# Proposed Subdivision
# Hereford Hill - Stage 5
# Site Classification

## Springfield Drive, Lochinvar

NEW17P-0054B-AG
10 July 2024

Qualtest
LABORATORY (NSW) PTY LTD

GEOTECHNICAL I LABORATORY I EARTHWORKS I QUARRY I CONSTRUCTION MATERIAL TESTING

10 July 2024

McCloy Lochinvar Pty Ltd
Suite 2, Ground Floor, 317 Hunter Street
NEWCASTLE NSW 2300

**Attention: Mr Rylan Gibson**

Dear Sir,

**RE: PROPOSED SUBDIVISION – HEREFORD HILL, STAGE 5**
**SPRINGFIELD DRIVE, LOCHINVAR**
**SITE CLASSIFICATION (LOTS 501 TO 524)**

Please find enclosed our geotechnical report for the proposed residential subdivision of Hereford Hill, Stage 5, to be located at Springfield Drive, Lochinvar.

The report includes recommendations for Site Classification in accordance with AS2870-2011, "Residential Slabs and Footings" following the completion of site regrading earthworks.

If you have any questions regarding this report, please do not hesitate to contact Shannon Kelly, Ben Edwards, or the undersigned.

For and on behalf of Qualtest Laboratory (NSW) Pty Ltd

Jason Lee
Principal Geotechnical Engineer

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## Attachments:

## 1.0 Introduction

Qualtest Laboratory NSW Pty Ltd (Qualtest) is pleased to present this geotechnical site classification report to McCloy Lochinvar Pty Ltd (McCloy), for Stage 5 of the Hereford Hill residential subdivision located at Springfield Drive, Lochinvar.

A preliminary Site Classification has previously been provided for Stages 3 to 5, (Qualtest Report Ref: NEW17P-0054B-AB.Rev1, dated 9 March 2022). Based on the brief and drawings provided in an email from McCloy dated 27 May 2024, it is understood the extent of Stage 5 comprises subdivision into 24 residential lots (Lots 501 to 524), as shown on Figure AG1.

The scope of work included providing site classification with respect to reactive soils, in accordance with the requirements of AS2870-2011 'Residential Slabs and Footings', for Stage 5 following completion of site regrade works.

This report presents the results of the field work investigations and laboratory testing, and provides recommendations for the scope outlined above.

## 2.0 Desktop Study

The scope of work has included a review of the following reports by Qualtest:

- Level 1 Site Re-grade Assessment Report, 'Hereford Hill – Stage 5, Lochinvar', (Report Reference: NEW20P-0146C-AA, dated 6 June 2024);
- Geotechnical Assessment, 'Proposed Subdivision – Stages 3 to 5, Lot 11 DP 1248129, New England Highway, Lochinvar', (Report Reference: NEW17P-0054B-AB.Rev1, 9 March 2022);
- Preliminary Geotechnical Assessment, 'Proposed Subdivision – Lots 1 to 3, DP 1218389, New England Highway, Lochinvar', (Report Reference: NEW17P-0054-AA.Rev1, 23 August 2017).

This report includes selected results from the reports referenced above, to supplement information collected during the current investigations where applicable. Reference should be made to the reports outlined above for further details of site conditions, field work and laboratory testing conducted, site supervision, and testing carried out.

## 3.0 Field Work

The field work investigations were carried out on 31 May 2024 and comprised of:

- DBYD search and visual check of proposed test locations for the presence of underground services;
- Site walkover to make observations of surface features at the property and in the immediate surrounding area;
- Drilling 14 boreholes (BH501 to BH514) using a 2.7 tonne excavator equipped with a 300mm diameter auger attachment. Boreholes were terminated at depths of between 2.10m and 2.30m;
- Boreholes were backfilled with the excavation spoil and compacted using the excavator auger and tracks.

Investigations were carried out by an experienced Geotechnical Engineer from Qualtest who located the boreholes, carried out the testing and sampling, produced field logs of the boreholes, and made observations of the site surface conditions.

Approximate borehole locations are shown on the attached Figure AG1. Boreholes were located in the field by handheld GPS and relative to existing site features including topographic features, lot boundaries, existing developments and trees.

Engineering logs of the boreholes are presented in Appendix A.

# 4.0 Site Description

## 4.1 Site Regrade Works

Initial Site Re-grade Works – Performed During Stage 5 Bulk Earthworks

Following an initial site visit, stripping assessment and recommendations performed on 20 September 2021, initial site re-grading works within Stage 5 were conducted between 21 September 2021 and 27 September 2021.

Re-grade works predominately included filling within all or portions of the lots directly south and west of Herdsmen Road (Lots 509 to 517).

Subsequent Site Re-grade Works – Performed During Stage 4 Bulk Earthworks

Following subsequent site visits, stripping assessments and recommendations performed on 1 August 2022 and 10 August 2022, additional site re-grading works were conducted between 2 August 2022 and 27 September 2022, predominately on portions of Stage 5 and Stage 6.

Recent Additional Site Re-grade Works – Performed During Stage 5 Bulk Earthworks

Following additional site visits, stripping assessments and recommendations performed on 14 November 2023, additional site re-grading works were conducted between 16 November 2023 and 20 November 2023.

These subsequent re-grade works included filling within all or portions of Lots within Stage 5, which included Lots 515 to 518, 523 and 524.

Filling Method Performed

Prior to filling, re-grade areas were stripped of topsoil and unsuitable material to expose the suitable natural foundation profile. Preparation works were then performed, which consisted of tining, re-conditioning and re-compaction of the stripped surface, prior to filling with approved site fill to design finish levels.

Filling was performed using site stockpiled material won from excavations cut from around the site. The fill material could generally be described as mixtures of Residual (CI-CH) Sandy CLAY, medium to high plasticity, brown / red / grey in colour, with fine to coarse grained Sand and trace Gravel.

The approximate depth of fill placed (excluding topsoil), ranged in the order of 0.3m to about 2.7m, with the deepest areas generally being at the rear of Lots 509 to 518.

The approximate depth of fill placed in each lot area ranged in the order of:

- Lot 509 to 518 – 0.3m to 2.7m;
- Lot 519 – 1.8m to 2.1m;
- Lot 520 to 523 – 1.0m to 2.4m;
- Lot 524 – 0.3m to 0.6m.

The fill was compacted in maximum lifts of 0.3m thickness. Any unsuitable or deleterious material within the fill was removed by hand or mechanical means prior to final compaction of the material.

As the geotechnical testing authority engaged for the project, Qualtest state that the filling performed for the re-grade areas within Stage 5 (as detailed in the site regrade report, and shown approximately on Figure AG1), was carried out to Level 1 criteria as defined in Clause 8.2 – Section 8 of AS3798-2007, "*Guidelines on Earthworks for Commercial and Residential Developments*".

The recommendations of this report are based on the understanding that any existing lot re-grade works are limited to the controlled earthworks supervised by Qualtest, placement of the fill material observed to depths of 0.4m or less within boreholes, and placement of low reactivity topsoil material such that total depth of topsoil and uncontrolled fill does not exceed 0.4m. Qualtest should be informed without delay if additional earthworks are known to have been carried out.

At the time of the field investigations on 31 May 2024, several small fill stockpiles were present on some of the Stage 5 lots. It is understood and expected that the fill stockpiles will be removed prior to development on the lots.

## 4.2 Surface Conditions

The site comprises of proposed Stage 5 of Hereford subdivision, located off Springfield Drive, Lochinvar, as shown on Figure AG1.

The site is bounded by existing Stages 3 & 4 of the subdivision to the north, open grass fields to the east and south, with future Stage 6 to the south, and existing dwellings to the west.

On the day of the field investigation, the site had been cleared, with the exception of small fill stockpiles associated with the excavation and installation of services generally fronting lots 509 to 516, retaining walls had been constructed along the rear of lots 509 to 518, and topsoil had been placed in most areas of the lots.

The majority of the site was judged to be moderately drained by way of surface run off, and inter-allotment drainage systems located at the rear of allotments.

The site was judged to have good trafficability by way of 4WD vehicle on the day of the field investigation.

Selected photographs of the site taken on the day of the site investigation, are shown below.

**Photograph 1:** From near BH501, facing east.

**Photograph 2:** From near BH501, facing south.

**Photograph 3:** From near BH502, facing southeast.

**Photograph 4:** Near BH502 facing southwest.

**Photograph 5:** From near BH504 facing south.

**Photograph 6:** From near BH504 facing west.

**Photograph 7:** From near BH506, facing northeast.

**Photograph 8:** From near BH506, facing east.

**Photograph 9:** From BH508, facing northeast.

**Photograph 10:** Near BH508, facing east.

**Photograph 11:** From near BH510, facing north.

**Photograph 12:** From near BH06, facing east.

**Photograph 13:** From near BH513, facing northwest.

**Photograph 14:** Near BH513, facing east.

## 4.3 Subsurface Conditions

Reference to the 1:100,000 Cessnock Regional Geology Series Sheet 9132 indicates the site to be underlain by the Lochinvar Formation of the Dalwood Group, which is characterised by lithic feldspathic sandstone, siltstone, shale, tuff, basalt flows and erratics.

Table 1 presents a summary of the typical soil / rock types encountered at the borehole locations during the field investigation, divided into representative geotechnical units.

Table 2 contains a summary of the distribution of the above geotechnical units at the test locations.

**TABLE 1 – SUMMARY OF GEOTECHNICAL UNITS AND SOIL TYPES**

| Unit | Soil Type | Description |
|---|---|---|
| 1A | FILL – TOPSOIL | CLAY / Sandy CLAY / Gravelly CLAY - medium to high plasticity, dark brown / grey, fine to coarse grained (mostly fine grained) sand, fine to medium grained angular gravel, root affected. |
| 1B | FILL – UNCONTROLLED | Fill Stockpile remnants, only encountered in BH506 to 0.05m depth.<br>Sandy GRAVEL - fine to medium grained angular, grey-brown, fine to coarse grained sand, trace fines of low plasticity. |
| 1C | FILL – CONTROLLED | CLAY - medium to high plasticity, various colour combinations of dark brown to grey-brown, pale brown, red-brown, pale grey to grey, orange-brown, trace fine to coarse grained sand, trace fine grained sub-rounded to angular gravel in places.<br>Gravelly CLAY - medium to high plasticity, brown to pale brown, fine to medium grained angular gravel, with Clayey Gravelly SAND pockets. |
| 2 | TOPSOIL | CLAY - medium to high plasticity, brown, trace pale brown, root affected. |
| 3 | SLOPEWASH / COLLUVIUM | Not Encountered within current investigation. |
| 3 | RESIDUAL SOIL | CLAY - medium to high plasticity, various colour combinations of brown to dark brown, grey-brown to dark grey-brown, pale brown, pale grey, red-brown and white, with Clayey Gravelly SAND / Sandy CLAY pockets in places.<br>Sandy CLAY / Gravelly Sandy CLAY / Gravelly Clayey SAND - low to medium plasticity, pale brown, fine to medium grained sand, trace clay pockets. |
| 4 | EXTREMELY WEATHERED (XW) ROCK with soil properties | Andesite: breaks down into Clayey Sandy GRAVEL - fine to medium grained angular, pale brown, fine to coarse grained sand, fines of low plasticity. |
| 5 | HIGHLY WEATHERED (HW) ROCK | ANDESITE – mostly pale brown, with some pale grey, estimated variable rock strength ranging from very low strength to high strength. |

