Report on Construction testing & Final Site Classification

Hillcrest Estate – Stage 1

304001145-001

Prepared for
Newpro20 Pty Ltd

29 February 2024

Stantec

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Table of Contents

Appendices

Tables

1 Introduction

This report presents the findings of a geotechnical investigation for final site classification (FSC) undertaken by Stantec Australia Pty Ltd (Stantec), for Stage 1 of the Hillcrest Estate residential development located in Lochinvar, NSW. The work was commissioned by Tom Gould on behalf of Newpro20 Pty Ltd.

To assist with planning the investigation and preparation of the subsequent report, Stantec were supplied with subdivision work certificate plans prepared by GCA Engineering Solutions (GCA) titled *"Proposed Subdivision – 48 Windermere Road Lochinvar – Stage 1",* Job No. 22083, Sheets C00-C65 Rev. 3, Dated. 22/011/2022 [1].

Stantec has also reviewed previous investigation reports prepared by Cardno (NSW/ACT) Pty Ltd (Cardno) pertaining to the development:

- "*Report on Geotechnical Investigation – 48 Windermere Road, Lochinvar NSW"* Ref. 81021034-002, Rev 5, dated 29/11/2022 [2].
- "*Preliminary Site Investigation and Salinity Assessment – 48 Windermere Road, Lochinvar NSW"* Ref. 81021034-001, Rev 2, dated 5/07/2021 [3]

Data from the previous investigations has been utilised where appropriate within this report.

Based on the supplied plans, it is understood stage 1 of the development is to comprise the following:

- Creation of sixty (60) residential allotments (Lots 101-160).
- Creation of one (1) residual allotment (Lot 161).
- Construction of approximately 932 m of internal road pavements:
  - Hewitt Road Ch 0 – 395 m.
  - Mahoney Street Ch 0 – 78 m.
  - Boland Road Ch 0 – 176 m.
  - Heaghney Street Ch 146 – 310 m.
  - Cahill Close Ch 0 – 119 m.
- Construction of approximately 280 m of external road pavements (Windermere Road).
- Construction of associated civil infrastructure (e.g. retaining structures, in ground utilities, etc).
- Construction of one (1) bioretention basin and associated drainage infrastructure.

It is noted Stantec were engaged to provide geotechnical consulting and testing services during earthworks for the development. Following construction, a final site classification including commentary on lot filling is required for submission to Maitland City Council.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions to inform the following:

- Final site classification of residential lots in accordance with AS 2870-2011 [4].
- Founding conditions for future residential structures, including allowable bearing capacities.
- Compaction test results for lot filling with reference to AS 3798-2007 [5].
- Comment on basin decommissioning and construction.

2 Previous Investigations

Stantec (previously as Cardno (NSW/ACT) Pty Ltd) undertook investigation to provide preliminary site investigation (PSI) and preliminary geotechnical investigation report for submission with a development application with Maitland City Council (MCC). The investigations were reported under covers:

- "*Report on Geotechnical Investigation – 48 Windermere Road, Lochinvar NSW"* Ref. 81021034-002, Rev 5, dated 29/11/2022 [2].
- "*Preliminary Site Investigation and Salinity Assessment – 48 Windermere Road, Lochinvar NSW"* Ref. 81021034-001, Rev 2, dated 5/07/2021 [3].

The previous investigation comprised the overall Hillcrest Lochinvar development, with Stage 1 situated within the northern portion of the previous investigation footprint.

The investigation for both reports was undertaken concurrently and comprised the excavation of thirty (30) test pits to a target depth of 1.5 m below ground level (BGL) and collection of samples for laboratory testing. Subsurface conditions encountered during the investigation comprised:

- FILL: Filling comprising Silty CLAY encountered in one test pit to depths in the range of 0-0.3 m BGL.
- ALLUVIAL SOIL: comprising Silty CLAY of low plasticity with varying fractions of gravel and sand were encountered in one test pit in the north-eastern portion of the site, bordering the existing creek.
- COLLUVIUM SOILS: comprising Silty CLAY of varying plasticity were encountered at depths of 0.10-0.45 m BGL.
- RESIDUAL SOILS: comprising Silty CLAYs of pale to reddish brown colour were encountered in all test pits to depths of 0.6 to 2.0 m BGL.
- EXTREMELY WEATHERED MATERIAL (EWM): comprising Silty / Sandy CLAY and Clayey SAND, encountered to depths of 1.3 to 2.0 m BGL.
- WEATHERED ROCK: comprising weathered SANDSTONE, fine to medium grained and reddish brown in colour, encountered in one test pit at depths of 0.9 m BGL.

Geotechnical laboratory testing comprised a range of CBR, shrink swell, Atterberg, Emerson Class and permeability testing. Iss results from shrink swell testing ranged from 2.7-6.6 %, indicating site soils are highly reactive.

Findings from the previous geotechnical report have been included herein where relevant.

3 Site Identification

The Site is identified as an irregular parcel of land identified as Lot 1 DP 537313, situated at 48 Windermere Road, Lochinvar. The site comprises Stage 1 of the overall development is bounded by:

- Rural residential properties to the north.
- Windermere road long the western boundary with rural residential properties further west.
- Lochinvar creek to the east.
- Future stages of the Hillcrest Lochinvar development to the south.

Topographically the site is located within regionally sloping gently undulating terrain. Site regrade activities were typically minimal, associated with pad regrade surrounding the basin and minor regrade on lots ot provided level pads.

Generally, site slopes comprise 2-4 degree falls from west to east. Drainage is expected to comprise surface runoff and via stormwater infrastructure towards the bioretention basin and Lochinvar Creek east of the Site. The site was generally devoid of vegetation with sporadic grass and weeds noted across the Site. The following features were observed at the time of site investigation:

- Subdivision construction was nearing completion with stormwater installation and basin works still under construction.
- Spreading of topsoil over the residential was in progress.
- Internal Roads had been constructed to subbase level with footpaths being installed.
- A large topsoil stockpile was present within lots 145-150.
- Small stockpiles of construction material were noted within various allotments associated with current works.

4 Earthworks & Construction Testing

4.1 Extent of Earthworks

Earthworks for the development commenced in April 2023, undertaken by Yates Civil Pty Ltd (Yates). Earthworks for the development was constructed in accordance with supplied regrade plans prepared by GCA [1]. It should be noted that the supplied plans do not include allowance for pavement box out, as such, some of the regrade areas that are noted as requiring fill were dealt with during pavement construction. The extent of earthworks generally comprised:

- Regrade in Lots 112-117, 121, 123-127, 139-141 and 155-160 comprising predominantly filling to depths in the order of 0.1 to 1.0 m to create level building platforms.
- Regrade in Lots 137 and 138 generally comprising cut to fill operations with cut depths comprising between 0 - 0.5 m to create level building platforms.
- Deeper filling within Lots 118 – 120 to remediate the existing farm dam. Filling depths in the order of 0.5-2.0 m were required following de-silting and removal of any unsuitable materials. Further details are in Section 4.5 below.
- Predominantly cutting to the internal road alignments to depths ranging from 0.3 to 0.5 m to achieve subgrade design levels, with filling of Hewitt between Ch 285-354 m and Boland Road between Ch 46-75 m ranging from 0.2 to 0.7 m. Windemere Road pavement widening works generally comprised minor cutting to accommodate the pavement thickness.
- Cutting of the basin floor to depths of up to 2.5 m and filling to form the impoundment of the proposed bioretention basin in the order of up to 2.8 m to achieve final design levels.

4.2 Material Quality

Materials used for filling were sourced from on-site cut areas and boxing of the internal road segments during development. Site won and stockpiled materials other than topsoil were generally deemed suitable for use as general fill.

4.3 Methodology

Regrade operations were generally undertaken by removing topsoil to expose natural in situ soils that were free of significant organic matter. Tree roots were suitably cleared where possible, however, a component of deeper roots may remain in the stripped areas. Unsuitable materials were removed and replaced with site-won general fill.

Fill operations were undertaken by placing layers of approximately 200 mm to 300 mm thickness and compacting to specified limits. Compacted fill layers were then tested for compaction in accordance with the guidelines indicated in AS 3798-2007 Guidelines for Earthworks on Residential and Commercial Developments (Australian Standard AS3798-2007) [5].

Table 5.1 Item 1 of AS 3798-2007 [5] was adopted as the appropriate compaction for the work with a minimum relative compaction of 95% standard required as appropriate for residential - lot fill housing sites.

Fill was tested in accordance with Table 8.1 Frequency of Field Density Tests for Type 1 Large Scale Operations (Australian Standard AS3798-2007) [5]. Placement and compaction of fill was undertaken by NATA accredited laboratory site personnel providing level 1 onsite inspection and testing services during earthworks activities in accordance with AS 3798-2007 [5] .

4.4 Lot Fill Test Results

Results of compaction testing of all structural fill areas undertaken by a NATA accredited construction materials laboratory indicate that the filling operations have satisfied the compaction criteria for “controlled fill” as defined in Clause 1.8.13 of AS2870-2011 [4] and compaction requirements as per Maitland City Council (MCC) guidelines.

All testing has either met with or exceeded the specification adopted of 95% standard compaction at moisture contents of generally 85% to 115% of Standard Optimum Moisture Content (SOMC) at the time of

placement. Some tests returned values dry and wet of this range; however, as specified compaction was achieved this is expected to have minimal adverse impacts on proposed residential structures.

Geotechnical services provided during regrade comply with AS 3798-2007 [5] with testing undertaken to the minimum frequency as indicated in Table 8.1 for Type 1 – Large Scale Operations.

A total of eighty-six (86) compaction tests were conducted on structural fill placed during earthworks (identified as both general fill and lot fill on test reports or those tests deemed as lot fill), with results shown on NATA accredited test certificates attached in Appendix C.

4.5 Decommissioning of the Existing Rual Dams

Further to the above, earthworks were undertaken to decommission the existing rural dams within Lots 118-120 and at the western edge of the newly constructed basin. Decommissioning generally comprised draining of the dams followed by de-silting and removal of any unsuitable material (including any over-wet or highly organic impacted material) from the former dams and immediate excavation of the existing flow paths. Excavation was undertaken until stiff or better suitable natural material was encountered and exposed, confirmed by inspection by a suitably qualified geotechnical consultant from Stantec.

Inspection of the dam decommissioning was undertaken by a qualified geotechnical consultant to confirm removal of deleterious material and suitability of the stripped surface prior to controlled fill operations to design levels in accordance with AS 3798-2007 [5]. No indications of foreign material within the dam floor were observed during stripling of dam sediments. Testing was undertaken on all filling works in accordance with Section 8 of AS 3798-2007 [5].

4.6 Biofiltration Basin Construction

It is noted a stormwater quality basin was constructed in the eastern portion of the site as part of the subdivision development.

During construction, several inspections were undertaken by a geotechnical principal from Stantec during progressive stripping of the basin and removal of the basin sidewalls. The inspections indicated the basin impoundment area was founded within the residual clay and EWM profile which was considered suitable for the proposed construction.

Further inspection was undertaken to assess the suitability of the basin keyway. The keyway was noted to be founded within the residual clay and EWM profile. The exposed foundation was considered suitable for the keyway and construction of the basin core. The core was constructed utilising selected lower reactive site won clays and placed and compacted in nominal 300 mm layers, to a compaction specification of 98% standard compaction. Testing was undertaken in accordance with AS 3798-2007. Progressive inspections were undertaken during filling works to confirm suitability of the basin wall.

Inspection of seepage collars was undertaken by a geotechnical consultant from Stantec during construction to confirm construction as per the design requirements.

5 Final Site Classification

Stantec have previously undertaken geotechnical investigations within the Site for the purpose of geotechnical investigation, pavement design, and recommendations for the proposed residential development. Inspections and engineering advice were also provided during civil construction.

A review of previously investigations within the Site was undertaken, with relevant geotechnical data utilised within the current investigation (where appropriate).

5.1 Investigation Methodology

5.1.1 Site Investigation

Site investigation was undertaken over two consecutive days on the 5th and 6th December 2023 and comprised the drilling of twenty (20) test bores within the proposed Stage 1 allotment areas. Test bores were advanced utilising a 4WD ute-mounted drill rig fitted with either 125 mm solid flight auger and v-bit/tc-bit drilling head attachment or a 300 mm short spiral auger with TC attachments. Test bores were advanced to a target depth of 2.0 m with prior refusal on possible weathered sandstone/siltstone rock occurring within test bore locations TB004-TB006, TB008-TB009, TB013 and TB018-TB019 at depths ranging from 0.8 to 1.9 m BGL.

Dynamic cone penetrometer tests (DCP) were conducted at each test bore location to aid in the assessment of subsurface strength conditions. Three (3) thin wall tube (50 mm diameter) samples and four (4) disturbed samples, where density impacted the ability to retrieve undisturbed samples, of natural and materials placed as fill were collected for subsequent laboratory testing.

All fieldwork including logging of subsurface profiles and collection of samples was conducted by a geotechnical consultant from Stantec. Test locations were located by reference to client supplied plans, as shown in Appendix A. Test locations are shown overlaid on georeferenced aerial imagery and client supplied regrade plans on Figure F1, attached as Appendix A.

