Preliminary Geotechnical Assessment

Huntlee New Town Stage 2 DA

304001022-003

Prepared for
Huntlee Pty Ltd

5 December 2023

Stantec

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Table of Contents

Appendices

Tables

Figures

1 Introduction

This Preliminary Geotechnical Assessment supports an Environmental Impact Statement (EIS) and State Significant Development Application (SSDA) that seeks consent for the Huntlee New Town Stage 2 development, comprising the concept development for the Stage 2 sites including Villages 2 and 3, land off Old North Road and the Town Centre North area, and the detailed development for the central and southern areas of Village 2. The proposal represents the next phase of an extensive planning, assessment and consultation process completed to date for the development of the Huntlee New Town site.

Specifically, this SSDA proposes the following works for the Huntlee New Town:

- A Concept Master plan for the Stage 2 site, comprising:
  - Overall Stage 2 development footprint, including:
    - The remaining Town Centre North area,
    - Villages 2 and 3, and
    - A large lot residential area located to the south of the site on Old North Road;
  - Proposed land use and development yield, including the provision for residential subdivision of approximately 5,000 lots.
  - Associated new road network and required upgrades to existing network.
  - Site-wide open space and riparian areas.
- Detailed development of Village 2 Central and South and eastern connection to the Town Centre, comprising:
  - Demolition and clearing of existing built form structures.
  - Clearing of existing vegetation within proposed development footprints.
  - Open space, recreation, community, and riparian areas.
  - Construction of road and access infrastructure.
  - Bulk earthworks.
  - Stormwater and drainage works.
  - Utilities and services, including:
    - Sewer and potable water reticulation.
    - Electricity and communications infrastructure.
  - Subdivision to facilitate approximately 1,750 lots across the Village 2 Central and South areas and Town Centre development lots, comprising approximately 1,730 residential lots, eight (8) medium density super lots, two (2) commercial/mixed use lots and open space areas.
  - Select clearing and grading to establish temporary Asset Protection Zones where development interfaces with the Concept Master plan area.

Figure 1-1 demonstrates the location of the Stage 2 Concept and Detailed areas, in the context of the surrounding development. Stantec were also supplied with the layout plans prepared by *Daly Smith* (ref. 20406, sheet. 1, ver. 7, date. 25/07/2023), attached in **Appendix A.**

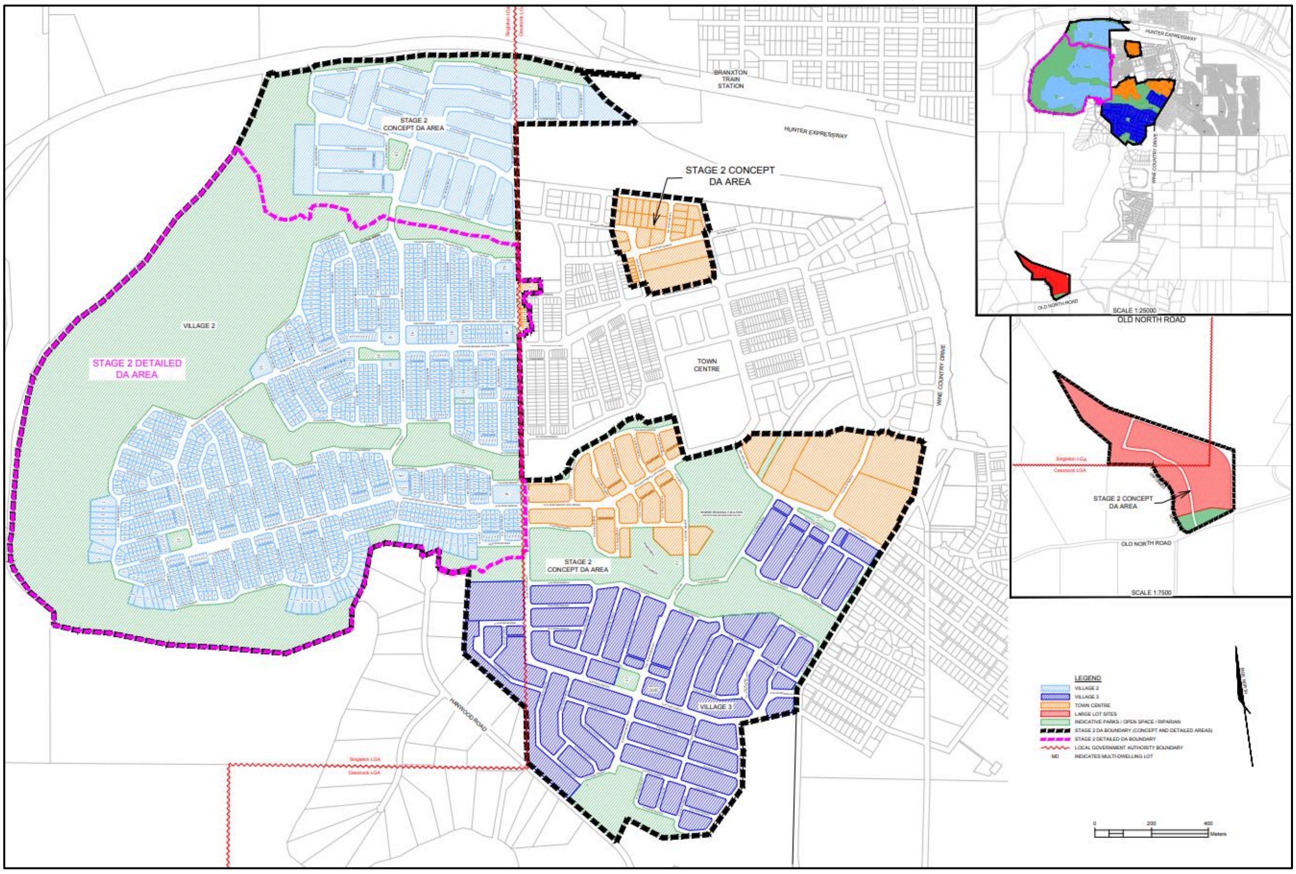

Figure 1-1 Proposed Concept and Detailed Layout Area (Source: *Daly Smith*)

2 The Site

The subject site forms a large component of the 1,622 hectare Huntlee New Town, situated to the south of Branxton in the Hunter Valley. It is located approximately 20km north of Cessnock, 23km south-east of Singleton, and 55km north-west of Newcastle.

The subject site comprises a number of allotments located in both Cessnock and Singleton Local Government Areas (LGAs). It has a combined area of approximately 541.71 ha, is irregular in shape and is generally extended to the west and south of the approved Huntlee Town Centre. The site is bound to the west by the Black Creek and floodplain. An aerial photo of the site is provided at **Figure 2-1**.

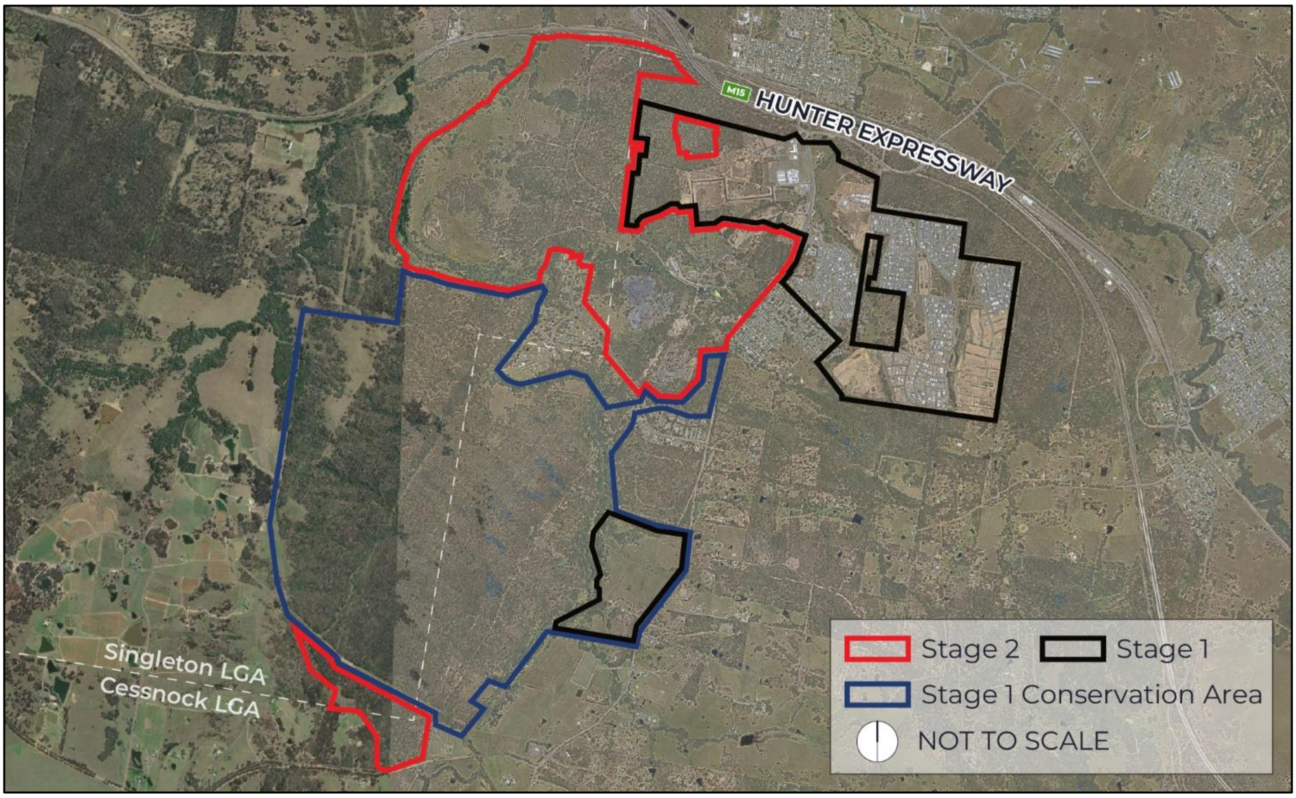

Figure 2-1 Site Aerial

3 Objectives & Scope

3.1 Objectives

The primary objective of this assessment was to obtain geotechnical data throughout the proposed Huntlee Stage 2 DA area as a basis to provide commentary on the following:

- Surface and subsurface conditions, including groundwater.
- Identification of geotechnical site constraints / considerations for the proposed development, including (but not limited to):
  - Soil erosion, salinity, and acid sulfate soils.
  - Soil reactivity, slope stability.
  - Other geotechnical-related issues e.g. presence of uncontrolled fill materials.
- Recommendation on remediation to address geotechnical constraints, tailored to the expected development.
- General development recommendations for proposed design and construction, with preliminary recommendations for likely elements forming the development, including:
  - Earthworks operations.
  - Basin construction.
  - Foundation conditions, including footing recommendations.
  - Retaining walls.
  - Pavement design and construction recommendations.
- Recommendations for further geotechnical assessment.

3.2 Scope of Works

The scope of the assessment was predominantly limited to site inspection and desktop review of available published information and previous investigations undertaken by Stantec or others.

Following the outcomes of the initial inspection and review, limited subsurface investigation was undertaken to supplement the existing data. The limited investigation generally comprised the drilling of boreholes and collection of samples, with subsequent laboratory assessment for acid sulfate soils and soil salinity. The scope of the limited borehole investigation is detailed in **Section 6** below.

4 Previous Investigations

Stantec (*and former entities)* and others have previously undertaken extensive geotechnical investigation throughout the overall Huntlee New Town development area to provide recommendations and commentary for pavement design and construction, site classification, basin construction, preliminary acid sulphate soils and salinity assessments, earthworks recommendations, and environmental assessment.

Review of previous investigations was conducted, with relevant geotechnical data utilised within the current investigation (where appropriate). Previous data utilised within the current assessment was sourced from previous investigations carried out within the following Huntlee development areas:

> Huntlee Estate Residential Development

> Huntlee Town Centre Development (Commercial and Residential)

> Wine Country Drive and Hunter Expressway Upgrades.

5 Site Description

5.1 Site Identification & Surrounds

As described in **Section 2**, the subject site is defined as Stage 2 (the 'site') of the Huntlee New Town development and consists of three irregular shaped parcels of land spanning the suburbs of North Rothbury, Rothbury, Branxton, and Belford in the Hunter Region of NSW.

The two northern land parcels (defined herein as the 'northern site area') form most of the subject site area and are located off Wine Country Drive, predominantly west of the existing Stage 1 of the Huntlee New Town development ('Stage 1'), with the smaller parcel of land enclosed within the existing Stage 1 boundary. The southern land parcel (defined herein as the 'southern site area') is located approximately 3.5km south of the northern site area, off Old North Rd.

Site locality to the defined site areas is depicted in **Figure 5-1** below, and shown overlain on aerial imagery in **Drawing 1** and **2**, attached in **Appendix B**.

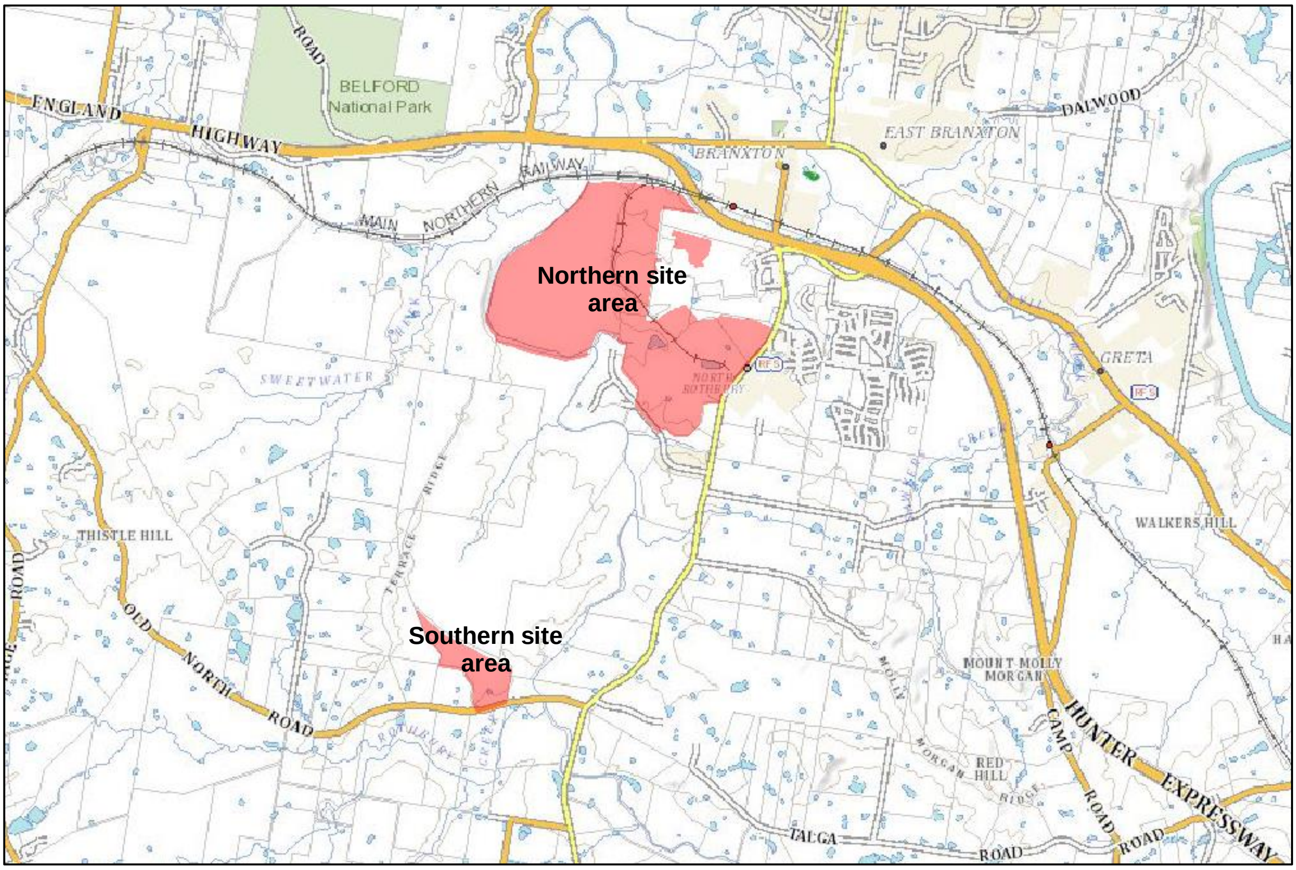

Figure 5-1 Locality of Stage 2 site area

With respect to the lots and depositional plots constituting the subject site area, relevant site details were obtained, listed in **Table 5-1** below.

Table 5-1 Site Details

Item	Description
Defined Site Address	▪ 1707, 1729, 1771 & 1823 Wine Country Drive, North Rothbury ▪ 62 Old North Rd, Belford
Registered Lots	▪ Lots 3-4 DP 813163 ▪ Lots 11-13 DP 1137569 ▪ Lots 695-696 DP 1263808 (parts of) ▪ Lot 240 DP 1105591 (part of)

Item	Description
Coordinates (site centre)	▪ Northern Site Area: E 343724m, N 6383792m ▪ Southern Site Area: E 341891m, N 6379798m
Site Area	▪ Approximately 542 hectares
Site Elevation	▪ Approximately 25 to 102m AHD
Local Government Area/s	▪ Singleton Shire Council (SSC) ▪ Cessnock City Council (CCC)
Land Zoning	▪ R1: General Residential ▪ R2: Low Density Residential ▪ R5: Large Lot Residential ▪ MU1: Mixed Use ▪ C1: National Parks and Nature Reserves ▪ SP2: Infrastructure

Generally, the overall site currently appears to be vacant and largely comprises undeveloped native bushland and pasture, however with several areas of previous heavy disturbance related to the former *Ayrfield No.3 Colliery* and former quarry area/s, and disused rail corridor. The site is generally bounded by the following:

> Northern site area:
  - Main Northern rail corridor and existing Huntlee Town Centre (TC) development to the north.
  - Wine Country Drive and existing / future TC development to the east.
  - Black Creek and existing residential township to the south.
  - Black Creek to the west.

> Southern site area:
  - Approximately east-west spanning overhead powerline easement and designated conservation area comprising native bushland to the north.
  - Commercial vineyard *(Black Creek Farm)* and constructed north-south spanning access track to the east. Black Ck is also noted approximately 300m to the east.
  - Old North Road and rural residential properties to the south.
  - Undeveloped bushland and rural residential properties to the west.

5.2 Topography & Drainage

Regionally, the overall site is largely set within gently undulating terrain and characterised by a network gullies and tributaries within the Anvil and Black Creek catchments. Terrain to the west of the northern site area comprises relatively level alluvial plains associated with Black Ck, with Black Ck defining part of the northern site area boundary to the west.

Topographic site contours developed from publicly available LIDAR information, is depicted in **Drawing 3**, attached in **Appendix B**, and summarised for each site area below.

5.2.1 Topography

Site elevations (AHD) to the northern site area range from approximately 20-25m within Black Ck, to 80m within the northern portion of the former colliery area.

Natural site slopes typically range from <1 to 5° and ultimately fall to the west (locally variable) towards Black Ck, with minor areas to the northern site extent and former quarry area falling generally north to north-east towards tributaries of Anvil Ck. Site slopes within the former colliery and quarry areas are highly variable, ranging from flat associated with former building footprints to steep cut faces generated from past extractive activities.

Site elevations (AHD) to the southern site area range from approximately 42m at the south-eastern site limits, to 102m at the crest of a generally north-south trending ridgeline to the west of site.