**TABLE 2 – SUMMARY OF GEOTECHNICAL UNITS ENCOUNTERED AT TEST LOCATIONS**

| Location | Unit 1A Fill - Topsoil | Unit 1B Fill - Uncontrolled | Unit 1C Fill -Controlled | Unit 2 Topsoil | Unit 3 Colluvium / Alluvium | Unit 4 Residual Soil | Unit 5 XW Rock | Unit 6 HW Rock |
|---|---|---|---|---|---|---|---|---|
| | **Depth in metres (m)** | | | | | | | |
| BH501 | 0.00 - 0.10 | - | 0.10 - 0.60 | - | - | 0.60 - 2.30 | - | - |
| BH502 | - | - | - | - | - | 0.00 - 1.90 | - | 1.90 - 2.30* |
| BH503 | - | - | - | - | - | 0.00 - 2.30 | - | - |
| BH504 | - | - | - | - | - | 0.00 - 1.00 | 1.00 - 2.10^ | - |
| BH505 | - | - | - | 0.00 - 0.10 | - | 0.10 - 2.30 | - | - |
| BH506 | - | 0.00 - 0.05 | 0.05 - 1.30 | - | - | 1.30 - 2.30 | - | - |
| BH507 | 0.00 - 0.10 | - | 0.10 - 1.90 | - | - | 1.90 - 2.30 | - | - |
| BH508 | 0.00 - 0.10 | - | 0.10 - 2.30 | - | - | - | - | - |
| BH509 | 0.00 - 0.10 | - | 0.10 - 2.30 | - | - | - | - | - |
| BH510 | 0.00 - 0.05 | - | 0.05 - 1.00 | - | - | 1.00 - 2.30 | - | - |
| BH511 | 0.00 - 0.10 | - | 0.10 - 1.20 | - | - | 1.20 - 2.30 | - | - |
| BH512 | 0.00 - 0.10 | - | 0.10 - 2.10 | - | - | 2.10 - 2.30 | - | - |
| BH513 | 0.00 - 0.05 | - | 0.05 - 1.50 | - | - | 1.50 - 2.30 | - | - |
| BH514 | 0.00 - 0.10 | - | 0.10 - 1.00 | - | - | 1.00 - 2.30^ | - | - |
| **Previous Investigation (Report Ref: NEW17P-0054B-AB.Rev1, dated 9 March 2022)** | | | | | | | | |
| TP307 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.40 | 1.40 - 2.00 | - |
| TP308 | - | - | - | 0.00 - 0.20 | - | 0.20 - 0.65 | 0.65 - 1.20 | 1.20 - 1.30* |
| TP309 | - | - | - | 0.00 - 0.15 | - | 0.15 - 1.10 | 1.10 - 1.40* | 1.40* |

| Location | Unit 1A Fill - Topsoil | Unit 1B Fill - Uncontrolled | Unit 1C Fill -Controlled | Unit 2 Topsoil | Unit 3 Colluvium / Alluvium | Unit 4 Residual Soil | Unit 5 XW Rock | Unit 6 HW Rock |
|---|---|---|---|---|---|---|---|---|
| | Depth in metres (m) | | | | | | | |
| TP407 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.30 | 1.30 - 1.60 | 1.60 - 1.75* |
| TP408 | - | - | - | 0.00 - 0.20 | - | 0.20 - 0.95 | 0.95 - 1.50 | 1.50 - 1.55* |
| TP411 | - | - | - | 0.00 - 0.15 | - | 0.15 - 1.40 | 1.40 - 1.50 | 1.50 - 1.60* |
| TP501 | - | - | - | 0.00 - 0.25 | - | 0.25 - 0.80 | 0.80 - 2.00 | - |
| TP502 | - | - | - | 0.00 - 0.25 | - | 0.25 - 0.60 | 0.60 - 2.00 | - |
| TP503 | - | - | - | 0.00 - 0.25 | - | 0.25 - 0.55 | 0.55 - 2.00 | - |
| TP504 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.00 | 1.00 - 1.40 | 1.40 - 1.50* |
| TP505 | - | - | - | 0.00 - 0.30 | - | 0.30 - 0.70 | 0.70 - 1.40 | 1.40 - 1.65* |
| TP506 | - | - | - | 0.00 - 0.15 | - | 0.15 - 0.70 | 0.70 - 1.30 | 1.30 - 1.45* |
| TP507 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.20 | 1.20 - 1.40 | 1.40 - 1.50* |
| TP508 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.90 | 1.90 - 2.00 | - |
| TP509 | - | - | - | 0.00 - 0.20 | - | 0.20 - 0.70 | 0.70 - 1.15 | 1.15 - 1.20* |
| TP510 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.40 | 1.40 - 1.90^ | - |
| TP511 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.20 | 1.20 - 1.55 | 1.55 - 1.60* |
| TP512 | - | - | - | 0.00 - 0.25 | - | 0.25 - 1.20 | - | 1.20 - 1.30* |
| TP513 | - | - | - | 0.00 - 0.25 | - | 0.25 - 2.05 | - | 2.05 - 2.15* |
| TP514 | - | - | - | 0.00 - 0.30 | - | 0.30 - 2.00 | - | - |
| TP515 | - | - | - | 0.00 - 0.30 | - | 0.30 - 1.40 | 1.40 - 1.80 | 1.80 - 2.00 |
| TP516 | - | - | - | 0.00 - 0.20 | - | 0.20 - 1.35 | - | 1.35 - 1.40* |
| TP517 | - | - | - | 0.00 - 0.15 | - | 0.15 - 1.40 | 1.40 - 2.05 | 2.05 - 2.10 |

| Location | Unit 1A<br>Fill - Topsoil | Unit 1B<br>Fill - Uncontrolled | Unit 1C<br>Fill -Controlled | Unit 2<br>Topsoil | Unit 3<br>Colluvium / Alluvium | Unit 4<br>Residual Soil | Unit 5<br>XW Rock | Unit 6<br>HW Rock |
|---|---|---|---|---|---|---|---|---|
| | **Depth in metres (m)** | | | | | | | |
| TP518 | - | - | - | 0.00 - 0.30 | - | 0.30 - 1.20 | 1.20 - 2.00 | - |
| TP519 | - | 0.00 - 0.40 | - | - | 0.40 - 0.60 | 0.60 - 2.00 | - | - |
| TP520 | - | - | - | 0.00 - 0.30 | - | 0.30 - 2.00 | - | - |
| **Previous Investigation (Ref: NEW17P-0054-AA.Rev1, dated: 23 August 2017)** | | | | | | | | |
| TP07 | – | - | - | 0.00 - 0.08 | 0.08 - 0.80 | - | 0.80 - 2.30 | - |
| TP08 | – | - | - | 0.00 - 0.10 | 0.10 - 0.90 | 0.90 - 1.10 | 1.10 - 2.20 | - |
| Note: | ^ = Slow to very slow progress of 2.7 tonne excavator.<br>* = Refusal or Practical refusal of 2.7 tonne excavator met on Highly Weathered Rock. | | | | | | | |

No groundwater levels or inflows were encountered in the boreholes during the limited time that they remained open on the day of the field investigations.

It should be noted that groundwater conditions can vary due to rainfall and other influences including regional groundwater flow, temperature, permeability, recharge areas, surface condition, and subsoil drainage.

## 5.0 Laboratory Testing

Samples collected during the current field investigations were returned to our NATA accredited Warabrook Laboratory for testing which comprised of:

- (17 no.) Shrink / Swell tests; and,
- (1 no.) Atterberg Limits test.

Results of the laboratory testing are presented in Appendix B, with a summary of the Shrink/Swell and Atterberg Limits test results presented in Tables 3 and 4, respectively.

**TABLE 3 – SUMMARY OF SHRINK / SWELL TESTING RESULTS**

| Location | Depth (m) | Material Description | $I_{ss}$ (%) |
|---|---|---|---|
| BH501 | 0.60 – 0.73 | (CH) CLAY | 1.2 |
| BH502 | 0.50 – 0.65 | (CH) CLAY | 4.2 |
| BH503 | 0.90 – 1.05 | (CH) CLAY | 5.0 |
| BH504 | 0.50 – 0.73 | (CH) CLAY | 3.1 |
| BH505 | 0.50 – 0.65 | (CH) CLAY | 3.0 |
| BH506 | 0.50 – 0.65 | FILL: (CH) CLAY | 1.9 |
| BH507 | 0.50 – 0.70 | FILL: (CH) CLAY | 3.7 |
| BH507 | 1.10 – 1.30 | FILL: (CH) CLAY | 4.4 |
| BH509 | 0.50 – 0.70 | FILL: (CH) CLAY | 3.2 |
| BH510 | 0.50 – 0.65 | FILL: (CH) CLAY | 1.8 |
| BH510 | 1.10 – 1.30 | (CH) CLAY | 4.7 |
| BH511 | 0.50 – 0.75 | FILL: (CH) CLAY | 2.7 |
| BH512 | 0.50 – 0.70 | FILL: (CH) CLAY | 1.9 |
| BH512 | 1.10 – 1.25 | FILL: (CH) CLAY | 3.1 |
| BH513 | 0.50 – 0.70 | FILL: (CH) CLAY | 2.2 |
| BH514 | 0.50 – 0.72 | FILL: (CH) CLAY | 3.8 |
| BH514 | 1.00 – 1.20 | (CH) CLAY | 3.9 |
| **Previous Investigation (Ref: NEW17P-0054B-AB, dated: 28 October 2020)** | | | |
| TP308 | 0.30 – 0.60 | (CH) CLAY | 2.8 |
| TP309 | 0.45 – 0.60 | (CH) CLAY | 3.2 |
| TP407 | 0.30 – 0.45 | (CH) CLAY | 2.7 |
| TP408 | 0.30 – 0.45 | (CH) CLAY | 3.8 |
| TP411 | 0.25 – 0.45 | (CH) CLAY | 5.2 |
| TP501 | 0.40 – 0.55 | (CH) CLAY | 3.6 |

| Location | Depth (m) | Material Description | $I_{ss}$ (%) |
|---|---|---|---|
| TP502 | 0.30 – 0.55 | (CH) CLAY | 4.1 |
| TP503 | 0.30 – 0.50 | (CH) CLAY | 1.7 |
| TP505 | 0.50 – 0.70 | (CH) CLAY | 3.5 |
| TP506 | 0.30 – 0.50 | (CH) CLAY | 4.0 |
| TP507 | 0.60 – 0.80 | (CH) CLAY | 3.3 |
| TP508 | 0.40 – 0.55 | (CH) CLAY | 3.8 |
| TP511 | 0.70 – 0.90 | (CH) CLAY | 3.9 |
| TP512 | 0.40 – 0.60 | (CH) CLAY | 4.3 |
| TP513 | 0.90 – 1.10 | (CH) CLAY | 3.1 |
| TP514 | 0.70 – 0.95 | (CH) CLAY | 3.5 |
| TP515 | 0.90 – 1.05 | (CI) Gravelly Sandy CLAY | 1.8 |
| TP516 | 0.30 – 0.65 | (CH) CLAY | 4.8 |
| TP517 | 1.00 – 1.20 | (CI) Sandy CLAY | 1.1 |
| **Previous Investigation (Ref: NEW17P-0054-AA.Rev1, dated: 23 August 2017)** | | | |
| TP07 | 0.50 – 0.75 | (CH) Sandy CLAY | 4.7 |
| TP08 | 0.50 – 0.75 | (CH) Sandy CLAY | 5.6 |

**TABLE 4 – SUMMARY OF ATTERBERG LIMITS TESTING RESULTS**

| Location | Depth (m) | Material Description | Liquid Limit (%) | Plasticity Index (%) | Linear Shrinkage (%) |
|---|---|---|---|---|---|
| BH508 | 0.50 – 0.65 | FILL: (CH) CLAY | 61 | 41 | – |
| **Previous Investigation (Ref: NEW17P-0054B-AB, dated: 9 March 2022)** | | | | | |
| TP307 | 0.65 – 0.85 | (CI) Gravelly Sandy CLAY | 39 | 14 | 7.5 |
| TP504 | 0.70 – 0.90 | (CI) Sandy CLAY | 39 | 14 | 8.5 |
| TP509 | 0.50 – 0.70 | (CI) Sandy CLAY | 37 | 13 | 7.5 |
| TP510 | 0.40 – 0.55 | (CI) Sandy CLAY | 37 | 14 | 7.0 |

The results of laboratory Shrink / Swell and Atterberg Limits tests indicate that the residual clays at the site are generally highly reactive.

