011 Expansive Soils

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 foreseeably 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
• 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
• 20 mm – 40 mm	Class M	Moderately expansive
• 40 mm – 60 mm	Class H1	Highly expansive
• 60 mm – 75mm	Class H2	Highly expansive
• > 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).

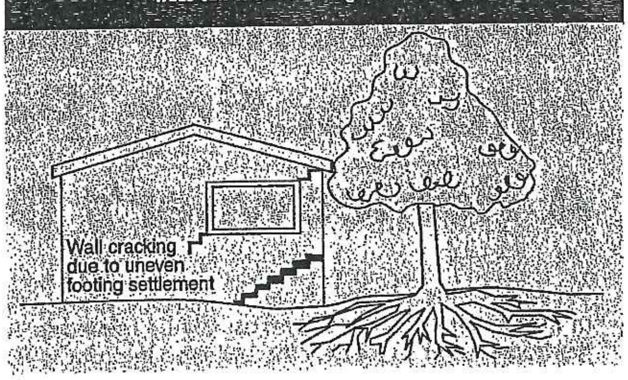
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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.

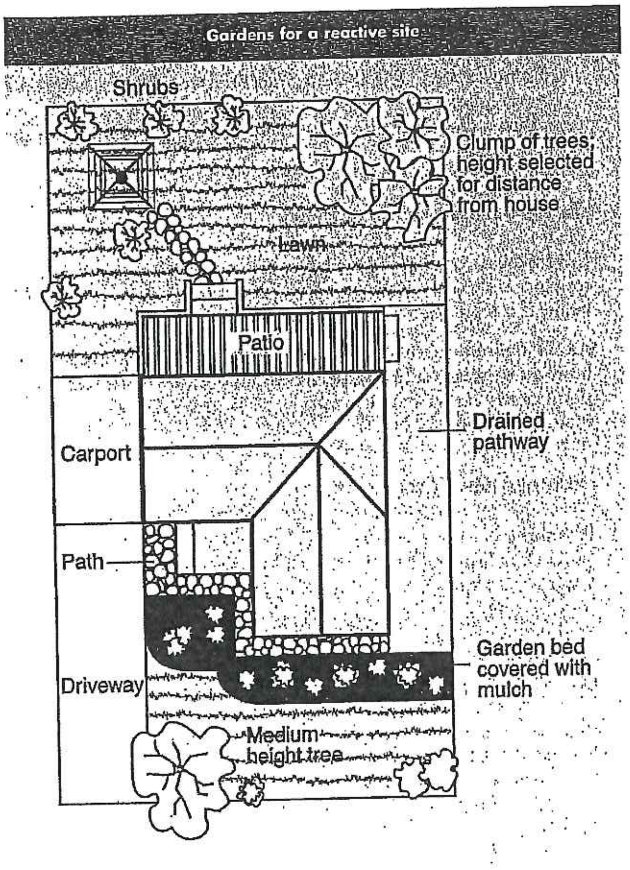
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