Natural site slopes typically range from 2 to 6° across site and predominantly fall to the east and south-east towards tributaries of Rothbury and Black Creek, with a minor portion of the site to the west falling to the north-west. Relatively flat benches and steep cut faces are noted within the envelope of the possible former quarry area to the east of site.

5.2.2 Drainage

Drainage throughout the site is predominantly expected to comprise of overland flows in the direction of the existing natural or modified site slopes. Initial overland sheet flows would generally converge to shallow concentrated flows via the ephemeral gullies / tributaries present throughout site, before discharging into the primary perennial watercourses consisting of Black, Anvil, and Rothbury Creeks.

Some subsurface drainage and infiltration could be expected within the shallower granular colluvial/alluvial materials, however unlikely to be predominant given the site slopes. Due to the presence of sodic (dispersive) site clays, typically having poor drainage potential, waterlogged conditions could occur at times in areas of flatter terrain.

5.3 Soil Landscape

Reference to the *Soil and Land Resources of Central and Eastern NSW* dataset [1] indicates the site area spans several reported soil landscapes consisting of erosional, alluvial, and disturbed landforms, depicted in **Figure 5-2** below.

Erosional landform encompasses most of the site area, with reported landscapes *Wallalong (wgx), Dochra (dot)* and *Pokolbin (pku)*, typically characterised by gently undulating rises to undulating low hills on Permian-aged sedimentary formations of the Maitland and Dalwood Groups.

Alluvial landform exists to the west of the northern site area adjacent Black Creek, with reported landscape *Rothbury (ron)*, characterised by very gently inclined floodplains and terraces on Quaternary alluvium.

Disturbed landform encompasses a portion of the northern site area, associated with the former *Ayrfield No. 3 Colliery* and quarry sites. The reported *Disturbed Terrain (xxz)* landscape is generally defined as heavily disturbed land arising from human activity, with features of the original landform extensively modified.

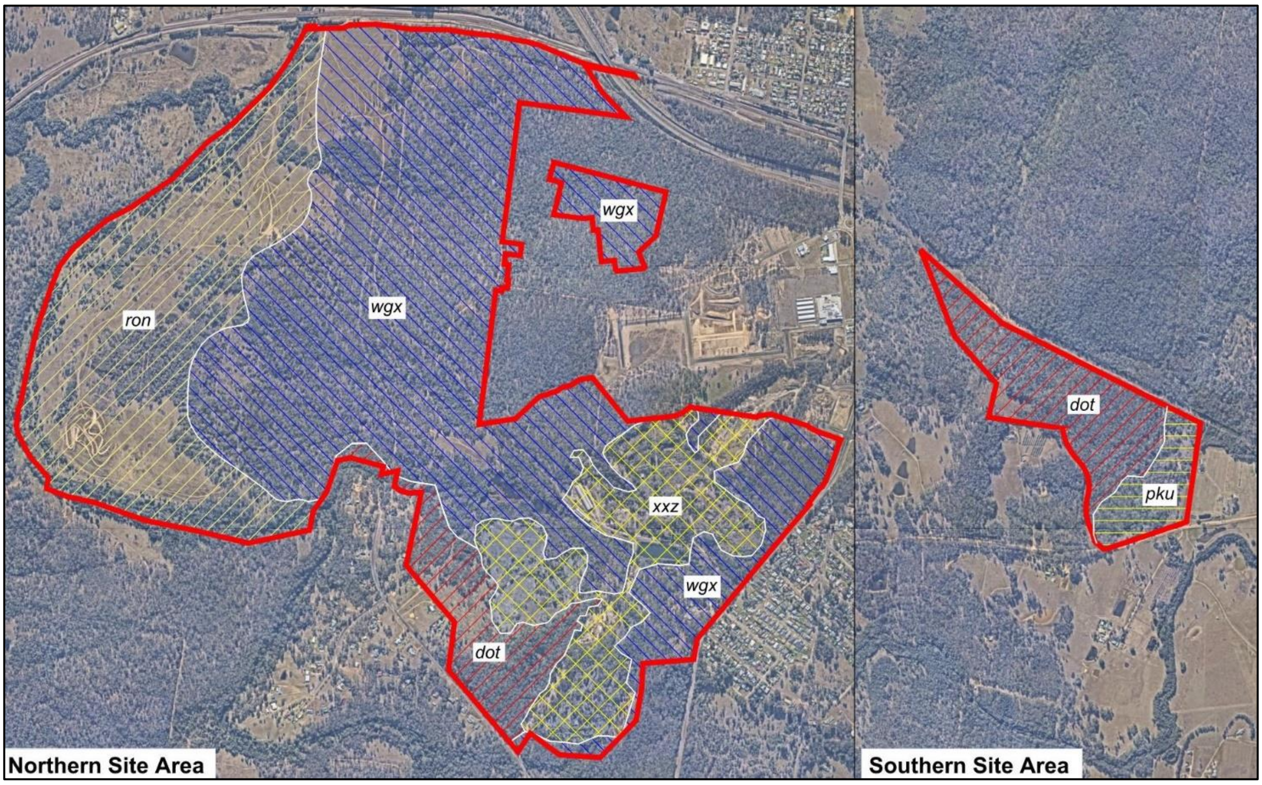

Figure 5-2 Extract of published soil landscape maps

5.4 Geology & Hydrogeology

Reference to the Newcastle Coalfield Regional Geology [2] map, depicted in **Figure 5-3**, indicates the site is immediately underlain primarily by the *Branxton Formation* (Pmb) of the *Maitland Group*, which is known to comprise conglomerate, sandstone, and siltstone. The *Greta Coal Measures* (Pg) is reported to underlie the *Branxton Formation*, however, is noted to daylight along the eastern boundary to the northern and southern site areas, and generally dips to the west. The *Greta Coal Measures* typically comprises sandstone, conglomerate, siltstone, and coal.

Quaternary-aged *Alluvium* (Qa) associated with the Black Ck alignment, overlies the *Branxton Formation* at a minor portion of the site to the north-west, and typically comprises gravel, sand, silt, and clay soils.

The generally north-west trending *Greta Fault* is noted to intercept the northern site area.

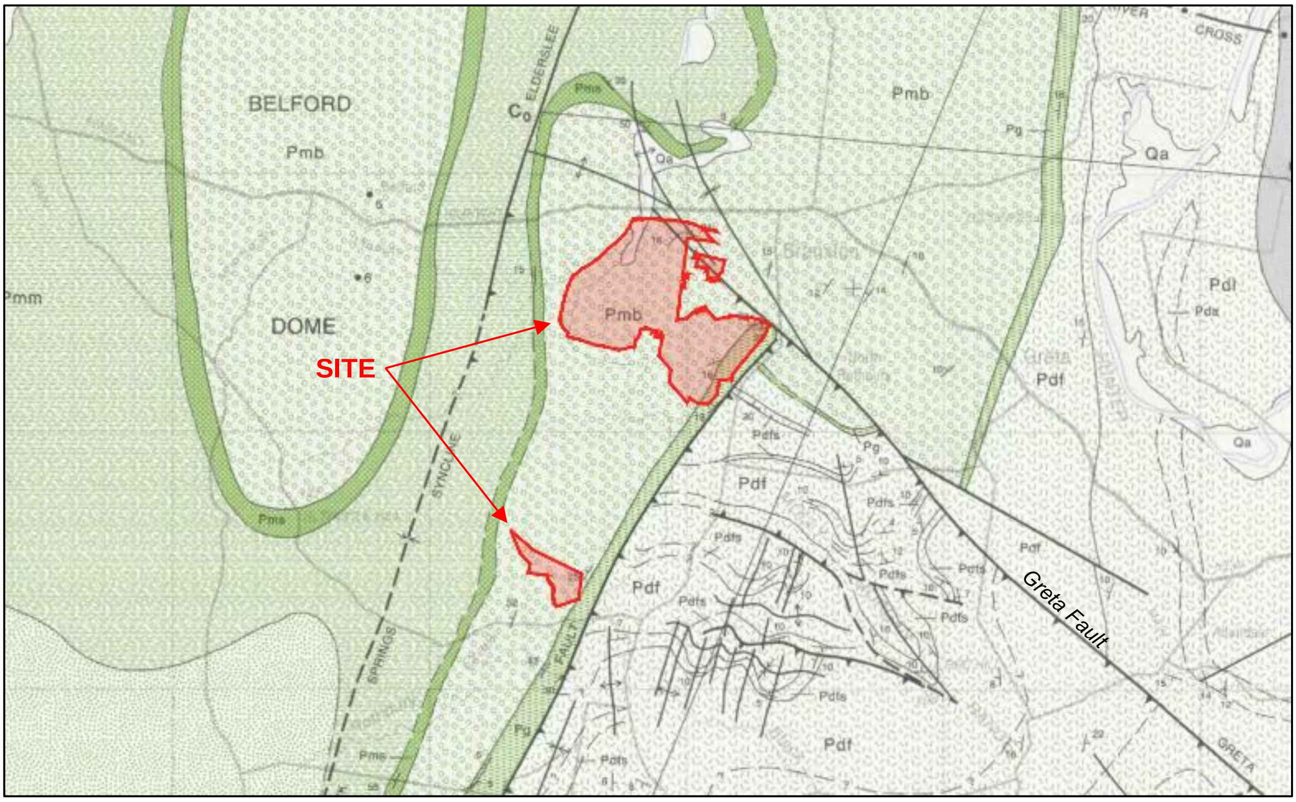

Figure 5-3 Extract of published geology map

Site soils overlying the reported geological formations are expected to comprise alluvial / colluvial materials derived from the parent rock, and residual soils generated through in-situ weathering to the parent rock.

Reference of the *Hydrogeology of Australia* [3] map indicates the site is located within a hydrogeological setting comprising of fractured or fissured, extensive aquifers of low to moderate productivity.

Stantec also retains information on groundwater levels relevant to the site area from previous and ongoing investigations, discussed in **Section 7.2.3**.

5.5 Acid Sulphate Soils

Review of the NSW *Acid Sulphate Soils (ASS) Risk* dataset [4] indicates the site is not located within a mapped area of probable ASS occurrence. Further review of the CSIRO's *Atlas of Australian Acid Sulfate Soils* dataset [5] revealed the entire site is within an area mapped as extremely low probability of occurrence for ASS.

5.6 Vegetation

Vegetation to the site generally comprises dense native bushland consisting of semi-mature to mature trees and shrub to the east of the northern site area and majority of the southern. Heavily grassed pasture is predominant within the alluvial flood plain to the west of the northern site area, and includes scattered trees, predominantly in proximity to the existing drainage lines. Several areas were devoid of vegetation due to previous disturbance, associated with the former colliery and quarries, disused rail corridor, and existing access tracks.

5.7 Acid Mine Drainage

Review of NSW EPA's *Contaminated Land Record of Notices* revealed a previous notice issued to Misthold Pty Ltd for the former Ayrfield No. 3 Colliery site (notice no. 330). The notice related to suspected environmental degradation associated with acidic surface and groundwater generated from the existing CWR stockpiles at the site. EPA issued direction for the development of a management plan to control acid water generation and erosion of the stockpiles.

5.8 Mine Subsidence

Review of the NSW Government Planning Portal '*Spatial Viewer'* web application [6] indicates portions of the northern and southern site areas are situated within the declared Branxton Mine Subsidence District, with reported historical underground coal mining below the site. It is understood that a mine subsidence impact assessment is currently being undertaken for the development by others.

5.9 Site Features

A site inspection was conducted on 3 August 2023 by a geotechnical engineer from Stantec. Inspection generally comprised a visual appraisal of the overall site, including recording and photography of salient site conditions and features.

Relevant site features observed during the inspection are summarised below, with site photographs attached in **Appendix C**. Site features and associated photo locations are also depicted in **Drawing 4** and **5**, attached in **Appendix B**.

- Numerous small existing dams constructed throughout the site, ranging from 150 to 400m^2 in storage area, with three larger dams associated with the former colliery operation, ranging from 3,000 to 14,000m^2. Tunnel erosion was noted within the wall of the existing dam in the southern site area.
- Several areas of uncontrolled filling, predominantly consisting of:
  - Two large coarse CWR stockpiles, reported at approximately 500,000m^3, to the south of the colliery.
  - Fine CWR emplacement, including several previously constructed landfill cells to the north of the colliery.
  - Other general filling associated with building pads, colliery dam walls, access tracks, land fill cell construction, etc.
  - Mixture of soil, building rubble, and other general refuse backfilled within the south of the quarry void.
  - Large amounts of building rubble / waste and general refuse observed at surface level throughout the colliery and quarry areas, appeared to be related to demolition of former structures, waste from former operations, and likely fly tipping.
  - Several small overgrown stockpiles / berms towards south-west of the northern site area and east of the southern site area, where observable, comprised building rubble.
  - General fill material used for construction of the railway embankment and smaller existing dam walls.
  - Isolated areas of general refuse, including numerous abandoned motor vehicles, throughout the overall site, commonly off existing access tracks.
- Several abandoned and/or partially demolished residential-style structures and industrial sheds within the colliery area.
- Possible former quarry or borrow area to the east of the southern site area.
- Numerous access track / trails throughout, largely unformed, however several tracks comprised coarse CWR surfacing to the south-west of the northern site area.
- Disused railway spanning the northern site area, constructed in both cut and fill. Fill heights and cut depths were variable based on natural topography, however expected to exceed 4 to 5m (cut and fill) in areas.
- Significant erosion / rutting observed within drainage lines and bare areas throughout site. Extensive sheet erosion and scour is also noted across the large CWR stockpiles within the colliery area.

- No visual indicators of acid sulphate or saline soils were observed.
- No indications of large-scale creep movements or deep-seated slope instability were observed at surface levels.
- Some minor areas of shallow or surficial instability were observed within locally steeper gully/creek banks due to erosion of surface soils and minor rock falls and rilling in areas of steep to near-vertical cut faces within the rail corridor and former quarries.

6 Limited Investigation Works

6.1 Rationale

It was identified that most of the proposed Stage 2 development area falls within published soil and geological landscapes which have previously been assessed (extensively) by Stantec throughout previous investigations for the adjacent Stage 1 of the development. Previous data on subsurface conditions is generally expected to be representative of ground conditions to most of the current site area. It is however understood that the western portion of the northern site area falls within a reported alluvial soil landscape *(ron – Rothbury landscape)*, with no existing information on ground conditions from previous investigations retained by or available to Stantec. As such, limited subsurface investigation and laboratory assessment was undertaken to supplement the desktop review of previous and published data.

The investigation generally comprised targeted boreholes drilled east and west of the reported alluvial landscape boundary and with respect to the proposed developed extents, for the purpose of:

> assessing ground conditions to the alluvial landscape (previously unassessed);

> verifying extents of the reported alluvial landscape; and

> qualifying the consistency in ground conditions within the previously assessed landscape/s (east of the alluvial landscape).

6.2 Investigation Methodology

6.2.1 Site Investigation

Intrusive investigation was undertaken on the 13th of September 2021 and comprised the drilling of 4 boreholes (BH01-BH04) to depths ranging from 0.8 to 6.6m bgl using a ute-mounted drilling rig, equipped with solid flight augers.

Disturbed environmental samples were regularly collected for subsequent laboratory analysis for salinity and acid sulphate soil assessment.

All fieldwork, including logging of subsurface profiles was conducted under the supervision of a geotechnical engineer from Stantec. Borehole locations are shown overlaid on georeferenced aerial imagery and client supplied DA plans in **Drawing 6**, attached in **Appendix B**.

6.2.2 Laboratory Testing

Laboratory analysis was conducted on the recovered soil samples to inform acid sulfate soil and salinity assessments, with testing comprising the following:

> Five (5) salinity profiling tests, including CEC, ESP (Sodicity), Cl^-, SO_4^{2-} , pH, EC, and resistivity.

> Nine (9) electrical conductivity (EC) tests.

> Fourteen (14) acid sulphate soil field screenings.

> Six (6) detailed acid sulphate soils tests (S_{CR} analysis).

All chemical laboratory analysis was undertaken at a NATA accredited chemical testing laboratory.

6.3 Investigation Findings

6.3.1 Subsurface Conditions

Based on the reported soil landscape boundaries, BH01 was drilled within the previously unassessed *Rothbury (ron)* alluvial landform, with BH02-BH04 drilled within the *Wallalong (wgx)* erosional landform (previously assessed). The encountered subsurface conditions are summarised in **Table 6-1** below, and detailed on engineering logs attached in **Appendix D**.

Table 6-1 Summary of Encountered Subsurface Conditions

Origin	Unit Description
Topsoil	Silty SAND surficial material with organic inclusions, typically 50-100mm in thickness and encountered at all test locations.
Alluvium	Fine to medium grained Silty / Clayey SAND and low to medium plasticity Silty / Sandy CLAY, variable grey, brown and orange in colour, encountered in BH01 to a depth of 6.4m bgl. Moisture condition to the alluvial soils was generally variable ranging from below to above the plastic limit for clays and dry to moist condition in sands.
Colluvium	Fine to medium grained Silty SAND with some gravel inclusion, brown to grey-brown in colour, encountered in BH02-BH04 to depths ranging from 0.1 to 0.6m bgl. Colluvial sands were generally dry to moist in condition.
Residual	High plasticity Silty CLAY, orange- and red-brown in colour, encountered in BH02 and BH04 to depths of 0.7 and 0.8m bgl, respectively. Residual clays were generally below to above the plastic limit in moisture condition.
Extremely Weathered Material (EWM)	Extremely weathered siltstone / sandstone, white mottled red and orange in colour, encountered in BH04 to a depth of 1.3m bgl. Extremely weathered materials were generally consistent with a low plasticity Silty Sandy CLAY with low moisture content (below the plastic limit).
Weathered Rock	Highly to moderately (distinctly) weathered SILTSTONE and SANDSTONE bedrock, generally orange and grey in colour, encountered in all boreholes below overlying soil and extremely weathered profiles at depths ranging from 0.7 to 6.4m bgl. Drilling refusal with a TC-bit occurred at BH01-BH02 and BH03 at depths ranging from 0.8 to 6.6m bgl.

No groundwater or seepage was encountered within any of the borehole locations at the time of the investigation. It should be noted that groundwater levels are likely to fluctuate with variations in climatic and site conditions.

Subsurface conditions encountered in boreholes drilled within the previously assessed landscape (BH02-BH04), to the east of the alluvial landform boundary, were generally confirmed to be consistent with subsurface conditions observed during the previous Stage 1 investigations. In the main, all encountered subsurface conditions were generally considered to be consistent with the published geology and soil landscape mappings, including extents.

6.3.2 Laboratory Test Results

The results of the laboratory testing undertaken on recovered site soils are summarised in below tables and detailed on NATA-endorsed laboratory reports sheets attached in **Appendix E**.