## 6.0 Site Classification to AS2870-2011

Based on the results of the field work and laboratory testing, residential lots located within proposed Stage 5 of Hereford Hill residential subdivision located off Springfield Drive, Lochinvar, are classified in their current condition, in accordance with AS2870-2011 '*Residential Slabs and Footings*' as shown in Table 5.

**TABLE 5 – SITE CLASSIFICATION TO AS2870-2011**

| Stage 5 | Lot Numbers | Site Classification |
|---|---|---|
| Natural Soil Profile | 501 to 508 | **H2** |
| Level 1 Filled Lots | 509 to 524 | **E** |

A characteristic free surface movement of 60mm to 75mm is estimated for lots classified as **Class 'H2'** in their existing condition.

A characteristic free surface movement of 75mm to 115mm is estimated for lots classified as **Class 'E'** in their existing condition.

The effects of changes to the soil profile by additional cutting and filling and the effects of past and future trees should be considered in selection of the design value for differential movement. If site re-grading works involving cutting or filling are performed after the date of this assessment the classification may change and further advice should be sought.

Footings for the proposed development should be designed and constructed in accordance with the requirements of AS2870-2011.

The classification presented above assumes that:

- All footings are founded in controlled fill (if applicable) or in the natural clayey soils or rock below all non-controlled fill, topsoil material and root zones, and fill under slab panels meets the requirements of AS2870-2011, in particular, the root zone must be removed prior to the placement of fill materials beneath slabs;
- The performance expectations set out in Appendix B of AS2870-2011 are acceptable, and that site foundation maintenance is undertaken to avoid extremes of wetting and drying;
- Footings are to be founded outside of or below all zones of influence resulting from existing or future service trenches;
- The constructional and architectural requirements for reactive clay sites set out in AS2870-2011 are followed;
- Adherence to the detailing requirement outlined in Section 5 of AS2870-2011 '*Residential Slabs and Footings*' is essential, in particular Section 5.6, '*Additional requirements for Classes M, H1, H2 and E sites*' including architectural restrictions, plumbing and drainage requirements; and,
- Site maintenance complies with the provisions of CSIRO Sheet BTF 18, "*Foundation Maintenance and Footing Performance: A Homeowner's Guide*", a copy of which is attached in Appendix C.

All structural elements on all lots should be supported on footings founded beneath all uncontrolled fill, topsoil, layers of inadequate bearing capacity, soft/loose, wet or other potentially deleterious material.

If any localised areas of uncontrolled fill of depths greater than 0.4m are encountered during construction, footings should be designed in accordance with engineering principles for Class 'P' sites.

# 7.0 Limitations

This report comprises the results of an investigation carried out for a specific purpose and client as defined in the document. The report should not be used by other parties or for purposes or projects other than those assumed and stated within the report, as it may not contain adequate or appropriate information for applications other than those assumed or advised at the time of its preparation. The contents of the report are for the sole use of the client and no responsibility or liability will be accepted to any third party. The report should not be reproduced either in part or in full, without the express permission of Qualtest.

Geotechnical site investigation is based on data collection, judgment, experience, and opinion. By its nature, it is less exact than other engineering disciplines. The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical design practices and standards. To our knowledge, they represent a reasonable interpretation of the general conditions of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

The recommended depth and properties of any soil, rock, groundwater, or other material referred to in this report is an engineering estimate based on the information available at the time of its writing. The estimate is influenced and limited by the fieldwork method and testing carried out in the site investigation, and other relevant information as has been made available. In cases where information has been provided to Qualtest for the purposes of preparing this report, it has been assumed that the information is accurate and appropriate for such use. No responsibility is accepted by Qualtest for inaccuracies within any data supplied by others.

The extent of testing associated with this assessment is limited to discrete test locations. It should be noted that subsurface conditions between and away from the test locations may be different to those observed during the field work and used as the basis of the recommendations contained in this report.

If site conditions encountered during construction differ from those given in this report, further advice should be sought without delay.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

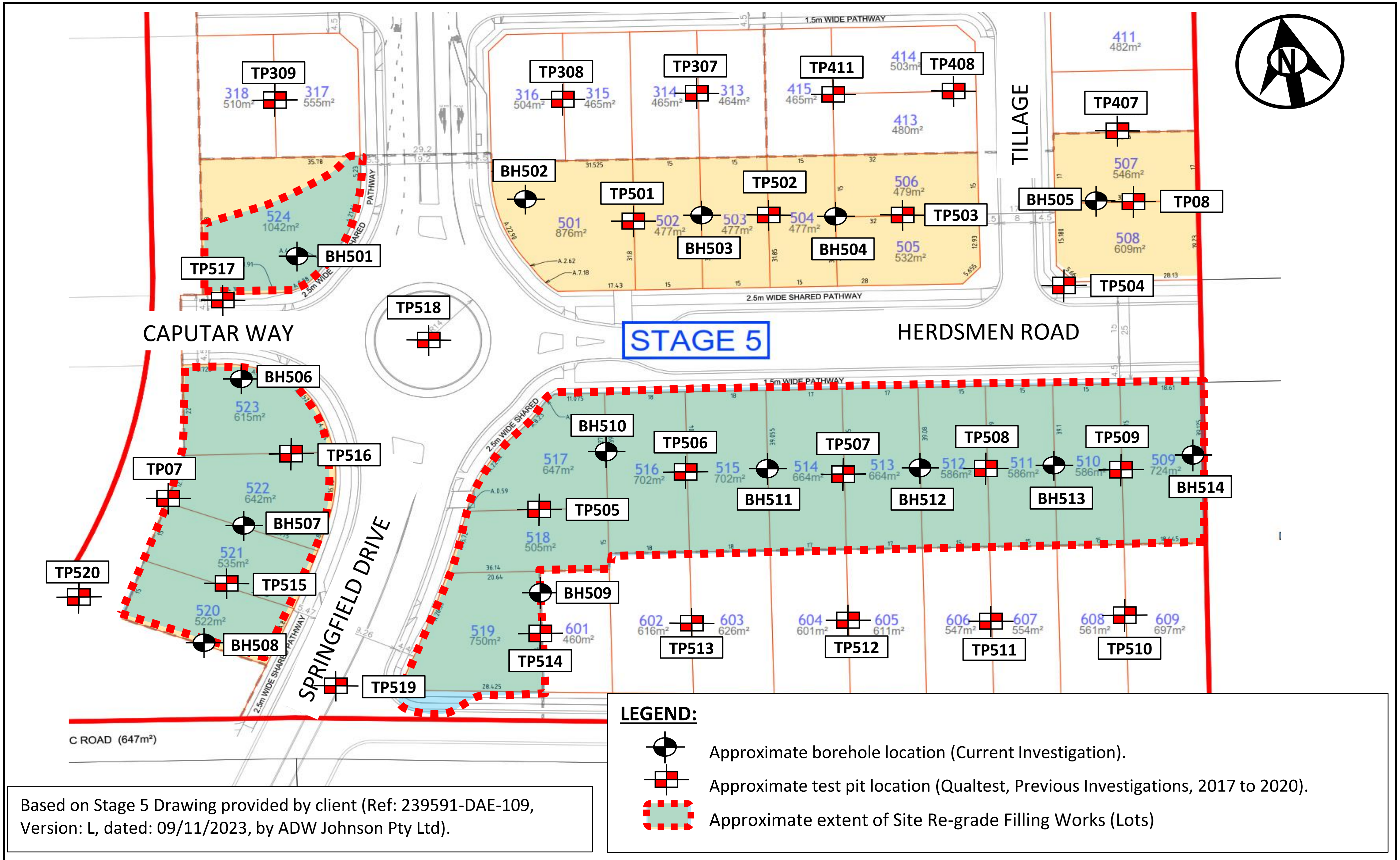
If you have any further questions regarding this report, please do not hesitate to contact Ben Edwards, Shannon Kelly, or the undersigned.

For and on behalf of Qualtest Laboratory (NSW) Pty Ltd.

Jason Lee
Principal Geotechnical Engineer

# Figure AG1

## Site Plan and Approximate Test Locations




Based on Stage 5 Drawing provided by client (Ref: 239591-DAE-109, Version: L, dated: 09/11/2023, by ADW Johnson Pty Ltd).

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| Client: | McCLOY LOCHINVAR PTY LTD | Drawing No: | FIGURE AG1 |
| Project: | PROPOSED SUBDIVISION - STAGE 5 | Project No: | NEW17P-0054B |
| Location: | SPRINGFIELD DRIVE, LOCHINVAR | Scale: | NOT TO SCALE |
| Title: | SITE PLAN & APPROXIMATE TEST LOCATIONS | Date: | 10 JULY 2024 |

# APPENDIX A:

## Results of Field Investigations

# ENGINEERING LOG - BOREHOLE

| | |
|---|---|
| **BOREHOLE NO:** | **BH501** |
| **CLIENT:** | McCLOY LOCHINVAR PTY LTD |
| **PAGE:** | 1 OF 1 |
| **PROJECT:** | HEREFORD HILL SUBDIVISION - STAGE 5 |
| **JOB NO:** | NEW17P-0054B |
| **LOCATION:** | SPRINGFIELD DRIVE, LOCHINVAR |
| **LOGGED BY:** | BE |
| **DATE:** | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**

**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | 0.10m | | 0.10m | CH | FILL-TOPSOIL: Gravelly CLAY - medium to high plasticity, grey, fine to medium grained angular gravel. | M > $W_P$ | | | | FILL-TOPSOIL |
| | | U50 0.30m | | 0.60m | CH | FILL: Gravelly CLAY - medium to high plasticity, brown to pale brown, fine to medium grained angular gravel, with Clayey Gravelly SAND pockets. | M > $W_P$ | St | HP | 150 | FILL-CONTROLLED |
| | | 0.60m U50 0.73m | | 1.50m | CH | CLAY - medium to high plasticity, brown to grey-brown. With Clayey Gravelly SAND pockets. | M > $W_P$ | St | HP | 150 | RESIDUAL SOIL |
| | | | | | | | | | HP | 150 | |
| | | | | 2.30m | CL | Sandy CLAY - low to medium plasticity, pale brown to grey-brown, fine to medium grained sand. | M < $W_P$ | VSt / Fb | | | |
| | | | | | | Hole Terminated at 2.30 m | | | | | |

