VICTORIAN PLANNING AUTHORITY

MAY 2023

SODIC/DISPERSIVE SOILS PEER REVIEW AND ASSESSMENT

MERRIMU PRECINCT

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Sodic/Dispersive Soils Peer Review and Assessment
Merrimu Precinct

Victorian Planning Authority

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REV	DATE	DETAILS
A	19 December 2022	Draft for review
B	26 May 2023	Final incorporating VPA comments
C	06 August 2023	Minor update to precinct end-use description – VPA

	NAME	DATE	SIGNATURE
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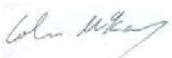
Reviewed by:	C McKay	26 May 2023	
Approved by:	S Giliam	26 May 2023	

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EXECUTIVE SUMMARY

WSP Australia Pty Limited (WSP) was engaged by the Victorian Planning Authority (VPA) on 7 November 2022 to provide specialist services relating to a preliminary, desk-based, sodic/dispersive soils risk assessment at the Merrimu Precinct, at Merrimu, Victoria.

The Merrimu precinct is located northeast of Bacchus Marsh town centre approximately 46 km northwest of Melbourne and covers an area of approximately 1,016 hectares. The precinct is bounded by the existing Darley neighbourhood and Gisborne Road to the west, Bences Road to the north, Possumtail Run and Pyrites Creek to the east, and Lerderderg Park Road and the Western Freeway to the south. The precinct is proposed to provide accommodation for approximately 5,900 to 6,700 households and up to 1,800 jobs, requiring extensive development to occur.

Most of the precinct is situated on a plateau, understood to comprise Newer Volcanics (3.5 to 4 million years old) clay and basalt, which acts as a cap over the underlying (and surrounding) alluvial white to grey clays, sands and gravels of the Werribee Formation (5.3 to 56 million years old). Beneath the Werribee Formation is the Ordovician aged (444 to 488 million years old) Castlemaine Group which comprises of slate, shale, siltstone, and sandstone and outcrops predominantly in the lowest slopes of the escarpment, particularly along Pyrites Creek but also at the western boundary of the precinct. The thickness of the Newer Volcanics is likely less than 20 m in the Merrimu precinct and has been eroded away on the scarps surrounding the plateau where the Werribee Formation can be seen at the surface.

A large number of assessments have been completed for the Merrimu precinct, focussing on geotechnical constraints, extent of sodic and dispersive soils, impacts of development on stormwater and options for managing discharge to within likely constraints (flow volumes). The work completed identified:

- Erosion risks associated with the presence of sodic and dispersive soils (particularly of the Werribee formation), gully erosion (existing and potential impact resulting from development) and thin topsoils.
- Erosion risks were particularly associated with stormwater discharge and steep slopes along the escarpment, and that stringent controls would be required to control risk posed by the development.

A re-analysis of laboratory results by WSP found that although the ESP in the Newer Volcanics is often elevated and within the sodic to very sodic range, the physical dispersity testing (Emerson aggregate and pin hole tests) typically shows this soil type to be non-dispersive or only dispersive following remoulding. In contrast, while the ESPs for Werribee Formation were generally lower than those in the Newer Volcanics (albeit still classifying as sodic soil), the physical dispersion testing (by Emerson aggregate only) showed the soil to be generally dispersive and representing a likely high risk of erosion. Whilst the Newer Volcanics may be some metres thick in the centre of the plateau, they appear to thin on the margins and are incised in gully's and on the scarps.

Overall, WSP considered the dataset provided was adequate for the purposes of this precinct level assessment of sodicity and erosion risk. On making conclusions and recommendations on a precinct level scale the limitation of sample distribution should be considered, notably that field observations indicate variability in mapped geology (e.g. rocky vs clay, variable thickness of the capping Newer Volcanics) and erosion conditions at identified gullies along the escarpment (e.g. visible erosion vs well vegetated stable channels) within the same geological setting. At the precinct planning level, these variations can be integrated conservatively into the precinct planning process; however, at a development scale these variations may impact engineering controls required or the ability to construct particular infrastructure, suggesting that site specific detailed investigation (including intrusive assessment) is likely to be required to inform particular controls and constraints for individual development elements (e.g. stormwater infrastructure, works within steeply sloping land, etc.).

The soil erosion risk and assessment has been based upon a literature review and site visit. The risk ranking is general in nature and has been assessed at a Precinct scale.

Erosion risk is highest along the escarpment and in steeply sloping areas (note: mostly outside the precinct boundary), is impacted by the generally thin topsoil across the precinct, and the nature of the infrastructure to be built:

- **Soil erosion:** Low – Medium risk on the plateau, High risk on escarpment slopes.
- **Buildings and infrastructure:** Low – Medium risk on the plateau, High risk on escarpment slopes
- **Water quality:** Low – Medium risk on the plateau, High risk on the escarpment slopes

Further works are recommended based on the findings of this assessment, which will further inform the risk profile at the Precinct and enable appropriate control of planning/design of infrastructure to meet the objectives of the Precinct Planning process underway.

1. **Precinct scale Erosion risk plans:** Precinct-scale plans which highlight areas of high risk, medium risk and low risk in relation to erosion potential, were prepared as part of the assessment, to inform strategic and statutory controls. VPA should seek agreement and approval of the prepared figures (Figure 8, Figure 9 and Figure 10, **Appendix A**) to formalise these as the Precinct-scale Erosion Risk Plans for the PSP.
2. **Precinct scale erosion controls:** The erosion control component of the precinct structure plan (PSP) should include the following precinct scale considerations:
    - **Waterway and gully management:** Implemented at the **statutory level** by applying an environmental overlay (or equivalent) to require/encourage particular management in these areas (e.g. enforce riparian land management controls, minimise disturbance to native vegetation, etc.). At the **strategic level**, this land could be incorporated into the precinct to enable developer control over greenspace development/establishment.
    - **Topsoil and urban run-off management:** To minimise the risks during and post construction, **strategic controls** may include implementing water sensitive urban design in the precinct, and **statutory controls** may include specifying conservative stormwater retention and discharge parameters to reduce impact to waterways to acceptable levels (as established by others).
    - **Greenspace and buffer zones:** The **strategic** implementation of a green corridor along the escarpment has the dual benefit of improving land management along the highest risk part of the precinct and preventing the construction of housing too close to the edge of the plateau.
3. **Development or Lot scale erosion controls:** To control erosion risk during and post development, the PSP may specify strategic controls for development, or require proponents to demonstrate appropriate controls are in place as part of the planning application process (statutory conditions). **Strategic** controls may include staging release of development and consideration of development that is sympathetic to the landform (as may be applicable in particular areas), and **Statutory** conditions may include a requirement for an erosion control management plan addressing risks and providing best-practice mitigations and which has been endorsed by a suitably qualified professional (e.g. a certified professional in erosion and sediment control or soil science), requirement for intrusive (physical) soil investigations where constructions are deemed medium to high risk (e.g. along the escarpment, steep slopes, or where infrastructure is likely to be placed within the Werribee formation) to confirm soil conditions and erosion risk (driven by dispersivity), and a general condition for a minimum thickness of topsoil to be retained or placed in exposed soil areas (nature strips, yards, parks, etc.) to provide a suitable depth of growing media to support vegetation growth and cover.