5.1.2 Laboratory Testing

Laboratory testing on selected samples recovered during fieldwork comprised seven (7) shrink swell tests on representative samples of the encountered natural and fill clayey soils at the site.

The geotechnical testing was conducted at a NATA accredited construction materials testing laboratory. Results of laboratory testing are detailed in the reports sheets attached in Appendix C and summarised in Section 6.3 below.

6 Investigation Findings

6.1 Published Geology

Reference to the New South Wales Seamless Geology dataset [6] indicates the site is underlain by the Lochinvar Formation (Pdal) of the Dalwood Group. The formation consists of basalt, siltstone, sandstone and residual soils derived from weathering of these materials.

6.2 Subsurface Conditions

The subsurface conditions encountered across the site can generally be summarised as follows:

Topsoil Fill	Silty SAND / Sandy Silty CLAY surficial material fine to coarse grained, of low plasticity, brown / dark brown in colour, with variable gravel components. Surficial Fill placed as topsoil was encountered to depths ranging approximately 0.05 to 0.35 m in thickness, encountered within all test bores excluding TB006 & TB014.
Controlled Fill	Generally, Silty / Silty Sandy / Sandy CLAY site-won materials varying from low to high plasticity, with variable sand and gravel inclusions, and predominantly dark brown to brown in colour. Controlled fill materials were encountered in test bores TB001-TB003, TB014-TB015 and TB017-TB019, to depths generally consistent with the supplied earthworks plans, ranging from 0.25 m to 1.3 m BGL. Fill materials were typically moist in condition and generally well-compacted (based on DCP testing).
Colluvial	Predominantly medium to high plasticity Silty CLAY, generally brown in colour, encountered in test bore locations TB004-TB006 and TB008-TB012 to depths ranging from 0.2 to 0.35 m BGL. Colluvial clay materials were generally above the plastic limit in moisture conditions, and predominantly stiff to very stiff in consistency.
Alluvial	Predominantly medium to high plasticity Silty CLAY, generally yellow- brown in colour, with varying components of sand and gravel present, encountered in test bore locations TB001 & TB002 to the extent of target depth of 2.0 m BGL. Alluvial clay materials ranged from less than to above the plastic limit in moisture conditions, and predominantly very stiff to hard in consistency.
Residual	Predominantly medium to high plasticity Silty CLAY, generally brown in colour, with varying components of sands and gravels encountered in all test bore locations with the exception of TB001 and TB002 to depths ranging from 0.7 to >2.0 m BGL. Residual clay materials ranged from equal to above the plastic limit in moisture conditions, and generally ranged from firm to very stiff in consistency.
Extremely Weathered Material (EWM)	Extremely weathered Sandy/ Sandy Silty / Silty CLAY encountered in test bore locations TB003-TB006, TB008-TB009, TB013 & TB018-TB020 from depths ranging from 0.7 to 1.9 m BGL. Extremely weathered materials were typically grey yellow and brown in colour, and generally consistent with very stiff to hard, low to medium plasticity. Moisture condition of the extremely weathered materials were assessed as generally below the plastic limit.
Weathered Rock	Weathered Sandstone rock was encountered in test bore TB009 from a depth of 1.3 m BGL. The sandstone was grey-brown in colour with fine to course sand grains. The sandstone was of a low strength increasing with depth resulting in TC refusal at a depth of 1.6m BGL.

No groundwater or seepage was encountered within any of the test bore locations across the proposed development at the time of fieldwork. It should be noted that groundwater levels are likely to fluctuate with variations in climatic and site conditions.

The subsurface conditions are detailed in the engineering logs attached in Appendix B, together with explanatory notes.

6.3 Laboratory Results

The results of the laboratory shrink swell tests undertaken on representative cohesive subsoils across the site in current conditions are summarised below in Table 6-1 with the test report sheets attached in Appendix C.

Table 6-1 Summary of Shrink Swell Test Results

Test Bores	Depth (m)	Sample Type	Soil Type	E_{SH} (%)	E_{SW} (%)	I_{SS} (%)
TB001	1.3-1.5	D	Silty CLAY	7.7	1.8	4.8
TB002	0.4-0.8	D	FILL: Silty Sandy CLAY	3.9	0.4	2.3
TB008	0.3-0.9	U50	Silty CLAY	6.3	0.7	3.7
TB010	0.6-1.0	U50	Silty CLAY	6.5	0.6	3.8
TB014	0.1-0.7	D	FILL: Silty CLAY	4.6	0.8	2.8
TB017	0.8-1.5	D	Silty CLAY	6.0	1.7	3.8
TB020	0.3-0.8	U50	Silty CLAY	5.6	0.1	3.1

Notes to table:
U50 Testing undertaken on thin walled 50mm diameter tube
D Disturbed
E_{SW} Swelling Strain
E_{SH} Shrinkage Strain
I_{SS} Shrink Swell Index

7 Final Site Classification

7.1 General

Australian Standard AS 2870-2011 [4] establishes performance requirements and specific designs for common foundation conditions as well as providing guidance on the design of footing systems using engineering principles. Site classes as defined on Table 2.1 and 2.3 of AS 2870 are presented on Table 7-1 below.

Table 7-1 General Definition of Site Classes

Site Class	Foundation	Characteristic Surface Movement
A	Most sand and rock sites with little or no ground movement from moisture changes	
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes	0 - 20mm
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 - 40mm
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 - 60mm
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 - 75mm
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes	> 75mm
A to P	Filled sites (refer to clause 2.4.6 of AS 2870)	
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.	

Reactive sites are sites consisting of clay soils that swell on wetting and shrink on drying, resulting in ground movements that can damage lightly loaded structures. The amount of ground movement is related to the physical properties of the clay and environmental factors such as climate, vegetation and watering. A higher probability of damage can occur on reactive sites where abnormal moisture conditions occur, as defined in AS 2870, due to factors such as:

- Presence of trees on the building site or adjacent site, removal of trees prior to or after construction, and the growth of trees too close to a footing. The proximity of mature trees and their effect on foundations should be considered when determining building areas within each allotment (refer to AS 2870);
- Failure to provide adequate site drainage or lack of maintenance of site drainage, failure to repair plumbing leaks and excessive or irregular watering of gardens;
- Unusual moisture conditions caused by removal of structures, ground covers (such as pavements), drains, dams, swimming pools, tanks etc.

In regard to the performance of footings systems, AS 2870 states “footing systems designed and constructed in accordance with this Standard on a normal site (see Clause 1.3.1) [1] that is:

(a) not subject to abnormal moisture conditions; and

(b) maintained such that the original site classification remains valid and abnormal moisture conditions do not develop;

are expected to experience usually no damage, a low incidence of damage category 1 and an occasional incidence of damage category 2.”

Damage categories are defined in Appendix C of AS 2870, which is reproduced in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner’s Guide.

The laboratory shrink-swell test results summarised in Table 6-1 and review of the previous report, indicate that the tested cohesive soils at the site from the current and previous investigations are;

- Natural site clays; moderately to highly reactive, with I_{ss} values in the range of 3.1% to 4.8%; and
- Fill Soils; moderately reactive, with I_{ss} values in the range of 2.3% to 2.8%.

The classification of sites with controlled fill more than 0.40 m deep of material other than sand would be Class P. An alternative classification may however be given to sites with controlled fill where consideration is made to the potential for movement of the fill and underlying soil based on the moisture conditions at the time of construction and the long-term equilibrium moisture conditions.

The following classifications are provided under the assumption that all topsoil, slopewash (if encountered) and deleterious materials are removed prior to construction. This includes addressing any surficial soils negatively impacted by inclement weather and ponding of stormwater.

7.2 Site Classification

Based on the subsurface profiles encountered during the investigation and laboratory shrink swell test results, and in accordance with the AS2870-2011 [4], the lots in their existing condition following the removal of stockpiled materials within lots 145-150 and in the absence of abnormal moisture conditions would be classified as shown in Table 7-2.

Table 7-2 Site Classification for Stage 1 Lots

Site Classification	Existing Condition - Lot Numbers
Class H2 – Highly Reactive	Lots: 109-121 & 155-160
Class H1 – Highly Reactive	Lots: 101-108, 124-136 & 140-154
Class M – Moderately Reactive	Lots: 122-123 & 137-139

The above site classifications are based on a calculated characteristic surface movement of between **60-70 mm** for the **Class H2** lots, **40-56 mm** for the **Class H1** lots and between **25-35 mm** for the **Class M** lots within the site in its existing condition. Calculations were based on the soil profile, depth of cut / fill and depth to rock encountered at the test bore locations at the time of fieldwork.

Footings for residential structures shall be designed and constructed in accordance with Section 7.3 below. The classifications assume that all footings (edge beams, internal beams and load support thickenings) are founded below any topsoil, uncontrolled fill or deleterious materials.

It should be appreciated that the site classifications provided above are based on test bores, laboratory results and tactile assessment of multiple layers over the depth of total soil suction change in the soil profile. It should be noted that individual lot development can include other geotechnical studies and care should be taken that single laboratory results are not allocated to the full depth of the soil profile; as biased site classifications can result.

The above site classifications and footing recommendations are for the site conditions present at the time of fieldwork and consequently the site classification may need to be reviewed with consideration of any site works that may be undertaken subsequent to the investigation and this report.

Site works may include:

- Changes to the existing soil profile by cutting and filling;
- Landscaping, including trees removed or planted in the general building area; and
- Drainage and watering systems.

Design methods presented in AS 2870-2011 [4] are based on the performance requirement that significant damage can be avoided provided that site conditions are properly maintained. Performance requirements and foundation maintenance are outlined in Appendix B of AS 2870. The above site classification assumes that the performance requirements as set out in Appendix B of AS 2870 are acceptable and that site foundation maintenance is undertaken to avoid extremes of wetting and drying.

Details on appropriate site and foundation maintenance practices are presented in Appendix B of AS 2870-2011 and in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's Guide, which is attached as Appendix D of this report.

Adherence to the detailing requirement outlined in Section 5 of AS 2870-2011 [4] is essential, in particular Section 5.6. Additional requirements for Classes S, M and H1/H2 sites, including architectural restrictions, plumbing and drainage requirements.

7.3 Footings

All foundations should be designed and constructed in accordance with AS 2870-2011, Residential Slabs and Footings [4] with reference to the site classifications within Table 7-2.

All footings should be founded below any topsoil, deleterious soils, uncontrolled fill (if encountered) or residual soils with a significant organic component. The residual profile and general fill profiles encountered was of reasonable consistency at the time of fieldwork and would generally be suitable for the foundation of footings, subject to inspection at the time of construction.

All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements.

All footings excavations should be inspected prior to installation of structural steel by Stantec or a qualified geotechnical consultant to confirm that the founding conditions are as described in this report. All loose material should be cleared from the footing excavations before concrete is poured.

7.3.1 High-Level Footings

High-level footing alternatives could be expected to comprise slabs on ground with edge beams or pad footings for the support of concentrated loads. Such footings designed in accordance with engineering principles and founded in stiff or better natural soils (below topsoil, uncontrolled fill (if encountered), deleterious material or soils affected by tree roots) or in controlled fill (placed and compacted in accordance with AS3798-2007 [5]) may be proportioned on an allowable bearing capacity of 100 kPa.

If preparation for ground slabs encounters materials affected by organics such as tree roots, over excavation to remove the materials may be required.

The founding conditions should be assessed by a geotechnical consultant or experienced engineer to confirm suitable conditions.

7.3.2 Piered Footings

Piered footings are considered as an alternative to deep edge beams or high-level footings. It is suggested that piered footings, founded in stiff or better clay soils or controlled fill could be proportioned on an end bearing pressure of 100 kPa. Where uniformly founded in the underlying bedrock, an end bearing pressure of 500 kPa could be adopted.

Where piered footings are utilised, the potential for volume change in the subsurface profile should be taken into consideration by the designer, along with potential settlement.

All footings should be founded below any topsoil, deleterious soils, uncontrolled fill (if encountered) or soils affected by tree roots. All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements.

Inspection of high level or pier footings excavations should be undertaken to confirm the founding conditions and the base should be cleared of fall-in prior to the formation of the footing.

8 Limitations

Stantec have performed investigation and consulting services for this project in general accordance with current professional and industry standards. The extent of testing was limited to discrete test locations and variations in ground conditions can occur between test locations that cannot be inferred or predicted.

A geotechnical consultant or qualified engineer shall provide inspections during construction to confirm assumed conditions in this assessment. If subsurface conditions encountered during construction differ from those given in this report, further advice shall be sought without delay.

Stantec, or any other reputable consultant, cannot provide unqualified warranties nor does it assume any liability for the site conditions not observed or accessible during the investigations. Site conditions may also change subsequent to the investigations and assessment due to ongoing use.

This report and associated documentation was undertaken for the specific purpose described in the report and shall not be relied on for other purposes. This report was prepared solely for the use by Newpro20 Pty Ltd and any reliance assumed by other parties on this report shall be at such parties own risk.

9 References

[1] GCA Engineering Solutions Pty Ltd, ""Proposed Subdivision – 48 Windermere Road Lochinvar – Stage 1", Job No. 22083, Sheets C00-C65 Rev. 3," 2022.