Table 6-2 Summary of Salinity Testing Results

Bore ID	Depth (m)	Soil Description	Structure	EC (µS/cm)	EC_e(1) (µS/m)	Salinity Class(2)	ESP (%)	Sodicity Class(2)
BH01	0.3	Silty Sand	Alluvium	16	272	*Non-Saline*	NT(3)	*Non-Sodic*
	1.0	Sandy Clay	Alluvium	62	527	*Non-Saline*	-	-
	1.4	Silty Clay	Alluvium	180	1440	*Non-Saline*	27	*Highly Sodic*
	2.3	Clayey Sand	Alluvium	180	2520	*Slightly Saline*	-	-
	2.8	Silty Sandy Clay	Alluvium	320	2720	*Slightly Saline*	-	-
	3.3	Silty Clay	Alluvium	300	2400	*Slightly Saline*	-	-
	4.3	Silty Sand	Alluvium	220	3740	*Slightly Saline*	-	-
	4.7	Sandy Clay	Alluvium	370	3145	*Slightly Saline*	-	-
	5.1	Silty Sand	Alluvium	280	3920	*Slightly Saline*	-	-
	5.8	Clayey Sand	Alluvium	210	2940	*Slightly Saline*	-	-
BH02	0.2	Silty Sand	Colluvium	40	680	*Non-Saline*	-	-
	0.5	Silty Clay	Residual	250	1750	*Non-Saline*	15	*Sodic*
BH03	0.4	Silty Sand	Colluvium	34	578	*Non-Saline*	NT(3)	*Non-Sodic*

Bore ID	Depth (m)	Soil Description	Structure	EC (µS/cm)	EC_e[(1)] (µS/m)	Salinity Class[(2)]	ESP (%)	Sodicity Class[(2)]
BH04	0.3	Silty Clay	Residual	430	3010	*Slightly Saline*	14	*Sodic*

Notes to table:
EC: Electrical Conductivity
ESP: Exchangeable Sodium Percentage
NT: Not Tested
(1) EC_e is the estimated electrical conductivity, adjusted based on soil texture, in accordance with DLCW NSW, 2002: Site Investigations for urban salinity [7].
(2) Salinity and sodicity classifications defined by representative EC_e and ESP values, as per DCLW NSW Guidelines [7].
(3) Exchangeable sodium content below laboratory reporting limits (<0.1 meq/100g).

Table 6-3 Summary of Preliminary Acid Sulfate Test Results – Field Screening Method

Bore ID	Depth (m)	Soil Description	Structure	pH_F	pH_{FOX}	ΔpH	Reaction Rate
BH01	0.3	Silty Sand	Alluvium	6.3	3.7	2.6	Low
	1.0	Sandy Clay	Alluvium	6.6	3.9	2.7	Medium
	1.4	Silty Clay	Alluvium	6.2	3.5	2.7	Medium
	2.3	Clayey Sand	Alluvium	6	4.4	1.6	Low
	2.8	Silty Sandy Clay	Alluvium	6.8	5.5	1.3	Medium
	3.3	Silty Clay	Alluvium	7.5	5.6	1.9	Medium
	4.3	Silty Sand	Alluvium	7.8	6.3	1.5	Low
	4.7	Sandy Clay	Alluvium	8.3	5.6	2.7	High
	5.1	Silty Sand	Alluvium	8.6	5.7	2.9	Medium
	5.8	Clayey Sand	Alluvium	9.4	6	3.4	Medium
BH02	0.2	Silty Sand	Colluvium	6.7	3.3	3.4	High
	0.5	Silty Clay	Residual	6.6	4.8	1.8	Medium
BH03	0.4	Silty Sand	Colluvium	6.1	2.9	3.2	High
BH04	0.3	Silty Clay	Residual	5.9	3	2.9	High

Notes to table:
pH_F: Field pH level
pH_{FOX}: Field peroxide pH level - pH levels following oxidation with hydrogen peroxide solution
ΔpH = $pH_F - pH_{FOX}$

Table 6-4 Summary of Detailed Acid Sulfate Test Results – Chromium Reducible Sulphur (S_{CR}) Method

Bore ID	Depth (m)	Soil Description	Structure	pH_{KCl}	TAA (mole H+/t)	S_{CR} (%S)	Net Acidity (mole H+/t)
BH01	0.3	Silty Sand	Alluvium	4.7	10	<0.005	12
BH01	1.4	Silty Clay	Alluvium	4.5	12	<0.005	14
BH01	4.7	Sandy Clay	Alluvium	6.4	<5	<0.005	<5
BH02	0.2	Silty Sand	Colluvium	5.0	6	0.005	8.5
BH03	0.4	Silty Sand	Colluvium	4.6	18	0.005	21
BH04	0.3	Silty Clay	Residual	4.9	14	<0.005	15

Notes to table:
pH_{KCl}: Potassium Chloride Extractable pH
TAA: Titratable Actual Acidity
S_{CR} Chromium Reducible Sulfur

7 Geotechnical Considerations

7.1 General

As summarised in **Section 1**, it is understood that geotechnical assessment is required to support the development application of the proposed Stage 2 of the Huntlee New Town development. The development generally comprising subdivision for residential and commercial areas, and works associated with the internal roadway construction and creation of various open space, park, and riparian areas.

The following sections have incorporated the findings of the desktop study and limited site investigation / inspection, to inform the geotechnical considerations for the proposed development.

It should be noted that comments and recommendations discussed within are preliminary only, and further detailed geotechnical investigation and assessment would be required during the detailed design phase of the development.

7.2 Subsurface Conditions

As discussed, Stantec retain significant information of subsurface conditions to the adjacent Stage 1 of the Huntlee New Town development ('Stage 1') from previous investigations, which is largely considered representative of most of the proposed Stage 2 development area. Limited subsurface investigation was undertaken to obtain supplementary information on ground conditions to the west of the Stage 2 northern site area, noted to fall within a reported alluvial landscape, which has not previously been assessed.

Most of the overall Stage 2 site area, approximately 90%, is largely undeveloped or comprises land with minimal disturbance, with heavily disturbed lands associated with previous intensive activities (e.g. former mining / quarry activities) forming approximately 10% of the site area. Expected subsurface conditions within these areas have been discussed separately in below sections.

7.2.1 Areas of Minimal Disturbance

7.2.1.1 Topsoils

Surface observations across the site indicate topsoils would be present throughout most of the site area and are generally expected to comprise surficial root-affected silty sands and sandy silts. Topsoil thickness is likely be in the order of 50 to 100mm, however deeper topsoils could be expected in proximity to existing drainage paths or natural site depressions.

7.2.1.2 Colluvial Soils

Colluvial soils (*or slope wash)* are likely to be present below existing topsoils, and largely comprising granular materials typically composed of silty / clayey / gravelly sands. Colluvium / slope wash is generally expected throughout the majority of the site area, however particularly within the soil landscapes defined as 'erosional landform', as described in **Section 5.3**. Depths of 0.3 to 0.4m for the colluvium would likely be common throughout, however depths greater than 1.0m could be envisaged with the existing gully lines or on lower slopes, where deposited soils may accumulate.

7.2.1.3 Alluvial Soils

As defined within by the published soil landscape maps, alluvial soils would be present in the western portion of the northern site area, adjacent black creek. Limited borehole investigation undertaken as part of the current assessment, indicated layered alluvium consisting of variably composed granular and fine-grained soils to a depth of 6.4m at the drilled location. It is expected that depths of alluvium would increase to the west closer to the Black Ck alignment and decrease to the east as site elevations increase.

7.2.1.4 Residual Soils

In-situ residual soils derived from the weathering / decomposition of the underlying parent bedrock (sandstone, siltstone, conglomerate) are expected across most of the site and occurring below the abovementioned depositional soils (and existing filling). Residual soils are largely expected to comprise clay-based soils composed of silty and sandy clays with some minor clayey sands envisaged in areas.

Excluding areas with deeper overlying colluvial / alluvial soils or filling, residual soils are expected to be encountered at relatively shallow depths, commonly 0.3 to 1.0m, before grading towards the underlying weathered bedrock. DCP testing conducted within residual profile across the adjacent Stage 1 development, generally indicate stiff or better soils, with soil strength typically improving with depth.

7.2.1.5 Bedrock

Based on the available geology maps, previous intrusive investigation data, and exposed rock observations suggest bedrock across the site would largely comprise weathered sandstone, siltstone, and conglomerate. Site observations generally suggest weathered bedrock would be encountered at shallow depths across most of the site, with previous Stage 1 investigations typically identifying rock ranging from depths of 0.5 to 2.0m below natural / undisturbed ground levels. Deeper rock depths are expected in areas of deep alluvial profiles and areas of filling. Conversely, bedrock was observed at surface level in areas of previous excavations / cutting (former quarry, disused rail corridor) and soil erosion, typically due to preferential overland flow paths or steeper gully banks.

It is expected that residual soils would be immediately underlain by extremely weathered rock materials consistent with higher strength soils, before grading into more competent medium to high strength bedrock.

An exposed coal seam of the *Greta Coal Measures* was observed within the former quarry void located towards the east of the northern site area, however appeared to occur at depth below the overlying sandstone and conglomerate. As discussed in **Section 0**, the coal measures (*and associated coal seams)* are reported to increase in depth towards the west below the *Branxton Formation*, and as such, the coal is not expected to daylight naturally or during expected civil construction across the site.

7.2.2 Areas of Heavy Disturbance

Although most of the site area comprises largely undeveloped or minimally disturbed site conditions, numerous areas of the site burdened by the presence of uncontrolled filling have been identified and summarised below.

Areas of observed uncontrolled filling within the northern and southern site areas are indicated in **Drawing 4** and **5**, attached in **Appendix B**.

7.2.2.1 Rail Corridor

Existing filling associated with construction of the now disused rail line which spans through the northern site area, from the former Ayrfield Colliery to the Main Northern Rail line (north of site). Fill materials are expected to comprise general embankment filling and selected materials used for the track formation e.g. ballast. Embankment filling is likely to comprise site-won materials generated from sections of cut along the tracks, however coal wash reject (CWR) materials could also be present given the availability.

Fill embankment heights were noted to be variable, governed by the natural undulating topography. Embankment heights greater than 5m were observed where the track spanned relative low-lying areas, such as gully line or riparian zones.

7.2.2.2 Former Colliery Area

The former *Ayrfield No. 3 Colliery* within the northern site area currently retains significant quantities of uncontrolled filling associated with the previous colliery operation and subsequent use as a landfill facility. Based on a review of site history and previous site assessments, uncontrolled fill materials present are expected to comprise:

> Large stockpiles of coarse CWR materials, with previous estimates (by others) indicating volumes in the order 500,000m^3.
> Emplacement of fine CWR materials within existing landfill cells (*former settling ponds)* and generally throughout majority of the colliery area.
> General filling associated with construction of former coal stockpile pads, coal fine settling ponds, and existing large colliery dam walls.
> Variable construction waste and general refuse visible at surface throughout the colliery area.
> Putrescible waste previously reported to overly the existing coal fine landfill cells.

7.2.2.3 Former Quarry Area

Stantec have previously conducted extensive subsurface investigations for part of the former quarry site as part of a detailed environmental assessment, currently being progressed (to be reported under ref.

304100914). The investigation identified significant areas of uncontrolled filling within the existing quarry void, associated with the former use, generally comprising the following:

- Variably sized stockpiles of gravelly clays and clayey gravel overburden materials, topsoils, and coal wash reject materials (CWR).
- Filled berms and walls appeared constructed for surface water interception and existing farm dam (east of quarry void).
- Quarry void backfilling with variably composed soil materials and significant component of foreign materials generally consisting of construction/demolition waste, general (non-putrescible) refuse, bituminous materials, and organic matter.

7.2.2.4 Other Minor Filling

Additional to the above areas of significant existing fill materials, lesser / minor quantities of fill materials were also observed in isolation throughout the overall site area, generally comprising the following:

- Several small stockpiles observed to comprise building waste / debris.
- Filled berms or walls associated with construction of small rural farm dams and recreational motorbike tracks to the west of the northern site area.
- Shallow filling for surfacing of access tracks, with appeared imported pavement quality gravel used in the southern site area and coarse CWR material from the colliery used in the northern site area.

7.2.3 Groundwater

Intrusive borehole investigation conducted by RCA (2015) [8] and Stantec (2022-23) as part of previous and ongoing assessments associated with stages of the Huntlee development. Groundwater levels encountered during the investigations are summarised in **Table 7-1**, with relevant borehole locations shown in **Drawing 6**, attached in **Appendix B**.

It should be noted that several of the boreholes undertaken as part of Stantec's investigation were drilled within the void of the former quarry, where existing ground levels have been significantly lowered from the native topography.

Table 7-1 Summary of Available Groundwater Data

Bore ID	Date	Bore Collar RL (mAHD)	GW Depth (m bgl)	GW RL (mAHD)	Water Bearing Zone	General Location	Comments
BH102	18/08/15	48.4	13.1	35.3	Weathered Rock	Offsite *(quarry area)*	RCA (2015)
BH106	19/08/15	50.3	7.9	42.4	Weathered Rock	Offsite *(quarry area)*	RCA (2015)
BH107	19/08/15	50.2	10.2	40.0	Weathered Rock	Offsite *(quarry area)*	RCA (2015)
BH108	19/08/15	50.3	9.0	41.3	Weathered Rock	Offsite *(quarry area)*	RCA (2015)
BH123	21/08/15	56.0	23.5	32.5	Weathered Rock	Offsite *(quarry area)*	RCA (2015)
MW01	30/08/22	53.9	13.5	40.4	Weathered Rock	Offsite *(quarry area)*	Stantec (2022-23)(1)
MW02	30/08/22	51.7	12.0	39.7	Weathered Rock	Offsite *(quarry area)*	Stantec (2022-23)(1)
MW04	31/08/22	66.5	9.8	56.7	Weathered Rock	Onsite *(quarry area)*	Stantec (2022-23)(1)
MW05	3/04/23	69.9	18.5	51.4	Weathered Rock	Onsite *(quarry area)*	Stantec (2022-23)(1)
MW06	3/04/23	66.8	18.5	48.3	Weathered Rock	Onsite *(quarry area)*	Stantec (2022-23)(1)

Notes to table:
(1) Stantec investigation currently ongoing, to be reported under reference. 304100914-001.

No groundwater was encountered during the limited borehole investigation undertaken as part of the current assessment, and it is noted that all boreholes were advanced to depths ranging from 0.8 to 6.4m where refusal on the weathered bedrock was encountered.

Based on the available information, groundwater is expected to occur within the weathered rock profile and at significant depths below existing surface levels, as such, unlikely to be impacted by the proposed development. It should however be noted that groundwater levels are likely to fluctuate with variances in climatic and site conditions.

7.2.4 Summary

Natural subsurface conditions, which are typically expected to comprise topsoils, overlying alluvium / colluvium, overlying residual soils grading to weathered rock, are not considered to present any significant constraints to proposed building or pavement foundations, provided suitable site preparation and civil construction practices are implemented. It is recommended that geotechnical investigation is undertaken during the design phase to identify any local or site-specific issues such as weak or deleterious soils. Similarly, no development constraints pertaining to groundwater is envisaged, given the expected depths.

Generally, all site uncontrolled filling in the current condition is considered unsuitable foundation material for proposed residential/commercial structures and pavements, as such, would require remediation.

Onsite fill materials, such as the stockpiled or emplaced coal wash reject and existing embankment filling (e.g. dam walls, railway, landfilled cell walls), could be considered geotechnically suitable for reuse subject to geotechnical review and potential reconditioning. Reconditioning would generally comprise removal of organics, screening for oversize, moisture reconditioning, and possible blending with other site materials. It should be noted that uncontrolled fill materials would also be subject to environmental assessment and possible treatment and remediation prior to disposal or reuse. Uncontrolled materials consisting of construction waste and general refuse would generally require offsite disposal, however inert / non-putrescible materials, could be considered in non-structural fill areas.

Uncontrolled fill materials are estimated to cover approximately 10% of the overall site area, as such, it is recommended to maximise onsite reuse of these materials where possible to minimise offsite disposal costs.

7.3 Soil Erosion

7.3.1 Erosion Potential

The relevant soil landscapes encompassing the site area, summarised in **Section 5.3**, largely report localised gully, sheet, and streambank erosions hazards, including varying severities of existing erosion ranging from slight to very high, particularly in cleared areas with minimal vegetation cover. The *Dochra (Dot)* soil landscape which covers a minor portion of the northern site area and most of the southern, is noted to comprise highly dispersible and erodible subsoils, and reports a wide-spread gully and sheet erosion hazard. The severity of existing erosion within this landscape is reported to range moderate to extreme.

Inspection undertaken across the site identified evidence of erosion, generally throughout the entire site area, consistent with published soil landscapes. Existing erosion observed on site commonly comprised shallow to deep rutting within existing drainage lines and preferential overland flow paths, with observed depths rutting greater than 1m or top of the weathered rock profile in areas. Where sufficient vegetation surface cover was present, erosion was generally minimal or not observed.

Consistent with the findings of previous Stage 1 investigations, laboratory test results from the current assessment summarised in **Table 6-2**, indicated non-sodic (ESP < 5%) granular alluvial and colluvial soils and natural site clays sodic to highly sodic (ESP > 5%) in nature, and as such, susceptible to erosion. Although non-sodic in nature, granular colluvial and alluvial soils present within drainage lines would generally be prone to erosion in the absence of suitable vegetation cover, given the material composition.

Considering the above, erosion potential would generally be considered a constraint to the proposed development, as such appropriate treatment of soils (as required) and erosion management practices should be undertaken to maintain acceptable levels during and following construction to the development.

7.3.2 Erosion Management

Amelioration of exposed soils may be required and could be undertaken via the application of gypsum, which has previously been observed to be effective throughout the existing Stage 1 development. A nominal gypsum application rate of 2 kg/m^2 could be considered, however validation testing following preliminary excavations and dosing would be required to verify application rates. No specific treatment is expected to be required for general site soils protected by topsoiling and revegetation.

Additional to treatment and/or protection of erosion prone soils, preventive erosion and sedimentation control measures should be nominated during the design stage and implemented throughout construction to the development. Control measures should be suitable for the prevailing the site conditions, and in accordance with the guidelines set out within the 'Blue Book' *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004) [9].

7.4 Soil Salinity

Soil salinity has been classified with reference to the criteria set out within the '*Department of Land and Water Conservation NSW, 2002: site investigations for urban salinity'* [7].

Review of previous laboratory testing undertaken on soil samples recovered throughout the adjacent Stage 1 development, generally indicates that colluvial/alluvial and residual soils are commonly classified as non- to slightly saline (EC_e < 4 dS/m), with moderately saline soils (4 < EC_e < 8 dS/m) occasionally encountered in isolated areas.

Laboratory test results from the current investigation, summarised in **Table 6-2**, indicated that all tested natural site soils (alluvium, colluvium, residual) ranged from non- to slightly saline, generally consistent with findings of the previous Stage 1 investigations.

Based on the above, soil salinity is not considered to be a significant constraint to the development, however further sampling and testing for EC is recommended during the design phase, particularly within the areas largely impacted by uncontrolled filling.

Monitoring for visual signs of soil salinity (e.g. salt scalding) should be conducted during development construction, in addition to minimising activities which may affect groundwater balance, resulting in groundwater level rises and impacting near-surface soils. However, given the expected depth of groundwater throughout the site, groundwater impacts on surface soil salinity are unlikely to be an issue.

7.5 Acid Sulphate Soils

As summarised in **Section 5.5**, the overall site is situated in area of extremely low probability of acid sulfate soil (ASS) occurrence. A review of previous investigations undertaken across the adjacent Stage 1 development indicated that site soils are naturally acidic, however were not considered to be acid sulfate soils, due to negligible levels of oxidisable sulphur reported in laboratory testing (often less than reporting limits).

Limited laboratory testing undertaken within the current investigation, summarised in **Section 6.3.2**, indicated that tested site soils were acidic based on pH levels and TAA, however with negligible reducible sulphur content either less than or equal to the LOR. Results of the current investigation are generally considered to be consistent with the findings of the previous Stage 1 investigations.

The relevant action criteria set out within the NSW *Acid Sulfate Soils Assessment Guidelines* (1998) [10] (ASSAG), provide the basis for which an acid sulfate soil management plan (ASSMP) is required. Although uncommon, minor exceedances to the action criteria for net acidity have previously been observed in isolation within the Stage 1 development. It is noted that previous exceedances in net acidity was based on the presence of existing acidity (or TAA) rather than potential acid generation from oxidisable sulphur content. As such, the provision of an ASSMP is generally not required, however potential impacts of acidic soils to proposed infrastructure should be considered (e.g., aggressivity to buried structural elements).