1 PURPOSE AND OBJECTIVES

WSP Australia Pty Limited (WSP) was engaged by the Victorian Planning Authority (VPA) on 7 November 2022 to provide specialist services relating to a preliminary, desk-based, sodic/dispersive soils risk assessment at the Merrimu Precinct, at Merrimu, Victoria (precinct/site).

A precinct figure is provided as Figure 1, **Appendix A**.

1.1 PURPOSE

The purpose of the assessment was to assist VPA in understanding the implications of the presence of sodic/dispersive soils within the precinct, to inform the precinct structure planning being undertaken and provide management options in property development context.

1.2 OBJECTIVES

The objectives of the proposed works were to:

- Review previously completed sodic/dispersive soils investigations within the Merrimu precinct to provide opinion on the assessments provided to date.
- Collate and review previously collected soil data and provide advice on management of soil erosion risks in a property development context and outline associated implications for planned future development.
- Provide outputs that will inform and assist the VPA precinct structure planning for the Merrimu PSP.

2 SCOPE OF WORKS

To achieve the assessment objectives identified in Section 1.2 the following scope of works was undertaken:

4 A literature review of previously completed land capability, geotechnical and catchment studies provided by VPA and publicly available information (including geology, soil type mapping, erosion risk, and site history), including a summary of findings pertaining to the objectives of the assessment. The literature review included discussion of:

- Project specific consultant reports (12 reports)
- Regional Victorian Government resources (4 resources)

5 Independent re-analysis of soil test data previously collected by others from various investigation locations across the precinct.

6 A Site inspection of the entire precinct was undertaken to enable familiarisation with local conditions, record relevant observations, and inform the literature review and assessment report. The inspection was undertaken by two field engineers (contaminated land specialists) within a single day from public areas (roadways and stream reserves).

7 Preparation of this report, incorporating:

- Discussion and recommendation of options to manage risks associated with identified sodic/dispersive and contaminated soils (if any), including:
  - Erosion risks,
  - Potential treatments,
  - Potential management options and control measures,
  - Potential infrastructure design and construction approaches related to public and private realms,
  - Potential non-structural control measures,
  - Any assumptions and limitations of the assessments,
  - Assessment of existing escarpment conditions and waterways based on visual observations and provision risk register,
  - Potential risks associated with future maintenance of infrastructure.
- Identification of a clear pathway for the management of risks associated with development and changes to hydrologic regimes, via the preparation of a risk management framework considering management options from the perspective of public asset owners and the private realm (e.g. landowners/developers).
- Consideration of novel approaches and options by seeking and incorporating expert input from senior WSP specialists in hydrology and erosion.
- Key considerations for the VPA planning process for Merrimu.
- Recommendations for additional work.

3 MERRIMU PRECINCT

The Merrimu precinct is located northeast of Bacchus Marsh town centre approximately 46 km northwest of Melbourne and covers an area of approximately 1,016 hectares. The precinct is bounded by the existing Darley neighbourhood and Gisborne Road to the west, Bences Road to the north, Possumtail Run and Pyrites Creek to the east, and Lerderderg Park Road and the Western Freeway to the south. Currently the precinct comprises a mix of grazing/cropping land and rural residential. We understand Merrimu is proposed to provide accommodation for approximately 5,900 to 6,700 households and up to 1,800 jobs.

The precinct boundary is shown in Figure 3.1 below.

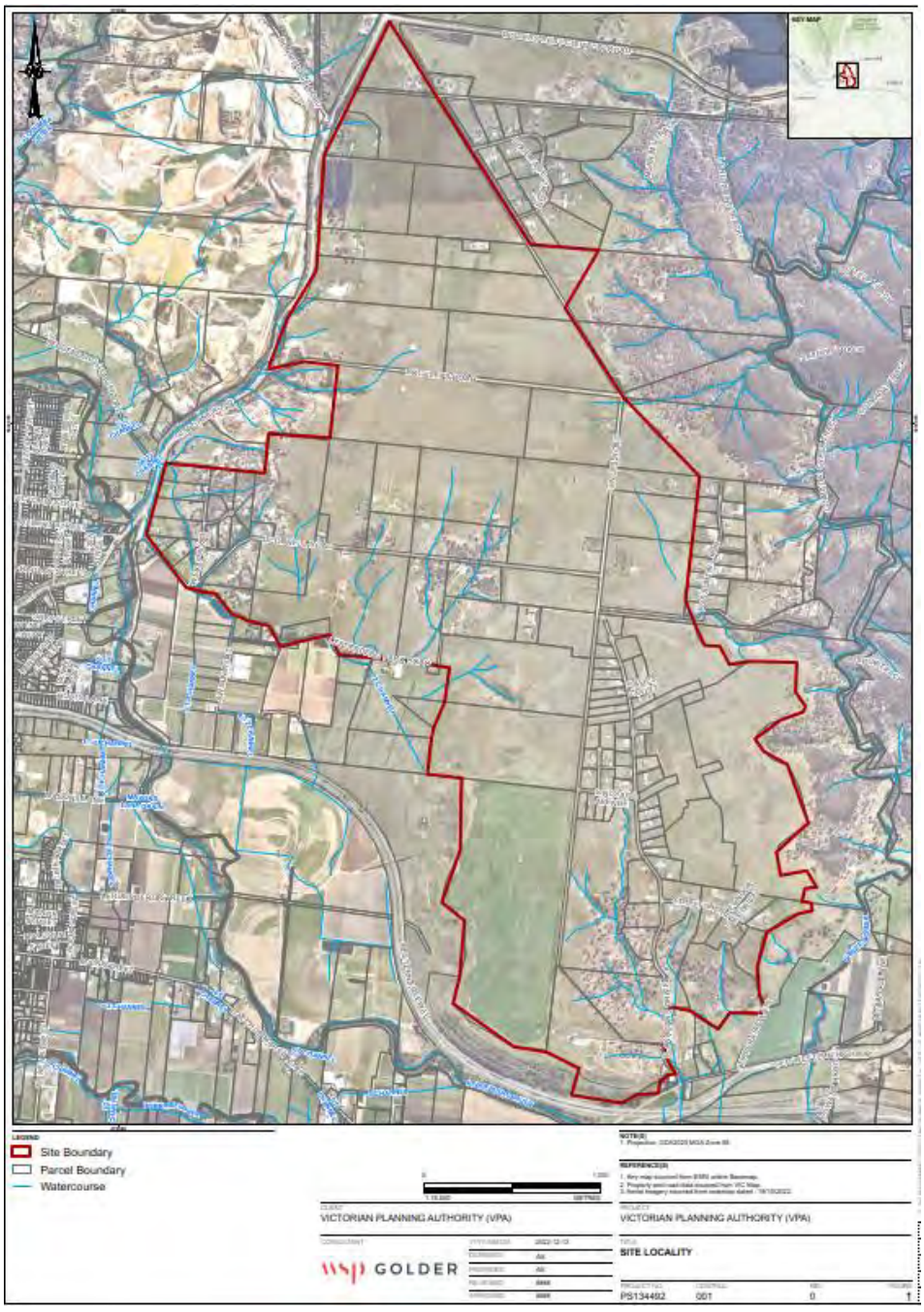


Figure 3.1 Merrimu Precinct boundary

Most of the precinct is situated on a plateau, understood to comprise Newer Volcanics (3.5 to 4 million years old) clay and basalt, which acts as a cap over the underlying (and surrounding) alluvial white to grey clays, sands and gravels of the Werribee Formation (5.3 to 56 million years old). Beneath the Werribee Formation is the Ordovician aged (444 to 488 million years old) Castlemaine Group which comprises of slate, shale, siltstone, and sandstone and outcrops predominantly in the lowest slopes of the escarpment, particularly along Pyrites Creek but also at the western boundary of the precinct.