[2] Cardno (NSW/ACT) Pty Ltd, "Report on Geotechnical Investigation 48 Windermere Road, Lochinvar NSW" Ref. 81021034-002, Rev 5," 2022.

[3] Cardno (NSW/ACT) Pty Ltd, "Preliminary Site Investigation and Salinity Assessment – 48 Windermere Road, Lochinvar NSW (81021034-001.2)," July 2021.

[4] Australian Standard AS2870-2011, "Residential Slabs and Footings," Standards Australia, 2011.

[5] Australian Standard AS3798-2007, "Guidelines on Earthworks for Commercial and Residential Structures," Standards Australia, 2007.

[6] NSW Department of Planning, Industry & Environment, "MinView," 2023.11.10. [Online]. Available: https://minview.geoscience.nsw.gov.au/. [Accessed October 2023].

Hillcrest Estate – Stage 1

APPENDIX

A

SITE DRAWINGS

Stantec

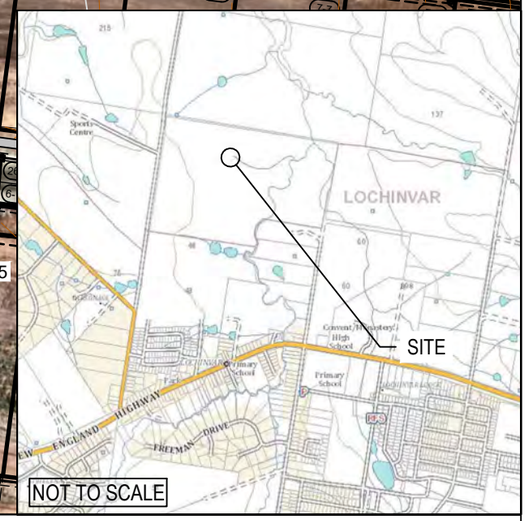
NOTES:

Image underlay adapted from metromaps aerial imagery.

LEGEND:

TBXXX Approximate test bore locations and numbers.

TB020
TB019
TB018
TB017
TB016
TB015
TB0013
TB0012
TB011
TB010
TB009
TB008
TB005



NOT TO SCALE

0 20 40m

SCALE 1:1000 @A3

NORTH

Stantec
Stantec Australia Pty Ltd | ABN 17 007 820 322
Suite 2, Level 2, 22 Honeysuckle Drive
Newcastle, NSW 2300
Tel: 02 4965 4555 Fax: 02 4965 4666
Web: www.stantec.com

Drawn	GE	Date 12/01/2024
Checked	KS	Date
Designed		Date
Verified		Date
Approved		

Client: Newpro20 Pty Ltd

Project: Geotechnical Investigation
Hillcrest Estate Stage 1
Lochinvar, NSW

Title: Test Location Plan

Status: FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
304001145	1:1000 m	A3

Figure Number: Site Plan Figure 1

Revision: 1

DATE PLOTTED: 12 January 2024 11:28 AM BY: EDWARDS, GEOFF

XREF's:
CAD File: U:\304001145\100_ex\drawings\working\304001145 - Windermere Rd.dwg

NOTES:

Image underlay adapted from metromaps aerial imagery.

LEGEND:

TBXXX Approximate test bore locations and numbers.

0 20 40m

SCALE 1:1000 @A3

NORTH

Stantec
Stantec Australia Pty Ltd | ABN 17 007 820 322
Suite 2, Level 2, 22 Honeysuckle Drive
Newcastle, NSW 2300
Tel: 02 4965 4555 Fax: 02 4965 4666
Web: www.stantec.com

Drawn	GE	Date 12/01/2024
Checked	KS	Date
Designed		Date
Verified		Date
Approved		

Client: Newpro20 Pty Ltd

Project: Geotechnical Investigation
Hillcreast Estate Stage 1
Lochinvar, NSW

Title: Test Location Plan

Status: FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
304001145	1:1000 m	A3

Figure Number: Site Plan Figure 2

Revision: 1

DATE PLOTTED: 12 January 2024 11:29 AM BY : EDWARDS, GEOFF

XREF's:
CAD File: U:\304001145\100_xx\drawing\working\304001145 - Windermere Rd.dwg

Hillcrest Estate – Stage 1

APPENDIX

B

ENGINEERING LOGS

Stantec

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TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB001

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
200mm AS		Stable	Not Encountered		6	0.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D		FILL
					11				0.20m FILL: Silty Sandy CLAY; nedium to high plasticity, dark brown, fine to coarse grained sand, with fine to coarse sub-rounded to angular gravel	M (≈PL) to M (>PL)		
					12							
					18	0.5			Light brown, trace cobbles			
					12						VSt to H	
					6					M (≈PL)		
					7	1.0			Medium plasticity, grey mottled red and yellow			
					7				1.20m Silty CLAY; medium plasticity, yellow brown, with fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel			ALLUVIUM
				SB 1.30 - 1.50 m	5							
					5	1.5						
					4					M (>PL)	St	
					4							
					6							
						2.0			2.00m TERMINATED AT 2.00 m Target depth			

METHOD
- EX Excavator bucket
- R Ripper
- HA Hand auger
- PT Push tube
- SON Sonic drilling
- AH Air hammer
- PS Percussion sampler
- AS Short spiral auger
- AD/V Solid flight auger: V-Bit
- AD/T Solid flight auger: TC-Bit
- HFA Hollow flight auger
- WB Washbore drilling
- RR Rock roller

PENETRATION
- VE Very Easy (No Resistance)
- E Easy
- F Firm
- H Hard
- VH Very Hard (Refusal)

WATER
- Water Level on Date shown
- water inflow
- water outflow

FIELD TESTS
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer
- DCP - Dynamic Cone Penetrometer
- PSP - Perth Sand Penetrometer
- MC - Moisture Content
- PBT - Plate Bearing Test
- IMP - Borehole Impression Test
- PID - Photoionisation Detector
- VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
- B - Bulk disturbed sample
- D - Disturbed sample
- ES - Environmental sample
- U - Thin wall tube 'undisturbed'

MOISTURE
- D - Dry
- M - Moist
- W - Wet
- PL - Plastic limit
- LL - Liquid limit
- *w* - Moisture content

SOIL CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB002

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
200mm AS		Stable	Not Encountered		10	0.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D		FILL
						0.20m			FILL: Silty Sandy CLAY; medium to high plasticity, dark brown, fine to coarse grained sand, trace fine to medium sub-rounded to angular gravel			
				SB 0.40 - 0.80 m	13 16 12	0.5					H	
					5 4 6	1.0				M (≈PL) to M (>PL)	St to VSt	
					10 5							
				ZL 1.30 - 1.50 m	4	1.5			Silty CLAY; medium to high plasticity, light yellow brown, with fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel			ALLUVIUM
				ZL 1.50 - 1.80 m	4 2 3				Mottled red yellow and grey	M (>PL)	F to St	
					2	2.0						
					2 4 3 4	2.5			TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB003

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		11 5 4 5 4 3 2 3 4 4 5 9 14	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D		FILL
									0.15m FILL: Silty CLAY; medium plasticity, dark brown, with fine to coarse grained sand, trace fine to medium gravel	M (≈PL)	St	
									0.25m Silty CLAY; medium to high plasticity, light yellow brown, with fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel			RESIDUAL SOIL
									Grey mottled yellow	M (>PL)	F to St	
									1.50m Silty CLAY; medium plasticity, grey mottled yellow, trace fine to medium grained sand	M (>PL)	St to VSt	
									1.90m Silty CLAY; low to medium plasticity, grey mottled yellow	M (<PL)	H	EXTREMELY WEATHERED
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

Water Level on Date shown
water inflow
water outflow

FIELD TESTS

SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY

VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY

VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB004

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	SB 0.30 - 0.70 m	8 3 4 5 6 19 22 22	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown 0.10m	D		FILL
									Sandy Silty CLAY; medium plasticity, dark brown, fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel 0.25m	M (≈PL)	St	COLLUVIUM
									Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine to medium sub-rounded to angular gravel 0.90m	M (≈PL) to M (>PL)	St to VSt	RESIDUAL SOIL
									Sandy CLAY; medium plasticity, yellow brown, fine to coarse grained sand (Sandstone/Siltstone) 1.40m	M (<PL)	H	EXTREMELY WEATHERED
									TERMINATED AT 1.40 m V-bit refusal on weathered rock			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB005

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling				Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		6	0.5			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									0.10m Sandy Silty CLAY; medium plasticity, dark brown, fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (≈PL)	St	COLLUVIUM
					4				0.20m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine to medium sub-rounded to angular gravel	M (>PL)	VSt	RESIDUAL SOIL
					8							
					11							
					14				0.70m Sandy CLAY; medium plasticity, brown grey, fine to coarse sand	M (≈PL) to M (>PL)	H	EXTREMELY WEATHERED
					15	1.0						
					20							
					22							
						1.5			1.90m TERMINATED AT 1.90 m V-bit refusal on weathered rock			
						2.0						

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB006

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		9 5 7 16 22	0.5 1.0 1.5 2.0			Silty CLAY; medium plasticity, dark brown, trace fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (≈PL)		COLLUVIUM
									0.20m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (>PL)	St to VSt	RESIDUAL SOIL
									0.70m Sandy Silty CLAY; low to medium plasticity, brown, fine to coarse grained sand, trace fine to medium sub-rounded to angular gravel	D	H	Possibly EXTREMELY WEATHERED
									1.10m TERMINATED AT 1.10 m Refusal			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

Water Level on Date shown
water inflow
water outflow

FIELD TESTS

SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY

VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY

VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB007

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling				Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		4	0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
					3	0.25m						
					6				Silty CLAY; medium to high plasticity, yellow brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (>PL)	St to VSt	RESIDUAL SOIL
					6	0.5						
					6							
					10							
					9	1.00m						
					10	1.0			Silty CLAY; medium to high plasticity, grey mottled orange and brown, trace fine to coarse grained sand, trace fine to sub-rounded gravel			
					12							
					14					M (>PL)	VSt to H	
					18	1.5						
					24				Grey mottled yellow and brown			
						2.00m						
						2.0			TERMINATED AT 2.00 m Target depth			

METHOD
- EX Excavator bucket
- R Ripper
- HA Hand auger
- PT Push tube
- SON Sonic drilling
- AH Air hammer
- PS Percussion sampler
- AS Short spiral auger
- AD/V Solid flight auger: V-Bit
- AD/T Solid flight auger: TC-Bit
- HFA Hollow flight auger
- WB Washbore drilling
- RR Rock roller

PENETRATION
- VE Very Easy (No Resistance)
- E Easy
- F Firm
- H Hard
- VH Very Hard (Refusal)

WATER
- Water Level on Date shown
- water inflow
- water outflow

FIELD TESTS
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer
- DCP - Dynamic Cone Penetrometer
- PSP - Perth Sand Penetrometer
- MC - Moisture Content
- PBT - Plate Bearing Test
- IMP - Borehole Impression Test
- PID - Photoionisation Detector
- VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
- B - Bulk disturbed sample
- D - Disturbed sample
- ES - Environmental sample
- U - Thin wall tube 'undisturbed'

MOISTURE
- D - Dry
- M - Moist
- W - Wet
- PL - Plastic limit
- LL - Liquid limit
- *w* - Moisture content

SOIL CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB008

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	U50 0.30 - 0.80 m	8 9 5 5 5 3 4 6 8 8 13 17	0.5 1.0 1.5 2.0			0.05m TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									Sandy Silty CLAY; medium to high plasticity, dark brown, fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (>PL)	VSt	COLLUVIUM
									0.25m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel		St	RESIDUAL SOIL
									As above, colour change to Brown red	M (>PL)		
									1.70m		VSt	
									Sandy CLAY; low to medium plasticity, brown, fine to coarse grained sand	M (≈PL)	H	EXTREMELY WEATHERED
									1.90m TERMINATED AT 1.90 m V-bit refusal on weathered rock			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

Water Level on Date shown
water inflow
water outflow

FIELD TESTS

SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY

VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY

VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB009

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
200mm AS		Stable	Not Encountered		4 4 8 12 16 22	0.5 1.0 1.5 2.0			0.05m FILL: Silty CLAY; medium to high plasticity, brown, with fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (<PL)		FILL
									Silty CLAY; medium plasticity, dark brown, trace fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (>PL)	St	COLLUVIUM
									0.30m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (>PL)	VSt to H	RESIDUAL SOIL
									0.80m Sandy CLAY; low to medium plasticity, yellow brown, fine to coarse grained sand, trace fine to medium sub-rounded gravel	M (>PL)	H	EXTREMELY WEATHERED
									1.30m SANDSTONE; low strength, grey-brown, fine to coarse grained	M (≈PL) to M (>PL)		WEATHERED ROCK
									1.60m TERMINATED AT 1.60 m Refusal			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB010

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	U50 0.60 - 1.05 m	4 10 6 5 4 4 2 3 3 3 4 6 5	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									0.10m Sandy Silty CLAY; medium to high plasticity, dark brown, fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (>PL)	VSt	COLLUVIUM
									0.35m Silty CLAY; medium to high plasticity, mottled red brown black, trace fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (>PL)	F to St	RESIDUAL SOIL
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB011