Depth scale: 0.5, 1.0, 1.5, 2.0

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| **CLIENT:** | McCLOY LOCHINVAR PTY LTD | **BOREHOLE NO:** | **BH502** |
| **PROJECT:** | HEREFORD HILL SUBDIVISION - STAGE 5 | **PAGE:** | 1 OF 1 |
| **LOCATION:** | SPRINGFIELD DRIVE, LOCHINVAR | **JOB NO:** | NEW17P-0054B |
| | | **LOGGED BY:** | BE |
| | | **DATE:** | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.00–0.20m | CH | CLAY - medium to high plasticity, pale brown to brown, trace fine to coarse grained sand. | M > $W_P$ | VSt | | | RESIDUAL SOIL / COLLUVIUM |
| | | 0.50m U50 0.65m | | 0.20–1.30m | CH | CLAY - medium to high plasticity, pale brown, with pale grey. Pale brown. | M > $W_P$ | VSt | HP<br>HP<br>HP<br>HP<br>HP<br>HP<br>HP | 350<br>320<br>280<br>280<br>220<br>210<br>250 | RESIDUAL SOIL |
| | | | | 1.30–1.60m | CL | Sandy CLAY - low plasticity, pale brown, fine to medium grained sand. | M < $W_P$ | H / Fb | | | |
| | | | | 1.60–1.90m | CL | Gravelly Sandy CLAY / Gravelly Clayey SAND - low plasticity, pale brown, fine to coarse (mostly fine to medium) grained sand, fine grained angular gravel. | M < $W_P$ | H / Fb | | | RESIDUAL SOIL / EXTREMELY WEATHERED ROCK |
| | | | | 1.90–2.30m | | ANDESITE - pale brown, with some pale grey, estimated very low strength. Pale grey, estimated low to medium strength. Medium to high strength. | D | | | | HIGHLY WEATHERED ROCK |

Hole Terminated at 2.30 m
Refusal

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

**BOREHOLE NO:** BH503
**PAGE:** 1 OF 1
**JOB NO:** NEW17P-0054B
**LOGGED BY:** BE
**DATE:** 31/5/24

**CLIENT:** McCLOY LOCHINVAR PTY LTD
**PROJECT:** HEREFORD HILL SUBDIVISION - STAGE 5
**LOCATION:** SPRINGFIELD DRIVE, LOCHINVAR

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.0 | | CH | CLAY - medium to high plasticity, brown to dark brown. | M < $W_P$ | H | | | RESIDUAL SOIL |
| | | | | | | | | | | HP | 550 | |
| | | | | | | | | | | HP | 550 | |
| | | | | 0.5 | | | | M > $W_P$ | VSt | HP | 350 | |
| | | | | | | | With red-brown, trace white. | | | HP | 220 | |
| | | | | | | | | | | HP | 220 | |
| | | U50 0.90m–1.05m | | 1.0 | | | | | St | HP | 200 | |
| | | | | | | | | | | HP | 180 | |
| | | | | 1.5 | | | With pale brown. | | | | | |
| | | | | | | | Trace orange. | | VSt | HP | 200 | |
| | | | | | | | | | | HP | 250 | |
| | | | | 2.0 | | | | | | | | |
| | | | | | | | | | | HP | 250 | |
| | | | | 2.30m | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| CLIENT: | McCLOY LOCHINVAR PTY LTD | BOREHOLE NO: | BH504 |
| PROJECT: | HEREFORD HILL SUBDIVISION - STAGE 5 | PAGE: | 1 OF 1 |
| LOCATION: | SPRINGFIELD DRIVE, LOCHINVAR | JOB NO: | NEW17P-0054B |
| | | LOGGED BY: | BE |
| | | DATE: | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | | CH | CLAY - medium to high plasticity, brown to dark brown. | M > $W_P$ | VSt | HP | 350 | RESIDUAL SOIL |
| | | 0.50m U50 0.73m | | 0.5 | | | | | HP | 350 | |
| | | | | | | Pale brown, with Sandy CLAY pockets. | | | HP | 350 | |
| | | | | | | | M < $W_P$ | H / Fb | | | |
| | | | | 1.00m | GC | Extremely weathered Andesite with soil properties: breaks down into Clayey Sandy GRAVEL - fine to medium grained angular, pale brown, fine to coarse grained sand, fines of low plasticity. | D - M | VD | | | EXTREMELY WEATHERED ROCK |
| | | | | 2.10m | | Hole Terminated at 2.10 m<br>Slow progress | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

**Consistency**

| | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

**Moisture Condition**

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

**Density**

| | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH505
**PAGE:** 1 OF 1
**JOB NO:** NEW17P-0054B
**LOGGED BY:** BE
**DATE:** 31/5/24

Qualtest LABORATORY (NSW) PTY LTD

**CLIENT:** McCLOY LOCHINVAR PTY LTD
**PROJECT:** HEREFORD HILL SUBDIVISION - STAGE 5
**LOCATION:** SPRINGFIELD DRIVE, LOCHINVAR

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT
**SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm
**DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | | | CH | TOPSOIL: CLAY - medium to high plasticity, brown, trace pale brown, root affected. | $M < W_P$ | | | | TOPSOIL |
| | | | | 0.10m | | CH | CLAY - medium to high plasticity, brown, trace pale brown. | $M < W_P$ | H | HP | 400 | RESIDUAL SOIL |
| | | | | | | | | $M > W_P$ | VSt | HP | 300 | |
| | | | | | | | | | | HP | 250 | |
| | | 0.50m U50 0.65m | | 0.5 | | | | | | HP | 220 | |
| | | | | 0.60m | | CL | Sandy CLAY - low to medium plasticity, pale brown, fine to medium grained sand. | | | | | |
| | | | | | | | With fine grained angular to sub-angular gravel. | | | | | |
| | | | | 1.0 | | | | | | HP | 220 | |
| | | | | 1.5 | | | With Clay pockets. | | | HP | 220 | |
| | | | | 2.0 | | | | | | | | |
| | | | | 2.30m | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH506
**PAGE:** 1 OF 1
**CLIENT:** McCLOY LOCHINVAR PTY LTD
**PROJECT:** HEREFORD HILL SUBDIVISION - STAGE 5
**JOB NO:** NEW17P-0054B
**LOCATION:** SPRINGFIELD DRIVE, LOCHINVAR
**LOGGED BY:** BE
**DATE:** 31/5/24

Qualtest LABORATORY (NSW) PTY LTD

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT
**SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm
**DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.00–0.05m | GP | FILL: Sandy GRAVEL - fine to medium grained angular, grey-brown, fine to coarse grained sand, trace fines of low plasticity. | M | | | | FILL STOCKPILE REMNANTS |
| | | 0.50m U50 0.65m | | 0.05–0.90m | CH | FILL: CLAY - medium to high plasticity, brown and grey-brown, trace pale brown, trace fine grained angular to sub-angular gravel. | M > Wp | VSt | HP | 220 | FILL-CONTROLLED |
| | | | | 0.90–1.30m | CH | FILL: CLAY - medium to high plasticity, brown to grey-brown, trace fine to coarse grained sand, trace fine grained sub-angular gravel. | M < Wp | H | HP / HP | 450 / 450 | FILL-CONTROLLED / POSSIBLE RESIDUAL SOIL |
| | | | | 1.30–2.20m | CH | CLAY - medium to high plasticity, brown to grey-brown, trace fine to coarse grained sand. | M > Wp | VSt | HP / HP / HP | 300 / 300 / 280 | RESIDUAL SOIL |
| | | | | 2.20–2.30m | CL | Sandy CLAY - low to medium plasticity, pale brown, fine to medium grained sand. | | | | | |
| | | | | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- — — Gradational or transitional strata
- —— Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| **CLIENT:** | McCLOY LOCHINVAR PTY LTD | **BOREHOLE NO:** | **BH507** |
| **PROJECT:** | HEREFORD HILL SUBDIVISION - STAGE 5 | **PAGE:** | 1 OF 1 |
| **LOCATION:** | SPRINGFIELD DRIVE, LOCHINVAR | **JOB NO:** | NEW17P-0054B |
| | | **LOGGED BY:** | BE |
| | | **DATE:** | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.10m | | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine grained sand, root affected. | M > Wp | | | | FILL-TOPSOIL |
| | | 0.50m U50 0.70m; 1.10m U50 1.30m | | 1.90m | | CH | FILL: CLAY - medium to high plasticity, pale grey and dark brown. Pale brown to brown, trace fine to coarse grained sand, trace fine grained sub-rounded gravel. Brown to red-brown, trace fine grained angular to sub-angular gravel. Brown to pale brown. | | St (to 1.30m); VSt | HP; HP; HP; HP; HP; HP; HP; HP | 140; 190; 150; 190; 180; 300; 220; 200 | FILL-CONTROLLED |
| | | | | 2.30m | | CH | CLAY - medium to high plasticity, pale grey and pale orange to red-brown. | | St; VSt | HP; HP | 180; 220 | RESIDUAL SOIL |
| | | | | | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- – – Gradational or transitional strata
- —— Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

**BOREHOLE NO:** BH508
**PAGE:** 1 OF 1

**CLIENT:** McCLOY LOCHINVAR PTY LTD
**JOB NO:** NEW17P-0054B
**PROJECT:** HEREFORD HILL SUBDIVISION - STAGE 5
**LOGGED BY:** BE
**LOCATION:** SPRINGFIELD DRIVE, LOCHINVAR
**DATE:** 31/5/24

Qualtest LABORATORY (NSW) PTY LTD

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT
**SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm
**DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.00–0.10 | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine grained sand, root affected. | M > $W_P$ | | | | FILL-TOPSOIL |
| | | | | 0.10 | CH | FILL: CLAY - medium to high plasticity, brown to red-brown, with pale grey. | | St | | | FILL-CONTROLLED |
| | | | | | | | | | HP | 100 | |
| | | 0.50m U50 0.65m | | 0.5 | | | | | HP | 120 | |
| | | | | | | Brown and grey-brown, trace fine to medium grained angular to sub-angular gravel. | | St | HP | 150 | |
| | | 1.00m U50 1.20m | | 1.0 | | | | | HP | 170 | |
| | | | | | | | | VSt | HP | 180 | |
| | | | | 1.5 | | | | | HP | 220 | |
| | | | | | | | | St | HP | 200 | |
| | | | | | | | | | HP | 190 | |
| | | | | 2.0 | | | | St | HP | 180 | |
| | | | | 2.30 | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| **CLIENT:** | McCLOY LOCHINVAR PTY LTD | **BOREHOLE NO:** | **BH509** |
| **PROJECT:** | HEREFORD HILL SUBDIVISION - STAGE 5 | **PAGE:** | 1 OF 1 |
| **LOCATION:** | SPRINGFIELD DRIVE, LOCHINVAR | **JOB NO:** | NEW17P-0054B |
| | | **LOGGED BY:** | BE |
| | | **DATE:** | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**

**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| Drilling and Sampling | | | | | Material description and profile information | | | | | Field Test | | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | |
| AD/T | Not Encountered | | | 0.10m | | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine grained sand, root affected. | M > $W_P$ | | | | FILL-TOPSOIL |
| | | | | | | CH | FILL: CLAY - medium to high plasticity, brown to dark brown, trace fine grained sand. | | VSt | HP | 250 | FILL-CONTROLLED |
| | | | | | | | | | | HP | 300 | |
| | | 0.50m U50 0.70m | | 0.5 | | | Pale brown, with orange and pale grey to grey, trace white, trace fine to medium grained angular gravel. | | St | HP | 120 | |
| | | | | | | | Dark brown to grey-brown. | | VSt | HP | 220 | |
| | | 1.10m U50 1.30m | | 1.0 | | | | | | HP | 220 | |
| | | | | 1.5 | | | | | | HP | 220 | |
| | | | | 2.0 | | | | | | HP | 250 | |
| | | | | 2.30m | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**

- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**

- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

| | | | |
|---|---|---|---|
| **CLIENT:** | McCLOY LOCHINVAR PTY LTD | **BOREHOLE NO:** | **BH510** |
| **PROJECT:** | HEREFORD HILL SUBDIVISION - STAGE 5 | **PAGE:** | 1 OF 1 |
| **LOCATION:** | SPRINGFIELD DRIVE, LOCHINVAR | **JOB NO:** | NEW17P-0054B |
| | | **LOGGED BY:** | BE |
| | | **DATE:** | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.05m | CH | FILL-TOPSOIL: Sandy CLAY - medium to high plasticity, pale brown to brown, fine to medium grained sand, root affected. | M > Wp | | | | FILL-TOPSOIL |
| | | | | 1.00m | CH | FILL: CLAY - medium to high plasticity, dark brown and grey-brown, trace fine to coarse grained sand. | M > Wp | VSt | HP<br>HP<br>HP | 350<br>380<br>250 | FILL-CONTROLLED |
| | | 0.50m U50 0.65m | | 0.5 | | | | | | | |
| | | 1.10m U50 1.30m | | 1.50m | CH | CLAY - medium to high plasticity, brown to dark brown. | M > Wp | VSt | HP | 350 | RESIDUAL SOIL |
| | | | | 2.30m | CL | Sandy CLAY - low to medium plasticity, pale brown, fine to medium grained sand, trace fine grained sub-rounded to sub-angular gravel, trace clay pockets. | M < Wp / M > Wp | VSt / Fb / VSt | HP<br>HP | 350<br>350 | |
| | | | | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| CLIENT: | McCLOY LOCHINVAR PTY LTD | BOREHOLE NO: | BH511 |
| PROJECT: | HEREFORD HILL SUBDIVISION - STAGE 5 | PAGE: | 1 OF 1 |
| LOCATION: | SPRINGFIELD DRIVE, LOCHINVAR | JOB NO: | NEW17P-0054B |
| | | LOGGED BY: | BE |
| | | DATE: | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.00–0.10m | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine to coarse grained sand, root affected. | M > Wp | | | | FILL-TOPSOIL |
| | | 0.50m U50 0.75m; 0.90m U50 1.10m | | 0.10–1.20m | CH | FILL: CLAY - medium to high plasticity, dark brown and grey-brown, trace fine to coarse grained sand. | M > Wp | VSt | HP<br>HP<br>HP<br>HP | 220<br>250<br>220<br>220 | FILL-CONTROLLED |
| | | | | 1.20–1.80m | | CLAY - medium to high plasticity, dark grey-brown, with dark brown. | M < Wp (to ~1.4m); M > Wp | H; VSt | HP<br>HP<br>HP<br>HP<br>HP | 410<br>480<br>410<br>380<br>250 | RESIDUAL SOIL |
| | | | | 1.80–2.30m | | Sandy CLAY - low to medium plasticity, pale brown, fine to medium grained sand, trace clay pockets.<br>Grading into extremely weathered rock. | M > Wp; M < Wp | VSt; H | | | |
| | | | | 2.30m | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

| | | | |
|---|---|---|---|
| **CLIENT:** | McCLOY LOCHINVAR PTY LTD | **BOREHOLE NO:** | **BH512** |
| **PROJECT:** | HEREFORD HILL SUBDIVISION - STAGE 5 | **PAGE:** | 1 OF 1 |
| **LOCATION:** | SPRINGFIELD DRIVE, LOCHINVAR | **JOB NO:** | NEW17P-0054B |
| | | **LOGGED BY:** | BE |
| | | **DATE:** | 31/5/24 |

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics,colour,minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.10m | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine grained sand, root affected. | M > W$_P$ | | | | FILL-TOPSOIL |
| | | | | | CH | FILL: CLAY - medium to high plasticity, brown, with grey-brown and pale brown, trace fine grained sand. | | St | HP | 150 | FILL-CONTROLLED |
| | | | | | | | | VSt | HP | 200 | |
| | | | | | | | | | HP | 280 | |
| | | 0.50m U50 0.70m | | 0.5 | | | | | HP | 280 | |
| | | | | 1.0 | | | | | HP | 280 | |
| | | 1.10m U50 1.25m | | | | Trace orange-brown and grey, trace fine to coarse (mostly fine to medium) grained sand, trace fine to medium grained angular gravel. | | | HP | 220 | |
| | | | | 1.5 | | | | | HP | 350 | |
| | | | | 2.0 / 2.10m | CH | CLAY - medium to high plasticity, dark grey-brown. | | | HP | 320 | RESIDUAL SOIL |
| | | | | 2.30m | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

**BOREHOLE NO:** **BH513**

**CLIENT:** McCLOY LOCHINVAR PTY LTD

**PAGE:** 1 OF 1

**PROJECT:** HEREFORD HILL SUBDIVISION - STAGE 5

**JOB NO:** NEW17P-0054B

**LOCATION:** SPRINGFIELD DRIVE, LOCHINVAR

**LOGGED BY:** BE

**DATE:** 31/5/24

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**

**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.05m | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine grained sand, root affected. | M > $W_P$ | | | | FILL-TOPSOIL |
| | | | | | CH | FILL: CLAY - medium to high plasticity, grey-brown, trace fine grained sand. | | St | HP | 150 | FILL-CONTROLLED |
| | | | | | | | | | HP | 180 | |
| | | 0.50m U50 0.70m | | 0.5 | | | | VSt | HP | 220 | |
| | | 1.10m U50 1.40m | | 1.0 | | Dark brown to grey-brown, trace orange to red-brown. With Clayey SAND pockets, trace fine to medium grained angular to sub-angular gravel. | | | HP | 250 | |
| | | | | | | | | St | HP | 150 | |
| | | | | 1.50m | CH | CLAY - medium to high plasticity, pale brown. | | VSt | HP | 220 | RESIDUAL SOIL |
| | | | | 2.0 | | | | | HP | 250 | |
| | | | | 2.30m | | | | | HP | 250 | |
| | | | | | | Hole Terminated at 2.30 m | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# ENGINEERING LOG - BOREHOLE

Qualtest LABORATORY (NSW) PTY LTD

**CLIENT:** McCLOY LOCHINVAR PTY LTD
**PROJECT:** HEREFORD HILL SUBDIVISION - STAGE 5
**LOCATION:** SPRINGFIELD DRIVE, LOCHINVAR

**BOREHOLE NO:** **BH514**
**PAGE:** 1 OF 1
**JOB NO:** NEW17P-0054B
**LOGGED BY:** BE
**DATE:** 31/5/24

**DRILL TYPE:** 2.7 TONNE EXCAVATOR WITH AUGER ATTACHMENT **SURFACE RL:**
**BOREHOLE DIAMETER:** 300 mm **DATUM:**

| METHOD | WATER | SAMPLES | RL (m) | DEPTH (m) | CLASSIFICATION SYMBOL | MATERIAL DESCRIPTION: Soil type, plasticity/particle characteristics, colour, minor components | MOISTURE CONDITION | CONSISTENCY DENSITY | Test Type | Result | Structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AD/T | Not Encountered | | | 0.10m | CH | FILL-TOPSOIL: CLAY - medium to high plasticity, dark brown, trace fine grained sand, root affected. | M > W<sub></sub> | | | | FILL-TOPSOIL |
| | | | | | CH | FILL: CLAY - medium to high plasticity, grey-brown, trace fine grained sand. | M > $W_P$ | St | HP | 180 | FILL-CONTROLLED |
| | | | | | | | | | HP | 180 | |
| | | | | | | | | | HP | 150 | |
| | | 0.50m U50 0.72m | | 0.5 | | | | | | | |
| | | | | | | | | | HP | 180 | |
| | | | | | | | | | HP | 180 | |
| | | 1.00m U50 1.20m | | 1.00m | CH | CLAY - medium to high plasticity, grey-brown, trace pale brown and pale grey, trace fine grained sand, trace Clayey SAND pockets. | M > $W_P$ | VSt | HP | 280 | RESIDUAL SOIL |
| | | | | | | | | | HP | 210 | |
| | | | | 1.5 | | Brown. | | | HP | 220 | |
| | | | | 1.70m | CL | Sandy CLAY / Clayey SAND - low plasticity, pale brown, fine to coarse grained sand. | M < $W_P$ | H / Fb | | | RESIDUAL SOIL / EXTREMELY WEATHERED ROCK |
| | | | | 2.0 | | | | | | | |
| | | | | 2.30m | | Hole Terminated at 2.30 m<br>Slow progress | | | | | |

**LEGEND:**

**Water**
- Water Level (Date and time shown)
- Water Inflow
- Water Outflow

**Strata Changes**
- Gradational or transitional strata
- Definitive or distict strata change

**Notes, Samples and Tests**

| | |
|---|---|
| $U_{50}$ | 50mm Diameter tube sample |
| CBR | Bulk sample for CBR testing |
| E | Environmental sample (Glass jar, sealed and chilled on site) |
| ASS | Acid Sulfate Soil Sample (Plastic bag, air expelled, chilled) |
| B | Bulk Sample |

**Field Tests**

| | |
|---|---|
| PID | Photoionisation detector reading (ppm) |
| DCP(x-y) | Dynamic penetrometer test (test depth interval shown) |
| HP | Hand Penetrometer test (UCS kPa) |

| Consistency | | UCS (kPa) |
|---|---|---|
| VS | Very Soft | <25 |
| S | Soft | 25 - 50 |
| F | Firm | 50 - 100 |
| St | Stiff | 100 - 200 |
| VSt | Very Stiff | 200 - 400 |
| H | Hard | >400 |
| Fb | Friable | |

| Moisture Condition | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| $W_p$ | Plastic Limit |
| $W_L$ | Liquid Limit |

| Density | | |
|---|---|---|
| V | Very Loose | Density Index <15% |
| L | Loose | Density Index 15 - 35% |
| MD | Medium Dense | Density Index 35 - 65% |
| D | Dense | Density Index 65 - 85% |
| VD | Very Dense | Density Index 85 - 100% |

# APPENDIX B:

## Results of Laboratory Testing

# Material Test Report

Newcastle Laboratory
2 Murray Dwyer Circuit Mayfield West NSW 2304
Phone: (02) 4968 4468
Email: admin@qualtest.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

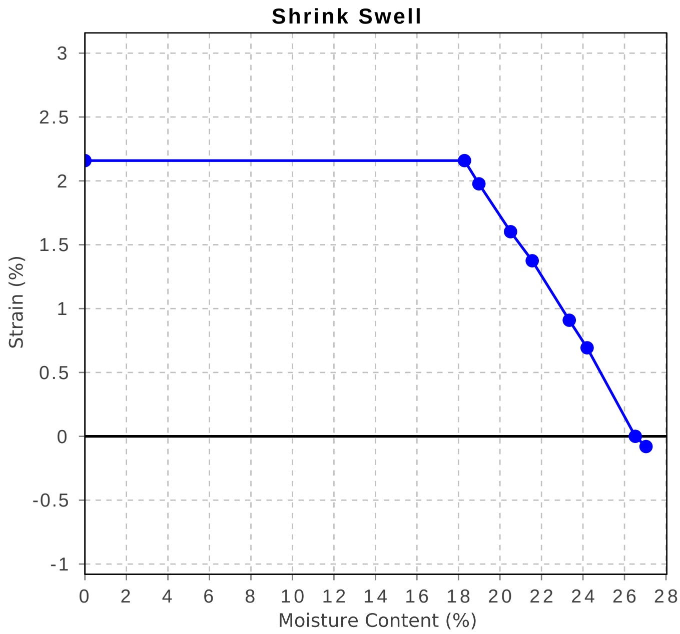
Approved Signatory: Kyle Spencer
Senior Geotechnican
NATA Accredited Laboratory Number: 18686