A geological map with precinct location is presented in Figure 3 of **Appendix A**.

The thickness of the Newer Volcanics is likely less than 20 m in the Merrimu precinct and has been eroded away on the scarps surrounding the plateau where the Werribee Formation can be seen at the surface.

The precinct location and layout is presented in further detail as Figure 1 in **Appendix A**, while pertinent site details are summarised in Table 3.1 below.

Table 3.1 Pertinent Site Details

PARAMETER		DETAILS	
Locality		Merrimu, Victoria	
Address		The precinct is bounded by the following features: the existing Darley neighbourhood and Gisborne Road (west); Bences Road (north); Possumtail Run, Pyrites Creek, and the western extent of Long Forest Nature Reserve (east); Lerderderg Park Road and the Western Freeway (south).	
Site Owner(s)		Land parcels are understood to be owned by several individuals and developers, in addition to control of public roads by local and state government authorities.	
Current Land Use		Agricultural with associated homestead/farmhouse residential uses Residential along Possumtail Run and Flanagans Drive	
Past Land Use		Agricultural with associated homestead/farmhouse residential uses	
Site Investigation Area		Approximately 1,016 hectares (ha)	
Local Government Authority		Moorabool Shire Council	
Coordinates (approx. centre of site):		N: 5829428, E: 277284	Projection: MGA Zone 55 (GDA2020)
Site Zoning		Farming Zone (FZ) and Rural Conservation Zone (RCZ)	
Overlays		Design and Development Overlay – Schedule 1 (DDO) – Bences Road Area Design and Development Overlay – Schedule 2 (DDO) – Visual amenity and building design Significant Landscape Overlay – Schedule 1 (SLO) - Scenic Hilltops and Ridge Line Areas. Environmental Significance Overlay – Schedule 3 (ESO) – Long Forest and Werribee Gorge	
Surrounding Land Use	**North**	Bences Road, followed by agricultural (predominantly cropping/grazing, and including farmhouses) and bushland reserve.	
	East	Possumtail Run and Pyrites Creek, followed by bushland reserve and low density residential.	
	South	Lerderderg Park Road and Western Freeway, followed by agricultural (predominantly cropping/grazing, and including farmhouses) and low density residential.	
	West	Darley neighbourhood and Gisborne Road, followed by low density residential.	

4 TECHNICAL BACKGROUND

4.1 SODIC AND DISPERSIVE SOILS IN VICTORIA

4.1.1 DEFINITION OF SODIC AND DISPERSIVE SOILS

Sodic soils are soils that containing a relatively high proportion of exchangeable sodium. Sodium is a cation (positive ion) that is held loosely to the surfaces of clay particles in the soil. Other cations in the soil include calcium, magnesium, potassium and hydrogen. However, when sodium makes up more than about 6% of all these loosely bound or "exchangeable" cations, soil structural problems begin to occur, and the soil is said to be sodic.

The amount of sodium as a proportion of all exchangeable cations is the main measure of sodicity, is termed the exchangeable sodium percentage (ESP) and can be calculated from chemical tests of the soils cation exchange capacity (CEC).

As the sodium is generally associated with clay particles sodic soils are often clay dominated but may also be sandy with some clay present in the matrix (clayey or gravelly sands).

Sodic soil may have the following problems (Hazelton and Murphy, 2007):

- Very severe surface crusting
- Very low infiltration and hydraulic conductivity
- Very hard, dense subsoils
- High susceptibility to severe gully erosion
- High susceptibility to tunnel erosion

The reason these soils are highly susceptible to erosion is that when a sodic soil encounters non-saline water or rainwater, water molecules are drawn in-between the clay platelets resulting in swelling of the clay and, often, the detachment of clay platelets into the water making the water cloudy in a process called dispersion. Dispersed clay particles are readily suspended in the water and can be transported in the water. Dispersion can lead to the development of tunnel, gully and surface erosion.

Figure 4.1 Tunnel erosion of dispersive clay subsoil, https://vro.agriculture.vic.gov.au (accessed 2022) (Left), and construction of dam in dispersive soils leading to rill erosion, https://nre.tas.gov.au (accessed 2022) (Right)

4.1.2 SODICITY AND DISPERSION TESTING AND CLASSIFICATIONS

The sodium content in a soil (sodicity) is commonly categorised on the basis of exchangeable sodium percentage (ESP) after Rengasamy and Churchman (1999) and Northcote and Skene (1972) as shown below.

Table 4.1 Soil sodicity based on exchangeable sodium percentage (from vro.agriculture.vic.gov.au, map: sodicity – upper subsoil)

DESCRIPTION	EXCHANGEABLE SODIUM PERCENTAGE (ESP)
Non-sodic or low-sodic	< 6%
Sodic	6 -15%
Strongly sodic	15-25%
Very strongly sodic	>25%

Note that while sodic soils are generally dispersive, not all sodic soils disperse and not all dispersive soils are sodic according to the above definitions. Evidence of historical dispersion at a site may be identified in the field while dispersion potential can also be assessed using field and/or laboratory physical tests.

A common physical test to predict dispersive behaviour in soils is the Emerson soil crumb test (AS 1289.3.8.1-2017). Soils are divided into 7 classes based on their coherence in water. This empirical test was developed by Emerson in 1967, and updated in 2002 (Emerson, 2002). Figure 4.2 below shows the Emerson classes. Emerson Class 1 and 2 are considered susceptible to tunnel erosion (DPIPWE, 2009).