Limited laboratory testing for ASS should be conducted during geotechnical investigations at the civil design stage to verify conditions, particularly in lower lying site areas or drainage lines where local ASS could occur.

7.6 Acid Mine Drainage

As stated, potential impacts from existing coarse CWR stockpiles within the former colliery area have previously been reported, associated with potentially acid generating conditions. Laboratory analysis of the CWR materials previously conducted by Stantec (*then Cardno Geotech Solutions*) and others, has generally indicated that materials are acidic in nature (based on pH levels), with some potential for further acid generation noted.

Coarse CWR materials are expected to be geotechnically suitable for reuse within the proposed development, following removal and reworking. Treatment of the CWR materials through the application of lime would also be required to prior to reuse. The application of lime would serve to neutralise existing (and potential) acidity, thus returning pH levels to acceptable threshold limits for reuse and minimising impacts associated within mine acid drainage. Given the CWR materials are predominantly granular, incorporation of lime could be readily undertaken during the removal and reworking operation.

7.7 Soil Reactivity

Classification to finished residential and commercial (if appropriate) allotments within the proposed development are to be compliant with the requirements set out in AS2870-2011 '*Residential slabs and footings'* [11].

Expected subsurface condition to most of the site is expected to comprise predominantly granular surficial soils, overlying natural site clays grading to weathered rock, with uncontrolled filling noted in areas of disturbance. Review of shrink-swell index (I_{SS}) testing previously undertaken throughout the adjacent Stage 1 development indicates the presence of natural site clays ranging from slightly (I_{ss}<1%) to highly reactive (I_{ss}>2.5%), however overall volumes of reactive clays are considered relatively minor, owing to a shallow rock profile.

Generally, soil reactivity is not considered to be a significant constraint on the proposed development, and on the basis any reactive site soils are suitably controlled during construction, relevant infrastructure associated with the development may be founded on them, if appropriately designed.

Considering the expected subsurface conditions, and on the basis that the site is suitably prepared, including removal of vegetation, uncontrolled filling (and reworking if suitable) and deleterious materials, site classifications ranging from Class S to Class H1 are anticipated.

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

7.8 Slope Stability

An assessment of slope stability has been undertaken for the site, based on the observed site conditions and in general accordance with the principles outlined in Australian Geomechanics Society (AGS) publication *'Practice Note Guidelines for Landslide Risk Management 2007c'* [12].

7.8.1 Assessment Methodology

The risk assessment procedure adopted herein is in general accordance with the principles outlined AGS 2007c [12]. Stantec have assessed the risk to property using the qualitative assessment matrices of the AGS 2007 Guidelines. This involves utilisation of risk matrices that comprise qualitative descriptions for levels of consequence and likelihood of occurrence.

Assessment of landslide hazards includes an assessment of the likelihood of occurrence. Likelihood has been assessed based on the site-specific models derived from the geological mapping and observations, anecdotal evidence, the relationship between geomorphology and geology combined with judgement and experience have been used to estimate likelihood of failure for the current condition.

Likelihood (**Table 7-2**) and consequence (Table **7-3**) are combined in the matrix shown in **Table 7-4**, resulting in risk level that can range from very low (VL) to very high (VH). The standard definition of the risk levels from AGS 2007c are presented in **Table 7-5**.

Table 7-2 Qualitative Measures of Likelihood

Level	Descriptor	Description	Approximate Annual Probability
A	Almost Certain	The event is expected to occur over the design life	1:10
B	Likely	The event will probably occur under adverse conditions over the design life	1:100
C	Possible	The event could occur under adverse conditions over the design life	1:1,000
D	Unlikely	The event might occur under very adverse circumstances over the design life	1:10,000
E	Rare	The event is conceivable but only under exceptional circumstances over the design life	1:100,000
F	Barely Credible	The event is inconceivable or fanciful over the design life	1:1,000,000

Table 7-3 Qualitative Measures of Consequences to Property

Level	Descriptor	Description	Indicative Damage Cost
1	Catastrophic	Structure(s) completely destroyed and/or large-scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage	200%
2	Major	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage	60%
3	Medium	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage	20%
4	Minor	Limited damage to part of structure, and/or part of site requiring reinstatement stabilisation works	5%
5	Insignificant	Little damage	0.5%

Table 7-4 Qualitative Risk Analysis Matrix

Likelihood Level	Consequence to Property Level				
	1: Catastrophic *(200%)*	**2**: Major *(60%)*	**3**: Medium *(20%)*	**4**: Minor *(5%)*	**5**: Insignificant *(0.5%)*
A: Almost Certain *(10^{-1})*	VH	VH	VH	H	M or L(1)
B: Likely *(10^{-2})*	VH	VH	H	M	L
C: Possible *(10^{-3})*	VH	H	M	M	L
D: Unlikely *(10^{-4})*	H	M	L	L	VL
E: Rare *(10^{-5})*	M	L	L	VL	VL
F: Barely Credible *(10^{-6})*	L	VL	VL	VL	VL

Notes to table:
(1) Low Risk acceptable where consequence to property <0.1%.

Table 7-5 Risk Level Implications

Risk Level		Example Implications
VH	Very High	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work will likely cost more than the value of the property.
H	High	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	Moderate	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce risk to Low.
L	Low	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	Very Low	Acceptable. Manage by normal slope maintenance procedures.

7.8.2 Slope Stability Assessment

Based on the findings of the site inspection, an assessment has been undertaken considering the future risk of slope instability on the proposed development, with respect to the current site conditions i.e., excluding regrade or remedial measures.

In the main, most of the site area presents minimal slope stability hazards which would generally be considered 'very low risk' given the gentle natural site slopes (typically ≤ 6°), however several specific hazards were observed, identified as the following:

- **Hazard 1**: Surficial colluvial / alluvial / sodic clay soils within ephemeral drainage lines (natural gullies and riparian zones) and/or where surface vegetation is devoid.
- **Hazard 2a**: Steep soil slopes (>18°) within perennial watercourses (Black Creek).
- **Hazard 2b**: Steep soil slopes (>18°) associated with fill embankments (rail corridor, land fill cells).
- **Hazard 3**: Large CWR stockpiles.
- **Hazard 4**: Very steep to near-vertical (>45°) rock faces within quarry areas and rail corridor.

Generally, slope failures associated with surficial soils would be most common, with mechanisms comprising of erosion / creep / slumping of soil slopes, due to concentrated overland flow paths. Due to the presence of medium to high strength bedrock, typically at shallow depths, probability of deeper-seated failure mechanisms is generally considered to be low.

The above identified slope hazards have been assessed in accordance with AGS 2007c procedures, with results of the assessment summarised in **Table 7-6**.

Table 7-6 Slope Stability Risk Levels to Proposed Development – Existing Condition

Hazard	Mechanism	Likelihood	Consequence	Current Risk Level
Hazard 1	Erosion of surface soils	Almost Certain	Minor	**High**
	Creep of surface soils	Possible	Minor	**Moderate**
	Slumping of surface soils	Rare	Medium	**Low**
	Deep-seated slope failure	Barely Credible	Major	**Very Low**
Hazard 2a	Erosion of surface soils	Almost Certain	Insignificant (1)	**Low**
	Creep of surface soils	Likely	Insignificant (1)	**Low**
	Slumping of surface soils	Possible	Insignificant (1)	**Low**
	Deep-seated slope failure	Rare	Major (1)	**Low**
Hazard 2b	Erosion of surface soils	Possible	Minor	**Moderate**
	Creep of surface soils	Possible	Minor	**Moderate**
	Slumping of surface soils	Possible	Medium to Major(2)	**Moderate to High**
	Deep-seated slope failure	Unlikely	Major	**Moderate**
Hazard 3	Erosion of surface soils	Almost Certain	Minor	**High**
	Creep of surface soils	Almost Certain	Minor	**High**
	Slumping of surface soils	Likely	Catastrophic	**Very High**
	Deep-seated slope failure	Barely Credible	Catastrophic	**Low**
Hazard 4	Rock fall from exposed cutting	Likely	Medium	**High**
	General slope failure	Unlikely	Catastrophic	**High**
	Deep-seated / global failure	Rare	Catastrophic	**Moderate**

Notes to table:
Probability of deep-seated failures generally considered to be low throughout, due to depth and strength of underlying bedrock.
(1) Based on locality of Black Ck and potential extent of failure mechanism in relation to proposed residential or civil infrastructure areas.
(2) Extent of potential property damage variable dependent on overall slope height.

The relevant regulator is the appropriate authority to set the standards for tolerable risk which may relate not only to perceived safety in relation to other risks, but also to government policy [12]. AGS [12] suggests that risk levels of 'very low' or 'low' is an appropriate acceptance criterion for tolerable risk for *developments* near or on existing slopes. Regulators usually adopt this risk level as the measure to gauge risk for existing developments.

When considering risk, it should be noted that:

- Estimations of risk are approximate, and the acceptance criteria / tolerable risk level should not be considered absolute values. Variations of up to one order of magnitude may be appropriate for the acceptance criteria for particular circumstances.

> The risk can change with time because of natural processes and development, e.g. removal of vegetation by fire or other natural process, or new construction/development.

> It is ultimately up to the relevant governing agency to set its standard for tolerable risk criteria for loss to property.

Generally, it is expected that identified areas / hazards with risk levels ranging from moderate to high, would require remediation to return risk to acceptable levels.

7.8.3 Slope Stability Controls & Residual Risk

Although several areas with elevated risk levels were identified across the site, these areas are anticipated to be addressed during civil construction to the development.

Remediation recommendation that should be implemented to prevent destabilisation of the hazards identified as moderate (or higher) risk levels site are presented in **Table 7-7**, together with residual risk to the proposed development following implementation.

Table 7-7 Slope Stability Controls and Residual Risk Levels

Hazard	Current Risk Level	Recommended Controls	Residual Risk
Hazard 1	Very low to high	▪ Minimise disturbance to surface vegetation or revegetation in areas of regrade, including topsoiling sown with pasture grass. ▪ Treatment of site soils via the application of gypsum. ▪ Removal, reconditioning (and/or blending), and reinstatement of alluvial/colluvial materials. ▪ Appropriate overland stormwater control / diversion during construction, particularly upslope of stripped surfaces.	**Very low**
Hazard 2a	Low	▪ Generally considered acceptable in current condition, however if controls implemented consistent with ‘hazard 1’, risk level could be reduced.	**Very Low**
Hazard 2b	Moderate to high	▪ Removal of existing fill embankments as part of bulk earthworks. ▪ Maintain suitable development offset from toe of embankments, where adjacent development advances prior to removal.	**Very Low**
Hazard 3	Low to very high	▪ Removal of existing fill stockpiles as part of regrade. ▪ Maintain suitable development offset from toe of stockpiles, where adjacent development advances prior to removal.	**Very Low**
Hazard 4	Moderate to high	▪ Reinstate quarry voids and rail cutting as controlled fill operation to design levels. ▪ Maintain suitable development offsets from crest of rock faces and provide drainage to prevent overland flows overtopping crest.	**Very Low**

Given the proposed earthworks and development extents, and where the above controls are implemented for the proposed development, the development would be considered very low risk with regards to slope stability.

Consideration of the Australian Geoguide (LR8) Hillside Construction Practice document should also be made for the development (attached to this report as **Appendix G**).

8 General Development Recommendations

8.1 Earthworks

Based on the supplied DA plans and experience across the adjacent Huntlee New Town Stage 1 development, earthworks for the proposed development is generally expected to comprise cut and fill operations for the purpose of constructing level building platforms, internal roadways, stormwater basins, and other related civil infrastructure e.g., trenching and backfilling for in-ground services.

8.1.1 Site Preparation

Site preparation for the development should include the removal of any vegetation and stripping of existing topsoils from proposed building footprints and fill areas. Existing uncontrolled filling, high-silt content soils or other deleterious materials should also be removed.

All exposed surfaces should be inspected by an experienced geotechnical engineer following stripping of topsoils and removal of existing filling or other deleterious materials, to confirm founding conditions are suitable.

8.1.2 Excavation Conditions

Based on the expected subsurface conditions and likely construction associated with the proposed development, it is considered that excavations into all site soils, fill materials, and underlying bedrock would be required.

Excavations into all site soils and existing fill materials are expected to be readily undertaken using conventional earthmoving equipment. Excavation difficulties and slow production rates are anticipated within the weathered rock profile, based on experience within the existing Stage 1 development. As such, it is recommended to make allowance for hydraulic rock hammer excavation or use of large capacity excavator with a single ripper attachment, particularly where excavations to a significant depth below rock level are proposed e.g., deeper sections of utility installation.

8.1.3 Excavation Stability

Excavations or trenches into deeper granular alluvial/colluvial soils or uncontrolled filling could potentially be unstable and may require a suitable shoring system to render the excavations stable and safe for personnel access during installation of deep founded services. Residual stiff or better soils and the weathered rock profile is expected to stand close to vertical in the short-term. However, all unsupported excavations into the site soils and fill materials may undergo local slumping if elevated groundwater conditions exist and seepage occurs (e.g. after sustained periods of wet weather). Should areas of instability or significant groundwater flows be encountered during excavation, an experienced geotechnical engineer should inspect the excavations with respect to stability.

Where personnel are to enter excavations, options for short-term excavations include benching or battering back of the excavations at 1H:1V or the support of excavations within the natural site soils and uncontrolled filling. Short-term excavations within the more competent rock may be battered at steeper than 1H:1V and may not require support, however this would be subject to specific geotechnical assessment.

It is recommended that long-term excavations should be either battered at 2H:1V or flatter and protected against erosion or be supported by engineer designed and suitably constructed retaining walls. Excavations may be battered steeper than 2H:1V in rock materials, subject to specific geotechnical assessment.

8.1.4 Fill Materials

All materials proposed to be utilised as fill should be free of any vegetation or other organic matter, with maximum particle sizes less than 200mm or 2/3 of the compacted layer thickness. High silt containing materials should be blended with other suitable materials prior to use as controlled fill.

Generally, all natural site soils and weathered rock could be considered suitable for reuse as controlled fill, excluding topsoil or high-silt content colluvial / alluvial materials. Site-won materials would be subject to geotechnical inspection and potential reconditioning or blending prior to use.

Excluding encountered waste and deleterious materials, existing uncontrolled fill materials may also be considered for reuse, however would be subject geotechnical and environmental assessment at the design stage.

8.1.5 Fill Placement & Compaction

All filling should be placed, compacted, and tested in accordance with AS 3798-2007 *Guidelines on Earthworks for Commercial and Residential Developments* [13] and relevant council guidelines.

Following site preparation including stripping/removal of all unsuitable materials, proof-rolling of areas where fill is to be placed should be undertaken under the direction of an experienced geotechnical engineer, with any yielding areas over-excavated and reinstated with suitable replacement.

Where fill is to be placed with slopes steeper than 8H:1V, benching of the slopes would be required.

Clay filling of high reactivity should be placed a suitable distance from the surface to avoid negative impacts on site classifications and pavement performance, nominally >1.0m from the surface, and overlain with lower reactive material.

Fill is to be placed uniform horizontal layers with moisture contents and compaction of each layer to be in accordance with AS3798-2007 or relevant council specifications. Over compaction should also be avoided.

It is recommended that placement and compaction of controlled fill be conducted under 'Level 1' supervision, as defined with AS 3798-2007.

8.1.6 Batter Slopes

All fill should be battered at a slope of 2H:1V or preferably flatter and temporary erosion control should be provided. To prevent erosion in the long term, provision of protection by vegetation and with the provision of adequate drainage is also required. Where a batter of 2H:1V is not possible, the fill should be supported by an engineer designed and suitably constructed retaining walls.

8.1.7 Existing Dam Decommissioning

Several existing dams were identified throughout the northern site area and appeared to be related to historic agricultural uses and colliery operation. Existing dams would require decommissioning as part of earthwork operations for the development. Decommissioning of the dams should generally comprise the following:

- Breaching and draining of any impounded water as soon as practical to allow sediments to dry prior to removal.
- Removal of any existing fill (dam wall), slope-wash / colluvium, over-wet, organic or deleterious materials from the areas where fill is to be placed.
- Stripping within the existing dam footprints, including removal of all sediments, followed by inspection by an experience geotechnical engineer.

8.2 Basins

Consistent with Stage 1 of the overall development, stormwater basin infrastructure is expected to be implemented within the civil design and construction to the proposed Stage 2.

8.2.1 Embankment Material Requirements

Table 8-1 provides general material requirements and compaction specifications for the construction of a zoned embankment for temporary and permanent basins.

Table 8-1 Embankment Material Specification

Specification	Zone 1 – Clay Core Material	Zone 2 – Embankment Fill
Material property		
Plasticity Index	>15%	
Permeability	< 10^{-9} m/s	N/A
Emerson Class	Minimum Class 4	Minimum Class 2
Maximum Particle Size	50mm	75mm
% Fines Content (<0.075mm)	> 25%	> 20%
Compaction Requirements		
Minimum Compaction (Standard)	98% of SMDD	95% of SMDD
Moisture Content	-1 to +2 of SOMC	-1 to +2 of SOMC

Notes to table:
SMDD: Standard Maximum Dry Density
SOMC: Standard Optimum Moisture Content
N/A: Not applicable

Based on previous investigation findings, natural site clays generally suitable for use as embankment fill and clay core are expected to be present across the development area. Clays proposed to be used for basin construction should be inspected by an experienced geotechnical engineer during construction to confirm suitability and/or provide further guidance on treatment/conditioning. Additional conditioning of the residual clays prior to use, as well as gypsum treatment for the clay core may be required. Screening for oversize materials would likely be required for site won weathered rock materials proposed to be used in Zone 2 – Embankment Fill.

As outlined in **Section 7.4**, natural site clays are expected to be sodic in nature which can be managed by the application of Gypsum at a nominal rate of 2kg per/m^2 for materials used in clay core and any exposed surfaces. Validation testing following preliminary excavation and dosing would be required to confirm application rates.

8.2.2 Embankment Foundation Treatment

The following general foundation preparation requirements must be adopted:

> Removal of topsoil, colluvium, and weak / compressible soils.

> Static proof-rolling of the exposed foundation area under the embankment with a heavy (minimum 10 tonne) roller. Soft or weak areas detected during the proof rolling shall be excavated and replaced with compacted fill comprising low permeability clay meeting the requirements of Zone 1 material.

> Protection of the prepared foundation to prevent excessive wetting or drying prior to placement of embankment fill material. Trafficking of the exposed foundation should be limited (or avoided where possible) to prevent permanent deformation.

> Embankment clay core to have a minimum 500 mm key into the underlying natural profile.

> Inspection by an experienced geotechnical consultant shall be conducted to confirm foundation suitability.

8.2.3 Impoundment Area

Given diverse and shallow rock depths expected throughout the overall Huntlee area, the potential for the weathered rock profile to be encountered at founding levels of the impoundment area should be considered. Where exposed rock is encountered within the impoundment area of proposed basins, inspection would be required to assess any defects of the rock profile. Where excessive fracturing or large joints are observed, seepage would be expected and piping could occur. An impermeable clay liner, placed over the fractured or jointed rock to reduce potential seepage into the underlying strata, may be required.

8.2.4 Stormwater Outlets & Seepage Collars

Seepage collars would be required along stormwater pipes traversing the proposed basin embankments to increase the length of the percolation path and reduce the risk of piping developing around the stormwater pipes. Seepage collars are generally made of concrete with a required width depending on pipe diameter but are typically three times the pipe diameter.

8.2.5 Surface Erosion Control

Topsoil should be spread over the exposed surfaces of the embankment to a depth of at least 150mm and sown with pasture grass to establish a good cover as soon as practical. Jute mat is recommended over the topsoil to encourage the grass development and reduce topsoil/seed loss at early stages.