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



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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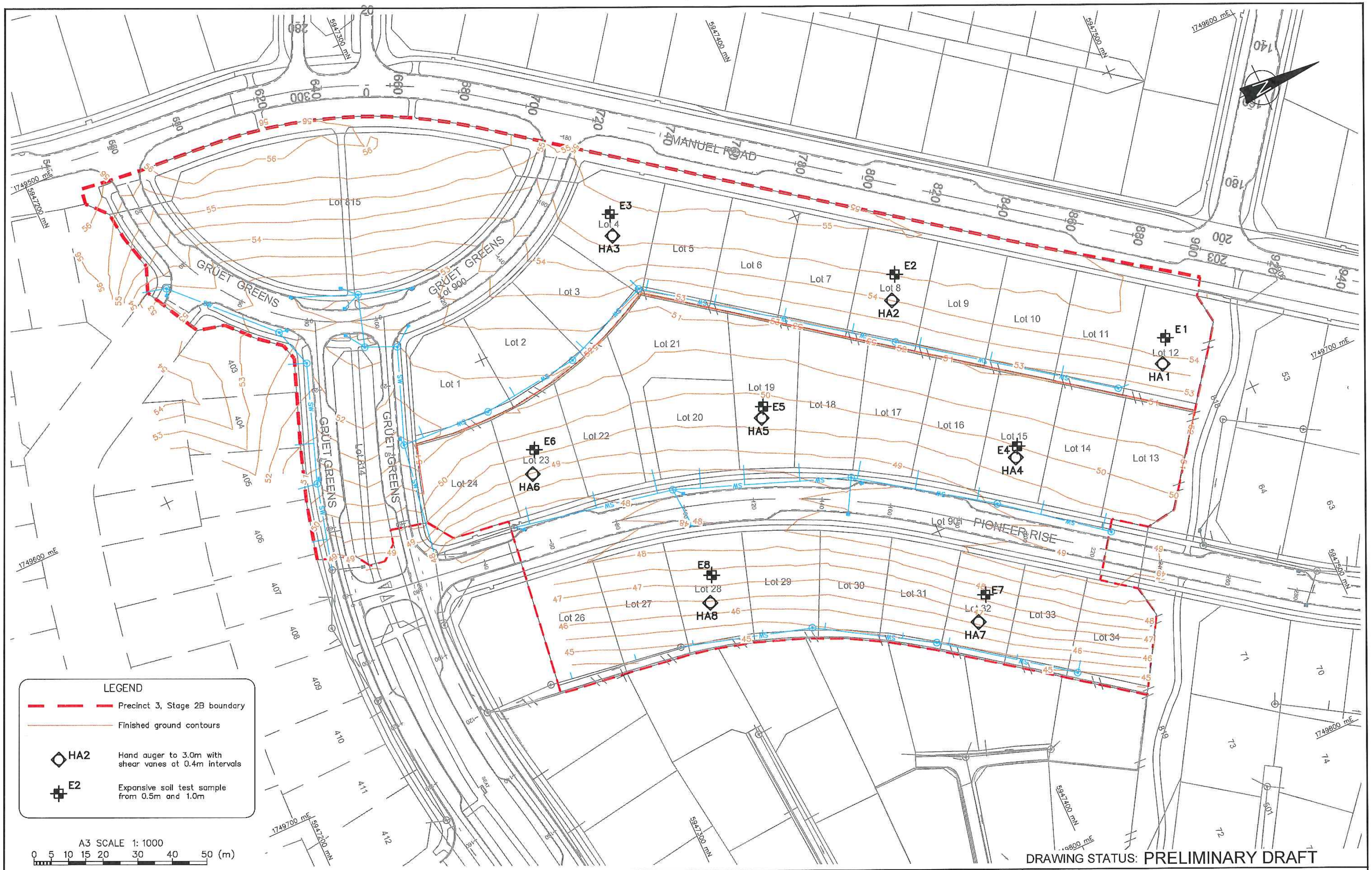
Appendix E: Post Earthworks Investigations

- 21854.008 – 2B - 101 Stage 2A Post Earthworks Investigation Plan
- 21854.008 – 2B - 102 Stage 2A Topsoil Depths Plan
- Soil Expansion Test Results
- Post Earthworks Investigation Borehole Logs



DRAWING STATUS: PRELIMINARY DRAFT

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DRAWN :	JATG	Mar. 15		
DESIGN CHECKED :				
DRAFTING CHECKED :				
CADFILE : \\21854.008-2B-101_102.dwg				
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REV.	DESCRIPTION	BY	DATE
0	First Issue		

NOTES :
1. All dimensions are in metres unless noted otherwise.
2. Asbuilt layout plan supplied by WOODS, reference no. "33302-01_BASE_ASBuilt (T&T).dwg", dated Feb 2015.

REFERENCE :