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		8 5 4 4 4 4 3 3 5 4 8 6	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									0.10m Silty CLAY; medium to high plasticity, dark brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (>PL)	St	COLLUVIUM
									0.30m Silty CLAY; medium to high plasticity, light brown, trace fine to coarse grained sand, trace fine to medium sub-rounded gravel			RESIDUAL SOIL
									Mottled grey brown red	M (>PL)	St	
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB012

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	SB 0.80 - 1.50 m	6 6 5 6 7 11 14 20 21	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown 0.10m Silty CLAY; medium to high plasticity, dark brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel 0.30m Silty CLAY; medium to high plasticity, light brown, trace fine to coarse grained sand, trace fine to medium sub-rounded gravel Red brown 2.00m TERMINATED AT 2.00 m Target depth	D to M M (>PL) M (>PL)	St St to VSt H	FILL COLLUVIUM RESIDUAL SOIL

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB013

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		8	0.5			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
					8				0.10m Silty CLAY; medium to high plasticity, dark brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (>PL)	St to VSt	RESIDUAL SOIL
					5				0.40m Silty CLAY; medium plasticity, red brown, trace fine to coarse grained sand	M (≈PL) to M (>PL)	St to VSt	
					6				0.70m Sandy CLAY; low to medium plasticity, light brown, fine to coarse grained sand	D to M (<PL)	H	EXTREMELY WEATHERED
					11				0.80m			
					15	1.0			TERMINATED AT 0.80 m Refusal			
						1.5						
						2.0						

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

Water Level on Date shown
water inflow
water outflow

FIELD TESTS

SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY

VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY

VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB014

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling				Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	SB 0.10 - 0.70 m	10, 9, 10, 8, 6, 10, 17, 8, 7, 6, 8, 11, 15	0.5, 1.0, 1.5, 2.0			FILL: Silty CLAY; medium plasticity, brown, trace fine to coarse grained sand, trace fine to coarse sub-rounded gravel	M (≈PL)	VSt	FILL
									1.10m Silty CLAY; medium plasticity, dark brown, trace fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (>PL)	VSt	RESIDUAL SOIL
									1.60m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (≈PL)	VSt to H	
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB015

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		10 6 8 7 6 6 12 10 7 10 6 6 5	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									0.10m FILL: Silty CLAY; medium plasticity, brown, trace fine to coarse grained sand, trace fine to coarse sub-rounded gravel	M (>PL)	St to VSt	
									0.50m FILL: Sandy CLAY; medium plasticity, brown grey, fine to coarse grained sand, trace fine to medium sub-rounded to sub-angular gravel	M (≈PL)	St to VSt	
									1.30m Silty CLAY; medium plasticity, brown, trace fine to coarse grained sand, trace fine to sub-rounded gravel Yellow brown	M (>PL)	St	RESIDUAL SOIL
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB016

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling				Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	SB 0.30 - 0.90 m	6 5 6 9 12 12 13 11 12 15 16 14 15	0.5 1.0 1.5 2.0			TOPSOIL FILL: Sandy Silty CLAY; medium plasticity, dark brown, fine to coarse grained sand, trace fine to coarse sub-rounded to sub-angular gravel	M (≈PL)		FILL
									0.35m Silty CLAY; medium to high plasticity, yellow brown, trace fine to coarse grained sand, trace fine sub-rounded gravel	M (≈PL) - M (>PL) M (>PL)	VSt H	RESIDUAL SOIL
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB017

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling				Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	SB 0.80 - 1.50 m	7 6 5 6 5 5 5 4 3 4 4 5 5	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									0.10m FILL: Sandy silty CLAY; medium plasticity, dark brown, fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (≈PL) to M (>PL)	St	
									0.40m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine to sub-rounded to sub-angular gravel	M (>PL)	St	RESIDUAL SOIL
									2.00m TERMINATED AT 2.00 m Target depth			

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
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IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB018

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		6 4 3 4 4 6 12 19 18 16 15 16 20	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown	D to M		FILL
									0.10m FILL: Sandy silty CLAY; medium plasticity, dark brown, fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel	M (≈PL) to M (>PL)	St	
									0.30m Silty CLAY; medium to high plasticity, brown, trace fine to coarse grained sand, trace fine to sub-rounded to sub-angular gravel	M (≈PL) to M (>PL)	St	RESIDUAL SOIL
									1.00m Sandy Silty CLAY; medium plasticity, brown, fine to coarse grained sand	M (>PL) M (≈PL) to M (>PL)	VSt to H	
									1.60m Sandy Silty CLAY; medium plasticity, red brown, fine to coarse grained sand	M (≈PL)	H	EXTREMELY WEATHERED
									1.70m TERMINATED AT 1.70 m Refusal			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

- Water Level on Date shown
- water inflow
- water outflow

FIELD TESTS

SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY

VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY

VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB019

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm 3 6 9 12		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered		12 9 6 6 7 VR 25	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown 0.10m FILL: Sandy silty CLAY; medium plasticity, dark brown, fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel 0.30m Sandy Silty CLAY; medium plasticity, brown, fine to coarse grained sand 1.10m Sandy Silty CLAY; medium plasticity, red brown, fine to coarse grained sand 1.30m TERMINATED AT 1.30 m Refusal	D to M M (≈PL) to M (>PL) M (≈PL) M (>PL)	 VSt St to VSt H H	FILL RESIDUAL SOIL EXTREMELY WEATHERED

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST BORE LOG SHEET

Client: Lochinvar Downs Pty Ltd
Project: Hillcrest
Location: Lochinvar

Hole No: TB020

Job No: 304001145 **Sheet:** 1 of 1

Position: Refer to site plan **Angle from Horizontal:** 90° **Surface Elevation:**

Machine Type: Ute Mounted Drill Rig **Excavation Method:**

Excavation Dimensions: **Contractor:** Stantec

Date Excavated: 5/12/23 **Logged By:** GE **Checked By:**

Drilling			Water	Sampling & Testing		Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (3 6 9 12)		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/V		Stable	Not Encountered	U50 0.30 - 0.80 m	6 5 3 2 3 3 3 3 4 5 10 12	0.5 1.0 1.5 2.0			TOPSOIL FILL: Silty SAND; fine to coarse grained, brown 0.10m Silty CLAY; medium plasticity, dark brown, with fine to coarse grained sand Medium to high plasticity, light brown, trace fine to coarse grained sand 1.80m Sandy CLAY; low to medium plasticity, brown, fine to coarse grained sand, trace fine sub-rounded to sub-angular gravel 2.00m TERMINATED AT 2.00 m Target depth	D to M M (≈PL) M (≈PL) to M (>PL) M (>PL) M (≈PL)	St VSt	FILL RESIDUAL SOIL EXTREMELY WEATHERED

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Explanatory Notes

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. Material descriptions are deduced from field observation or engineering examination, and may be appended or confirmed by in situ or laboratory testing. The information is dependent on the scope of investigation, the extent of sampling and testing, and the inherent variability of the conditions encountered.

Subsurface investigation may be conducted by one or a combination of the following methods.

Method	
Test Pitting: excavation/trench	
BH	Backhoe bucket
EX	Excavator bucket
R	Ripper
H	Hydraulic Hammer
X	Existing excavation
N	Natural exposure
Manual drilling: hand operated tools	
HA	Hand Auger
Continuous sample drilling	
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
Hammer drilling	
AH	Air hammer
AT	Air track
Spiral flight auger drilling	
AS	Auger screwing
AD/V	Continuous flight auger: V-bit
AD/T	Continuous spiral flight auger: TC-Bit
HFA	Continuous hollow flight auger
Rotary non-core drilling	
WB	Washbore drilling
RR	Rock roller
Rotary core drilling	
PQ	85mm core (wire line core barrel)
HQ	63.5mm core (wire line core barrel)
NMLC	51.94mm core (conventional core barrel)
NQ	47.6mm core (wire line core barrel)
DT	Diatube (concrete coring)

Sampling is conducted to facilitate further assessment of selected materials encountered.

Sampling method	
Soil sampling	
B	Bulk disturbed sample
D	Disturbed sample
C	Core sample
ES	Environmental soil sample
SPT	Standard Penetration Test sample
U	Thin wall tube ‘undisturbed’ sample
Water sampling	
WS	Environmental water sample

Field testing may be conducted as a means of assessment of the in situ conditions of materials.

Field testing	
SPT	Standard Penetration Test
HP/PP	Hand/Pocket Penetrometer
Dynamic Penetrometers (blows per noted increment)	
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
VS	Vane Shear
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photo Ionization Detector

If encountered, refusal (R), virtual refusal (VR) or hammer bouncing (HB) of penetrometers may be noted.

The quality of the rock can be assessed by the degree of natural defects/fractures and the following.

Rock quality description	
TCR	Total Core Recovery (%) (length of core recovered divided by the length of core run)
RQD	Rock Quality Designation (%) (sum of axial lengths of core greater than 100mm long divided by the length of core run)

Notes on groundwater conditions encountered may include.

Groundwater	
Not Encountered	Excavation is dry in the short term
Not Observed	Water level observation not possible
Seepage	Water seeping into hole
Inflow	Water flowing/flooding into hole

Perched groundwater may result in a misleading indication of the depth to the true water table. Groundwater levels are also likely to fluctuate with variations in climatic and site conditions.

Notes on the stability of excavations may include.

Excavation conditions	
Stable	No obvious/gross short term instability noted
Spalling	Material falling into excavation (minor/major)
Unstable	Collapse of the majority, or one or more face of the excavation

Explanatory Notes: General Soil Description

The methods of description and classification of soils used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. In practice, a material is described as a soil if it can be remoulded by hand in its field condition or in water. The dominant component is shown in upper case, with secondary components in lower case. In general descriptions cover: soil type, plasticity or particle size/shape, colour, strength or density, moisture and inclusions.

In general, soil types are classified according to the dominant particle on the basis of the following particle sizes.

Soil Classification		Particle Size (mm)
CLAY		< 0.002
SILT		0.002 0.075
SAND	fine	0.075 to 0.21
	medium	0.21 to 0.6
	coarse	0.6 to 2.36
GRAVEL	fine	2.36 to 6.7
	medium	6.7 to 19
	coarse	19 to 63
COBBLES		63 to 200
BOULDERS		> 200

Soil types may be qualified by the presence of minor components on the basis of field examination methods and/or the soil grading.

Terminology	In coarse grained soils		In fine soils
	% fines	% coarse	% coarse
Trace	≤5	≤15	≤15
With	>5, ≤12	>15, ≤30	>15, ≤30

The strength of cohesive soils is classified by engineering assessment or field/lab testing as follows.

Strength	Symbol	Undrained shear strength
Very Soft	VS	≤12kPa
Soft	S	12kPa to ≤25kPa
Firm	F	25kPa to ≤50kPa
Stiff	St	50kPa to ≤100kPa
Very Stiff	VSt	100kPa to ≤200kPa
Hard	H	>200kPa

Cohesionless soils are classified on the basis of relative density as follows.

Relative Density	Symbol	Density Index
Very Loose	VL	<15%
Loose	L	15% to ≤35%
Medium Dense	MD	35% to ≤65%
Dense	D	65% to ≤85%
Very Dense	VD	>85%

The plasticity of cohesive soils is defined by the Liquid Limit (LL) as follows.

Plasticity	Silt LL	Clay LL
Low plasticity	≤ 35%	≤ 35%
Medium plasticity	N/A	> 35% ≤ 50%
High plasticity	> 50%	> 50%

The moisture condition of soil (*w*) is described by appearance and feel and may be described in relation to the Plastic Limit (PL), Liquid Limit (LL) or Optimum Moisture Content (OMC).

Moisture condition and description	
Dry	Cohesive soils: hard, friable, dry of plastic limit. Granular soils: cohesionless and free-running
Moist	Cool feel and darkened colour: Cohesive soils can be moulded. Granular soils tend to cohere
Wet	Cool feel and darkened colour: Cohesive soils usually weakened and free water forms when handling. Granular soils tend to cohere

The structure of the soil may be described as follows.

Zoning	Description
Layer	Continuous across exposure or sample
Lens	Discontinuous layer (lenticular shape)
Pocket	Irregular inclusion of different material

The structure of soil layers may include: defects such as softened zones, fissures, cracks, joints and root-holes; and coarse grained soils may be described as strongly or weakly cemented.

The soil origin may also be noted if possible to deduce.

Soil origin and description	
Fill	Anthropogenic deposits or disturbed material
Topsoil	Zone of soil affected by roots and root fibres
Peat	Significantly organic soils
Colluvial	Transported down slopes by gravity/water
Aeolian	Transported and deposited by wind
Alluvial	Deposited by rivers
Estuarine	Deposited in coastal estuaries
Lacustrine	Deposited in freshwater lakes
Marine	Deposits in marine environments
Residual soil	Soil formed by in situ weathering of rock, with no structure/fabric of parent rock evident
Extremely weathered material	Formed by in situ weathering of geological formations, with the structure/fabric of parent rock intact but with soil strength properties

The origin of the soil generally cannot be deduced solely on the appearance of the material and the inference may be supplemented by further geological evidence or other field observation. Where there is doubt, the terms ‘possibly’ or ‘probably’ may be used

Explanatory Notes: General Rock Description

The methods of description and classification of rocks used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. In practice, if a material cannot be remoulded by hand in its field condition or in water, it is described as a rock. In general, descriptions cover: rock type, grain size, structure, colour, degree of weathering, strength, minor components or inclusions, and where applicable, the defect types, shape, roughness and coating/infill.