Appropriate management of sodic site clays through the application of gypsum treatment is required for any surface area of exposed clay material within the basin walls and impoundment area. This may not be necessary where turf is placed within the impoundment area (subject to inspection) however the clay core will need to be treated.

Large vegetation shall not be allowed to become established on or near the embankment. Tree roots (especially eucalyptus tree roots) can cause the core to crack and encourage piping development, resulting in the failure of the dam wall.

All trees and shrubs shall be restricted to a preferred minimum distance of 1.5 times the height of the tree away from the embankment of the basin. A reduced distance of 5m from the toe of the embankment could be considered feasible, on the basis that tree roots are not allowed to establish within the clay core of the embankment.

8.2.6 Embankment Construction & Upstream Batters

Following the preparation of the embankment foundations, formation of the embankments must be undertaken from foundation to the crown using the compaction requirements specified in **Table 8-1**. Compaction of the embankment materials must be undertaken using pad foot rollers.

Upstream batters of the basin embankments should be graded at 5H:1V or flatter, with diversion drains/bunds to divert any surface flows towards the specified inlet discharge points to limit erosion of the batter faces.

8.3 Footings

Design and construction to all footings for typical residential dwellings should be compliant with AS 2870-2011 [14] for the relevant site classification.

All footings should be founded below any topsoil, thin or unsuitable colluvial / alluvial soils, uncontrolled fill, or other deleterious materials. All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements. Where footings span founding conditions of varying reactivity (e.g. clay soil and rock), articulation of footings or overall strengthening of the footing system could be considered manage differential movements.

Conventional footing including slabs-on-ground with edge beams, spread footings, or piers are generally considered suitable foundation systems for residential structures. Based on the expected founding conditions at the completion of civil construction, the following allowable bearing pressures are anticipated:

> Stiff to very stiff clays or medium dense granular soils: 100 to 200 kPa
> Controlled Filling: 150kPa
> Extremely to very low strength weathered rock: 500 kPa
> Low strength (or better) rock: 1000 kPa

All footings excavations should be inspected prior to installation of structural steel by an experienced geotechnical engineer to confirm suitable founding conditions. All loose material should be cleared from the footing excavations before concrete is poured.

8.4 Retaining Walls

Retaining walls are likely to be incorporated into the civil design for the development to establish support levelled building platforms for residential and commercial structures.

All retaining structures in greater than 1.0m in height are to be designed by a suitably qualified engineer. Design of retaining structures should consider the following:

> Surcharge loading from slopes and structures above the wall.
> Account for loading from any proposed compaction or fill behind the wall.
> Provide adequate surface and subsurface drainage behind all retaining walls including a free draining granular backfill to prevent the build-up of hydrostatic pore pressures behind the wall.
> Utilise materials that are not susceptible to deterioration.
> Ensure all walls are founded in materials appropriate for the loading conditions.

It is recommended to calculate the lateral earth coefficient values for design based on expected retained materials and proposed wall geometry, type and backfill slopes.

Where retained material varies along the length of walls, wall articulation or overall strengthening of the walls should be implemented to account for differential wall deflections.

Foundations for proposed retaining walls should generally be in accordance with the footing recommendations, summarised in **Section 8.3** above.

8.5 Pavements

8.5.1 Pavement Thickness Design

Pavement thickness design should be undertaken in accordance with Austroads *Guide to Pavement Technology, Part 2: Pavement Structural Design* (AGPT02-17) [15] and relevant council guidelines.

Detailed geotechnical investigations should be undertaken during the design phase, in order to evaluate expected subsurface conditions and associated design parameters. Previous testing undertaken throughout the Stage 1, has generally indicated design subgrade CBR values in the order of the following:

> CBR = 3 to 4%, Natural site clays and general fill.
> CBR = 8 to 10%, Weathered rock, granular colluvium / alluvium, and select fill.

Design traffic loadings should be nominated in accordance with the relevant council guidelines, and generally based on assumed serviceable lots. Consideration should also be given to potential bus routes and relevant road hierarchy in accordance with the Huntlee Development Control Plan (DCP) [16].

8.5.2 Pavement Materials & Compaction

All materials for pavement layers should be compliant with the relevant council guidelines and as summarised in **Table 8-2**.

Table 8-2 Pavement Materials and Compaction Requirements

Pavement Course	Material Specification	Minimum Compaction Requirements
Wearing Course	Compliant with relevant council guidelines.	
Basecourse	Compliant with relevant council guidelines.	98% Modified Compaction, or 102% Standard Compaction
Subbase	Compliant with relevant council guidelines.	95% Modified Compaction, or 100% Standard Compaction
Select Fill	CBR ≥ 15%	100% Standard Compaction
Subgrade Fill / Replacement	CBR ≥ Adopted Design CBR	100% Standard Compaction

Minimum testing on all pavement materials should include a four-day soaked CBR, Atterberg Limits, Particle Size Distribution analysis and Wet/Dry strength determination. Pre-treatment of materials prior to testing would be advisable for material subject to breakdown.

All granular pavement material quality should be in general accordance with RMS QA Specification 3051 [17] for the relevant traffic category. The selection of appropriate construction materials that are durable and insensitive to moisture change is essential in areas subject to periodic inundation and/or wet ground conditions.

8.5.3 Subgrade Preparation

Subgrade preparation new pavement construction is expected to comprise:

> Following appropriate site preparation (summarised in **Section 8.1.1**), placement and compaction of general filling (summarised in 8.1.5) to subgrade formation level (500mm underside of pavement), or excavation to subgrade design level, with stockpiling of excavated materials for reuse as general fill or select, subject to moisture reconditioning and removal of oversize if required.

> Subgrades in weathered rock to be thoroughly ripped to a minimum 300mm below design subgrade level and to extend to the sides of the formation to provide drainage away from the pavement. Ripped rock materials to conform to the particle size characteristics defined for fill and compacted to form the subgrade construction layer.

> Over-excavation and replacement in areas to eliminate abrupt changes in subgrade conditions (e.g. rock to soil), including areas proposed to comprise a combination cut and fill based on geometric design.

> Identification of the need for removal and replacement of any potential higher reactive clays at subgrade level should be undertaken by visual inspection.

> Moisture reconditioning and blending of deep colluvial / alluvial granular profiles (if unsuitable) with other cohesive site materials may be required, subject to inspection.

> Proof rolling of the exposed subgrade with a heavy (minimum 10 tonne static) roller, with results of the proof roll used to determine the extent of remedial treatment, if required under the direction of onsite geotechnical engineer.

> Compaction of subgrade and/or select filling to a minimum 100% of SMDD at a moisture ratio generally between 60-90%, however less than 100% of SOMC, with compacted layer thickness not exceeding 300mm.

> in layers of not greater than 300 mm compacted thickness at a moisture ratio of generally between 60-90% but less than 100% of SOMC.

> Protection of the subgrade to prevent any excessive wetting or drying.

> Exposed subgrade should not be used as a haul road during construction, and efforts to minimise trafficking should be implemented to limit permanent deformations.

> Care should be taken in selection of compaction equipment and methods where pavement construction is undertaken in the vicinity of existing structures. Observation and monitoring of residences within adjacent residential developments for signs of distress should be undertaken in conjunction with proof rolling and compaction of the subgrade and pavement materials.

9 Summary

The geotechnical assessment undertaken for the proposed Stage 2 of the Huntlee New Town development, as summarised above, has indicated that most of the site is geotechnically suitable or could be readily rendered suitable for proposed residential and commercial development, on the basis appropriate construction practices, including reconditioning and treatment of site soils (if required) is implemented.

It is noted that the recommendations provided as part of this assessment are preliminary, and as such, it is recommended that further geotechnical investigations be undertaken during the detailed design stage, closer to the commencement of construction to inform the relevant civil design to the development.

10 Limitations

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

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

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

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

11 References

[1] Department of Planning, Industry and Environment, “Soil and Land Resources of Central and Eastern NSW, Version 3,” NSW Office of Environment and Heritage, Sydney, 2018.

[2] Hawley S.P., Glen R.A. and Baker C.J., Newcastle Coalfield Regional Geology 1:100,000, Sydney: Geological Survey of New South Wales, 1995.

[3] Lau J.E., Jacobson G., Hydrogeology of Australian 1:5 000 000, Bureau of Mineral Resources, Geology and Geophysics, Department of Resources and Energy, 1987.

[4] NSW Department of Planning and Environment, “Acid Sulfate Soils Risk - SEED Map,” NSW Government, [Online]. Available: https://datasets.seed.nsw.gov.au/dataset/acid-sulfate-soils-risk0196c.

[5] R. Fitzpatrick, B. Powell and S. Marvanek, “Atlas of Australian Acid Sulfate Soils,” Commonwealth Scientific & Industrial Research Organisation (CSIRO), 2011. [Online]. Available: https://doi.org/10.4225/08/512E79A0BC589.

[6] NSW Department of Planning, “NSW Planning Portal - Spatial Viewer,” NSW Government, [Online]. Available: https://www.planningportal.nsw.gov.au/spatialviewer/.

[7] Department of Land and Water Conservation, Site Investigations for Urban Salinity, Sydney, 2002.

[8] RCA, “Mine Stability Assessment - Huntlee Town Centre - 10915a-201/0,” Novemeber 2015.

[9] Landcom, “Managing Urban Stormwater: Soils and Construction,” NSW Government, 2004.

[10] ASSMAC, “Acid Sulfate Soil Manual, New South Wales,” Acid Sulfate Soil Management Advisory Committee, August 1998.

[11] Australian Standard AS2870-2011, “Residential Slabs and Footings,” Standards Australia, 2011.

[12] AGS Landslide Taskforce, “Practice Note Guidelines for Landslide Risk Management 2007c,” *Journal and News of the Austrailian Geomechsanics Society,* vol. 42, no. 1, pp. 63-114, 2007c.

[13] Australian Standard AS3798-2007, “Guidelines on Earthworks for Commercial and Residential Structures,” Standards Australia, 2007.

[14] Standards Australia, “AS 2780-2011 - Residential Slabs and Footings,” 2011.

[15] Austroads AGPT02-17, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2017.

[16] NSW Government: Planning and Infrastructure, Huntlee development Control Plan 2013, Sydney, NSW: Crown, May 2013.

[17] RMS QA Specification 3051 (Ed 6 Rev 2), “Granular Base and Subbase Materials for Surfaced Road Pavements,” Roads and Maritime Services, April 2011.

APPENDIX

A

DA PLANS

ISSUE	DATE	PURPOSE
(0)	24/01/2023	PRELIMINARY REVIEW BY CLIENT
(1)	30/01/2023	AMEND PER GS EMAIL TO ADD OLD NORTH ROAD, DETAILED/CONCEPT DA BDYS.
(2)	31/01/2023	AMEND DA AREA TITLES PER GS EMAIL.
(3)	01/02/2023	ADD OVERALL STAGE 2 DA BOUNDARY.
(4)	07/02/2023	AMEND PER GS EMAIL. ADD OLD NORTH ROAD DIAGRAM.
(5)	07/06/2023	AMEND TO LATEST MOD 21 STAGE 1 BOUNDARIES. AMEND STAGE 2 DA BOUNDARY EXTENTS.
(6)	24/07/2023	AMEND LAYOUT TO LATEST STAGE 1 MOD 21, VILLAGES 2-3 & OLD NORTH ROAD LARGE LOTS.
(7)	25/07/2023	AMEND LAYOUT TO LATEST TC. ADJUST STAGE 2 DA BOUNDARY NEAR HANWOOD ROAD.
(8)	28/07/2023	REMOVE STG 1. AMEND STG 2 BDY. ADD ROAD WIDTHS, LOT AREAS, DESCRIPTIONS.
(9)	31/07/2023	AMEND PER GS MARKUPS 28/07/2023.
(10)	01/08/2023	AMEND TO INCREASE STG 2 TC PUBLIC OPEN SPACE INCLUSION CLARITY.
(11)	05/09/2023	LOT AMENDMENTS IN TOWN CENTRE, VILLAGES 2-3.
(12)	19/09/2023	LOT AMENDMENTS IN ONR.
(13)	17/10/2023	LOT AMENDMENTS VILLAGES TC, 2, 3.

CLIENT: Huntlee / LWP bringing communities to life

SCALE: 1:4000
SHEET SIZE: A0
DRAWN BY: RB
CHECKED BY: ADM

DRAWING TITLE: HUNTLEE STAGE 2 DA

PROJECT: HUNTLEE STAGE 2 - DEVELOPMENT AREA
WINE COUNTRY DRIVE, HUNTLEE

CLIENT: HUNTLEE PTY.LTD.

DALY.SMITH
EXPERIENCE YOU CAN TRUST
A: 6 Doyalson Street, Morisset NSW 2264
A: 4/9 Lambton Road, Broadmeadow NSW 2292
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E: mail@dalysmith.com.au
DALYSMITH.COM.AU

DALY.SMITH JOB NO: 20406

SHEET NO: 1 OF 1

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APPENDIX

B

DRAWINGS

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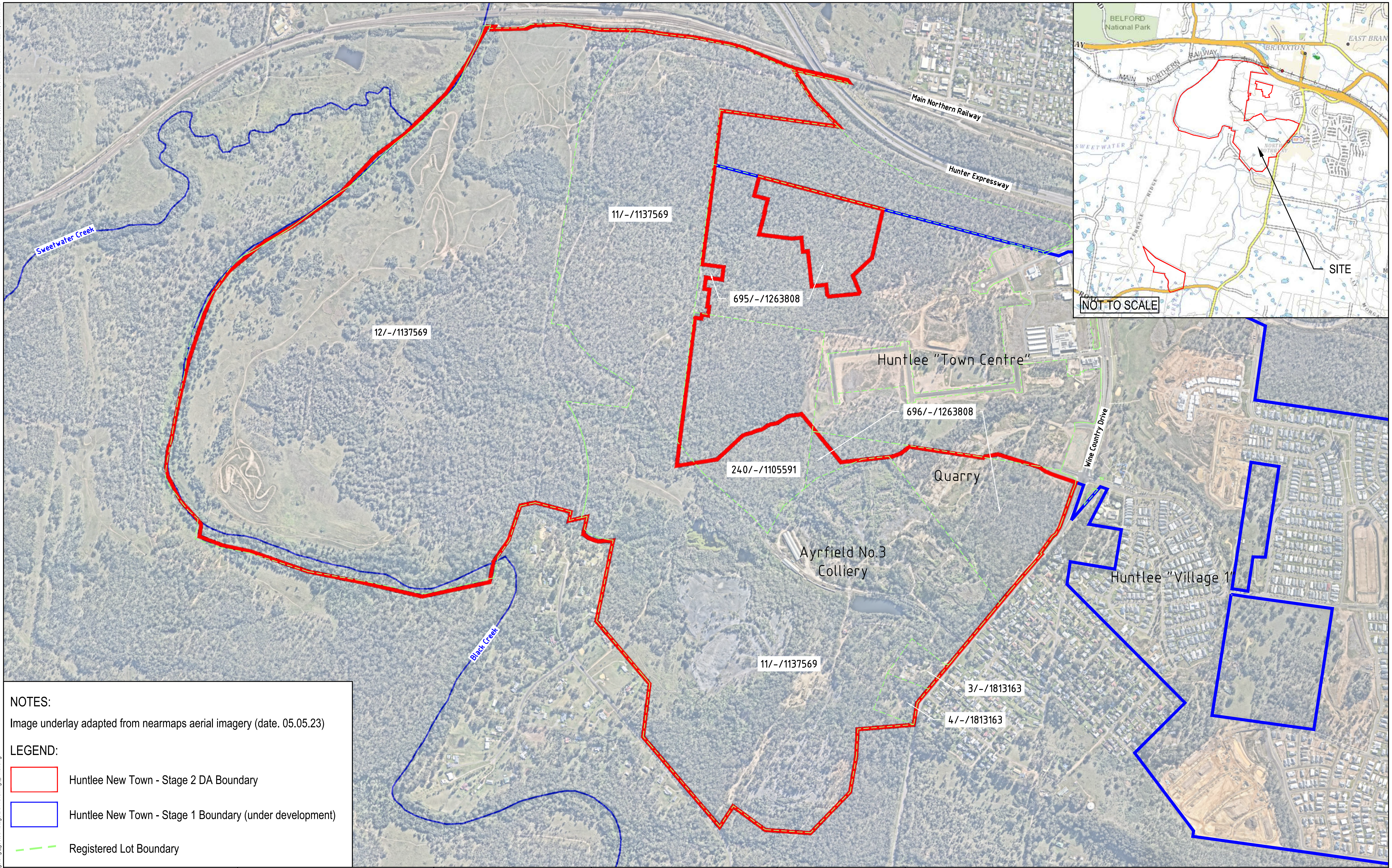

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NORTH

Stantec
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Suite 2, Level 2, 22 Honeysuckle Drive
Newcastle, NSW 2300
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Web: www.stantec.com

Drawn TB	Date 20.06.2023	
Checked	Date	
Designed	Date	
Verified	Date	
Approved		

Client: HUNTLEE PTY LTD

Project: GEOTECHNICAL ASSESSMENT
HUNTLEE NEW TOWN - STAGE 2 DA
NORTH ROTHBURY / BRANXTON / ROTHBURY / BELFORD

Title: SITE PLAN - GENERAL LOCALITY
NORTHERN SITE AREA
VILLAGE 2 / VILLAGE 3 / TOWN CENTRE

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

Project Number	Scale	Size
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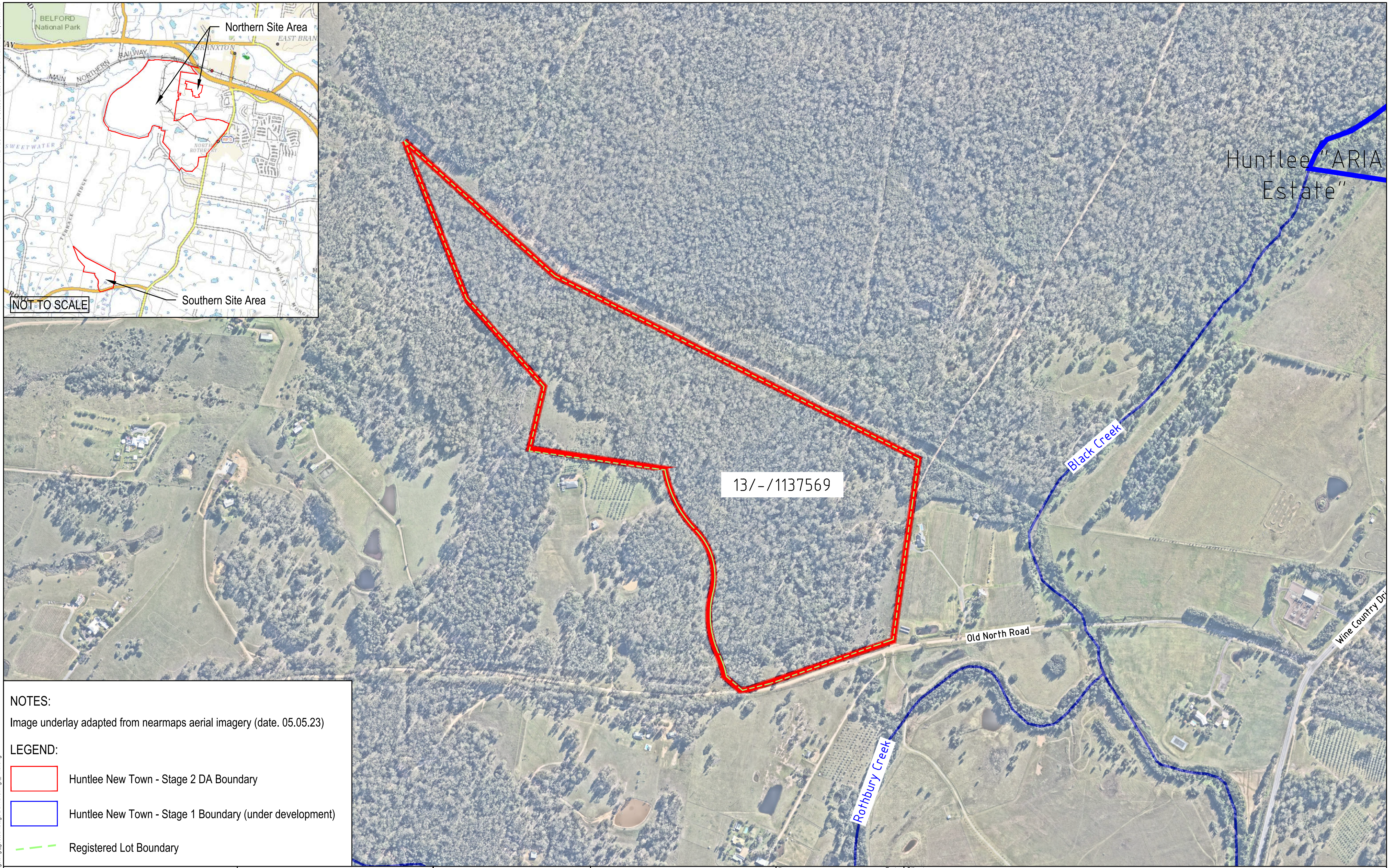
Drawing Number	Revision
Drawing 1	A