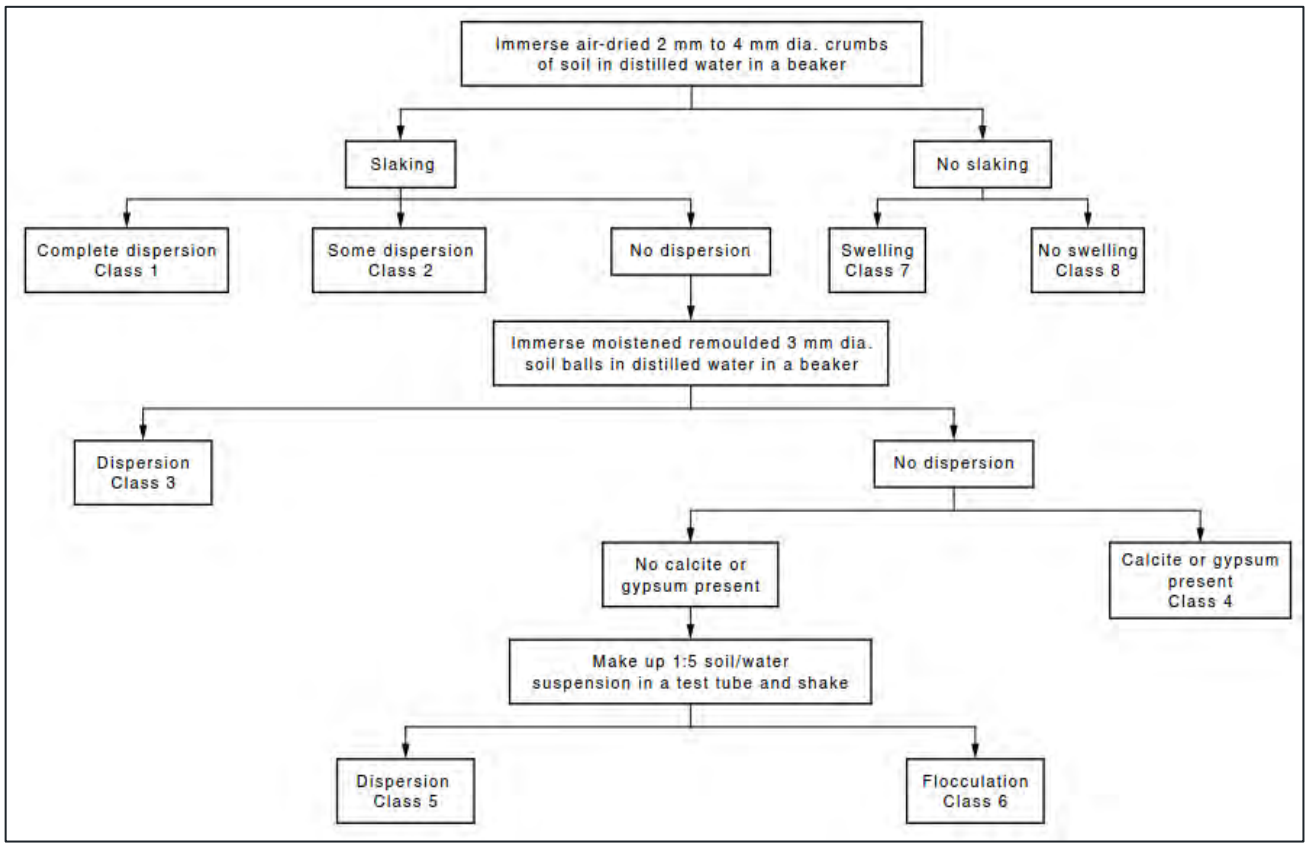


Figure 4.2 Emerson soil classes (extract from AS1289.3.8.9:2017)

An additional test analysed by Coffey (2020c) for five samples is the Pinhole Dispersion Test (AS 12893.8.3-1997). This empirical test is a semi-quantitative measurement of the dispersibility and subsequent erodibility of clay soils. The test involves flowing water through a small hole punched into a sample of the material. The pinhole is measured, and the shape of the pinhole inspected for erosion. The classification of soils is outlined in Table 4.2 below.

Table 4.2 Pinhole Dispersion classification

DESIGNATION	CLASSIFICATION AS PER COFFEY (2020C)
D1	Highly dispersive
D2	Dispersive
PD1	Potentially dispersive
PD2	Potentially dispersive (intermediate)
ND1	Non-dispersive
ND2	Completely non-dispersive

4.2 MANAGEMENT OF SODIC AND DISPERSIVE SOILS

4.2.1 SODIC AND DISPERSIVE SOILS IN VICTORIA

In Victoria, sodic soils are generally managed as a problem of agriculture, where routine management is required to maintain agricultural productivity of soils and limit adverse impacts such as erosion (e.g. application of gypsum, vegetation and slope management). Agriculture Victoria's (now Department of Jobs, Transport and Regions) Victorian Resources Online (VRO) website (now archived) contains a range of information on soils, including mapping of sodic soils in Victoria (https://vro.agriculture.vic.gov.au, accessed December 2022).