Rock types are generally described according to the predominant grain or crystal size, and in groups for each rock type as follows.

Rock type	Groups
Sedimentary	Deposited, carbonate (porous or non), volcanic ejection
Igneous	Felsic (much quartz, pale), Intermediate, or mafic (little quartz, dark)
Metamorphic	Foliated or non-foliated
Duricrust	Cementing minerology (iron oxides or hydroxides, silica, calcium carbonate, gypsum)

Reference should be made to AS1726 for details of the rock types and methods of classification.

The classification of rock weathering is described based on definitions in AS1726 and summarised as follows.

Term and symbol		Definition
Residual Soil	RS	Soil developed on rock with the mass structure and substance of the parent rock no longer evident
Extremely weathered	XW	Weathered to such an extent that the rock has 'soil-like' properties. Mass structure and substance still evident
Distinctly weathered	DW	The strength is usually changed and may be highly discoloured. Porosity may be increased by leaching, or decreased due to deposition in pores. May be distinguished into MW (Moderately Weathered) and HW (Highly Weathered).
Slightly weathered	SW	Slightly discoloured; little or no change of strength from fresh rock
Fresh Rock	FR	The rock shows no sign of decomposition or staining

The rock material strength can be defined based on the point load index as follows.

Term and symbol		Point Load Index I_s50 (MPa)
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1.0
High	H	1.0 to 3
Very High	VH	3 to 10
Extremely High	EH	> 10

It is important to note that the rock material strength as above is distinct from the rock mass strength which can be significantly weaker due to the effect of defects.

A preliminary assessment of rock strength may be made using the field guide detailed in AS1726, and this is conducted in the absence of point load testing.

The defect spacing measured normal to defects of the same set or bedding, is described as follows.

Definition	Defect Spacing (mm)
Thinly laminated	< 6
Laminated	6 to 20
Very thinly bedded	20 to 60
Thinly bedded	60 to 200
Medium bedded	200 to 600
Thickly bedded	600 to 2000
Very thickly bedded	> 2000

Terms for describing rock and defects are as follows.

Defect Terms			
Joint	JT	Sheared zone	SZ
Bedding Parting	BP	Seam	SM
Foliation	FL	Vein	VN
Cleavage	CL	Drill Lift	DL
Crushed Seam	CS	Handling Break	HB
Fracture Zone	FZ	Drilling Break	DB

The shape and roughness of defects in the rock mass are described using the following terms.

Planarity		Roughness	
Planar	PR	Very Rough	VR
Curved	CU	Rough	RF
Undulose	UN	Smooth	S
Irregular	IR	Slickensided	SL
Stepped	ST	Polished	POL
Discontinuous	DIS		

The coating or infill associated with defects in the rock mass are described as follows.

Infill and Coating		
Clean	CN	
Stained	SN	
Carbonaceous	X	
Minerals	MU	Unidentified mineral
	MS	Secondary mineral
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
Veneer	VNR	Thin or patchy coating
Coating	CT	Infill up to 1mm

Graphic Symbols Index

CLAY	SILT	SAND	GRAVEL
Silty CLAY	Clayey SILT	Clayey SAND	Clayey GRAVEL
Sandy CLAY	Sandy SILT	Silty SAND	Silty GRAVEL
Gravelly CLAY	Gravelly SILT	Gravelly SAND	Sandy GRAVEL
Silty Gravelly CLAY	Clayey Sandy SILT	Clayey Silty SAND	Clayey Silty GRAVEL
Silty Sandy CLAY	Clayey Gravelly SILT	Clayey Gravelly SAND	Clayey Sandy GRAVEL
Sandy Gravelly CLAY	Sandy Gravelly SILT	Silty Gravelly SAND	Silty Sandy GRAVEL

COBBLES & BOULDERS

PEAT, highly organic soil

TOPSOIL

FILL

FILL: Asphalt or Bituminous Seal

FILL: Ballast

FILL: Concrete

FILL: Roadbase

Sedimentary rock: fine, mostly clay (CLAYSTONE)

Sedimentary rock: fine, mostly silt (SILTSTONE)

Sedimentary rock: fine, silt and clay (MUDSTONE, SHALE, LAMINITE)

Sedimentary rock: medium (SANDSTONE, GREYWACKE)

Sedimentary rock: fine to coarse, angular (BRECCIA)

Sedimentary rock: coarse, rounded (CONGLOMERATE)

Sedimentary rock: Organic (COAL)

Sedimentary rock: Carbonate (LIMESTONE, DOLOMITE)

Sedimentary rock: Volcanic (TUFF, VOLCANIC BRECCIA, AGGLOMERATE)

Igneous rock: Felsic, fine (RHYOLITE)

Igneous rock: Felsic, coarse (GRANITE)

Igneous rock: Mafic, fine to medium (BASALT, DOLERITE)

Igneous rock: Mafic, coarse (GABBRO)

Metamorphic rock: Foliated, fine to medium (SLATE, PHYLLITE, SHIST)

Metamorphic rock: Foliated, coarse (GNEISS)

Metamorphic rock: Non-foliated (QUARTZITE, HORNFELS, MARBLE)

Hillcrest Estate – Stage 1

APPENDIX C

LABORATORY TEST REPORTS

Stantec

Material Test Report

Report Number: **PRJ896947-1**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5451
Date Sampled: 21/02/2023
Dates Tested: 22/02/2023 - 23/02/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Lochinvar
Material: General Fill

QUALITY GEOTECHNICAL SERVICES
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Approved Signatory: James O'Brien
Managing Director
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1					
Sample Number	M23-5451A	M23-5451B	M23-5451C	M23-5451D	M23-5451E
Test Number	1	2	3	4	5
Date Tested	21/02/2023	21/02/2023	21/02/2023	21/02/2023	21/02/2023
Time Tested	09:00	09:10	11:00	12:00	13:20
Test Request #/Location	Existing dam backfill	Existing dam backfill	Existing dam backfill	Existing dam backfill	Existing dam backfill
Easting	354697	354702	354702	354692	354689
Northing	638150	6381519	638153	6381516	6381511
Elevation (m)	26.4	26.8	27.1	27.4	27.7
Layer / Reduced Level	1	2	3	4	5
Thickness of Layer (mm)	300	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**	**
Field Wet Density (FWD) t/m^3	2.20	2.20	2.05	2.04	2.08
Field Moisture Content %	17.2	21.3	17.4	24.1	24.2
Field Dry Density (FDD) t/m^3	1.88	1.82	1.74	1.64	1.67
Peak Converted Wet Density t/m^3	2.21	2.24	2.08	2.09	2.12
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	19.7	23.7	17.2	23.7	24.8
Adj. Field Moisture Content % (AS1289.5.4.1)	17.2	21.3	17.4	24.1	24.2
Moisture Ratio % (AS1289.5.4.1)	87.0	89.5	101.5	101.5	97.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**	**
Moisture Variation (Wv) %	2.5	2.0	0.0	-0.5	0.5
Adjusted Moisture Variation %	**	**	**	**	**
Hilf Density Ratio (%)	**99.5**	**98.5**	**98.5**	**97.5**	**98.0**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Report Number: **PRJ896947-2**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5490
Date Sampled: 01/03/2023
Dates Tested: 02/03/2023 - 09/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: General Fill

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5490A	M23-5490B	
Test Number	6	7	
Date Tested	01/03/2023	01/03/2023	
Time Tested	14:20	15:15	
Test Request #/Location	Existing dam backfill	Existing dam backfill	
Easting	354692	354692	
Northing	6381517	6381510	
Elevation (m)	27.7	28.1	
Layer / Reduced Level	6	7	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	1.95	1.95	
Field Moisture Content %	23.8	20.9	
Field Dry Density (FDD) t/m^3	1.57	1.61	
Peak Converted Wet Density t/m^3	1.98	1.98	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	24.6	21.0	
Adj. Field Moisture Content % (AS1289.5.4.1)	23.8	20.9	
Moisture Ratio % (AS1289.5.4.1)	97.0	99.5	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	0.5	0.0	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**98.5**	**98.5**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-3**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5503
Date Sampled: 02/03/2023
Dates Tested: 02/03/2023 - 09/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: General Fill

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Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5503A	M23-5503B	M23-5503C
Test Number	8	9	10
Date Tested	02/03/2023	02/03/2023	02/03/2023
Time Tested	09:00	11:00	12:30
Test Request #/Location	Existing dam backfill	Existing dam backfill	Existing dam backfill
Easting	354700	354691	354687
Northing	6381518	6381525	6381502
Elevation (m)	28.0	28.5	28.6
Layer / Reduced Level	8	9	10
Thickness of Layer (mm)	300	300	300
Soil Description	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.
Test Depth (mm)	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**
Field Wet Density (FWD) t/m^3	1.95	1.90	1.97
Field Moisture Content %	24.1	21.4	25.0
Field Dry Density (FDD) t/m^3	1.57	1.57	1.58
Peak Converted Wet Density t/m^3	1.98	1.98	1.97
Adjusted Peak Converted Wet Density t/m^3	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	24.3	24.5	26.7
Adj. Field Moisture Content % (AS1289.5.4.1)	24.1	21.4	25.0
Moisture Ratio % (AS1289.5.4.1)	99.5	87.0	93.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**
Moisture Variation (Wv) %	0.0	3.0	1.5
Adjusted Moisture Variation %	**	**	**
Hilf Density Ratio (%)	**98.5**	**96.0**	**100.0**
Compaction Method	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Approved Signatory: James O'Brien
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NATA Accredited Laboratory Number: 19862

Report Number: **PRJ896947-4**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5516
Date Sampled: 03/03/2023
Dates Tested: 03/03/2023 - 09/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: General Fill

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-5516A	M23-5516B	M23-5516C	M23-5516D
Test Number	11	12	13	14
Date Tested	03/03/2023	03/03/2023	03/03/2023	03/03/2023
Time Tested	09:10	10:30	11:45	15:20
Test Request #/Location	Existing basin backfill	Existing basin backfill	Existing basin backfill	Existing basin backfill
Easting	354724	354683	354692	354698
Northing	6381498	6381502	6381527	6381499
Elevation (m)	28.0	28.7	28.9	29.2
Layer / Reduced Level	11	12	13	14
Soil Description	Sandy CLAY, brown.	Sandy CLAY, red / brown.	Sandy CLAY some gravel, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**
Field Wet Density (FWD) t/m^3	1.98	2.06	1.98	1.99
Field Moisture Content %	21.5	27.1	24.9	23.9
Field Dry Density (FDD) t/m^3	1.63	1.62	1.59	1.60
Peak Converted Wet Density t/m^3	1.99	2.02	2.00	1.96
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	21.8	27.1	24.2	25.7
Adj. Field Moisture Content % (AS1289.5.4.1)	21.5	27.1	24.9	23.9
Moisture Ratio % (AS1289.5.4.1)	98.5	100.0	103.0	93.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**
Moisture Variation (Wv) %	0.5	0.0	-0.5	1.5
Adjusted Moisture Variation %	**	**	**	**
Hilf Density Ratio (%)	**99.5**	**102.0**	**99.0**	**101.5**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-5**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5519
Date Sampled: 04/03/2023
Dates Tested: 06/03/2023 - 09/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Lochinvar
Material: General Fill

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NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5519A	M23-5519B	M23-5519C
Test Number	15	16	17
Date Tested	04/03/2023	04/03/2023	04/03/2023
Time Tested	07:50	10:40	12:15
Test Request #/Location	Existing basin backfill	Existing basin backfill	Existing basin backfill
Easting	354710	354699	354701
Northing	6381526	6381522	6381494
Elevation (m)	29.0	29.3	29.4
Layer / Reduced Level	15	16	17
Thickness of Layer (mm)	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, red / brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**
Field Wet Density (FWD) t/m^3	2.03	2.04	2.06
Field Moisture Content %	25.0	21.1	24.4
Field Dry Density (FDD) t/m^3	1.62	1.69	1.66
Peak Converted Wet Density t/m^3	2.05	2.05	2.00
Adjusted Peak Converted Wet Density t/m^3	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	24.8	23.6	24.7
Adj. Field Moisture Content % (AS1289.5.4.1)	25.0	21.1	24.4
Moisture Ratio % (AS1289.5.4.1)	100.5	89.0	99.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**
Moisture Variation (Wv) %	0.0	2.5	0.5
Adjusted Moisture Variation %	**	**	**
Hilf Density Ratio (%)	**99.0**	**99.5**	**103.0**
Compaction Method	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Report Number: **PRJ896947-6**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5526
Date Sampled: 06/03/2023
Dates Tested: 06/03/2023 - 14/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Lochinvar
Material: General Fill