NOTES:

Image underlay adapted from nearmaps aerial imagery (date. 05.05.23)

LEGEND:

- Huntlee New Town - Stage 2 DA Boundary
- Huntlee New Town - Stage 1 Boundary (under development)
- Registered Lot Boundary

0 150 300m

SCALE 1:7500 @A3

NORTH

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Drawn TB	Date 20.06.2023	
Checked	Date	
Designed	Date	
Verified	Date	
Approved		

Client	HUNTLEE PTY LTD
Project	GEOTECHNICAL ASSESSMENT HUNTLEE NEW TOWN - STAGE 2 DA NORTH ROTHBURY / BRANXTON / ROTHBURY / BELFORD
Title	SITE PLAN - GENERAL SITE LOCALITY SOUTHERN SITE AREA LARGE LOT SITE

Status		
FOR INFORMATION ONLY NOT TO BE USED FOR CONSTRUCTION PURPOSES		
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Drawing Number: Drawing 2		Revision: A

DATE PLOTTED: 16 October 2023 3:36 PM BY : BARTLETT, EDWARD

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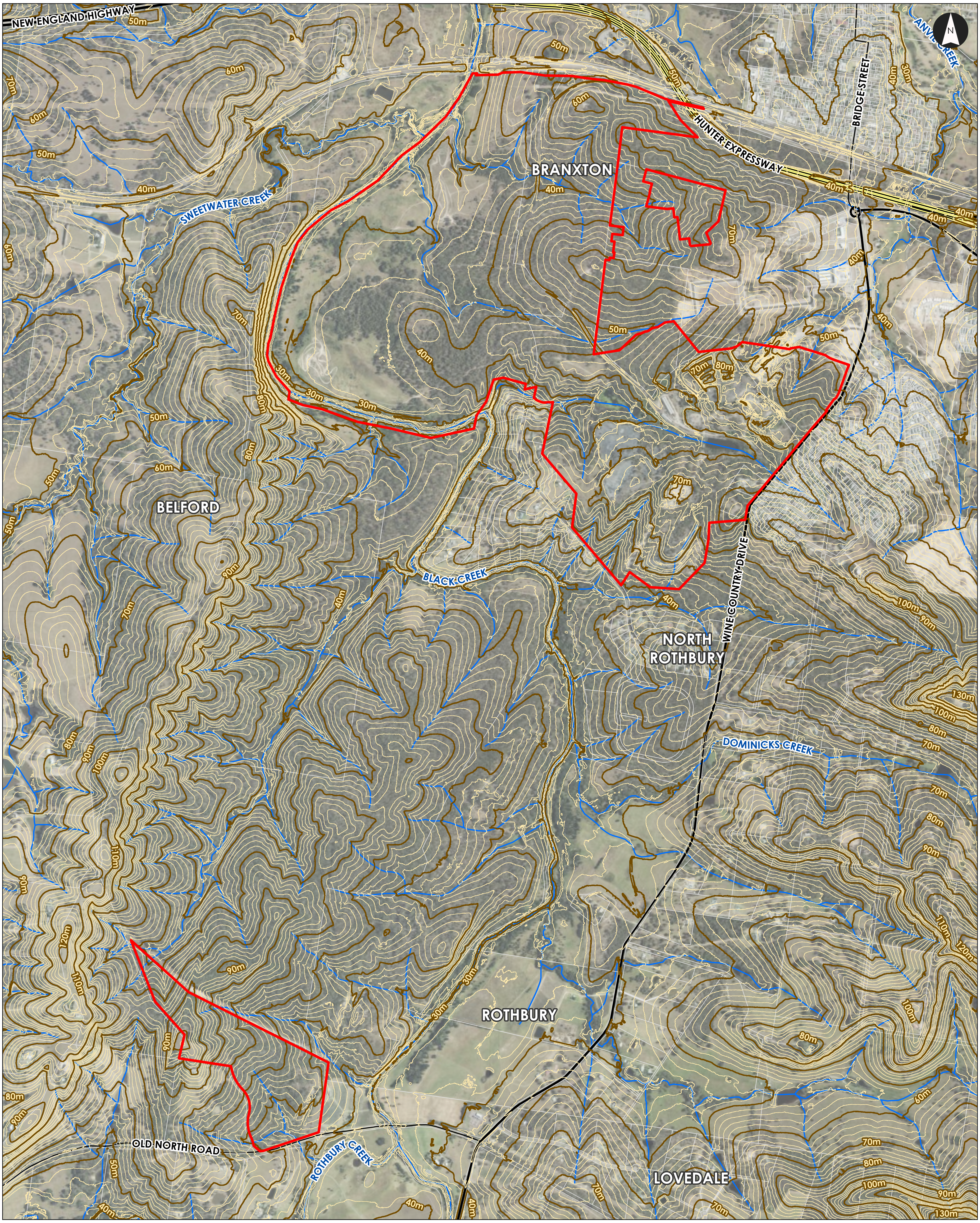

Site Plan - Topography

Huntlee New Town - Stage 2 DA
North Rothbury, Branxton, Rothbury and Belford, NSW

Project No: 304001022-003
Drawing No: Drawing 3
Drawn By: MM, Checked By: AS
Rev: 01
Date: 2023-10-05

Stantec

Legend

- Site Boundary
- Watercourse
- 2m Contours
- 10m Contours
- Cadastre

Roads

- Motorway
- Primary Road
- Arterial Road
- Sub Arterial Road

Notes:
1. Map displayed in GDA2020 MGA Zone 56

References:
1. Aerial imagery (MetroMap, Jan 2023)
2. Contours, Roads and Watercourses (NSW

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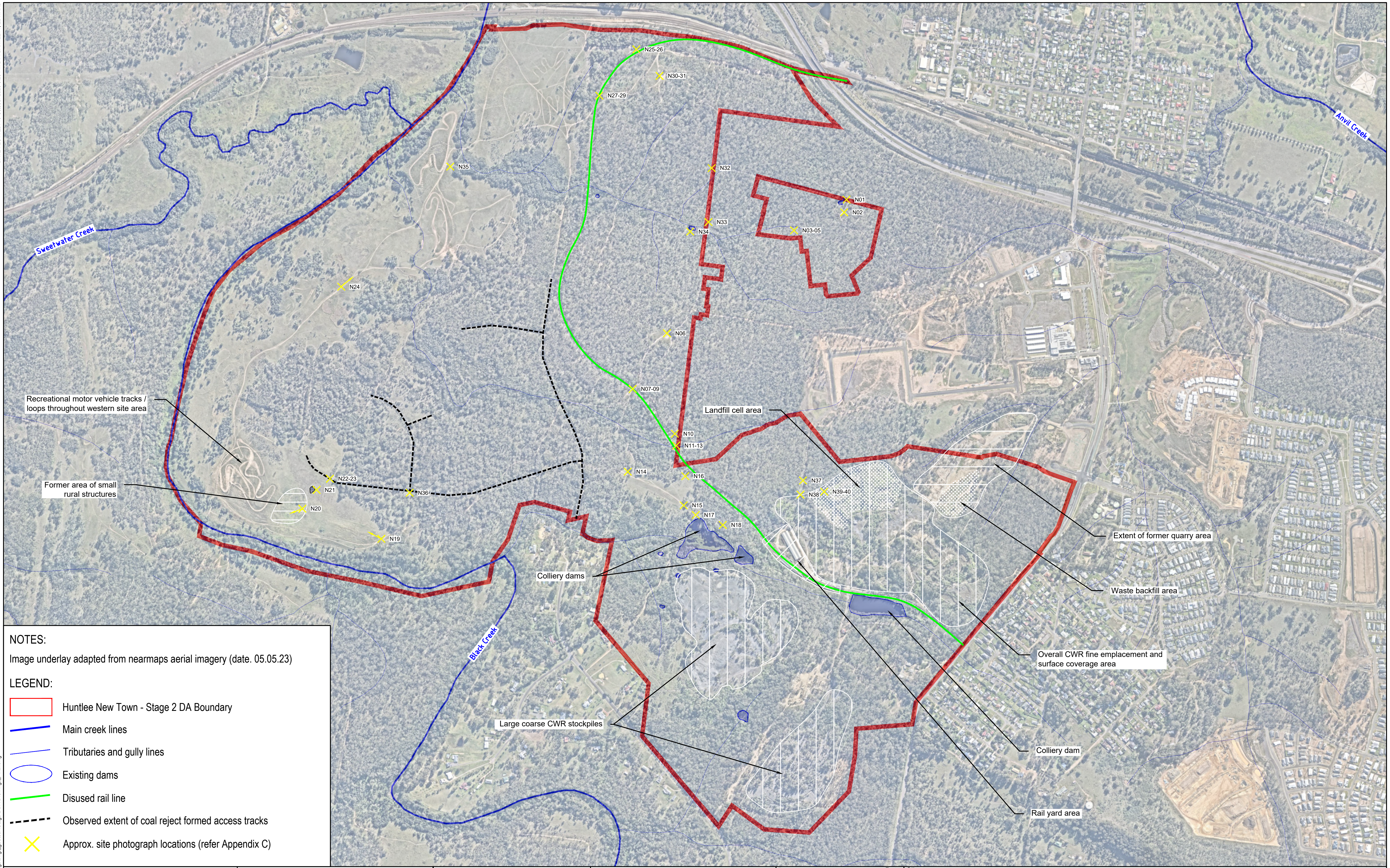

NOTES:

Image underlay adapted from nearmaps aerial imagery (date. 05.05.23)

LEGEND:

- Huntlee New Town - Stage 2 DA Boundary
- Main creek lines
- Tributaries and gully lines
- Existing dams
- Disused rail line
- Observed extent of coal reject formed access tracks
- Approx. site photograph locations (refer Appendix C)

0 250 500m

SCALE 1:12500 @A3

NORTH

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Drawn: TB	Date: 20.06.2023
Checked	Date
Designed	Date
Verified	Date
Approved	

Client: HUNTLEE PTY LTD

Project: GEOTECHNICAL ASSESSMENT
HUNTLEE NEW TOWN - STAGE 2 DA
NORTH ROTHBURY / BRANXTON / ROTHBURY / BELFORD

Title: SITE PLAN - SITE FEATURES
NORTHERN STAGE 2 DA AREA
VILLAGE 2 / VILLAGE 3 / TOWN CENTRE

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

Project Number	Scale	Size
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Drawing Number	Revision
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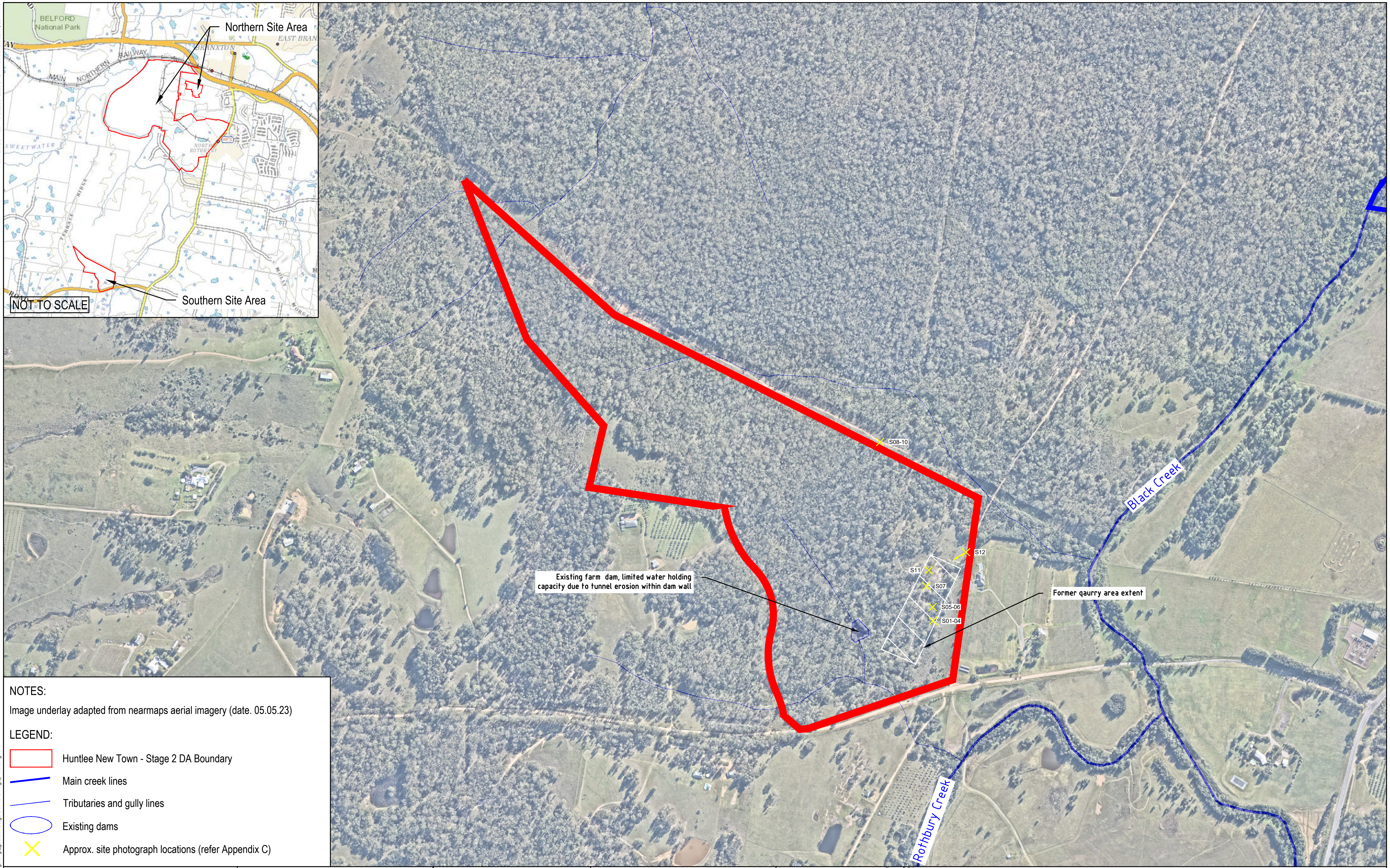

NOTES:

Image underlay adapted from nearmaps aerial imagery (date. 05.05.23)

LEGEND:

- Huntlee New Town - Stage 2 DA Boundary
- Main creek lines
- Tributaries and gully lines
- Existing dams
- Approx. site photograph locations (refer Appendix C)

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SCALE 1:7500 @A3

NORTH

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Drawn TB	Date 20.06.2023	
Checked	Date	
Designed	Date	
Verified	Date	
Approved		

Client: HUNTLEE PTY LTD

Project: GEOTECHNICAL ASSESSMENT
HUNTLEE NEW TOWN - STAGE 2 DA
NORTH ROTHBURY / BRANXTON / ROTHBURY / BELFORD

Title: SITE PLAN - SITE FEATURES
SOUTHERN SITE AREA
LARGE LOT SITE

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

Project Number	Scale	Size
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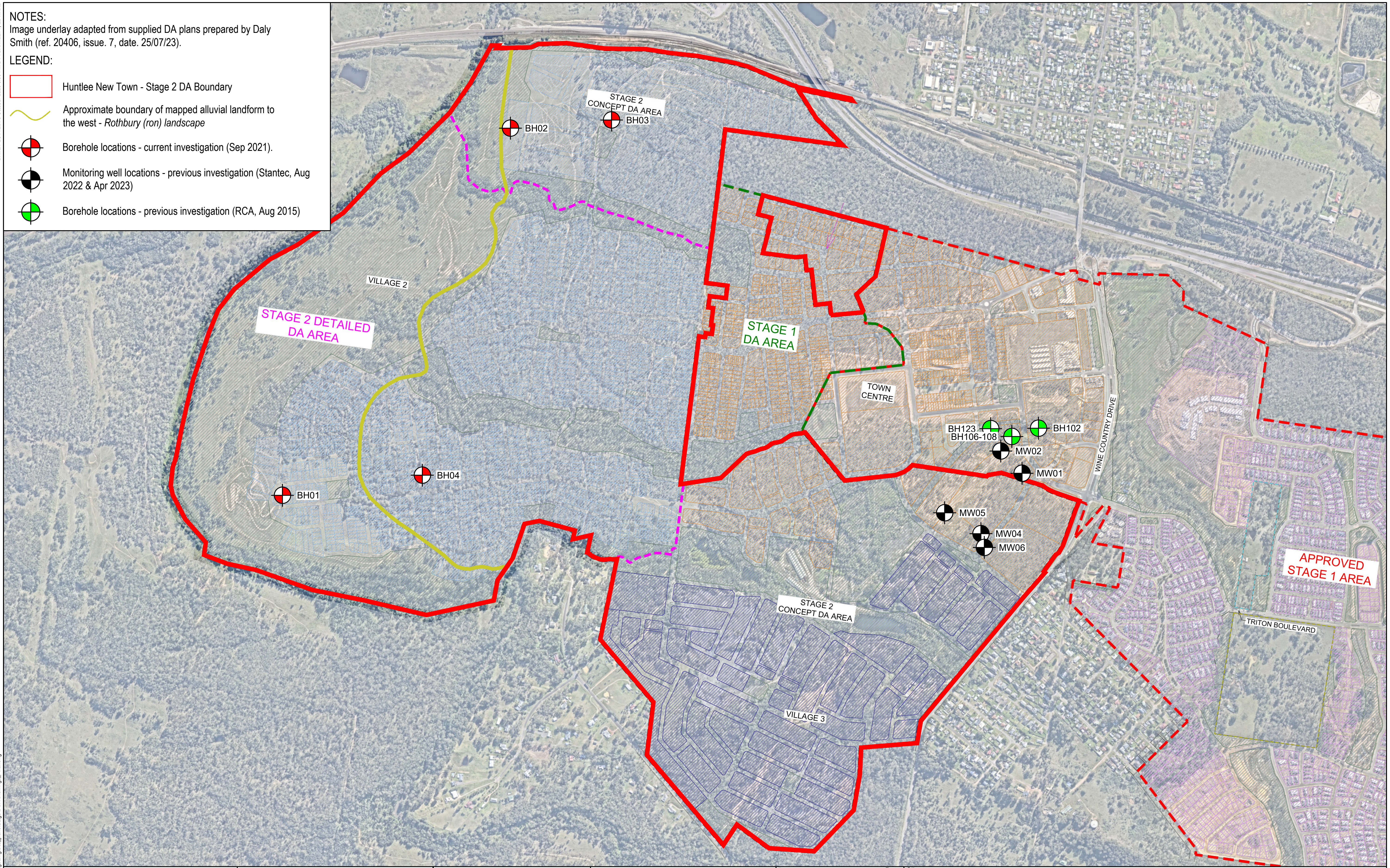
Drawing Number	Revision
Drawing 5	A

DATE PLOTTED: 16 October 2023 2:12 PM BY : BARTLETT, EDWARD

NOTES:
Image underlay adapted from supplied DA plans prepared by Daly Smith (ref. 20406, issue. 7, date. 25/07/23).