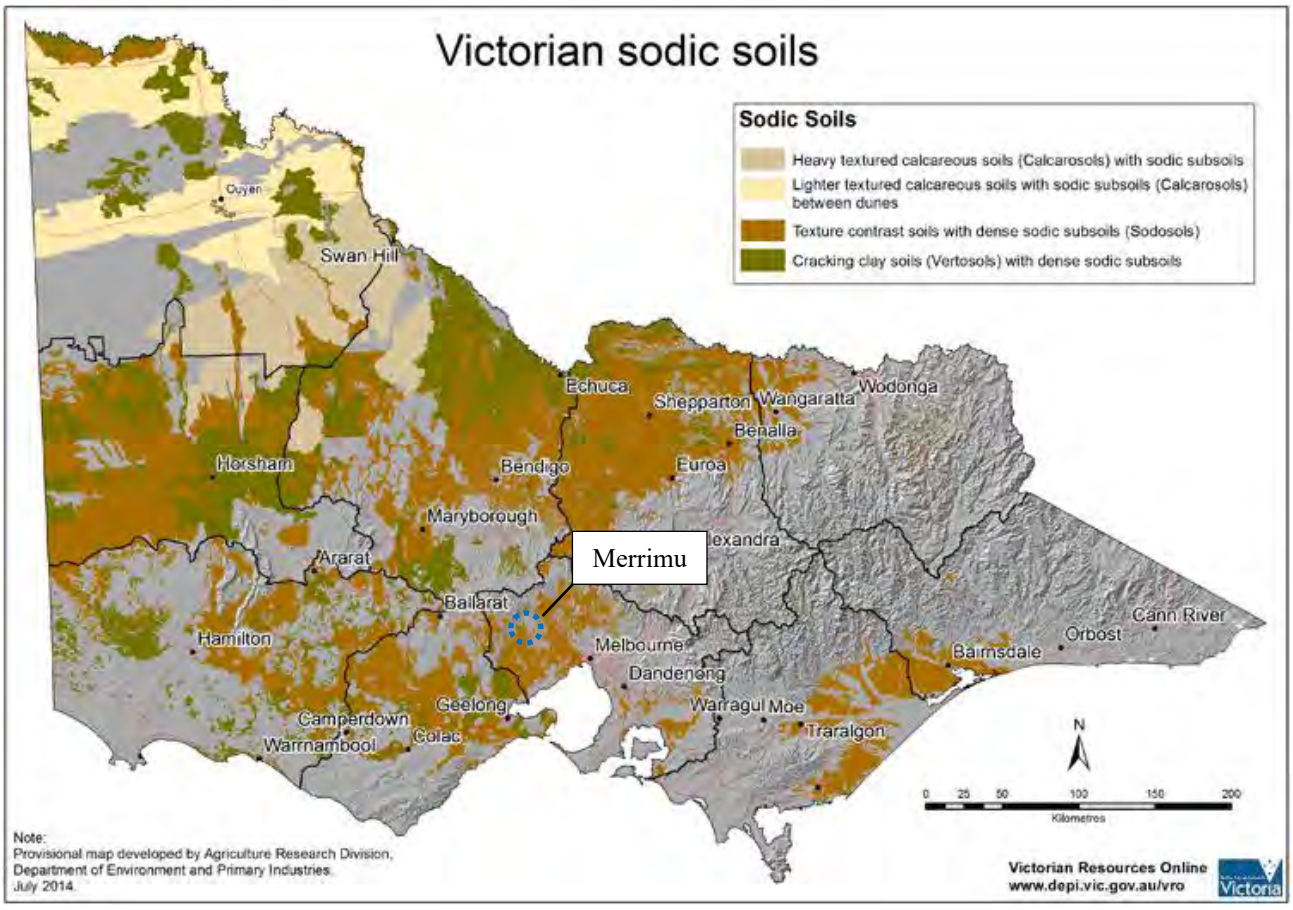


Figure 4.3 State of Victoria (Agriculture Victoria), 2014

As can be seen sodicity is particularly a problem in lower rainfall, alluvial deposits in the north-west of the state. However, localised sodic soils are also found across the state, predominantly also in alluvial deposits. In the vicinity of Merrimu the incidence of sodicity is sporadic and generally exists in texture contrast soils with dense sodic subsoils.

As erosion can impact surface waters, Catchment Management Authorities (CMAs) in affected areas have an interest in influencing land use (including revegetation of riparian zones) to minimise sediment loading in waterways (e.g. Port Phillip and Westernport Catchment Management Authority [CMA]) and manage environmental water quality. CMAs seek to implement a range of legislation, strategies and policies; including international agreements to protect waterways (e.g. Ramsar), the national Environment Protection and Biodiversity Conservation Act 1999, and the Victorian Environment Protection Act and Water Act, amongst others.

Planning provisions in Victoria also require Planning Authorities to ensure waterways are protected and enhanced (e.g. Moorabool Planning scheme, Clause 12.03-1S), and in particular, *"Limiting earthworks in proximity to waterway systems to minimise alterations to geomorphology, natural drainage, natural flows and water quality"*. One control that can be applied is an Erosion Management Overlay (EMO) to ensure this protection through the planning process.

4.2.2 URBAN DEVELOPMENT IN AREAS OF SODIC AND DISPERSIVE SOILS

The presence of sodic and dispersive soils can lead to the development of tunnel and surface erosion resulting in an increased risk of damage to buildings and service infrastructure because of the undermining of foundations and/or slumping and collapse of ground into voids and cavities that have been formed.

In almost all cases, tunnel, and surface erosion results from the surface disturbance of soil (such as during development of a precinct) though removal of stabilising vegetation and, where excavation occurs, allowing rainwater or stormwater to come into contact with dispersible subsoils. Changes to hydrology, including concentrating flow in culverts, runoff from hardstand areas, ponding of rainfall and land contouring further increase the risk of tunnel and gully erosion. Typical activities that increase the risk of exposing dispersive subsoils to rainfall and stormwater include:

- the removal of topsoil,
- soil excavation and ground profiling works,
- trenching and supply of services,
- road and culvert construction, and
- the construction of dams and detention basins.

Increased run-off from developed land can lead to downstream environmental harm by:

- Increased sediment loading (and reduced water quality) in receiving water bodies, and
- Changes in stream hydrology (e.g. increased flow volumes or intensity) leading to bank instability and increased erosion risks in waterways.

In summary, the key hazards arising from urban development in areas of sodic and dispersive soils relate to surface erosion, damage to buildings, damage to infrastructure, and negative impacts to waterways. It is important to note that hazards can manifest in the short term (e.g. during construction phase) and the long term (e.g. loss of topsoil, channel instability and longer-term water quality impacts).

5 LITERATURE REVIEW

A literature review was undertaken of publicly available reports and information (including geology, soil type mapping, erosion risk, and site history). This section provides a summary of information reviewed.

Reports reviewed include:

- Site specific consultant reports:
  - Jacobs (2018) Land Capability Assessment
  - Coffey (2019) Geotechnical Investigation
  - Alluvium (2019) Geomorphology and Vegetation Assessment
  - Coffey (2020a) Desktop Assessment
  - Coffey (2020b) Proposal for Additional Geotechnical Assessment
  - Coffey (2020c) Soil Sodicity and Dispersiveness Assessment (culmination of Coffey (2019), Coffey (2020a), and Coffey (2020b))
  - Alluvium (2021) Merrimu PCP Impact and Options Assessment for Managing Urban Stormwater
  - CDM Smith (2021) Hydrogeological Review (sub-contracted by Alluvium to conduct the hydrogeological aspect of Alluvium (2021) assessment on managing urban stormwater)
  - CDM Smith (2022) Memorandum for Merrimu Groundwater Modelling Plan
  - Rain (2021) Merrimu Integrated Water Management (IWM) Opportunities
  - Streamology (2021) Merrimu Stormwater Feasibility Investigation
  - Rain (2022) Merrimu Stormwater Management Strategy
- Regional Victorian Government resources:
  - Soil Conservation Authority (1965) Report on the Merrimu Lake Water Supply Catchment
  - Soil Conservation Authority (1981) Land Capability Study in the Shire of Bannockburn
  - Victorian Online Resources (2015) Sodicity – Upper Subsoil Map
  - Department of Transport (2021) Bacchus Marsh Eastern Link Preliminary Investigation Report

5.1 SITE SPECIFIC STUDIES

5.1.1 JACOBS (2018) LAND CAPABILITY ASSESSMENT

In 2018 Jacobs conducted a land capability assessment for the Merrimu Precinct Structure Plan (PSP). The Merrimu precinct had been identified as future land supply for residential use. This assessment attempted to provide opportunities and constraints relating to the hydrological, hydrogeological, geotechnical, and contaminated land conditions of the site. Jacobs (2018) concluded in their geotechnical assessment that highly reactive clay overlies the basalt rock, and that excised gullies and other erosional features are potentially present. However, potential sodic or dispersive soils are not explicitly mentioned in the assessment. As part of their assessment Jacobs (2018) recommended a site inspection be undertaken by an engineering geologist to map the erosional features.

In summary, Jacobs (2018) provided an in-depth desktop assessment, however field observations and a discussion on potential sodic or dispersive soils were limited. The site inspection which was conducted involved assessing possible contamination presence within the project area.

5.1.2 COFFEY (2019) GEOTECHNICAL INVESTIGATION

Coffey (2019) was commissioned by Creo Consultants in August 2019 to prepare a geotechnical investigation to assess subsurface conditions across the Merrimu precinct, and to provide comments and recommendations for planning and design of the proposed development. This investigation was ultimately to help inform the proposed Merrimu Precinct Structure Plan (PSP).

The fieldwork consisted of 25 test pits, and 12 Dynamic Cone Penetrometer (DCP) tests adjacent selected test pits. The subsurface conditions comprised a thin layer of topsoil overlying stiff to very stiff, medium to high plasticity clay overlying basalt. No groundwater inflow was encountered during the test pit excavation with the maximum depth of the test pits being 2.5 metres below ground level (mBGL).