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-5526A	M23-5526B	M23-5526C	M23-5526D
Test Number	18	19	20	21
Date Tested	06/03/2023	06/03/2023	06/03/2023	06/03/2023
Time Tested	10:40	10:50	11:40	12:15
Test Request #/Location	Detention Basin Floor	Detention Basin Floor	Existing Dam Backfill	Detention Basin Floor
Easting	354767	354775	354702	354770
Northing	6381492	6381492	6381524	6381491
Elevation (m)	23.9	24.3	29.6	24.6
Layer / Reduced Level	1	2	18	3
Thickness of Layer (mm)	300	300	300	300
Soil Description	Sandy CLAY, red/brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, red/ brown.
Test Depth (mm)	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**
Field Wet Density (FWD) t/m^3	2.06	2.04	2.05	2.01
Field Moisture Content %	23.8	24.0	22.3	30.7
Field Dry Density (FDD) t/m^3	1.67	1.64	1.67	1.54
Peak Converted Wet Density t/m^3	2.04	2.04	2.00	2.02
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	23.3	24.4	25.3	29.8
Adj. Field Moisture Content % (AS1289.5.4.1)	23.8	24.0	22.3	30.7
Moisture Ratio % (AS1289.5.4.1)	102.0	98.5	88.0	103.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**
Moisture Variation (Wv) %	-0.5	0.5	3.0	-1.0
Adjusted Moisture Variation %	**	**	**	**
Hilf Density Ratio (%)	**101.0**	**100.0**	**102.5**	**99.5**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-6**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5526
Date Sampled: 06/03/2023
Dates Tested: 06/03/2023 - 14/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Lochinvar
Material: General Fill

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NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-5526E	M23-5526F	M23-5526G	
Test Number	22	23	24	
Date Tested	06/03/2023	06/03/2023	06/03/2023	
Time Tested	12:50	14:35	15:30	
Test Request #/Location	Existing Dam Backfill	Detention Basin Floor	Existing Dam Backfill	
Easting	354711	354772	354682	
Northing	6381526	6381498	6381514	
Elevation (m)	29.4	25	29.8	
Layer / Reduced Level	19	4	20	
Thickness of Layer (mm)	300	300	300	
Soil Description	Sandy CLAY with gravel, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	
Field Wet Density (FWD) t/m^3	2.13	2.02	2.03	
Field Moisture Content %	22.7	24.9	22.1	
Field Dry Density (FDD) t/m^3	1.73	1.62	1.66	
Peak Converted Wet Density t/m^3	2.11	2.02	2.01	
Adjusted Peak Converted Wet Density t/m^3	**	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	22.9	25.2	24.7	
Adj. Field Moisture Content % (AS1289.5.4.1)	22.7	24.9	22.1	
Moisture Ratio % (AS1289.5.4.1)	99.0	98.5	89.5	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	
Moisture Variation (Wv) %	0.0	0.5	2.5	
Adjusted Moisture Variation %	**	**	**	
Hilf Density Ratio (%)	**101.0**	**99.5**	**101.0**	
Compaction Method	**Standard**	**Standard**	**Standard**	
Report Remarks	**	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-7**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5541
Date Sampled: 07/03/2023
Dates Tested: 08/03/2023 - 13/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: General Fill

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Approved Signatory: James O'Brien
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NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1						
Sample Number	M23-5541A	M23-5541B	M23-5541C	M23-5541D	M23-5541E	M23-5541F
Test Number	25	26	27	28	29	30
Date Tested	07/03/2023	07/03/2023	07/03/2023	07/03/2023	07/03/2023	07/03/2023
Time Tested	09:15	09:25	10:30	11:15	12:50	13:30
Test Request #/Location	Detention Basin Floor	Detention Basin Floor	Lot 118 / 119	Detention Basin Floor	Detention Basin Floor	Lot 118 / 119
Easting	354770	354767	354660	354762	354773	354663
Northing	6381497	6381495	6381545	6381497	6381494	6381545
Elevation (m)	25.1	25.4	30.7	25.7	25.8	30.8
Layer / Reduced Level	5	6	1	7	8	2
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Silty CLAY, red/brown.	Sandy CLAY with gravel, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**	**	**
Field Wet Density (FWD) t/m^3	2.00	1.99	1.81	2.08	1.97	2.00
Field Moisture Content %	18.8	20.0	26.1	25.1	22.5	24.1
Field Dry Density (FDD) t/m^3	1.68	1.66	1.44	1.67	1.61	1.61
Peak Converted Wet Density t/m^3	1.99	2.01	1.89	2.04	2.00	2.00
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	21.6	20.5	26.2	25.2	23.0	24.6
Adj. Field Moisture Content % (AS1289.5.4.1)	18.8	20.0	26.1	25.1	22.5	24.1
Moisture Ratio % (AS1289.5.4.1)	87.5	97.0	100.0	99.5	98.0	98.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**	**	**
Moisture Variation (Wv) %	2.5	0.5	0.0	0.0	0.5	0.5
Adjusted Moisture Variation %	**	**	**	**	**	**
Hilf Density Ratio (%)	**100.5**	**99.0**	**96.0**	**102.5**	**98.5**	**100.0**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Approved Signatory: James O'Brien
Managing Director
NATA Accredited Laboratory Number: 19862

Report Number: **PRJ896947-8**
Issue Number: 1
Date Issued: 17/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5545
Date Sampled: 08/03/2023
Dates Tested: 08/03/2023 - 13/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: General Fill

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1					
Sample Number	M23-5545A	M23-5545B	M23-5545C	M23-5545D	M23-5545E
Test Number	31	32	33	34	35
Date Tested	08/03/2023	08/03/2023	08/03/2023	08/03/2023	08/03/2023
Time Tested	10:10	12:30	12:50	14:10	15:40
Test Request #/Location	Lot 120	Boland Rd - LHS Footpath	Boland Rd - LHS Footpath	Lot 116	Lot 118
Easting	354693	354733	354728	354733	354659
Northing	6381540	6381523	6381504	6381522	6381541
Elevation (m)	30.6	29.2	28.7	32.3	31.2
Thickness of Layer (mm)	300	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**	**
Field Wet Density (FWD) t/m^3	2.04	2.00	1.95	1.92	1.93
Field Moisture Content %	22.7	21.3	21.0	26.7	23.9
Field Dry Density (FDD) t/m^3	1.66	1.65	1.61	1.52	1.56
Peak Converted Wet Density t/m^3	2.03	1.98	1.95	1.97	2.00
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	23.2	23.6	23.4	27.0	24.3
Adj. Field Moisture Content % (AS1289.5.4.1)	22.7	21.3	21.0	26.7	23.9
Moisture Ratio % (AS1289.5.4.1)	97.5	90.0	89.5	99.0	98.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**	**
Moisture Variation (Wv) %	0.5	2.0	2.5	0.5	0.5
Adjusted Moisture Variation %	**	**	**	**	**
Hilf Density Ratio (%)	**100.5**	**101.5**	**99.5**	**97.5**	**97.0**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Report Number: **PRJ896947-9**
Issue Number: 1
Date Issued: 31/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5578
Dates Tested: 10/03/2023 - 14/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest - Lochinvar
Material: Lot Fill
Material Source: Site Won

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5578A	M23-5578B	
Test Number	36	37	
Date Tested	09/03/2023	09/03/2023	
Time Tested	14:20	15:00	
Test Request #/Location	Lot 118	Lot 117	
Easting	354664	354638	
Northing	6381554	6381552	
Elevation (m)	31.6	31.4	
Layer / Reduced Level	6	5	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	2.04	2.03	
Field Moisture Content %	28.9	22.7	
Field Dry Density (FDD) t/m^3	1.58	1.66	
Peak Converted Wet Density t/m^3	2.08	2.07	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	30.3	22.9	
Adj. Field Moisture Content % (AS1289.5.4.1)	28.9	22.7	
Moisture Ratio % (AS1289.5.4.1)	95.5	99.0	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	1.0	0.0	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**98.0**	**98.0**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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NATA Accredited Laboratory Number: 19862

Report Number: **PRJ896947-11**
Issue Number: 1
Date Issued: 31/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5628
Date Sampled: 20/03/2023
Dates Tested: 20/03/2023 - 21/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Stg 1 Lochinvar
Material: Lot Fill
Material Source: Site Won

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5628A	M23-5628B	M23-5628C
Test Number	38	39	40
Date Tested	20/03/2023	20/03/2023	20/03/2023
Time Tested	09:05	09:15	11:00
Test Request #/Location	Lot 116	Lot 117	Hewitt Road Footpath
Easting	354610	354627	3546560
Northing	6381560	6381532	6381499
Elevation (m)	33.3	32.3	31.1
Layer / Reduced Level	N/A	N/A	N/A
Thickness of Layer (mm)	N/A	N/A	N/A
Soil Description	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.
Test Depth (mm)	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**
Field Wet Density (FWD) t/m^3	2.15	2.11	2.14
Field Moisture Content %	22.2	22.8	21.9
Field Dry Density (FDD) t/m^3	1.76	1.72	1.75
Peak Converted Wet Density t/m^3	2.11	2.12	2.12
Adjusted Peak Converted Wet Density t/m^3	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	22.9	22.7	23.9
Adj. Field Moisture Content % (AS1289.5.4.1)	22.2	22.8	21.9
Moisture Ratio % (AS1289.5.4.1)	97.0	100.5	91.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**
Moisture Variation (Wv) %	0.5	0.0	2.0
Adjusted Moisture Variation %	**	**	**
Hilf Density Ratio (%)	**102.0**	**99.5**	**100.5**
Compaction Method	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Report Number: **PRJ896947-12**
Issue Number: 1
Date Issued: 31/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5650
Date Sampled: 21/03/2023
Dates Tested: 22/03/2023 - 22/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Stage 1 Lochinvar
Material: General Fill
Material Source: Site Won

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5650A	M23-5650B	
Test Number	41	42	
Date Tested	21/03/2023	21/03/2023	
Time Tested	09:50	11:40	
Test Request #/Location	Lot 124	Detension Basin Floor	
Easting	354656	354794	
Northing	6381494	6381480	
Elevation (m)	31.6	24.9	
Layer / Reduced Level	3	N/A	
Thickness of Layer (mm)	N/A	N/A	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	1.96	2.08	
Field Moisture Content %	26.8	26.8	
Field Dry Density (FDD) t/m^3	1.54	1.64	
Peak Converted Wet Density t/m^3	1.97	1.99	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	25.9	26.8	
Adj. Field Moisture Content % (AS1289.5.4.1)	26.8	26.8	
Moisture Ratio % (AS1289.5.4.1)	103.5	100.0	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	-1.0	0.0	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**99.0**	**104.0**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-10**
Issue Number: 1
Date Issued: 31/03/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5661
Date Sampled: 22/03/2023
Dates Tested: 23/03/2023 - 23/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: General Fill
Material Source: Site Won

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Approved Signatory: James O'Brien
Managing Director
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5661A	M23-5661B	M23-5661C
Test Number	43	44	45
Date Tested	22/03/2023	22/03/2023	22/03/2023
Time Tested	10:05	11:50	14:40
Test Request #/Location	Detension Basin Floor	Detension Basin Floor	Detension Basin Floor
Easting	354791	354796	354801
Northing	6381489	6381489	6381489
Elevation (m)	25.2	25.4	25.5
Layer / Reduced Level	N/A	N/A	N/A
Thickness of Layer (mm)	N/A	N/A	N/A
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**
Field Wet Density (FWD) t/m^3	2.00	2.00	2.05
Field Moisture Content %	26.4	26.0	20.9
Field Dry Density (FDD) t/m^3	1.58	1.59	1.70
Peak Converted Wet Density t/m^3	1.98	1.95	1.98
Adjusted Peak Converted Wet Density t/m^3	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	24.9	26.2	20.2
Adj. Field Moisture Content % (AS1289.5.4.1)	26.4	26.0	20.9
Moisture Ratio % (AS1289.5.4.1)	106.0	99.0	104.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**
Moisture Variation (Wv) %	-1.5	0.0	-1.0
Adjusted Moisture Variation %	**	**	**
Hilf Density Ratio (%)	**101.0**	**102.5**	**103.5**
Compaction Method	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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NATA Accredited Laboratory Number: 19862

Report Number: **PRJ896947-14**
Issue Number: 1
Date Issued: 04/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5681
Date Sampled: 23/03/2023
Dates Tested: 24/03/2023 - 27/03/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Lochinvar
Material: General Fill

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5681A	M23-5681B	
Test Number	54	55	
Date Tested	23/03/2023	23/03/2023	
Time Tested	11:00	14:50	
Test Request #/Location	Detention Basin Floor & Wall	Detention Basin Floor & Wall	
Easting	354802	354799	
Northing	6381488	6381486	
Elevation (m)	25.7	25.9	
Layer / Reduced Level	N/A	N/A	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	1.98	1.94	
Field Moisture Content %	23.5	25.6	
Field Dry Density (FDD) t/m^3	1.60	1.54	
Peak Converted Wet Density t/m^3	1.97	1.98	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	23.4	26.7	
Adj. Field Moisture Content % (AS1289.5.4.1)	23.5	25.6	
Moisture Ratio % (AS1289.5.4.1)	100.0	96.0	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	0.0	1.0	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**100.5**	**98.0**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-15**
Issue Number: 1
Date Issued: 20/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5747
Date Sampled: 12/04/2023
Dates Tested: 13/04/2023 - 18/04/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest - Lochinvar
Material: General Fill