LEGEND:

- Huntlee New Town - Stage 2 DA Boundary
- Approximate boundary of mapped alluvial landform to the west - *Rothbury (ron) landscape*
- Borehole locations - current investigation (Sep 2021).
- Monitoring well locations - previous investigation (Stantec, Aug 2022 & Apr 2023)
- Borehole locations - previous investigation (RCA, Aug 2015)



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SCALE 1:12500 @A3

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Drawn TB	Date 20.06.2023
Checked	Date
Designed	Date
Verified	Date
Approved	

Client: HUNTLEE PTY LTD

Project: GEOTECHNICAL ASSESSMENT
HUNTLEE NEW TOWN - STAGE 2 DA
NORTH ROTHBURY / BRANXTON / ROTHBURY / BELFORD

Title: SITE PLAN - BOREHOLE LOCATIONS
NORTHERN STAGE 2 DA AREA
VILLAGE 2 / VILLAGE 3 / TOWN CENTRE

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

Project Number	Scale	Size
304001022-003	1:12500	A3

Drawing Number	Revision
Drawing 6	A

DATE PLOTTED: 8 October 2023 8:55 PM BY : BARTLETT, EDWARD

XREFs:
CAD File: U:\304001022\03_stg2da_g\drawings\dwg\site_plans\Stage 2 DA Drawings_Final.dwg

pers.

APPENDIX

C

SITE PHOTOGRAPHS

Stantec

S01: Southern Site Area (SSA) quarry – general view from eastern crest

S02: SSA quarry – view of benching (eastern side)

S03: SSA quarry - overgrown floor from eastern crest

S04: SSA quarry - near vertical rock face

	
S05: SSA quarry - fallen boulders withing quarry floor	**S06**: SSA quarry – exposed quarry face
	
S07: SSA general refuse	**S08**: SSA northern site boundary - significant rutting within easement access track (looking west)

	
S09: SSA northern site boundary - significant rutting within easement access track (looking east)	**S10**: SSA northern site boundary – erosion of exposed sodic residual clays

S11: SSA disturbance / clearing to the northern portion quarry (looking east)

S12: SSA overgrown filled berm / stockpile to the north of the former quarry (looking southwest)

N01: Northern Site Area (NSA) – exisiting farm dam along northern site boundary (smaller land parcel)

N02: NSA –abandoned motor vehicle wreck, and surrounding area towards the northern site boundary (smaller land parcel)

	
N03: NSA – area of significant scour / rutting and fallen tree southwest of smaller land parcel (looking east)	**N04**: NSA – area of significant scour / rutting and fallen tree southwest of smaller land parcel (close view)
	
N05: NSA – down slope of area of significant scour / rutting southwest of smaller land parcel (looking west)	**N06**: NSA – bare / cleared area

N07: NSA – southern level crossing (looking west)

N08: NSA – track view from southern level crossing (looking northwest)

N09: NSA – track view from southern level crossing (looking southeast)

N10: NSA – significant rutting within access track adjacent rail line (looking southeast)

N11: NSA – existing concrete culvert inlet below approx. 5m high rail embankment (looking west)

N12: NSA – existing concrete culvert (inlet side), no signs of significant blockage evident.

N13: NSA – Soft / moist surface soils immediately upstream of culvert (N11/N12).

N14: NSA – abandoned motor vehicle wreck

N15: NSA – abandoned motor vehicle wreck

N16: NSA – abandoned motor vehicle wreck

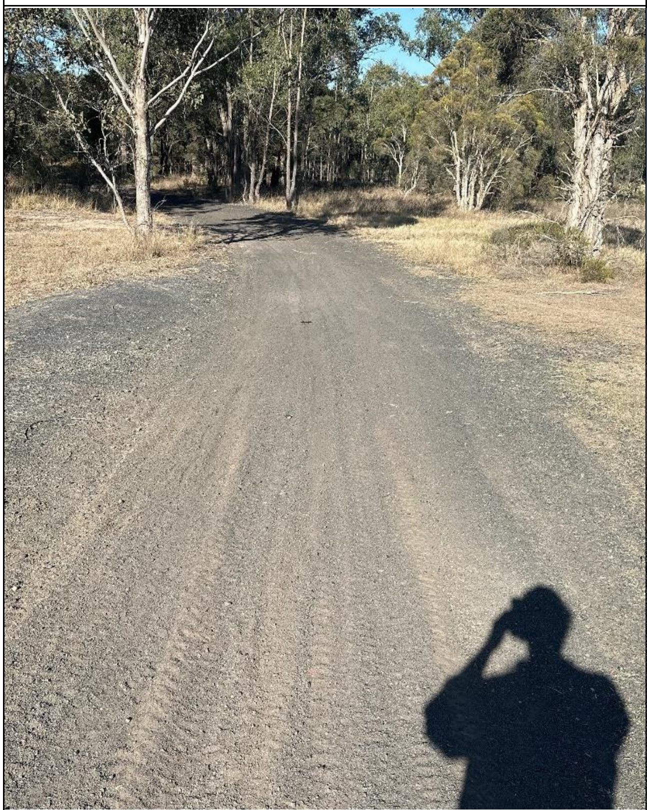
N17: NSA – large waterbody, westernmost colliery dam (looking south)

N18: NSA – multiple abandoned motor vehicle wrecks, north of the larger colliery dam

N19: NSA – general view of western alluvial plain area (looking northwest from the south)

N20: NSA – small building rubble stockpile, southwest of site

N21: NSA – small existing farm dam, southwest of site



N22: NSA – chitter surfaced access track, southwest of site (looking east)

N23: NSA – chitter surfaced access track, southwest of site (looking northwest)

N24: NSA – general view to the west (looking north)

N25: NSA – rock cutting along northern portion of rail alignment (western side of track)

N26: NSA – rock cutting along northern portion of rail alignment (western side of track)

	
N27: NSA – northern level crossing (looking east), approx transitional zone between cut and fill track construction, general refuse also noted in area	**N28**: NSA – general view of rail corridor from northern level crossing (looking northwest)
	
N29: NSA – general view of rail corridor from northern level crossing (looking south)	**N30**: NSA – cleared area, including abandoned motor vehichle wreck and general refuse

N31: NSA – cleared area, including pile of appeared building waste

N32: NSA – existing rutting within bare access track

N33: NSA – exposed surficial soils and residual clays in area of rutting

N34: NSA – existing farm dam within drainage line

N35: NSA – scoured slope face to the west

N36: NSA – overgrown filled berm

N37: NSA –built up access track, appeared to comprise overburden / waste rock material near colliery area

N38: NSA – access track / crest of possible landfill cell wall

	
N39: NSA – overlooking possible colliery landfill cell from crest of wall	**N40**: NSA – appeared overflow pipe, installed approx. 1-1.5m below crest level.

APPENDIX

D

BOREHOLE LOGS

Stantec

BOREHOLE LOG SHEET

Client: Huntlee Pty Ltd		**Hole No: BH01**
Project: Huntlee New Town Stage 2 DA		
Location: Branxton, NSW	**Job No: 304001022-103**	**Sheet: 1 of 2**
Position: Refer to site plan	**Angle from Horizontal: 90°**	**Surface Elevation:**
Rig Type: Edson Versadrill MRA 260	**Mounting: 4wd Ute**	**Driller: MH**
Casing Diameter: uncased		**Contractor: Stantec**
Date Started: 13/9/23 **Date Completed: 13/9/23**	**Logged By: TB**	**Checked By: IGP**

Drilling: Method: AD/T; Resistance: –; Casing: uncased; Water: Not Observed

Sample or Field Test	Depth (m)	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components, ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
ES 0.30 m	0.00	SM	Silty SAND: fine to medium grained, pale brown	M		ALLUVIUM 0.00 m: organics / rootlets <50mm bgl
ES 1.00 m	0.70m	CL	Sandy CLAY: low plasticity, mottled pale grey and orange, fine to medium grained sand	M (<PL)		
ES 1.40 m	1.20m	CI	Silty CLAY: medium plasticity, dark brown mottled orange and pale grey, with fine to medium grained sand	M (=PL)		
ES 2.30 m	2.00m	SC	Clayey SAND: fine to medium grained, brown	M		
ES 2.80 m	2.70m	CL-CI	Silty Sandy CLAY: low to medium plasticity, dark grey mottled orange, fine grained sand	M (>PL)		
ES 3.30 m	3.20m	CI	Silty CLAY: medium plasticity, grey mottled brown, with fine to medium grained sand	M (>PL)		

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

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

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

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

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

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

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

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

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

STANTEC AUSTRALIA PTY LTD

Stantec

BOREHOLE LOG SHEET

Client: Huntlee Pty Ltd
Project: Huntlee New Town Stage 2 DA
Location: Branxton, NSW

Hole No: BH01

Job No: 304001022-103
Sheet: 2 of 2

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Edson Versadrill MRA 260	**Mounting:** 4wd Ute	**Driller:** MH
Casing Diameter: uncased		**Contractor:** Stantec
Date Started: 13/9/23 **Date Completed:** 13/9/23	**Logged By:** TB	**Checked By:** IGP

Drilling: Method	Drilling: Resistance	Drilling: Casing	Water	Sampling & Testing: Sample or Field Test	Depth (m)	Classification	Material Description: SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/T		uncased	Not Observed		to 3.60m	CI		M (>PL)		ALLUVIUM
					3.60m – 4.10m	SC	Clayey SAND: fine to medium grained, orange-brown	D - M		
				ES 4.30 m	4.10m – 4.50m	SM	Silty SAND: fine to medium grained, pale brown and grey	D - M		
				ES 4.70 m	4.50m – 5.00m	CI	Sandy CLAY: medium plasticity, grey-pale grey mottled orange, fine to medium grained sand	M (<PL)		
				ES 5.10 m	5.00m – 5.50m	SM	Silty SAND: fine to medium grained, white mottled orange, with clay	M		
				ES 5.80 m	5.50m – 6.10m	SC	Clayey SAND: fine to medium grained, white mottled orange	M		
				ES 6.30 m	6.10m – 6.40m	CL-CI	Silty CLAY: low to medium plasticity, white mottled orange, friable	M (<PL)		6.10 m: friable
					6.40m – 6.60m		SANDSTONE, fine to medium grained, orange-brown, distinctly weathered			WEATHERED ROCK
					6.60m		TERMINATED AT 6.60 m Refusal			

Depth scale: 4.0, 4.5, 5.0, 5.5, 6.0, 6.5

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

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

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
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PBT - Plate Bearing Test
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PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

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

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

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

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

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

STANTEC AUSTRALIA PTY LTD

Stantec

BOREHOLE LOG SHEET

Client: Huntlee Pty Ltd
Project: Huntlee New Town Stage 2 DA
Location: Branxton, NSW

Job No: 304001022-103

Hole No: BH02

Sheet: 1 of 1

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Edson Versadrill MRA 260	**Mounting:** 4wd Ute	**Driller:** MH
Casing Diameter: uncased		**Contractor:** Stantec
Date Started: 13/9/23 **Date Completed:** 13/9/23	**Logged By:** TB	**Checked By:** IGP

Method	Resistance	Casing	Water	Sample or Field Test	Depth (m)	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/T		uncased	Not Observed		0.05m	SM	Silty SAND: fine to medium grained, brown, trace rootlets	D		TOPSOIL
				ES 0.20 m	0.35m	SM	Silty SAND: fine to medium grained, brown	M		COLLUVIUM
				ES 0.50 m	0.70m	CH	Silty CLAY: high plasticity, orange-brown, trace fine, subrounded gravel	M (>PL)		RESIDUAL SOIL
							0.60 m: becoming pale grey mottled orange, reducing plasticity	M (≈PL)		0.60 m: grading to weathered rock
					0.80m		SANDSTONE, fine grained, orange and grey, distinctly weathered			WEATHERED ROCK
							TERMINATED AT 0.80 m Refusal			

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

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

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

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
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VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

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MOISTURE
D - Dry
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LL - Liquid limit
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SOIL CONSISTENCY
VS - Very Soft
S - Soft
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VSt - Very Stiff
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RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

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

STANTEC AUSTRALIA PTY LTD

Stantec

BOREHOLE LOG SHEET

Client: Huntlee Pty Ltd
Project: Huntlee New Town Stage 2 DA
Location: Branxton, NSW

Hole No: BH03

Job No: 304001022-103
Sheet: 1 of 1

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Edson Versadrill MRA 260	**Mounting:** 4wd Ute	**Driller:** MH
Casing Diameter: uncased		**Contractor:** Stantec
Date Started: 13/9/23 **Date Completed:** 13/9/23	**Logged By:** TB	**Checked By:** IGP

Method	Resistance	Casing	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/T		uncased	Not Observed		0.10m		SM	Silty SAND: fine grained, grey-brown, trace rootlets	D		TOPSOIL
				ES 0.40 m	0.5 / 0.60m		SM	Silty SAND: fine to medium grained, brown, with fine to medium, subrounded gravel	D		COLLUVIUM
					0.80m			SANDSTONE, fine to medium grained, orange and grey, distinctly weathered			WEATHERED ROCK 0.60 m: thin clay veneer at weathered rock interface (<50mm)
					1.0 – 3.0			TERMINATED AT 0.80 m Refusal			

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

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E Easy
F Firm
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Water Level on Date shown
water inflow
water outflow

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VL - Very Loose
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VD - Very Dense

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STANTEC AUSTRALIA PTY LTD

Stantec

BOREHOLE LOG SHEET

Client: Huntlee Pty Ltd
Project: Huntlee New Town Stage 2 DA
Location: Branxton, NSW

Hole No: BH04

Job No: 304001022-103

Sheet: 1 of 1

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Edson Versadrill MRA 260	**Mounting:** 4wd Ute	**Driller:** MH
Casing Diameter: uncased		**Contractor:** Stantec
Date Started: 13/9/23 **Date Completed:** 13/9/23	**Logged By:** TB	**Checked By:** IGP

Method	Resistance	Casing	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
AD/T (0.00–1.50 m)		uncased (0.00–1.50 m)	Not Observed		0.00–0.10		SM	Silty SAND: fine to medium grained, grey-brown, with fine to medium gravel	D		COLLUVIUM 0.00 m: organics / rootlets <50mm bgl
				ES 0.30 m	0.10–0.80			Silty CLAY: high plasticity, red-brown	M (<PL)		RESIDUAL SOIL
					0.80–1.30			Silty Sandy CLAY: low plasticity, white mottled orange and red, fine to medium grained sand	M (<PL)		EXTREMELY WEATHERED
					1.30–1.50			SILTSTONE, pale grey, highly weathered			WEATHERED ROCK
					1.50			TERMINATED AT 1.50 m Target depth			

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
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SON Sonic drilling
AH Air hammer
PS Percussion sampler
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AD/T Solid flight auger: TC-Bit
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water outflow

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

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

STANTEC AUSTRALIA PTY LTD

APPENDIX

E

LABORATORY TEST REPORTS

CHAIN OF CUSTODY RECORD

Stantec

Laboratory:	Envirolab	***Client:***	Stantec Australia Pty Ltd
Address:	12 Ashley St Chatswood, NSW 2067	***Address:***	Suite 2, Level 2, 22 Honeysuckle Drive Newcastle, NSW 2300

Contact:	Ted Bartlett	**Results to:**	edward.bartlett@stantec.com
Ph:	0401 611 435	**Invoice to:**	edward.bartlett@stantec.com
Email:	edward.bartlett@stantec.com	**Invoice to:**	sapinvoices@stantec.com

Project:	Huntlee New Town Stage 2 DA	***Date Results Required:***	**4-Day TAT**
Project Ref:	304001022-103		
Sampled by:	Ted Bartlett		

Notes for the lab:
All samples chilled immediately following sampling.
Please retain samples for further SCr testing.

Lab ID	Client Sample ID	Date Sampled	Matrix: Soil	Containers / Preservation: Soil Jar					ASS Field Screen Suite: pHf, pHfox, reaction rate	Salinity Suite: ESP/Sodicity, pH, EC, Chloride, Sulphate, resistivity	-: EC	
									E22050	no code	E01150	
1	BH01 0.3m	13/09/2023	x	x					x	x		
2	BH01 1.0m	13/09/2023	x	x					x		x	
3	BH01 1.4m	13/09/2023	x	x					x	x		
4	BH01 2.3m	13/09/2023	x	x					x		x	
5	BH01 2.8m	13/09/2023	x	x					x		x	
6	BH01 3.3m	13/09/2023	x	x					x		x	
7	BH01 4.3m	13/09/2023	x	x					x		x	
8	BH01 4.7m	13/09/2023	x	x					x		x	
9	BH01 5.1m	13/09/2023	x	x					x		x	
10	BH01 5.8m	13/09/2023	x	x					x		x	
11	BH01 6.3m	13/09/2023	x	x								
12	BH02 0.2m	13/09/2023	x	x					x		x	
13	BH02 0.5m	13/09/2023	x	x					x	x		
14	BH03 0.4m	13/09/2023	x	x					x	x		
15	BH04 0.3m	13/09/2023	x	x					x	x		

Relinquished by Ted Bartlett Signature [signature] Date/Time 14/09/2023

Received by Signature Date/Time

ENVIROLAB Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 333100

Date Received: 15/9/23
Time Received: 1030
Received By: DL
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

EWS-COC-001/1

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 333100

Client Details	
Client	Cardno (NSW/ACT) Pty Ltd
Attention	Edward Bartlett
Address	PO Box 19, St Leonards, NSW, 1590

Sample Details	
Your Reference	**304001022-103 Huntlee New Town Stage 2 DA**
Number of Samples	15 Soil
Date samples received	15/09/2023
Date completed instructions received	15/09/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details	
Date results requested by	21/09/2023
Date of Issue	21/09/2023

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Inorganics Supervisor
Loren Bardwell, Development Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		333100-1	333100-2	333100-3	333100-4	333100-5
Your Reference	UNITS	BH01	BH01	BH01	BH01	BH01
Depth		0.3	1.0	1.4	2.3	2.8
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	18/09/2023	18/09/2023	18/09/2023	18/09/2023	18/09/2023
Date analysed	-	18/09/2023	18/09/2023	18/09/2023	18/09/2023	18/09/2023
pH 1:5 soil:water	pH Units	5.5	[NA]	5.5	[NA]	[NA]
Electrical Conductivity 1:5 soil:water	µS/cm	16	62	180	180	320
Chloride, Cl 1:5 soil:water	mg/kg	<10	[NA]	180	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	<10	[NA]	52	[NA]	[NA]
Resistivity in soil*	ohm m	640	[NA]	56	[NA]	[NA]