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511A |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 11/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH501 - (0.60 - 0.73m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **1.2** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **2.2** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Slightly Cracked |
| Crumbling | No |
| Moisture Content (%) | 26.5 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 340 |
| Final Pocket Penetrometer (kPa) | 280 |
| Initial Moisture Content (%) | 24.1 |
| Final Moisture Content (%) | 27.0 |
| **Swell (%)** | **0.1** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511B |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 11/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH502 - (0.50 - 0.65m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

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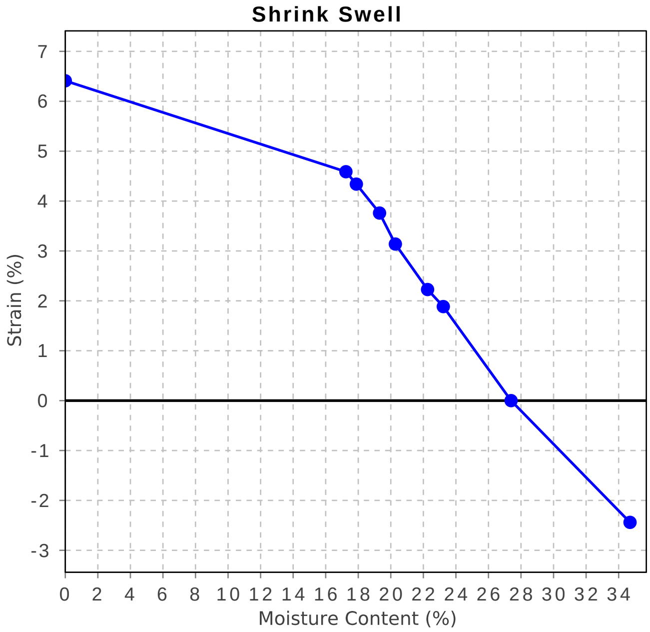
NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Kyle Spencer
Senior Geotechnican
NATA Accredited Laboratory Number: 18686

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **4.2** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **6.4** |
| Estimated % by volume of significant inert inclusions | 1 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 27.4 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 230 |
| Final Pocket Penetrometer (kPa) | 230 |
| Initial Moisture Content (%) | 32.1 |
| Final Moisture Content (%) | 34.7 |
| **Swell (%)** | **2.4** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd |
| | PO Box 2214, Dangar  NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511C |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 11/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department |
| | *The results apply to the sample as received* |
| **Sample Location:** | **BH503 - (0.90 - 1.05m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |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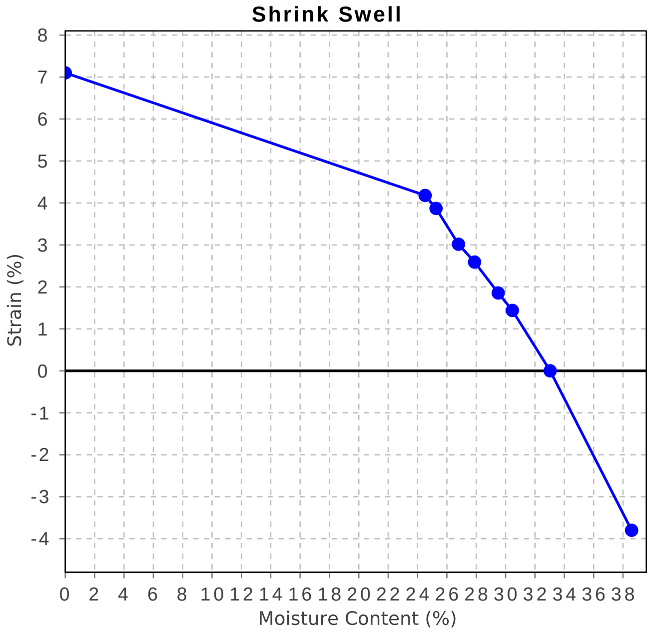
Senior Geotechnican
NATA Accredited Laboratory Number: 18686

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **5.0** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **7.1** |
| Estimated % by volume of significant inert inclusions | 1 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 33.0 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 200 |
| Final Pocket Penetrometer (kPa) | 240 |
| Initial Moisture Content (%) | 39.3 |
| Final Moisture Content (%) | 38.6 |
| **Swell (%)** | **3.8** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd |
| | PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511D |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 11/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department |
| | *The results apply to the sample as received* |
| **Sample Location:** | **BH504 - (0.50 - 0.73m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |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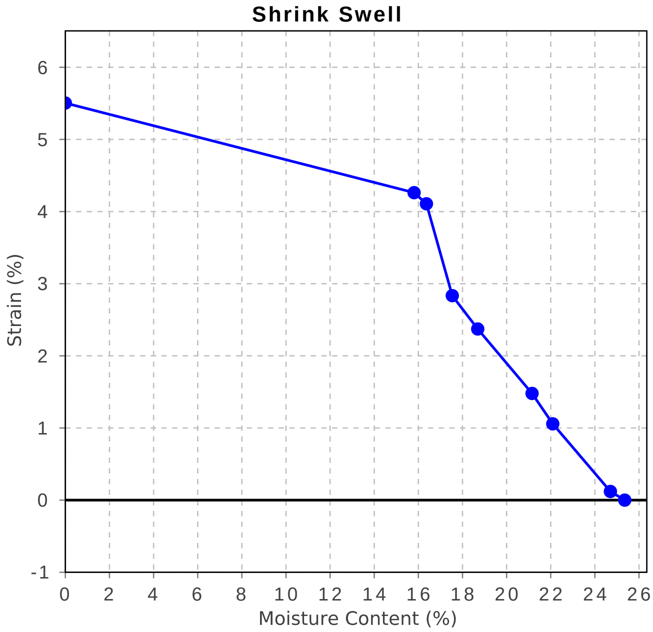
Senior Geotechnican

NATA Accredited Laboratory Number: 18686

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.1** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **5.5** |
| Estimated % by volume of significant inert inclusions | 1 |
| Cracking | Moderately Cracked |
| Crumbling | No |
| Moisture Content (%) | 25.4 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 220 |
| Final Pocket Penetrometer (kPa) | 280 |
| Initial Moisture Content (%) | 20.0 |
| Final Moisture Content (%) | 24.7 |
| **Swell (%)** | **-0.1** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd |
| | PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511E |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 11/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department |
| | *The results apply to the sample as received* |
| **Sample Location:** | **BH505 - (0.50 - 0.65m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |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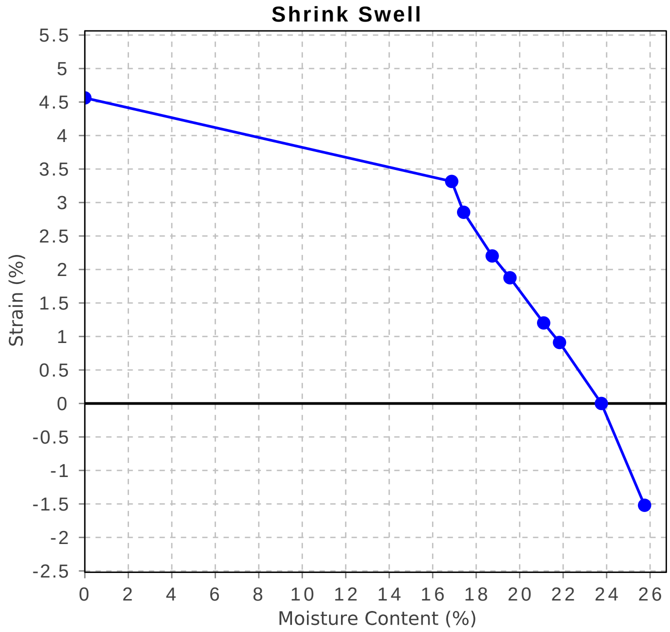
NATA Accredited Laboratory Number: 18686

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.0** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **4.6** |
| Estimated % by volume of significant inert inclusions | 1 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 23.8 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | >600 |
| Final Pocket Penetrometer (kPa) | 300 |
| Initial Moisture Content (%) | 22.5 |
| Final Moisture Content (%) | 25.7 |
| **Swell (%)** | **1.5** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



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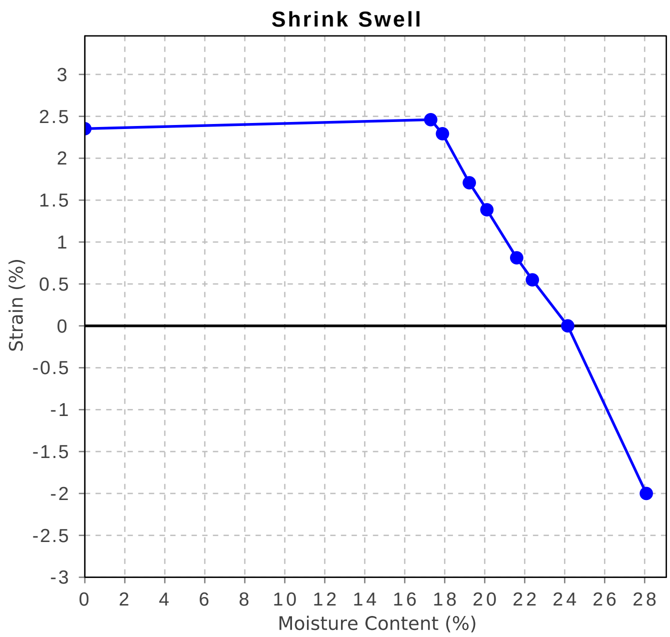
Senior Geotechnican
NATA Accredited Laboratory Number: 18686

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511F |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 11/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH506 - (0.50 - 0.65m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **1.9** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **2.4** |
| Estimated % by volume of significant inert inclusions | 1 |
| Cracking | Slightly Cracked |
| Crumbling | No |
| Moisture Content (%) | 24.2 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 500 |
| Final Pocket Penetrometer (kPa) | 380 |
| Initial Moisture Content (%) | 46.1 |
| Final Moisture Content (%) | 28.1 |
| **Swell (%)** | **2.0** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



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Senior Geotechnican

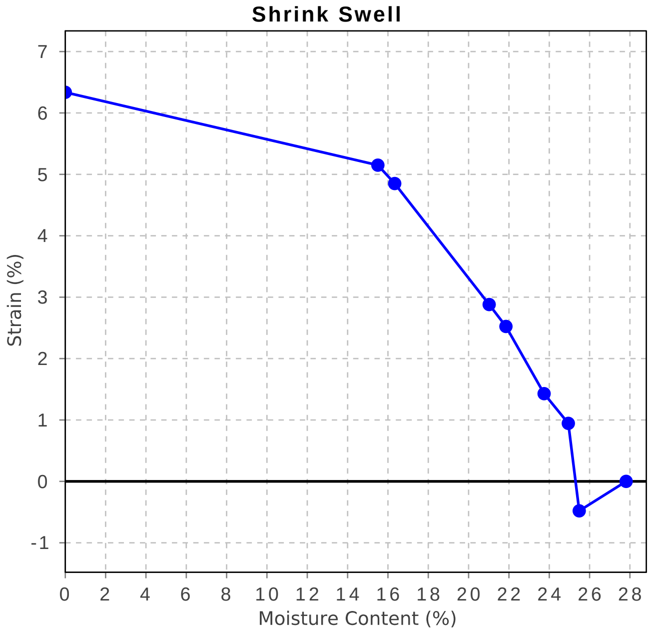
NATA Accredited Laboratory Number: 18686