Various recommendations concerning footings and pavements were made in the investigation. This included allowable bearing pressure for footings, expected excavation conditions, and suitability of re-use of site soils as engineered fill. The highly reactive nature of the natural clay was highlighted, and it was recommended that precautions be taken to control the moisture variations within the founding soils. However, limited observations or interpretations were made in relation to potential sodic or dispersive soils within the project area.

In summary, Coffey (2019) provides site specific data concerning the surface and subsurface conditions found in the project area. The report describes the regional stratigraphy as comprising thin topsoils underlain by stiff to very stiff, medium to high plasticity clay followed by Newer Volcanics, and possibly Werribee Formation at depth. Furthermore, the report provided recommendations on bearing pressure for footings, expected excavations conditions, and suitability of re-use of site soils as engineered fill. Limited discussion was present concerning the potential of sodic and dispersive soils within the project area.

5.1.3 ALLUVIUM (2019) GEOMORPHOLOGY AND VEGETATION ASSESSMENT

Alluvium Consulting (Alluvium) completed a geomorphology and vegetation assessment for the Merrimu precinct in November 2019, which we understand was prepared for Melbourne Water. The assessment attempted to provide a framework for assessing the risk associated with future waterway management and development within the Merrimu precinct. The investigation found that all waterways flowing from areas currently developable within the site flowed over highly erodible soils. All assessed waterways were described as eroding and it was advised that any increase in flow would lead to further erosion. The following specific aspects are of note:

5.1.3.1 GEOMORPHOLOGY ASSESSMENT

Alluvium (2019) described the landscapes within the study area as having a high basalt plateau, steep escarpments draining to receiving waterways, and areas of floodplain in lower areas. Tunnel erosion was described as a common feature amongst many of the headwater streams assessed, with active erosion being observed under current conditions. Much of the erosion observed was noted to be associated with the dispersive soils of the Werribee Formation. At some sites, where the Castlemaine Group outcropped, the soils were found to be sodic, but it was noted that the soils were less fragile particularly compared to those found on the Werribee Formation. Subsequently, the Newer Volcanics found predominantly on the plateau were assessed as being very resistant to erosion.

5.1.3.2 VEGETATION ASSESSMENT

Alluvium (2019) assessed the vegetation quality of riparian areas using Melbourne Waters Vegetation Visions template. Vegetation is classed into five categories ranging from 1. Very Low condition with highly modified riparian vegetation to 5. Very High condition where riparian vegetation is intact with all structural components present. A conclusion of their assessment was that no vegetation of very high condition was observed with categories 1 to 4 relatively evenly represented. Broadly, vegetation next to developed land was of low or very low quality whereas in public reserves vegetation was of higher quality.

In addition to quality, six vegetation classes were identified as most abundant; including Rocky Chenopod Woodland (EVC 64), Creekline Grassy Woodland (EVC 68), Stream Bank Shrubland (EVC 851), and Escarpment Shrubland (EVC 895). Importantly, all six vegetation classes were deemed vulnerable or endangered.

In summary, Alluvium (2019) interpreted the landscape to be highly sensitive to changes in the flow regime of the tributary waterways, and in turn these changes were found to have a large influence on the geomorphology and vegetation found within the precinct. One of the management interventions proposed was the non-development of the plateau, which Alluvium (2019) notes is a challenging option but was argued as an option due to the sensitivity of the landscape. In lieu of this intervention Alluvium (2019) suggested higher requirements on engineering and water management standards than is currently applied to development.

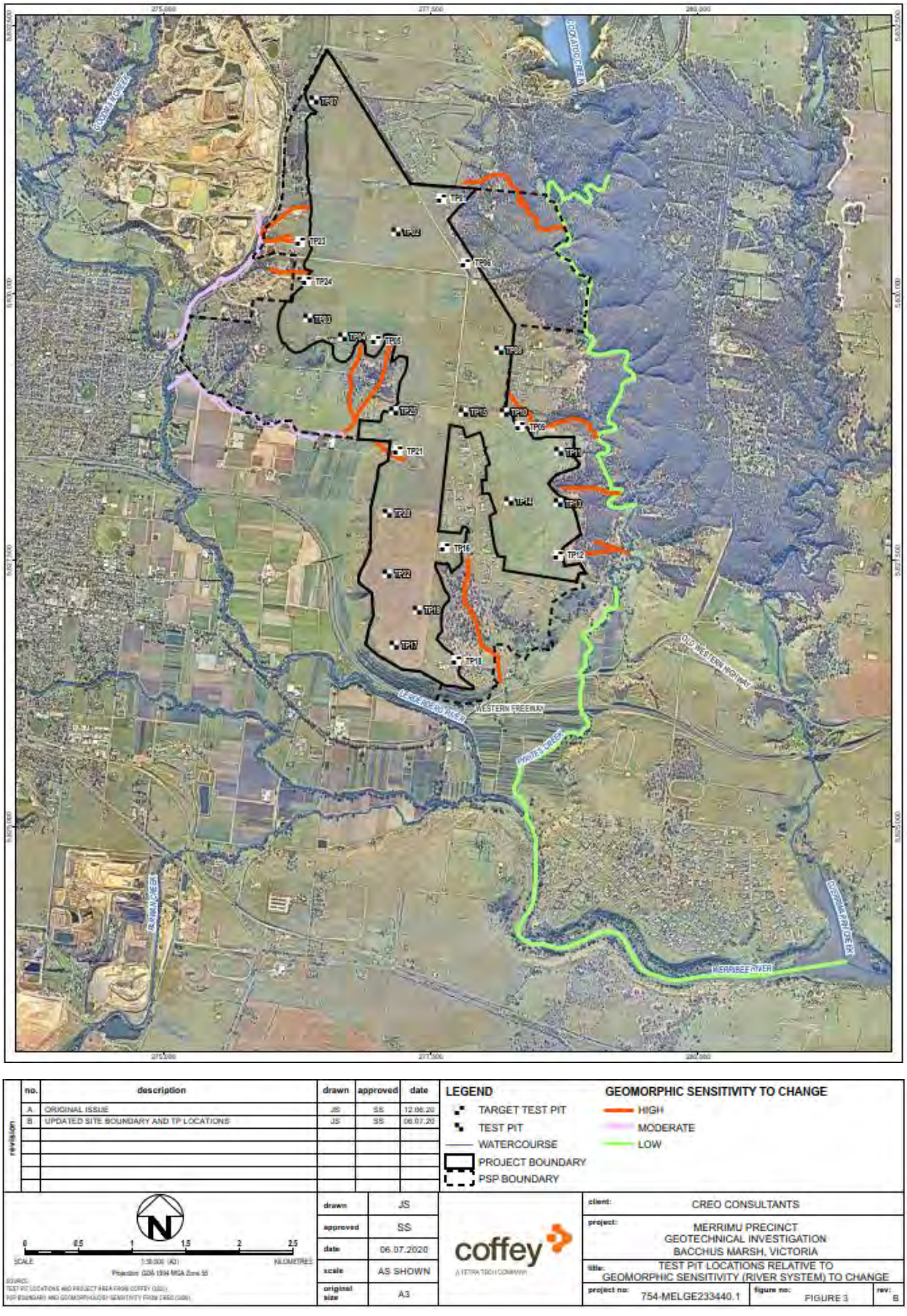
5.1.4 COFFEY (2020A) SODC SOILS DESKTOP ASSESSMENT

This desktop assessment was prepared for Creo Consultants in response to a memorandum sent by the Victorian Planning Authority (VPA) following a review of Coffey's proposal to undertake a soil sodicity and dispersiveness assessment for the Merrimu precinct. The desktop assessment was prepared using references which include the VPA memorandum dated 22 May 2020, Alluvium's Geomorphology and Vegetation Assessment, Geological Survey Victoria's Bacchus Marsh map sheet, Coffey's Geotechnical Assessment dated 6 December 2019, and a draft plan comparing developable areas.