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CLIENT, PROJECT
WFH PROPERTIES LTD
MILLWATER PRECINCT 3, STAGE 2A

TITLE
GEOTECHNICAL COMPLETION REPORT
Post Earthworks Investigation Plan

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 21854.008-2B-101
REV. 0

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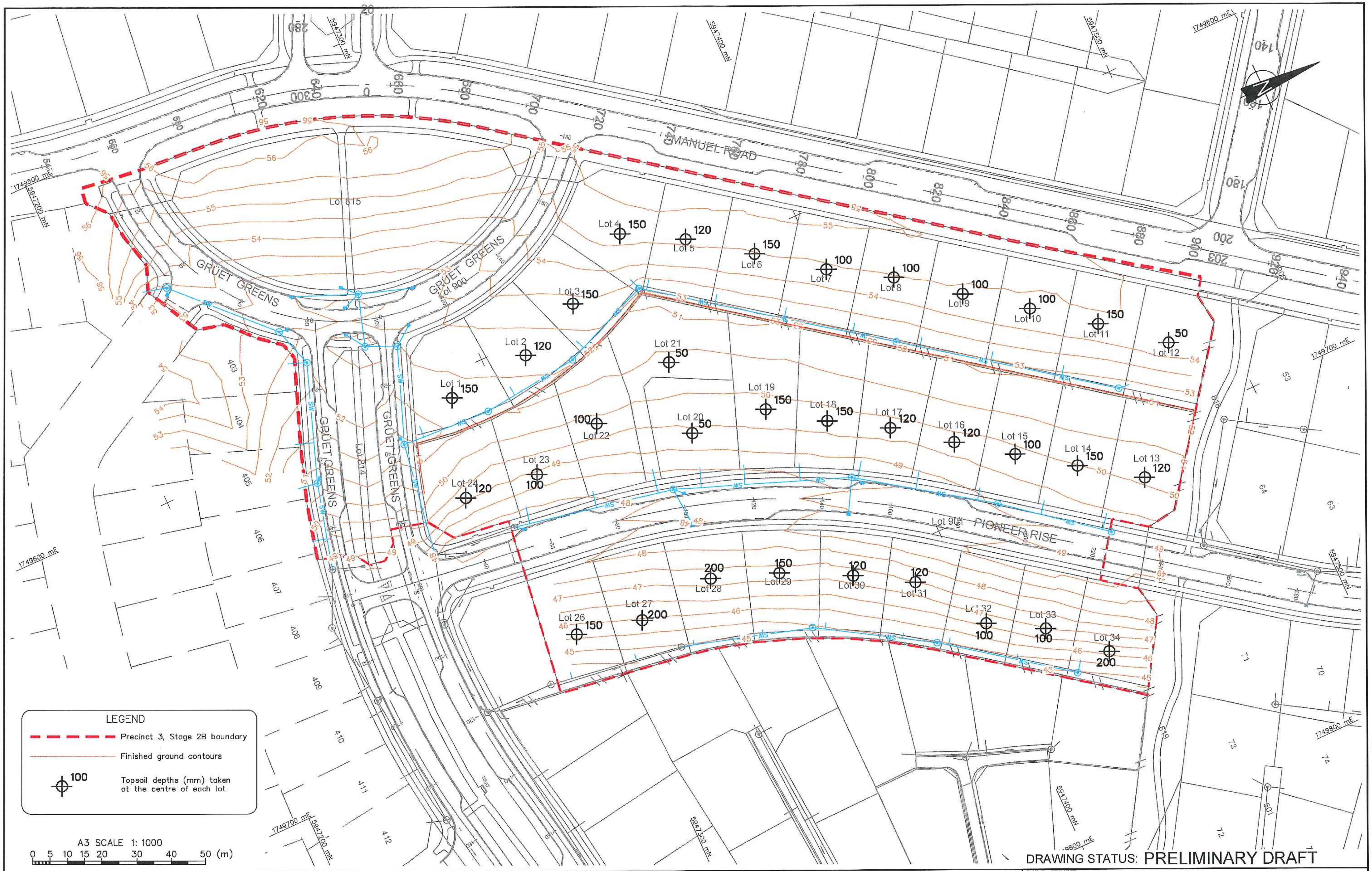