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Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5747A	M23-5747B	
Test Number	56	57	
Date Tested	12/04/2023	12/04/2023	
Time Tested	08:45	08:55	
Test Request #/Location	Detention Basin - Wall	Detention Basin - Wall	
Easting	354783	354782	
Northing	6381470	6381501	
Elevation (m)	26.6	27.0	
Layer / Reduced Level	N/A	N/A	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	2.11	2.07	
Field Moisture Content %	23.4	21.9	
Field Dry Density (FDD) t/m^3	1.71	1.70	
Peak Converted Wet Density t/m^3	2.07	2.03	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	23.3	21.4	
Adj. Field Moisture Content % (AS1289.5.4.1)	23.4	21.9	
Moisture Ratio % (AS1289.5.4.1)	100.5	102.0	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	0.0	-0.5	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**102.0**	**102.0**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-18**
Issue Number: 1
Date Issued: 21/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5771
Date Sampled: 14/04/2023
Dates Tested: 18/04/2023 - 18/04/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest - Lochinvar
Material: General Fill

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NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-5771A	M23-5771B	M23-5771C	M23-5771D
Test Number	61	62	63	64
Date Tested	14/04/2023	14/04/2023	14/04/2023	14/04/2023
Time Tested	10:50	11:00	11:40	14:05
Test Request #/Location	Detention Basin - Wall	Detention Basin - Wall	Detention Basin - Wall	Detention Basin - Wall
Easting	354799	354801	354798	354801
Northing	6381483	6381502	6381475	6381507
Elevation (m)	26.9	27.2	26.6	27.2
Layer / Reduced Level	N/A	N/A	N/A	N/A
Thickness of Layer (mm)	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**
Field Wet Density (FWD) t/m^3	2.10	2.09	2.07	2.05
Field Moisture Content %	23.3	23.5	23.7	24.3
Field Dry Density (FDD) t/m^3	1.70	1.69	1.67	1.65
Peak Converted Wet Density t/m^3	2.06	2.05	2.04	2.02
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	22.8	24.5	23.6	24.7
Adj. Field Moisture Content % (AS1289.5.4.1)	23.3	23.5	23.7	24.3
Moisture Ratio % (AS1289.5.4.1)	102.5	96.0	100.0	98.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**
Moisture Variation (Wv) %	-0.5	1.0	0.0	0.5
Adjusted Moisture Variation %	**	**	**	**
Hilf Density Ratio (%)	**102.0**	**102.0**	**101.5**	**101.5**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-17**
Issue Number: 1
Date Issued: 21/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5772
Date Sampled: 17/04/2023
Dates Tested: 18/04/2023 - 18/04/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest - Lochinvar
Material: General Fill

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5772A	M23-5772B	
Test Number	65	66	
Date Tested	17/04/2023	17/04/2023	
Time Tested	08:49	12:30	
Test Request #/Location	Detention Basin - Wall	Detention Basin - Wall	
Easting	354796	354801	
Northing	6381489	6381470	
Elevation (m)	27.5	27.7	
Layer / Reduced Level	N/A	N/A	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	1.98	2.05	
Field Moisture Content %	27.1	27.3	
Field Dry Density (FDD) t/m^3	1.56	1.61	
Peak Converted Wet Density t/m^3	1.99	2.01	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	25.2	26.1	
Adj. Field Moisture Content % (AS1289.5.4.1)	27.1	27.3	
Moisture Ratio % (AS1289.5.4.1)	107.5	104.5	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	-2.0	-1.0	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**99.5**	**102.0**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-19**
Issue Number: 1
Date Issued: 21/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5779
Date Sampled: 18/04/2023
Dates Tested: 19/04/2023 - 19/04/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 98% Standard
Location: Hillcrest - Lochinvar
Material: Basin - Keyway

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Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-5779A	M23-5779B	M23-5779C	M23-5779D
Test Number	69	70	71	72
Date Tested	18/04/2023	18/04/2023	18/04/2023	18/04/2023
Time Tested	11:10	11:30	12:10	13:00
Test Request #/Location	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway
Easting	354791	354791	354791	354796
Northing	6381482	6381470	6381482	6381468
Elevation (m)	24.2	24.6	25.0	25.3
Layer / Reduced Level	N/A	N/A	N/A	N/A
Thickness of Layer (mm)	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**
Field Wet Density (FWD) t/m^3	2.02	2.02	2.06	2.02
Field Moisture Content %	26.8	27.2	25.1	26.8
Field Dry Density (FDD) t/m^3	1.59	1.59	1.64	1.60
Peak Converted Wet Density t/m^3	2.02	2.01	2.06	2.03
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	26.7	26.3	24.9	26.4
Adj. Field Moisture Content % (AS1289.5.4.1)	26.8	27.2	25.1	26.8
Moisture Ratio % (AS1289.5.4.1)	100.0	103.5	100.5	101.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**
Moisture Variation (Wv) %	0.0	-1.0	0.0	-0.5
Adjusted Moisture Variation %	**	**	**	**
Hilf Density Ratio (%)	**100.0**	**100.5**	**99.5**	**99.5**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-21**
Issue Number: 1
Date Issued: 21/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5801
Date Sampled: 19/04/2023
Dates Tested: 20/04/2023 - 20/04/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 98% Standard
Location: Hillcrest - Lochinvar
Material: Basin - Keyway

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Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1						
Sample Number	M23-5801A	M23-5801B	M23-5801C	M23-5801D	M23-5801E	M23-5801F
Test Number	73	74	75	76	77	78
Date Tested	19/04/2023	19/04/2023	19/04/2023	19/04/2023	19/04/2023	19/04/2023
Time Tested	09:20	09:30	09:40	11:46	14:10	14:40
Test Request #/Location	Detension Basin - Keyway	Detension Basin - Keyway	Detension Basin - Keyway	Detension Basin - Keyway	Detension Basin - Keyway	Detension Basin - Keyway
Easting	354791	354793	354794	354782	354776	354765
Northing	6381473	6381474	6381470	6381445	6381440	6381429
Elevation (m)	25.5	25.8	26.2	26.5	26.8	27.2
Layer / Reduced Level	N/A	N/A	N/A	N/A	N/A	N/A
Thickness of Layer (mm)	300	300	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**	**	**
Field Wet Density (FWD) t/m^3	2.03	2.01	2.02	1.98	1.93	1.95
Field Moisture Content %	24.9	20.4	22.6	25.4	27.6	26.7
Field Dry Density (FDD) t/m^3	1.62	1.67	1.65	1.57	1.52	1.54
Peak Converted Wet Density t/m^3	2.01	2.00	2.02	1.99	1.97	1.97
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	25.6	20.5	23.4	27.1	28.1	26.6
Adj. Field Moisture Content % (AS1289.5.4.1)	24.9	20.4	22.6	25.4	27.6	26.7
Moisture Ratio % (AS1289.5.4.1)	97.5	99.5	96.5	93.5	98.5	100.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**	**	**
Moisture Variation (Wv) %	0.5	0.0	1.0	1.5	0.5	0.0
Adjusted Moisture Variation %	**	**	**	**	**	**
Hilf Density Ratio (%)	**101.0**	**100.5**	**100.0**	**99.5**	**98.5**	**98.5**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-20**
Issue Number: 1
Date Issued: 21/04/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5809
Date Sampled: 20/04/2023
Dates Tested: 20/04/2023 - 20/04/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 98% Standard
Location: Hillcrest - Lochinvar
Material: Basin - Keyway

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Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5809A	M23-5809B	
Test Number	79	80	
Date Tested	20/04/2023	20/04/2023	
Time Tested	08:50	09:15	
Test Request #/Location	Detention Basin - Keyway	Detention Basin - Keyway	
Easting	354769	354795	
Northing	6381539	6381515	
Elevation (m)	25.9	26.4	
Layer / Reduced Level	N/A	N/A	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	2.00	1.99	
Field Moisture Content %	23.0	22.2	
Field Dry Density (FDD) t/m^3	1.62	1.63	
Peak Converted Wet Density t/m^3	2.00	2.01	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	22.3	21.7	
Adj. Field Moisture Content % (AS1289.5.4.1)	23.0	22.2	
Moisture Ratio % (AS1289.5.4.1)	103.0	102.5	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	-0.5	-0.5	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**99.5**	**99.0**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-24**
Issue Number: 1
Date Issued: 03/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5828
Date Sampled: 26/04/2023
Dates Tested: 27/04/2023 - 01/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 98% Standard
Location: Hiilcrest - Lochinvar
Material: Detention Basin - Keyway

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Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1					
Sample Number	M23-5828A	M23-5828B	M23-5828C	M23-5828D	M23-5828E
Test Number	81	82	83	84	85
Date Tested	26/04/2023	26/04/2023	26/04/2023	26/04/2023	26/04/2023
Time Tested	10:50	11:00	12:40	14:30	15:15
Test Request #/Location	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway
Easting	354765	354797	354792	354792	354787
Northing	6381538	6381514	6381506	6381506	6381524
Elevation (m)	26.7	26.4	27.2	27.5	27.8
Layer / Reduced Level	N/A	N/A	N/A	N/A	N/A
Thickness of Layer (mm)	300	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**	**
Field Wet Density (FWD) t/m^3	2.02	2.01	1.99	1.97	1.96
Field Moisture Content %	24.2	28.5	25.8	27.7	27.7
Field Dry Density (FDD) t/m^3	1.62	1.57	1.58	1.54	1.54
Peak Converted Wet Density t/m^3	2.03	2.02	2.00	2.00	1.98
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	23.8	28.3	26.4	26.2	28.2
Adj. Field Moisture Content % (AS1289.5.4.1)	24.2	28.5	25.8	27.7	27.7
Moisture Ratio % (AS1289.5.4.1)	101.5	100.5	97.5	106.0	98.5
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**	**
Moisture Variation (Wv) %	-0.5	0.0	0.5	-1.5	0.5
Adjusted Moisture Variation %	**	**	**	**	**
Hilf Density Ratio (%)	**99.0**	**100.0**	**99.5**	**98.5**	**99.0**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-23**
Issue Number: 1
Date Issued: 03/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5840
Date Sampled: 27/04/2023
Dates Tested: 27/04/2023 - 01/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 98% Standard
Location: Hillcrest - Lochinvar
Material: General Fill

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Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 19862

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-5840A	M23-5840B	M23-5840C	M23-5840D
Test Number	98	99	100	101
Date Tested	27/04/2023	27/04/2023	27/04/2023	27/04/2023
Time Tested	08:40	09:00	09:10	09:20
Test Request #/Location	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway	Detention Basin - Keyway
Easting	354792	354791	354783	354784
Northing	6381525	6381528	6381537	6381539
Elevation (m)	27.7	28.0	28.3	28.6
Layer / Reduced Level	N/A	N/A	N/A	N/A
Thickness of Layer (mm)	300	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**
Field Wet Density (FWD) t/m^3	1.97	1.98	2.00	2.00
Field Moisture Content %	27.3	26.3	25.8	24.8
Field Dry Density (FDD) t/m^3	1.55	1.57	1.59	1.60
Peak Converted Wet Density t/m^3	1.95	1.96	1.95	1.98
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	26.4	26.0	25.1	24.8
Adj. Field Moisture Content % (AS1289.5.4.1)	27.3	26.3	25.8	24.8
Moisture Ratio % (AS1289.5.4.1)	103.5	101.0	103.0	100.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**
Moisture Variation (Wv) %	-1.0	0.0	-0.5	0.0
Adjusted Moisture Variation %	**	**	**	**
Hilf Density Ratio (%)	**101.5**	**101.5**	**102.5**	**101.0**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-26**
Issue Number: 1
Date Issued: 17/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5845
Date Sampled: 28/04/2023
Dates Tested: 01/05/2023 - 02/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 98% Standard
Location: Hillcrest Estate, Lochinvar NSW
Material: General Fill

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: James O'Brien
Managing Director
NATA Accredited Laboratory Number: 21234

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5845A	M23-5845B	M23-5845C
Test Number	102	103	104
Date Tested	28/04/2023	28/04/2023	28/04/2023
Time Tested	10:15	10:20	15:20
Test Request #/Location	Detension Basin Keyway	Detension Basin Keyway	Detension Basin Keyway
Easting	354792	354795	354794
Northing	6381461	6381474	6381486
Elevation (m)	27.9	28.3	28.6
Layer / Reduced Level	N/A	N/A	N/A
Thickness of Layer (mm)	300	300	300
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	Sandy CLAY, brown.
Test Depth (mm)	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**
Field Wet Density (FWD) t/m^3	1.96	1.94	2.00
Field Moisture Content %	22.7	24.8	23.3
Field Dry Density (FDD) t/m^3	1.60	1.56	1.62
Peak Converted Wet Density t/m^3	2.01	1.98	2.02
Adjusted Peak Converted Wet Density t/m^3	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	23.3	29.1	22.7
Adj. Field Moisture Content % (AS1289.5.4.1)	22.7	24.8	23.3
Moisture Ratio % (AS1289.5.4.1)	97.0	85.5	103.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**
Moisture Variation (Wv) %	0.5	4.0	-0.5
Adjusted Moisture Variation %	**	**	**
Hilf Density Ratio (%)	**98.0**	**98.5**	**99.0**
Compaction Method	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-28**
Issue Number: 1
Date Issued: 17/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5930
Date Sampled: 09/05/2023
Dates Tested: 10/05/2023 - 10/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Stage 1
Material: Lot Fill