A large part of the assessment, including the sodic and dispersive soils within the Merrimu precinct, was drawn from a review of Alluvium's Geomorphology and Vegetation Assessment (Alluvium, 2019). Coffey (2020a) refer to this assessment to determine the soils across the site as being sodosols and the Werribee Formation being highly dispersive due to the high sodium content.

The methodology for the field investigation in Coffey's Soil Sodicity and Dispersiveness Assessment (see Section 5.1.6 below) was outlined and justified in the desktop assessment. It mentions that the test pits for the assessment were targeting mainly the geomorphologically sensitive areas around the escarpment and near waterways close to the development area boundaries (labelled Target Test Pit). Additional test pits outside the sensitive areas were planned to assess the general subsurface conditions across the site (labelled Test Pit). No test pits were proposed further down towards the bottom of the escarpment or in the flood plains. The Coffey (2020a) proposed test pit locations are shown in Figure 5.1 (following page).

In summary, Coffey (2020a) used various references, in particular the Geomorphology and Vegetation Assessment by Alluvium (2019), to inform their proposal to undertake a soil sodicity and dispersiveness assessment. The regional geology, soil sodicity and dispersiveness, and geomorphological and vegetation information for the precinct was collated and an investigation methodology was devised.



revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE	JS	SS	12.06.20
	B	UPDATED SITE BOUNDARY AND TP LOCATIONS	JS	SS	06.07.20

LEGEND
- TARGET TEST PIT
- TEST PIT
- WATERCOURSE
- PROJECT BOUNDARY
- PSP BOUNDARY

GEOMORPHIC SENSITIVITY TO CHANGE
- HIGH
- MODERATE
- LOW

SCALE 1:30,000 (A3) KILOMETRES
0 0.5 1 1.5 2 2.5

drawn	JS
approved	SS
date	06.07.2020
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

client: CREO CONSULTANTS
project: MERRIMU PRECINCT GEOTECHNICAL INVESTIGATION BACCHUS MARSH, VICTORIA
title: TEST PIT LOCATIONS RELATIVE TO GEOMORPHIC SENSITIVITY (RIVER SYSTEM) TO CHANGE
project no: 754-MELGE233440.1
figure no: FIGURE 3
rev: B

Figure 5.1 Proposed test pits locations (Coffey, 2020a)

5.1.5 COFFEY (2020B) PROPOSAL FOR ADDITIONAL GEOTECHNICAL ASSESSMENT

After the submission of the desktop assessment on sodic soils at Merrimu precinct and following comments by Melbourne Water (MW) about the presence of likely tunnel erosion at two locations, Coffey (2020b) presented to Creo Consultants a proposed methodology for an additional geotechnical assessment at the Merrimu precinct. To help inform the scope of works, a site visit was conducted on 20 August 2020.

The first location identified with possible tunnel erosion was a deep gully on the "North site" (located just south of the intersection between Lindsay Avenue and Flanagans Drive). The gully was described as comprising Stony Rises basalt at the surface, basalt in the upper profile, and possibly Werribee Formation at depth. At the base of the gully some erosion and slope instability were observed. Coffey (2020b) outlined two possible locations where deep boreholes could be drilled with the intention of establishing the thickness of the basalt overlying the Werribee Formation.

Figure 5.2 North site with the two borehole locations

The second location named the "South site" (located along the southern boundary of the Merrimu Precinct) was described as having Werribee Formation in the lower slopes with Newer Volcanics in the upper slopes. Erosion was observed to comprised mostly channel and sheet erosion of varying size and area.

Figure 5.3 South site

Three options for the investigation were proposed to Melbourne Water including:

- Option 1: Shallow sampling using a hand auger. The collected samples would be tested to gain knowledge on the shallow soil types at different levels along the slope.
- Option 2: Deep boreholes using a drilling rig. This option would aim to establish the thickness of the basalt overlying the Werribee Formation.
- Option 3: Combined Option 1 & 2

The results of the additional geotechnical assessment are outlined in Coffey (2020c) (see Section 5.1.6 below). Based on the scope of works described in Coffey (2020c) it appears Option 3 was proceeded, as both shallow hand auger holes and deep boreholes were drilled.

In summary, Coffey (2020b) presented a proposed methodology to Creo Consultants to investigate two possible locations with possible tunnel erosion. Based on the observations described the soils on the site comprise basalt derived soils from weathered Newer Volcanics on the plateau with Werribee Formation soils visible in deeper gullies and on the scarp. The results of the drilling works are presented in Coffey (2020c) Soil Sodicity and Dispersiveness Assessment.

5.1.6 COFFEY (2020C) SOIL SODICITY AND DISPERSIVENESS ASSESSMENT

Coffey prepared a Soil Sodicity and Dispersiveness Assessment for the Merrimu precinct for Creo Consultants following two previous assessments, which included a geotechnical investigation (regarding recommendations on footings and pavements) in November 2019 (Coffey, 2019) and a desktop assessment (regarding geology and erosion potential of soils within the Merrimu precinct) in July 2020 (Coffey, 2020a).

The desktop assessment concluded that across the precinct the soils were classified as Sodosols, which in accordance with the Australian Soil Classification are soils which a have a strong texture contrast between surface (A) horizon and subsoil (B) horizon, with the subsoil horizon being sodic. These sodosols within the Werribee Formation were determined to be highly dispersive and present along the escarpment of the plateau, and, due to the highly erodible soils, managing the surface run-off from future development would be a key issue.

The Soil Sodicity and Dispersiveness Assessment followed the desktop assessment and aimed to sample the soils within the Merrimu PSP site. The objective of the work was to inform the VPA of the dispersity of the soils and to provide recommendations for mitigating or preventing erosion. The assessment also provided comments on the subsurface and groundwater conditions at the site, depth to and thickness of the Werribee Formation, and geotechnical considerations such as excavatability, and suitability of excavated material for re-use as engineered fill.

Two field investigations were undertaken by Coffey for the purposes of the assessment, with one investigation occurring between the 4th and 6th August 2020 involving 25 test pits, and the second occurring between the 5th and 7th October 2020 involving 2 additional boreholes and 10 shallow sample locations. Both investigations included collection and analysis of selected soil samples for exchangeable sodium percent (ESP) and Emerson soil crumb test. Additionally, the August 2020 investigation included Pinhole Dispersion testing; a technique to provide a qualitative measurement of the dispersibility and consequent erodibility of clay soils.