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CLIENT, PROJECT
WFH PROPERTIES LTD
MILLWATER PRECINCT 3, STAGE 2A

TITLE
GEOTECHNICAL COMPLETION REPORT
Topsoil Depths Plan

SCALES (AT A3 SIZE): 1: 1000
DWG. No.: 21854.008-2B-102
REV.: 0

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

File: P:\616531.000\ShrinkSwell\Precinct 3_Stage 2B_Silverdale_Summary.xlsx

Site: **Precinct 3, Stage 2B, Silverdale**

Your Job No: 21854.008

Our Job No: 616531.000

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

Sample ID			**E1**	**E1**	**E2**	**E2**	**E3**	**E3**	**E4**	**E4**
DEPTH		**(m)**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		**(kPa)**	**85**	**85**	**85**	**85**	**85**	**85**	**85**	**85**
INITIAL SAMPLE PARAMETERS	Initial Water Content	(%)	13.5	12.6	12.2	14.6	30.1	29.5	33.8	17.8
	Bulk Density	(t/m³)	2.02	2.14	2.17	2.08	1.86	1.88	1.81	1.96
	Dry Density	(t/m³)	1.78	1.90	1.93	1.82	1.43	1.45	1.35	1.66
	Solid Density (assumed)	(t/m³)	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
	Air Voids	(%)	10.0	5.7	5.0	6.0	4.0	3.5	4.4	9.0
SWELL TEST	Final Water Content	(%)	14.6	13.4	13.0	15.4	30.8	30.4	34.5	19.0
	Swelling Strain	(%)	0.01	0.01	0.08	0.03	0.00	0.03	0.02	0.42
SHRINKAGE TEST	Initial Water Content	(%)	14.7	18.0	14.5	12.6	33.8	25.9	21.8	12.3
	Estimated Shrinkage Limit	(%)	10.6	9.0	9.1	11.7	15.7	12.2	12.0	10.2
	Shrinkage Strain	(%)	3.2	2.6	2.7	3.6	8.3	5.7	4.5	2.1
	Cracking		Big Crack	Big Crack	Big Crack	Big Crack	Big Crack	Big Crack	Big Crack	Big Crack
SHRINK - SWELL INDEX		**(%)**	**1.8**	**1.4**	**1.5**	**2.0**	**4.6**	**3.2**	**2.5**	**1.3**

TEST REMARKS:

The duration of the swell tests were less than 24 hours because the change in swell rate was not significant after this time.

Entered by: ST Date: 23/2/15 Checked by: AH Date: 23/2/15

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Site: **Precinct 3, Stage 2B, Silverdale**

Your Job No: 21854.008

Our Job No: 616531.000

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

SUMMARY OF SHRINK - SWELL TEST RESULTS

			E5	E5	E6	E6	E7	E7	E8	E8
Sample ID			**E5**	**E5**	**E6**	**E6**	**E7**	**E7**	**E8**	**E8**
DEPTH		(m)	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**	**0.5**	**1.0**
Applied Pressure		(kPa)	**85**	**85**	**85**	**85**	**85**	**85**	**85**	**85**
INITIAL SAMPLE PARAMETERS	Initial Water Content	(%)	21.7	22.2	15.9	13.9	21.7	15.9	22.4	18.1
	Bulk Density	(t/m^3)	2.01	1.97	2.08	2.13	1.99	2.09	1.97	1.99
	Dry Density	(t/m^3)	1.65	1.61	1.79	1.87	1.64	1.80	1.61	1.69
	Solid Density (assumed)	(t/m^3)	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
	Air Voids	(%)	1.5	4.6	5.2	4.7	3.7	4.7	4.3	6.8
SWELL TEST	Final Water Content	(%)	22.8	22.9	16.8	14.6	22.3	17.0	23.2	18.9
	Swelling Strain	(%)	0.02	0.03	0.02	0.03	0.01	0.02	0.02	0.02
SHRINKAGE TEST	Initial Water Content	(%)	19.0	24.5	16.2	17.0	9.8	17.2	26.0	15.7
	Estimated Shrinkage Limit	(%)	11.8	12.1	6.3	9.1	10.1	8.6	9.8	10.8
	Shrinkage Strain	(%)	3.7	3.7	1.1	1.8	2.3	1.6	2.0	2.3
	Cracking		Big Crack	Big Crack	Big Crack	Big Crack	Big Crack	Big Crack	Big Crack	Big Crack
SHRINK - SWELL INDEX		(%)	**2.1**	**2.0**	**0.6**	**1.0**	**1.3**	**0.9**	**1.1**	**1.3**

TEST REMARKS:

The duration of the swell tests were less than 24 hours because the change in swell rate was not significant after this time.

Entered by: ST Date: 23/2/15 Checked by: AH Date: 23/2/15

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BOREHOLE LOG

BOREHOLE No:HA1
Hole Location: Refer site plan.
E1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 4/2/15
R.L.:	DRILL METHOD: HAND AUGER	HOLE FINISHED: 4/2/15
		DRILLED BY: HA
DATUM:	DRILL FLUID:	LOGGED BY: HA/RHN CHECKED:

GEOLOGICAL — ENGINEERING DESCRIPTION

Column headings: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | 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 (mm) 50 250 1000 2000 | SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Depth (m)	Method	Tests	Description
0.0 – 3.0	HAND AUGER		Silty, fine SAND; orange. Dry, low plasticity.
~0.4		UTP	
~0.6			- changes to grey.
~0.8		UTP	
~1.2		UTP	
~1.6		UTP	
~2.0		UTP	
~2.4		UTP	
~2.8		UTP	
3.0			**END OF BOREHOLE AT 3m.**