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511G |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 12/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH507 - (0.50 - 0.70m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.7** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **6.3** |
| Estimated % by volume of significant inert inclusions | 3 |
| Cracking | Slightly Cracked |
| Crumbling | Yes / No |
| Moisture Content (%) | 27.8 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 250 |
| Final Pocket Penetrometer (kPa) | 290 |
| Initial Moisture Content (%) | 24.1 |
| Final Moisture Content (%) | 25.5 |
| **Swell (%)** | **0.5** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511H |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 12/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH507 - (1.10 - 1.30m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

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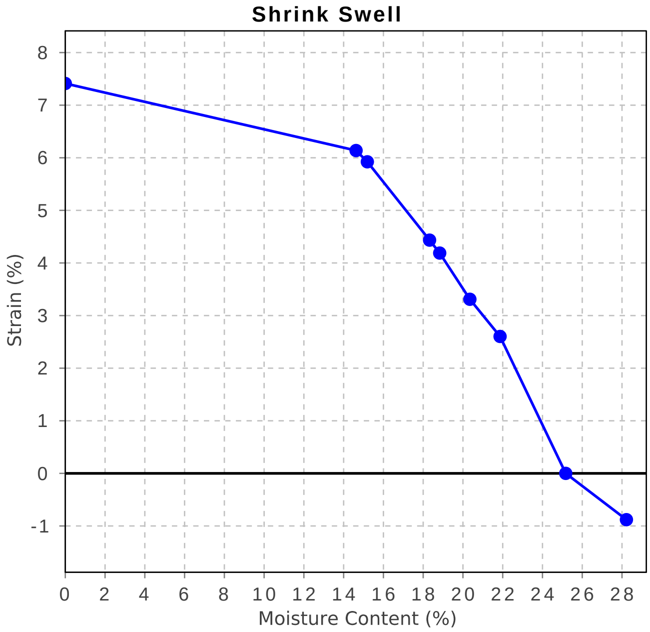
Approved Signatory: Kyle Spencer
Senior Geotechnican

NATA Accredited Laboratory Number: 18686

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **4.4** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **7.4** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 25.2 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 480 |
| Final Pocket Penetrometer (kPa) | 410 |
| Initial Moisture Content (%) | 29.9 |
| Final Moisture Content (%) | 28.2 |
| **Swell (%)** | **0.9** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511I |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 13/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH508 - (0.50 - 0.65m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

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| Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 61 | | |
| Plastic Limit (%) | 20 | | |
| **Plasticity Index (%)** | **41** | | |

# Material Test Report

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| | |
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| **Report Number:** | **NEW17P-0054B-1** |
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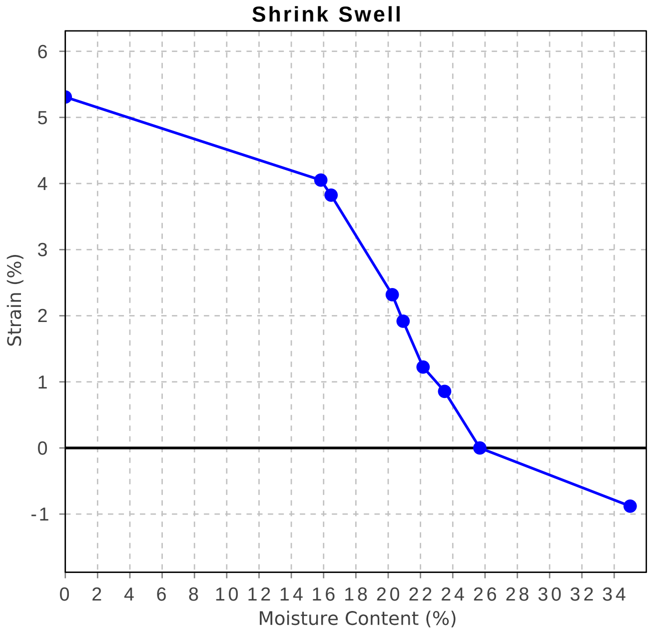
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511J |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 12/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH509 - (0.50 - 0.70m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.2** |
| Visual Description | Clayey Sand |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **5.3** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 25.7 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 270 |
| Final Pocket Penetrometer (kPa) | 230 |
| Initial Moisture Content (%) | 25.7 |
| Final Moisture Content (%) | 35.0 |
| **Swell (%)** | **0.9** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

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| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511K |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 12/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH510 - (0.50 - 0.65m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **1.8** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **2.6** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Moderately Cracked |
| Crumbling | No |
| Moisture Content (%) | 19.5 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | >600 |
| Final Pocket Penetrometer (kPa) | 470 |
| Initial Moisture Content (%) | 18.7 |
| Final Moisture Content (%) | 23.5 |
| **Swell (%)** | **1.3** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |

# Material Test Report

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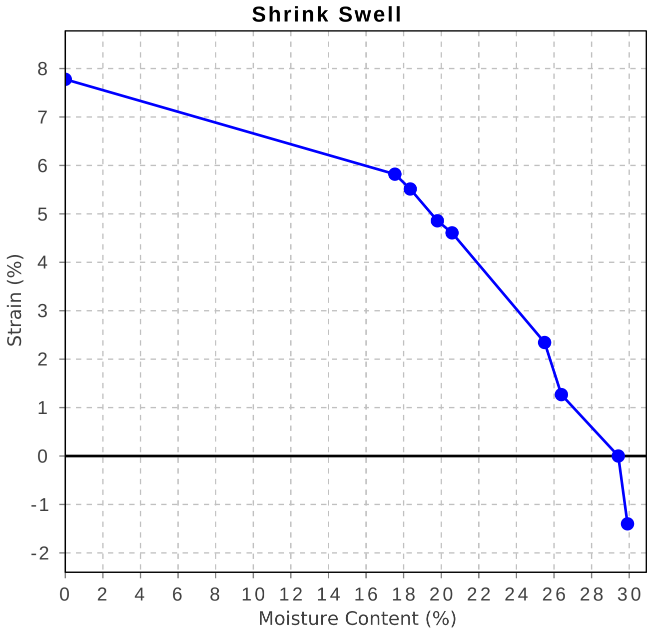
| | |
|---|---|
| **Report Number:** | **NEW17P-0054B-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511L |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 13/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH510 - (1.10 - 1.30m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **4.7** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **7.8** |
| Estimated % by volume of significant inert inclusions | 3 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 29.4 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 460 |
| Final Pocket Penetrometer (kPa) | 330 |
| Initial Moisture Content (%) | 25.4 |
| Final Moisture Content (%) | 29.9 |
| **Swell (%)** | **1.4** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

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Approved Signatory: Kyle Spencer
Senior Geotechnican
NATA Accredited Laboratory Number: 18686

**Report Number:** **NEW17P-0054B-1**
**Issue Number:** 1
**Date Issued:** 20/06/2024
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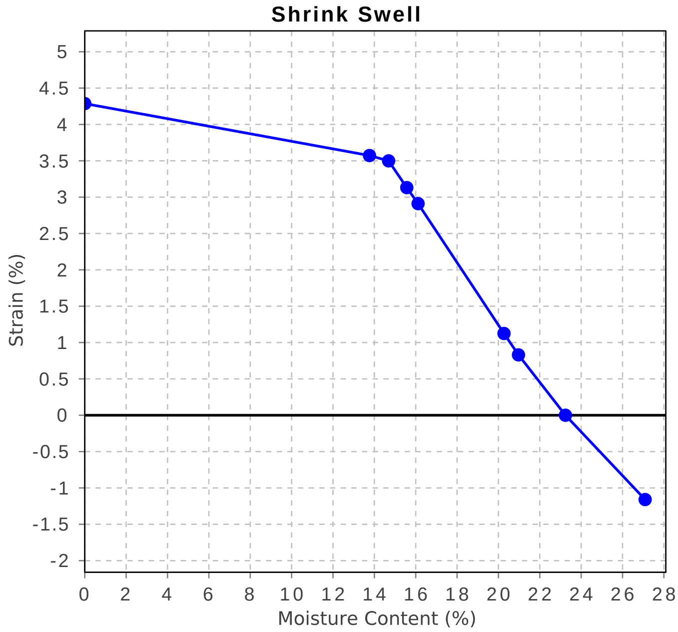
PO Box 2214, Dangar NSW 2309
**Contact:** Rylan Gibson
**Project Number:** NEW17P-0054B
**Project Name:** Proposed Subdivision - Hereford Hill Stage 5
**Project Location:** 853 New England Highway, Lochinvar
**Work Request:** 4511
**Sample Number:** NEW24S-4511M
**Date Sampled:** 31/05/2024
**Dates Tested:** 06/06/2024 - 13/06/2024
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **BH511 - (0.50 - 0.75m)**
**Material:** CLAY
**Material Source:** On-Site

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **2.7** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **4.3** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Moderately Cracked |
| Crumbling | No |
| Moisture Content (%) | 23.2 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 500 |
| Final Pocket Penetrometer (kPa) | 470 |
| Initial Moisture Content (%) | 23.7 |
| Final Moisture Content (%) | 27.1 |
| **Swell (%)** | **1.2** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# Material Test Report

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|---|---|
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| **Issue Number:** | 1 |
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd<br>PO Box 2214, Dangar  NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511N |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 13/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH512 - (0.50 - 0.70m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

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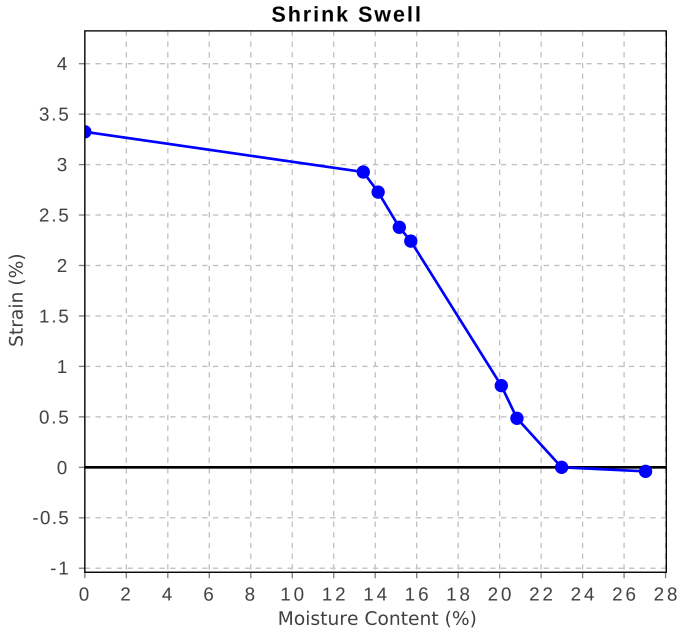
| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **1.9** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **3.3** |
| Estimated % by volume of significant inert inclusions | 4 |
| Cracking | Slightly Cracked |
| Crumbling | No |
| Moisture Content (%) | 23.0 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 280 |
| Final Pocket Penetrometer (kPa) | 300 |
| Initial Moisture Content (%) | 23.8 |
| Final Moisture Content (%) | 27.0 |
| **Swell (%)** | **0.0** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