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: James O'Brien
Managing Director
NATA Accredited Laboratory Number: 21234

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5930A	M23-5930B	
Test Number	111	112	
Date Tested	09/05/2023	09/05/2023	
Time Tested	11:50	14:45	
Test Request #/Location	Lot 161 - Temp basin backfill	Lot 161 - Temp basin backfill	
Easting	354816	354813	
Northing	6381382	6381373	
Elevation (m)	25.3	25.8	
Layer / Reduced Level	N/A	N/A	
Thickness of Layer (mm)	300	300	
Soil Description	Sandy CLAY, brown.	Sandy CLAY, brown.	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	1.93	1.95	
Field Moisture Content %	22.9	19.3	
Field Dry Density (FDD) t/m^3	1.57	1.64	
Peak Converted Wet Density t/m^3	1.96	1.95	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	24.3	22.1	
Adj. Field Moisture Content % (AS1289.5.4.1)	22.9	19.3	
Moisture Ratio % (AS1289.5.4.1)	94.0	87.5	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	1.5	2.5	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**98.5**	**100.5**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-29**
Issue Number: 1
Date Issued: 17/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5940
Date Sampled: 10/05/2023
Dates Tested: 11/05/2023 - 12/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: Lot Fill

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Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5940A		
Test Number	113		
Date Tested	10/05/2023		
Time Tested	11:50		
Test Request #/Location	Lot 161 - Temp basin backfill		
Easting	354815		
Northing	6381379		
Elevation (m)	26.1		
Layer / Reduced Level	3		
Thickness of Layer (mm)	300		
Soil Description	Sandy CLAY, brown.		
Test Depth (mm)	300		
Sieve used to determine oversize (mm)	19.0		
Percentage of Wet Oversize (%)	0		
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**		
Field Wet Density (FWD) t/m^3	1.95		
Field Moisture Content %	22.4		
Field Dry Density (FDD) t/m^3	1.60		
Peak Converted Wet Density t/m^3	2.05		
Adjusted Peak Converted Wet Density t/m^3	**		
Adj. Optimum Moisture Content % (AS1289.5.4.1)	21.7		
Adj. Field Moisture Content % (AS1289.5.4.1)	22.4		
Moisture Ratio % (AS1289.5.4.1)	103.0		
Adjusted Moisture Ratio % (AS1289.5.4.1)	**		
Moisture Variation (Wv) %	-0.5		
Adjusted Moisture Variation %	**		
Hilf Density Ratio (%)	**95.5**		
Compaction Method	**Standard**		
Report Remarks	**		

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Approved Signatory: James O'Brien
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NATA Accredited Laboratory Number: 21234

Report Number: **PRJ896947-30**
Issue Number: 1
Date Issued: 17/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5950
Date Sampled: 11/05/2023
Dates Tested: 12/05/2023 - 12/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate, Lochinvar
Material: Lot Fill

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5950A		
Test Number	119		
Date Tested	11/05/2023		
Time Tested	09:10		
Test Request #/Location	Lot 161 - Temp basin backfill		
Easting	354813		
Northing	6381378		
Elevation (m)	26.4		
Layer / Reduced Level	4		
Thickness of Layer (mm)	300		
Soil Description	Sandy CLAY, brown.		
Test Depth (mm)	300		
Sieve used to determine oversize (mm)	19.0		
Percentage of Wet Oversize (%)	0		
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**		
Field Wet Density (FWD) t/m^3	2.03		
Field Moisture Content %	21.8		
Field Dry Density (FDD) t/m^3	1.67		
Peak Converted Wet Density t/m^3	2.01		
Adjusted Peak Converted Wet Density t/m^3	**		
Adj. Optimum Moisture Content % (AS1289.5.4.1)	22.3		
Adj. Field Moisture Content % (AS1289.5.4.1)	21.8		
Moisture Ratio % (AS1289.5.4.1)	97.5		
Adjusted Moisture Ratio % (AS1289.5.4.1)	**		
Moisture Variation (Wv) %	0.5		
Adjusted Moisture Variation %	**		
Hilf Density Ratio (%)	**101.0**		
Compaction Method	**Standard**		
Report Remarks	**		

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

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Managing Director

NATA Accredited Laboratory Number: 21234

Report Number: **PRJ896947-31**
Issue Number: 1
Date Issued: 22/05/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 5987
Date Sampled: 12/05/2023
Dates Tested: 16/05/2023 - 18/05/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate - Lochinvar
Material: General Fill
Material Source: Site Won

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-5987A		
Test Number	120		
Date Tested	12/05/2023		
Time Tested	12:50		
Test Request #/Location	Temp Basin backfill		
Easting	354806		
Northing	6381375		
Elevation (m)	27.1		
Layer / Reduced Level	N/A		
Thickness of Layer (mm)	N/A		
Soil Description	Sandy CLAY with gravel, brown.		
Test Depth (mm)	300		
Sieve used to determine oversize (mm)	19.0		
Percentage of Wet Oversize (%)	0		
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**		
Field Wet Density (FWD) t/m^3	2.00		
Field Moisture Content %	18.5		
Field Dry Density (FDD) t/m^3	1.69		
Peak Converted Wet Density t/m^3	2.03		
Adjusted Peak Converted Wet Density t/m^3	**		
Adj. Optimum Moisture Content % (AS1289.5.4.1)	20.7		
Adj. Field Moisture Content % (AS1289.5.4.1)	18.5		
Moisture Ratio % (AS1289.5.4.1)	89.5		
Adjusted Moisture Ratio % (AS1289.5.4.1)	**		
Moisture Variation (Wv) %	2.0		
Adjusted Moisture Variation %	**		
Hilf Density Ratio (%)	**98.5**		
Compaction Method	**Standard**		
Report Remarks	**		

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-37**
Issue Number: 1
Date Issued: 06/07/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 6203
Date Sampled: 08/06/2023
Dates Tested: 09/06/2023 - 16/06/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest Estate Lochinvar
Material: General Fill

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Approved Signatory: James O'Brien
Managing Director
NATA Accredited Laboratory Number: 21234

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1				
Sample Number	M23-6203A	M23-6203B	M23-6203C	M23-6203D
Test Number	136	137	138	139
Date Tested	08/06/2023	08/06/2023	08/06/2023	08/06/2023
Time Tested	13:00	13:10	13:20	13:30
Test Request #/Location	Detension Basin Keyway	Detension Basin Keyway	Lot 156	Lot 158
Easting	354776	354739	354791	354760
Northing	6381431	6381428	6381382	6381386
Elevation (m)	28.7	29.5	28.1	29.4
Layer / Reduced Level	N/A	N/A	N/A	N/A
Thickness of Layer (mm)	N/A	N/A	N/A	N/A
Soil Description	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.	Sandy CLAY, red/brown.
Test Depth (mm)	300	300	300	300
Sieve used to determine oversize (mm)	19.0	19.0	19.0	19.0
Percentage of Wet Oversize (%)	0	0	0	0
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	**	**
Field Wet Density (FWD) t/m^3	2.07	2.08	2.10	2.08
Field Moisture Content %	19.4	18.4	23.4	16.9
Field Dry Density (FDD) t/m^3	1.73	1.76	1.70	1.78
Peak Converted Wet Density t/m^3	2.10	2.11	2.10	2.09
Adjusted Peak Converted Wet Density t/m^3	**	**	**	**
Adj. Optimum Moisture Content % (AS1289.5.4.1)	22.2	21.0	25.0	19.9
Adj. Field Moisture Content % (AS1289.5.4.1)	19.4	18.4	23.4	16.9
Moisture Ratio % (AS1289.5.4.1)	87.5	88.0	94.0	85.0
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	**	**
Moisture Variation (Wv) %	2.5	2.5	1.5	3.0
Adjusted Moisture Variation %	**	**	**	**
Hilf Density Ratio (%)	**98.5**	**98.5**	**100.0**	**100.0**
Compaction Method	**Standard**	**Standard**	**Standard**	**Standard**
Report Remarks	**	**	**	**

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Material Test Report

Report Number: **PRJ896947-38**
Issue Number: 1
Date Issued: 20/07/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: PRJ896947
Project Name: Hillcrest Lochinvar
Project Location: Lochinvar NSW
Work Request: 6470
Date Sampled: 12/07/2023
Dates Tested: 12/07/2023 - 14/07/2023
Sampling Method: AS 1289.1.2.1 6.4 (b) - Sampling from layers in earthworks or pavement - compacted
Specification: Minimum 95% Standard
Location: Hillcrest - Lochinvar
Material: Lot Fill

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NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Peter Redman
Senior Geotechnician
NATA Accredited Laboratory Number: 21234

Compaction Control AS 1289 5.7.1 & 5.8.1 & 2.1.1			
Sample Number	M23-6470A	M23-6470B	
Test Number	140	141	
Date Tested	12/07/2023	12/07/2023	
Time Tested	11:00	11:45	
Test Request #/Location	Lot 161	Lot 161	
Easting	354845	354843	
Northing	6381367	6381361	
Elevation (m)	26.1	26.6	
Layer / Reduced Level	N/A	N/A	
Thickness of Layer (mm)	N/A	N/A	
Soil Description	Sandy CLAY, brown	Sandy CLAY, brown	
Test Depth (mm)	300	300	
Sieve used to determine oversize (mm)	19.0	19.0	
Percentage of Wet Oversize (%)	0	0	
Percentage of Dry Oversize (%) (AS1289.5.4.1)	**	**	
Field Wet Density (FWD) t/m^3	1.94	1.96	
Field Moisture Content %	16.8	20.9	
Field Dry Density (FDD) t/m^3	1.66	1.62	
Peak Converted Wet Density t/m^3	1.98	1.95	
Adjusted Peak Converted Wet Density t/m^3	**	**	
Adj. Optimum Moisture Content % (AS1289.5.4.1)	19.8	23.6	
Adj. Field Moisture Content % (AS1289.5.4.1)	16.8	20.9	
Moisture Ratio % (AS1289.5.4.1)	85.0	88.5	
Adjusted Moisture Ratio % (AS1289.5.4.1)	**	**	
Moisture Variation (Wv) %	3.0	2.5	
Adjusted Moisture Variation %	**	**	
Hilf Density Ratio (%)	**98.0**	**100.5**	
Compaction Method	**Standard**	**Standard**	
Report Remarks	**	**	

Moisture Variation Note:
Positive values = test is dry of OMC
Negative values = test is wet of OMC

Hillcrest Estate – Stage 1

APPENDIX

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SHEET BTF 18

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Stantec

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

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

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

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

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

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

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

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

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

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

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

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

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

Trees can cause shrinkage and damage

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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

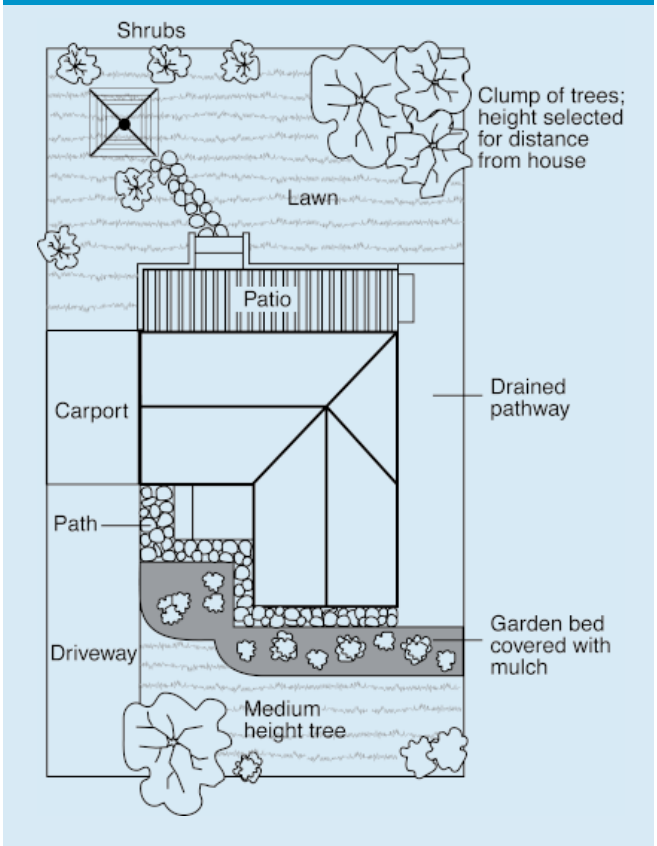
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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