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA2
Hole Location: Refer site plan. E2

SHEET 1 OF 1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 4/2/15
	DRILL METHOD: HAND AUGER	HOLE FINISHED: 4/2/15
R.L.:		DRILLED BY: RHN
DATUM:	DRILL FLUID:	LOGGED BY: RHN CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

Columns: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) | COMPRESSIVE STRENGTH (MPa) | DEFECT SPACING (mm) | SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Depth (m)	Tests	Description
0.0–0.5	>205kPa	Silty SAND; light brown, traces of grey. Dry, low plasticity.
0.5		Sandy SILT; brown. Dry, low plasticity.
	>205kPa	
~1.0	>205kPa	- grey to brown.
1.5	110/188kPa	- periodic minor increase in plasticity.
~1.6		Return to sandy SILT; grey brown. Dry, low plasticity.
2.0	>205kPa	
2.5	>205kPa	
~2.8–3.0	>205kPa >205kPa	
3.0		**END OF BOREHOLE AT 3m.**

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5

T+T DATATEMPLATE.GDT David

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BOREHOLE LOG

BOREHOLE No:HA3
Hole Location: Refer site plan.
E3

PROJECT: Millwater Precinct | LOCATION: P3 - Stage 2B | JOB No: 21854.008

CO-ORDINATES:

R.L.:

DATUM:

DRILL TYPE: Hand Auger

DRILL METHOD: HAND AUGER

DRILL FLUID:

HOLE STARTED: 4/2/15

HOLE FINISHED: 4/2/15

DRILLED BY: HA

LOGGED BY: HA

CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Method	Tests	Depth (m)	Soil Description
HAND AUGER		0.0	TOPSOIL.
		0.2	Silty, fine SAND, with minor clay; blue with traces of brown. Dry.
	>205kPa	~0.4	
		0.7	Sandy CLAY; brown. Moist.
	>205kPa	~0.8	
	>205kPa	~1.2	
		1.4	Sandy SILT; blue. Dry; sand, fine.
	UTP	~1.6	
	UTP	~2.0	
	UTP	~2.4	
	UTP	~2.8	- becomes purple.
	UTP	3.0	**END OF BOREHOLE AT 3m.**

Column headings: FLUID LOSS, WATER, CORE RECOVERY (%), METHOD, CASING, TESTS, SAMPLES, R.L. (m), DEPTH (m), GRAPHIC LOG, CLASSIFICATION SYMBOL, MOISTURE CONDITION / WEATHERING, STRENGTH/DENSITY CLASSIFICATION, SHEAR STRENGTH (kPa), COMPRESSIVE STRENGTH (MPa), DEFECT SPACING (mm)

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BOREHOLE LOG

BOREHOLE No:HA4
Hole Location: Refer site plan. E4

SHEET 1 OF 1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 5/2/15
R.L.:	DRILL METHOD: HAND AUGER	HOLE FINISHED: 5/2/15 DRILLED BY: HA
DATUM:	DRILL FLUID:	LOGGED BY: HA CHECKED:

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION — SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Columns: FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | 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 (mm) 50 250 1000 2000

Method: HAND AUGER

Tests	Depth (m)	Description
	0.0	TOPSOIL.
	0.1	Clayey SILT, with minor sand; blue with traces of orange-brown.
>205kPa		
	0.5	
>205kPa		
	0.8	Silty CLAY; orange brown with traces of blue. Soft, moist.
	1.0	
145/85kPa		
	1.3	SILT; blue. Dry.
	1.4	Silty CLAY; brown-blue. Firm, dry.
	1.5	
UTP		
>205kPa	2.0	
>205kPa		
	2.5	CLAY, with minor silt; brown with traces of orange. Soft, moist.
>205kPa		
145/85kPa	3.0	END OF BOREHOLE AT 3m.
	3.5	
	4.0	
	4.5	
	5	

T+T DATATEMPLATE.GDT David

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA5
Hole Location: Refer site plan.
E5
SHEET 1 OF 1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 5/2/15
R.L.:	DRILL METHOD: HAND AUGER	HOLE FINISHED: 5/2/15
		DRILLED BY: HA
DATUM:	DRILL FLUID:	LOGGED BY: HA CHECKED:

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

Columns: FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | 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 (mm) 50 250 1000 2000

ENGINEERING DESCRIPTION

SOIL DESCRIPTION — Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION — Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Method: HAND AUGER

Tests	Depth (m)	Description
	0.0	TOPSOIL.
		Clayey SILT; blue with traces of brown/orange.
>205kPa	0.5	
>205kPa	1.0	
>205kPa		Silty CLAY; brown with minor orange and blue. Firm, moist.
188/110kPa	1.5	
>205kPa	2.0	Trace of scoria and fine gravel.
171/100kPa	2.5	CLAY, with trace silt; brown with orange traces. Soft, moist.
180/105kPa		
171/100kPa	3.0	END OF BOREHOLE AT 3m.
	3.5	
	4.0	
	4.5	
	5	

T+T DATATEMPLATE.GDT David

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA6
Hole Location: Refer site plan.
E6
SHEET 1 OF 1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 5/2/15
	DRILL METHOD: HAND AUGER	HOLE FINISHED: 5/2/15
R.L.:		DRILLED BY: HA
DATUM:	DRILL FLUID:	LOGGED BY: HA CHECKED:

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION — SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Columns: FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | 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 (mm) 50 250 1000 2000

Method: HAND AUGER

Depth (m)	Tests	Description
0.0		TOPSOIL.
0.1		Clayey SILT; blue with minor brown. Firm, dry.
0.4	UTP	
0.6		SILT, minor clay.
0.8	>205kPa	
1.1		Clayey SILT.
1.2	>205kPa	
1.6	UTP	
1.7		SILT, minor clay.
2.0	UTP	
2.4	>205kPa	
2.5		Clayey SILT.
2.8	>205kPa	
3.0	>205kPa	**END OF BOREHOLE AT 3m.**

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5

T+T DATATEMPLATE.GDT David

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BOREHOLE LOG

BOREHOLE No:HA7
Hole Location: Refer site plan. E7
SHEET 1 OF 1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 9/2/15
R.L.:	DRILL METHOD: HAND AUGER	HOLE FINISHED: 9/2/15 DRILLED BY: HA
DATUM:	DRILL FLUID:	LOGGED BY: HA CHECKED:

GEOLOGICAL — ENGINEERING DESCRIPTION

Column headings: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | 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 (mm) 50 250 1000 2000 | SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Method: HAND AUGER

Tests	Depth (m)	Description
	0.0	TOPSOIL.
		Clayey SILT; brown with traces of yellow. Firm, moist.
>205kPa		
	0.5	
		- becomes blue with traces of yellow/brown.
>205kPa		
	1.0	
>205kPa		
	1.5	
>205kPa		
	2.0	
>205kPa		
>205kPa		
	2.5	Silty CLAY; brown with traces of blue. Firm, moist.
>205kPa		CLAY, with trace silt; yellow grey. Firm, moist.
>205kPa	3.0	**END OF BOREHOLE AT 3m.**
	3.5	
	4.0	
	4.5	
	5	

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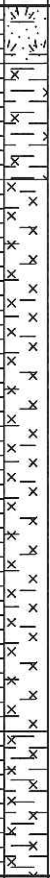
BOREHOLE LOG

BOREHOLE No:HA8
Hole Location: Refer site plan.
E8

SHEET 1 OF 1

PROJECT: Millwater Precinct	LOCATION: P3 - Stage 2B	JOB No: 21854.008
CO-ORDINATES:	DRILL TYPE: Hand Auger	HOLE STARTED: 10/2/15
	DRILL METHOD: HAND AUGER	HOLE FINISHED: 10/2/15
R.L.:		DRILLED BY: HA
DATUM:	DRILL FLUID:	LOGGED BY: HA CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	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 (mm) 50 250 1000 2000	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
				HAND AUGER					0.0–0.2								TOPSOIL.
						>205kPa			0.2–0.6								CLAY, with some silt; brown with traces white and blue. Firm, moist.
						171/100kPa			0.6–2.5								Clayey SILT; blue with some brown. Stiff, moist.
						>205kPa											
						>205kPa											
						UTP											
						>205kPa											
						>205kPa			2.5–3.0								Silty CLAY; brown with some blue. Firm, moist.
						>205kPa			3.0								**END OF BOREHOLE AT 3m.**

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5