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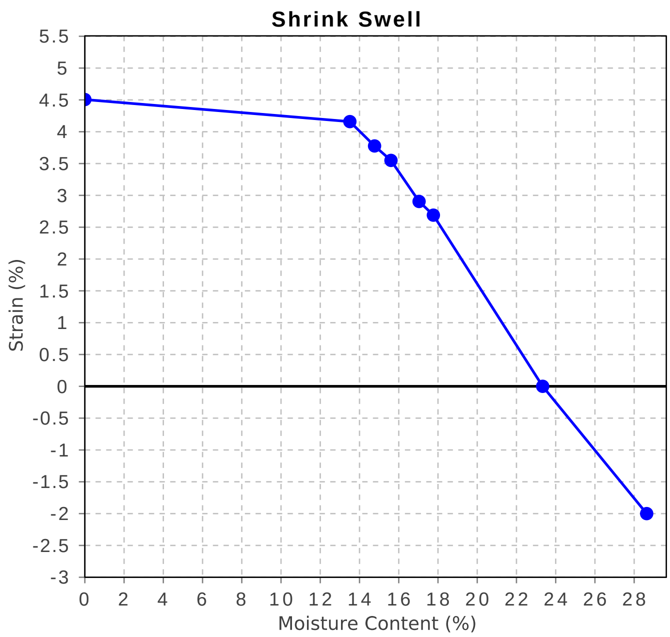
| **Date Issued:** | 20/06/2024 |
| **Client:** | McCloy Project Management Pty Ltd |
| | PO Box 2214, Dangar NSW 2309 |
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511O |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 14/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department |
| | *The results apply to the sample as received* |
| **Sample Location:** | **BH512 - (1.10 - 1.25m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.1** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **4.5** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Slightly Cracked |
| Crumbling | No |
| Moisture Content (%) | 23.3 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | >600 |
| Final Pocket Penetrometer (kPa) | 450 |
| Initial Moisture Content (%) | 23.9 |
| Final Moisture Content (%) | 28.6 |
| **Swell (%)** | **2.0** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



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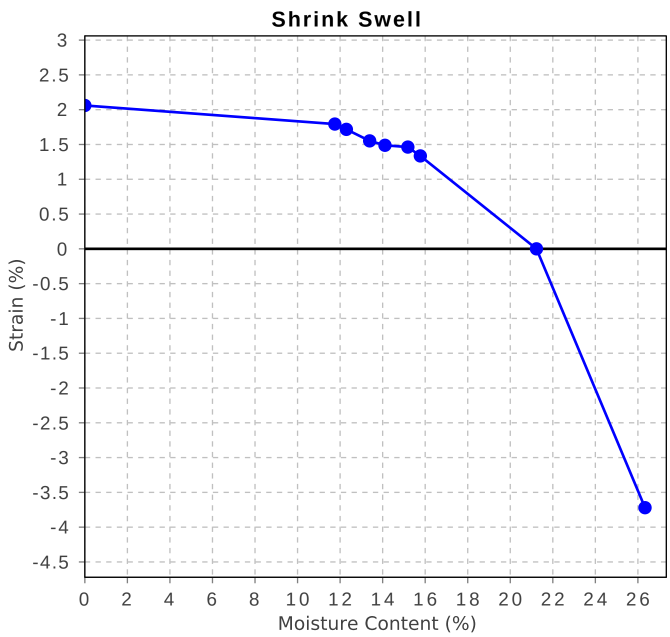
| **Contact:** | Rylan Gibson |
| **Project Number:** | NEW17P-0054B |
| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511P |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 14/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **BH513 - (0.50 - 0.70m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **2.2** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **2.1** |
| Estimated % by volume of significant inert inclusions | 3 |
| Cracking | Moderately Cracked |
| Crumbling | No |
| Moisture Content (%) | 21.2 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | >600 |
| Final Pocket Penetrometer (kPa) | 440 |
| Initial Moisture Content (%) | 19.3 |
| Final Moisture Content (%) | 26.3 |
| **Swell (%)** | **3.7** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



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|---|---|
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| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511Q |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 14/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department |
| | *The results apply to the sample as received* |
| **Sample Location:** | **BH514 - (0.50 - 0.72m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |

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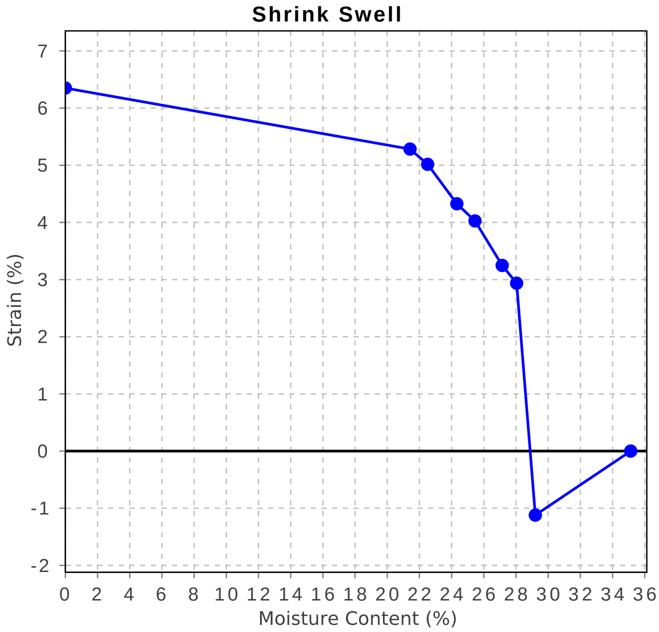
| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.8** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **6.4** |
| Estimated % by volume of significant inert inclusions | 3 |
| Cracking | Uncracked |
| Crumbling | No |
| Moisture Content (%) | 35.1 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 250 |
| Final Pocket Penetrometer (kPa) | 240 |
| Initial Moisture Content (%) | 25.9 |
| Final Moisture Content (%) | 29.2 |
| **Swell (%)** | **1.1** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



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|---|---|
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| **Project Name:** | Proposed Subdivision - Hereford Hill Stage 5 |
| **Project Location:** | 853 New England Highway, Lochinvar |
| **Work Request:** | 4511 |
| **Sample Number:** | NEW24S-4511R |
| **Date Sampled:** | 31/05/2024 |
| **Dates Tested:** | 06/06/2024 - 14/06/2024 |
| **Sampling Method:** | Sampled by Engineering Department |
| | *The results apply to the sample as received* |
| **Sample Location:** | **BH514 - (1.00 - 1.20m)** |
| **Material:** | CLAY |
| **Material Source:** | On-Site |


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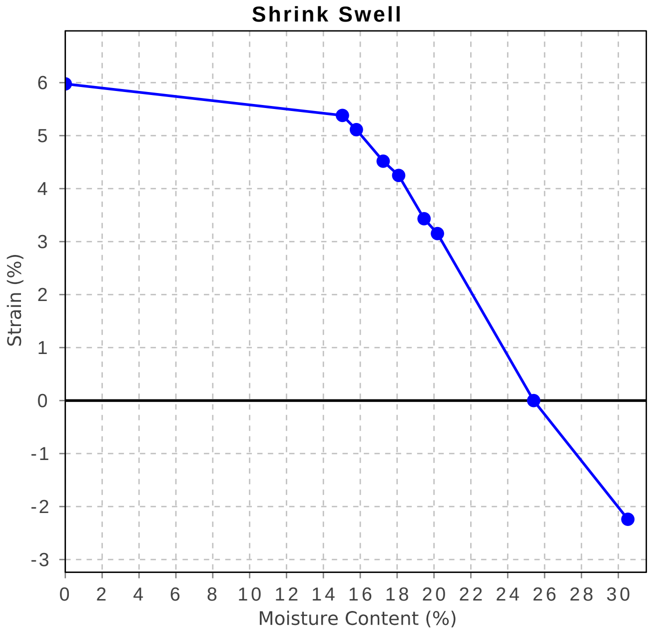
| Shrink Swell Index (AS 1289 7.1.1 & 2.1.1) | |
|---|---|
| **Iss (%)** | **3.9** |
| Visual Description | Clay |
| * Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction. | |

| Core Shrinkage Test | |
|---|---|
| **Shrinkage Strain - Oven Dried (%)** | **6.0** |
| Estimated % by volume of significant inert inclusions | 2 |
| Cracking | Slightly Cracked |
| Crumbling | No |
| Moisture Content (%) | 25.4 |

| Swell Test | |
|---|---|
| Initial Pocket Penetrometer (kPa) | 600 |
| Final Pocket Penetrometer (kPa) | 350 |
| Initial Moisture Content (%) | 25.3 |
| Final Moisture Content (%) | 30.5 |
| **Swell (%)** | **2.2** |
| * NATA Accreditation does not cover the performance of pocket penetrometer readings. | |



# APPENDIX C:

## CSIRO Sheet BTF 18

## Foundation Maintenance and Footing Performance: A Homeowner's Guide

# Foundation Maintenance and Footing Performance: A Homeowner's Guide

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).

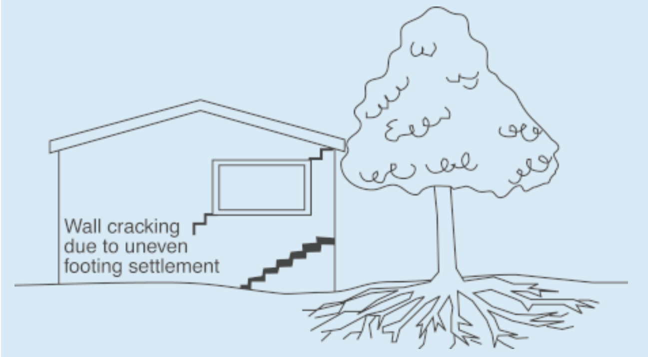
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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.

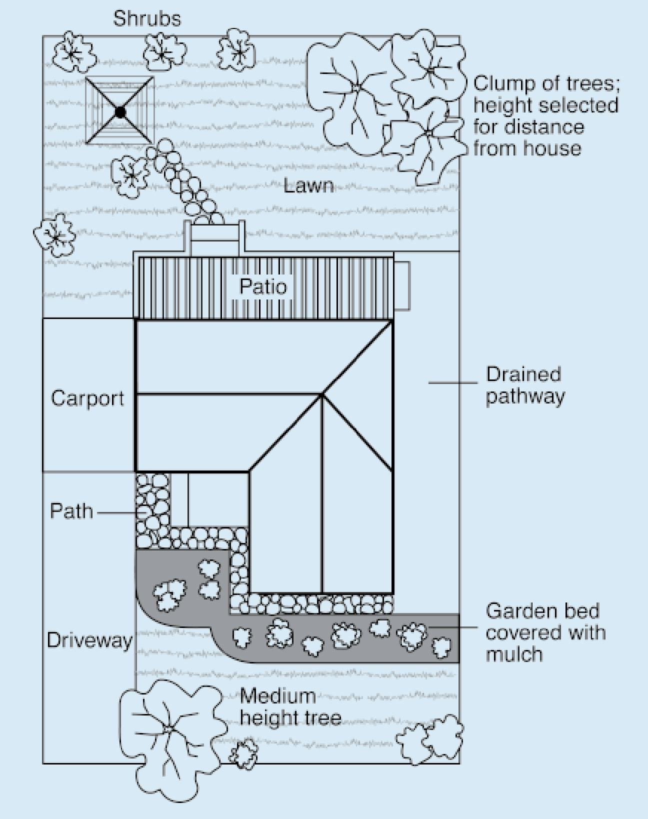
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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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