Misc Inorg - Soil						
Our Reference		333100-6	333100-7	333100-8	333100-9	333100-10
Your Reference	UNITS	BH01	BH01	BH01	BH01	BH01
Depth		3.3	4.3	4.7	5.1	5.8
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	18/09/2023	18/09/2023	18/09/2023	18/09/2023	18/09/2023
Date analysed	-	18/09/2023	18/09/2023	18/09/2023	18/09/2023	18/09/2023
Electrical Conductivity 1:5 soil:water	µS/cm	300	220	370	280	210

Misc Inorg - Soil					
Our Reference		333100-12	333100-13	333100-14	333100-15
Your Reference	UNITS	BH02	BH02	BH03	BH04
Depth		0.2	0.5	0.4	0.3
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	18/09/2023	18/09/2023	18/09/2023	18/09/2023
Date analysed	-	18/09/2023	18/09/2023	18/09/2023	18/09/2023
pH 1:5 soil:water	pH Units	[NA]	6.4	5.1	5.5
Electrical Conductivity 1:5 soil:water	µS/cm	40	250	34	430
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	150	<10	440
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	230	10	250
Resistivity in soil*	ohm m	[NA]	39	290	24

ESP/CEC						
Our Reference		333100-1	333100-3	333100-13	333100-14	333100-15
Your Reference	UNITS	BH01	BH01	BH02	BH03	BH04
Depth		0.3	1.4	0.5	0.4	0.3
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/09/2023	21/09/2023	21/09/2023	21/09/2023	21/09/2023
Date analysed	-	21/09/2023	21/09/2023	21/09/2023	21/09/2023	21/09/2023
Exchangeable Ca	meq/100g	0.2	0.1	2.1	0.4	<0.1
Exchangeable K	meq/100g	0.1	0.2	0.5	0.2	0.2
Exchangeable Mg	meq/100g	0.3	3.8	12	1.4	13
Exchangeable Na	meq/100g	<0.1	1.5	2.5	<0.1	2.2
Cation Exchange Capacity	meq/100g	<1	5.6	17	2.0	16
ESP	%	[NT]	26	15	[NT]	14

sPOCAS field test						
Our Reference		333100-1	333100-2	333100-3	333100-4	333100-5
Your Reference	UNITS	BH01	BH01	BH01	BH01	BH01
Depth		0.3	1.0	1.4	2.3	2.8
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/09/2023	19/09/2023	19/09/2023	19/09/2023	19/09/2023
Date analysed	-	19/09/2023	19/09/2023	19/09/2023	19/09/2023	19/09/2023
pH_F (field pH test)	pH Units	6.3	6.6	6.2	6.0	6.8
pH_{FOX} (field peroxide test)	pH Units	3.7	3.9	3.5	4.4	5.5
Reaction Rate*	-	Low reaction	Medium reaction	Medium reaction	Low reaction	Medium reaction

sPOCAS field test						
Our Reference		333100-6	333100-7	333100-8	333100-9	333100-10
Your Reference	UNITS	BH01	BH01	BH01	BH01	BH01
Depth		3.3	4.3	4.7	5.1	5.8
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	19/09/2023	19/09/2023	19/09/2023	19/09/2023	19/09/2023
Date analysed	-	19/09/2023	19/09/2023	19/09/2023	19/09/2023	19/09/2023
pH_F (field pH test)	pH Units	7.5	7.8	8.3	8.6	9.4
pH_{FOX} (field peroxide test)	pH Units	5.6	6.3	5.6	5.7	6.0
Reaction Rate*	-	Medium reaction	Low reaction	High reaction	Medium reaction	Medium reaction

sPOCAS field test					
Our Reference		333100-12	333100-13	333100-14	333100-15
Your Reference	UNITS	BH02	BH02	BH03	BH04
Depth		0.2	0.5	0.4	0.3
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	19/09/2023	19/09/2023	19/09/2023	19/09/2023
Date analysed	-	19/09/2023	19/09/2023	19/09/2023	19/09/2023
pH_F (field pH test)	pH Units	6.7	6.6	6.1	5.9
pH_{FOX} (field peroxide test)	pH Units	3.3	4.8	2.9	3.0
Reaction Rate*	-	High reaction	Medium reaction	High reaction	High reaction

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-OES analytical finish.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			18/09/2023	3	18/09/2023	18/09/2023		18/09/2023	[NT]
Date analysed	-			18/09/2023	3	18/09/2023	18/09/2023		18/09/2023	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	3	5.5	5.5	0	100	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	3	180	180	0	105	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	3	180	190	5	100	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	3	52	53	2	114	[NT]
Resistivity in soil*	ohm m	1	Inorg-002	<1	3	56	56	0	[NT]	[NT]

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	12	18/09/2023	18/09/2023		[NT]	[NT]
Date analysed	-			[NT]	12	18/09/2023	18/09/2023		[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	12	40	40	0	[NT]	[NT]

QUALITY CONTROL: ESP/CEC					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date prepared	-			21/09/2023	[NT]	[NT]	[NT]	[NT]	21/09/2023	[NT]
Date analysed	-			21/09/2023	[NT]	[NT]	[NT]	[NT]	21/09/2023	[NT]
Exchangeable Ca	meq/100g	0.1	Metals-020	<0.1	[NT]	[NT]	[NT]	[NT]	114	[NT]
Exchangeable K	meq/100g	0.1	Metals-020	<0.1	[NT]	[NT]	[NT]	[NT]	124	[NT]
Exchangeable Mg	meq/100g	0.1	Metals-020	<0.1	[NT]	[NT]	[NT]	[NT]	114	[NT]
Exchangeable Na	meq/100g	0.1	Metals-020	<0.1	[NT]	[NT]	[NT]	[NT]	115	[NT]

QUALITY CONTROL: sPOCAS field test					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			19/09/2023	[NT]	[NT]	[NT]	[NT]	19/09/2023	[NT]
Date analysed	-			19/09/2023	[NT]	[NT]	[NT]	[NT]	19/09/2023	[NT]
pH_F (field pH test)	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
pH_{FOX} (field peroxide test)	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments
ESP: Where the exchangeable Sodium is less than the PQL and CEC is less than 10meq/100g, the ESP cannot be calculated.

333100-A

21/09/23
18:39

CHAIN OF CUSTODY RECORD

Stantec

Laboratory:	Envirolab	*Client:*	Stantec Australia Pty Ltd
Address:	12 Ashley St Chatswood, NSW 2067	*Address:*	Suite 2, Level 2, 22 Honeysuckle Drive Newcastle, NSW 2300

Contact:	Ted Bartlett	Results to:	edward.bartlett@stantec.com
Ph:	0401 611 435	Invoice to:	edward.bartlett@stantec.com
Email:	edward.bartlett@stantec.com	Invoice to:	sapinvoices@stantec.com

Project:	Huntlee New Town Stage 2 DA	*Date Results Required:*	Standard TAT
Project Ref:	304001022-103		
Sampled by:	Ted Bartlett		

Notes for the lab:
All samples chilled immediately following sampling.
Please retain samples until final results are issued and reviewed.

Lab ID	Client Sample ID	Date Sampled	Matrix	Containers / Preservation					ASS SCr Suite			
			Soil	Soil Jar					Chromium Reducible Sulphur Suite E22020			
333100-1	BH01 0.3m	13/09/2023	×	×					×			
333100-3	BH01 1.4m	13/09/2023	×	×					×			
333100-8	BH01 4.7m	13/09/2023	×	×					×			
333100-12	BH02 0.2m	13/09/2023	×	×					×			
333100-14	BH03 0.4m	13/09/2023	×	×					×			
333100-15	BH04 0.3m	13/09/2023	×	×					×			

Relinquished by Ted Bartlett Signature [signature] Date/Time 21/09/2023

Received by Signature Date/Time

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 333100-A

Client Details

Client	Cardno (NSW/ACT) Pty Ltd
Attention	Edward Bartlett
Address	PO Box 19, St Leonards, NSW, 1590

Sample Details

Your Reference	**304001022-103 Huntlee New Town Stage 2 DA**
Number of Samples	15 Soil
Date samples received	15/09/2023
Date completed instructions received	21/09/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	28/09/2023
Date of Issue	28/09/2023

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Nick Sarlamis, Assistant Operation Manager

Authorised By
Nancy Zhang, Laboratory Manager

Chromium Suite						
Our Reference		333100-A-1	333100-A-3	333100-A-8	333100-A-12	333100-A-14
Your Reference	UNITS	BH01	BH01	BH01	BH02	BH03
Depth		0.3	1.4	4.7	0.2	0.4
Date Sampled		13/09/2023	13/09/2023	13/09/2023	13/09/2023	13/09/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/09/2023	28/09/2023	28/09/2023	28/09/2023	28/09/2023
Date analysed	-	28/09/2023	28/09/2023	28/09/2023	28/09/2023	28/09/2023
pH_{kcl}	pH units	4.7	4.5	6.4	5.0	4.6
s-TAA pH 6.5	%w/w S	0.02	0.02	<0.01	<0.01	0.03
TAA pH 6.5	moles H^+ /t	10	12	<5	6	18
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	0.005	0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	3	3
S_{HCl}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.018	0.022	<0.005	0.014	0.034
a-Net Acidity	moles H^+ /t	12	14	<5	8.5	21
Liming rate	kg $CaCO_3$ /t	0.9	1	<0.75	<0.75	2
a-Net Acidity without ANCE	moles H^+ /t	12	14	<5	8.5	21
Liming rate without ANCE	kg $CaCO_3$ /t	0.86	1.0	<0.75	<0.75	1.6
s-Net Acidity without ANCE	%w/w S	0.018	0.022	<0.005	0.014	0.034

Chromium Suite		
Our Reference		333100-A-15
Your Reference	UNITS	BH04
Depth		0.3
Date Sampled		13/09/2023
Type of sample		Soil
Date prepared	-	28/09/2023
Date analysed	-	28/09/2023
pH $_{kcl}$	pH units	4.9
s-TAA pH 6.5	%w/w S	0.02
TAA pH 6.5	moles H^+ /t	14
Chromium Reducible Sulfur	%w/w	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3
S_{HCl}	%w/w S	[NT]
S_{KCl}	%w/w S	[NT]
S_{NAS}	%w/w S	[NT]
ANC_{BT}	% $CaCO_3$	[NT]
s-ANC_{BT}	%w/w S	[NT]
s-Net Acidity	%w/w S	0.024
a-Net Acidity	moles H^+ /t	15
Liming rate	kg $CaCO_3$ /t	1
a-Net Acidity without ANCE	moles H^+ /t	15
Liming rate without ANCE	kg $CaCO_3$ /t	1.1
s-Net Acidity without ANCE	%w/w S	0.024

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Net acidity including ANC has a safety factor of 1.5 applied. Neutralising value (NV) of 100% is assumed for liming rate. The recommendation that the SHCL concentration be multiplied by a factor of 2 to ensure retained acidity is not underestimated, has not been applied in the SHCL result. However, it has been applied in the SNAS calculation: SNAS % = (SHCL-SKCL)x2

QUALITY CONTROL: Chromium Suite						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			28/09/2023	1	28/09/2023	28/09/2023		28/09/2023	[NT]
Date analysed	-			28/09/2023	1	28/09/2023	28/09/2023		28/09/2023	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	1	4.7	5.0	6	98	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	1	0.02	0.01	67	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	1	10	7	35	97	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	97	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	1	<3	<3	0	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	1	[NT]	[NT]		[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	1	[NT]	[NT]		[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	1	[NT]	[NT]		[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	1	[NT]	[NT]		100	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	1	[NT]	[NT]		[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	1	0.018	0.015	18	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	<5	1	12	9.2	26	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	1	0.9	<0.75	18	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	<5	1	12	9.2	26	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	1	0.86	<0.75	14	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	1	0.018	0.015	18	[NT]	[NT]

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PQL	Practical Quantitation Limit
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RPD	Relative Percent Difference
LCS	Laboratory Control Sample
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Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

APPENDIX

F

BTF SHEET 18

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

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

Seasonal swelling and shrinkage of soil

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

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

Shear failure

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

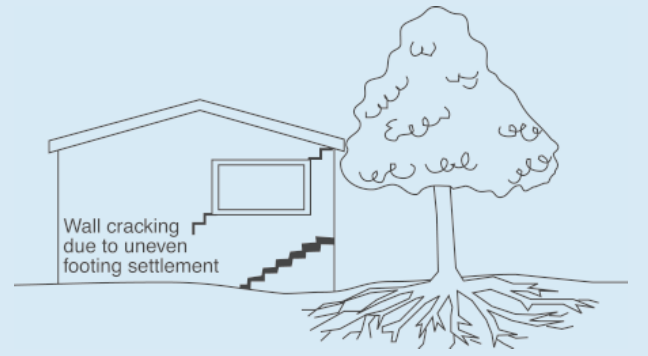
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

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

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

Trees can cause shrinkage and damage



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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

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

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

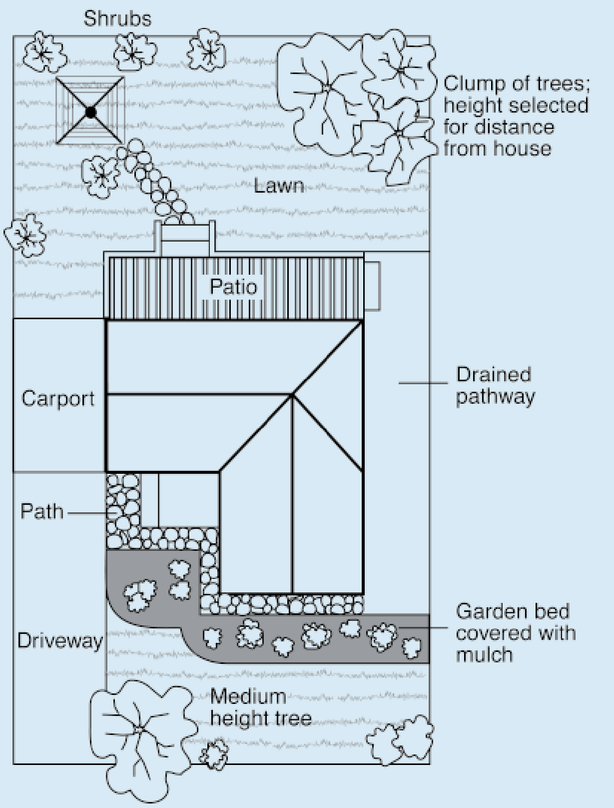
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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APPENDIX

G

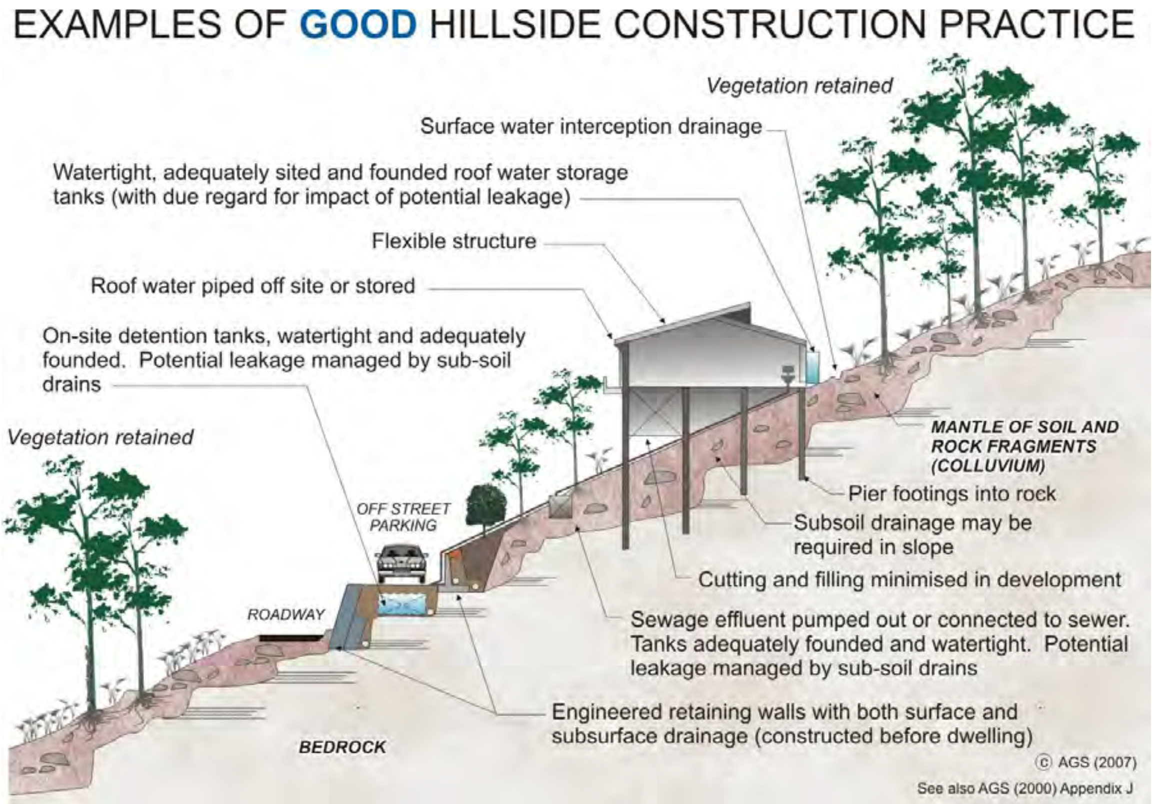
AUSTRALIAN GEOGUIDE (LR8) HILLSIDE CONSTRUCTION PRACTICE

Stantec

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

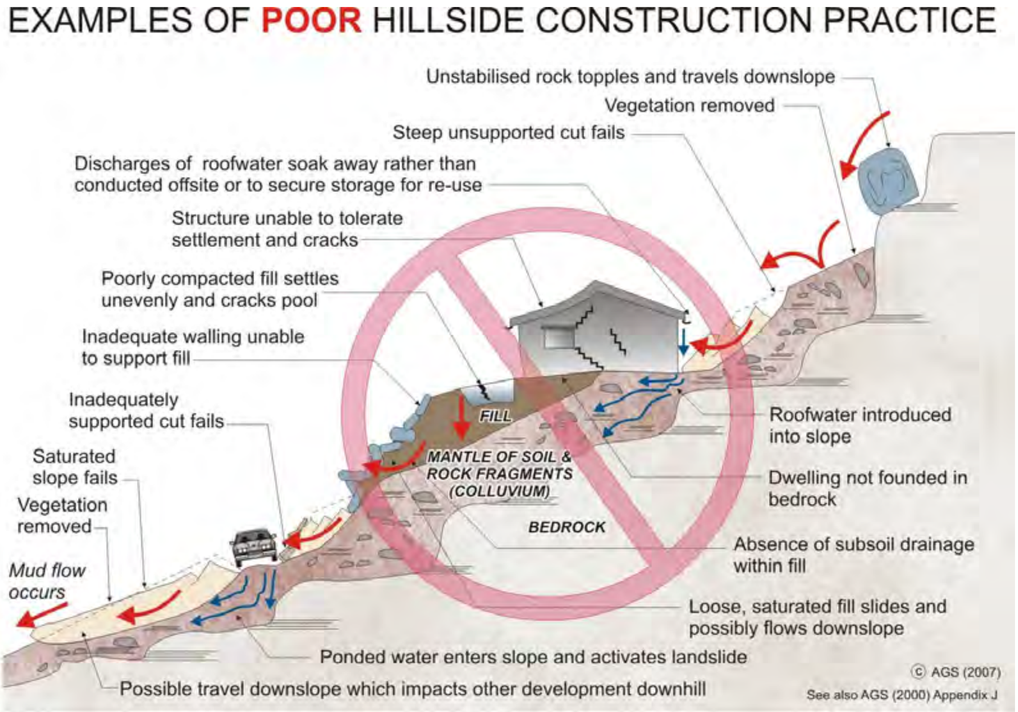
Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.