A figure showing the extent of the Coffey (2020a) study area is presented as

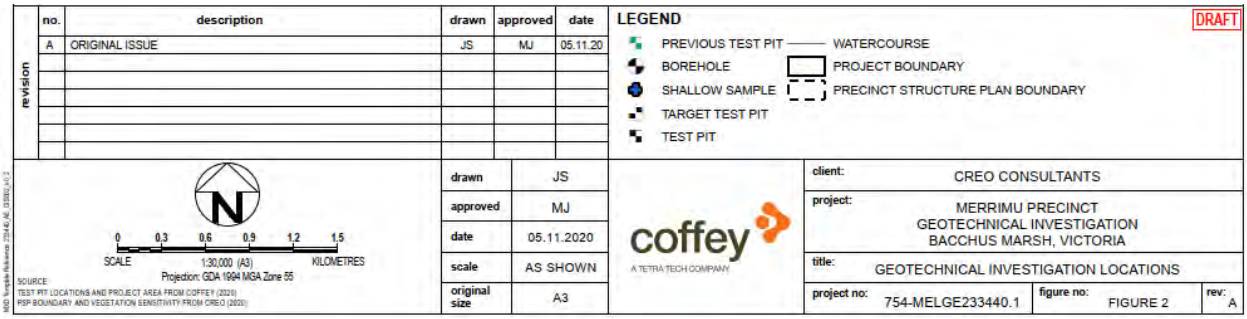
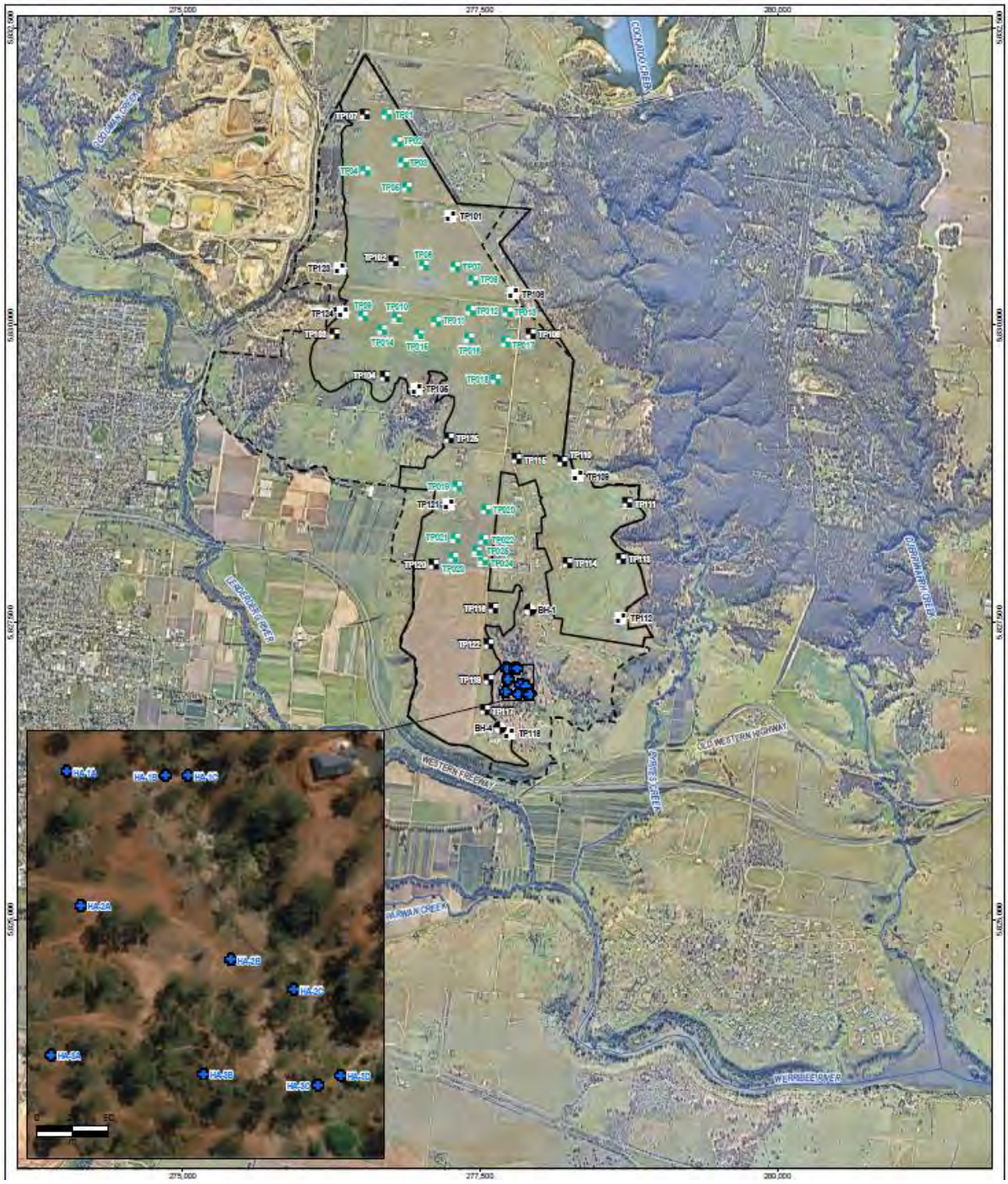


Figure 5.4 below.



revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE	JS	MJ	05.11.20

DRAFT

LEGEND

- PREVIOUS TEST PIT
- BOREHOLE
- SHALLOW SAMPLE
- TARGET TEST PIT
- TEST PIT
- WATERCOURSE
- PROJECT BOUNDARY
- PRECINCT STRUCTURE PLAN BOUNDARY

N

0 0.3 0.6 0.9 1.2 1.5

SCALE 1:30,000 (A3) KILOMETRES

Projection: GDA 1994 MGA Zone 55

SOURCE:
TEST PIT LOCATIONS AND PROJECT AREA FROM COFFEY (2020)
PSP BOUNDARY AND VEGETATION SENSITIVITY FROM CREO (2020)

drawn	JS
approved	MJ
date	05.11.2020
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

client:	CREO CONSULTANTS
project:	MERRIMU PRECINCT GEOTECHNICAL INVESTIGATION BACCHUS MARSH, VICTORIA
title:	GEOTECHNICAL INVESTIGATION LOCATIONS
project no:	754-MELGE233440.1
figure no:	FIGURE 2
rev:	A

Figure 5.4 Study Area, extracted from Coffey (2020c)

5.1.6.1 SOIL AND GEOLOGY

Coffey (2020a) determined the site to situated on a plateau underlain predominantly by Newer Volcanics (Bullengarook Flow) comprising residual basaltic clay overlying weathered basalt rock. Beneath the Newer Volcanics at depth the sand, silty sand, and minor clays of the Werribee Formation is present. The soils of the Werribee Formation outcrop, within the precinct, along the escarpment of the plateau.

A cross section showing the geological profile within the Merrimu precinct is presented as Figure 5.5.

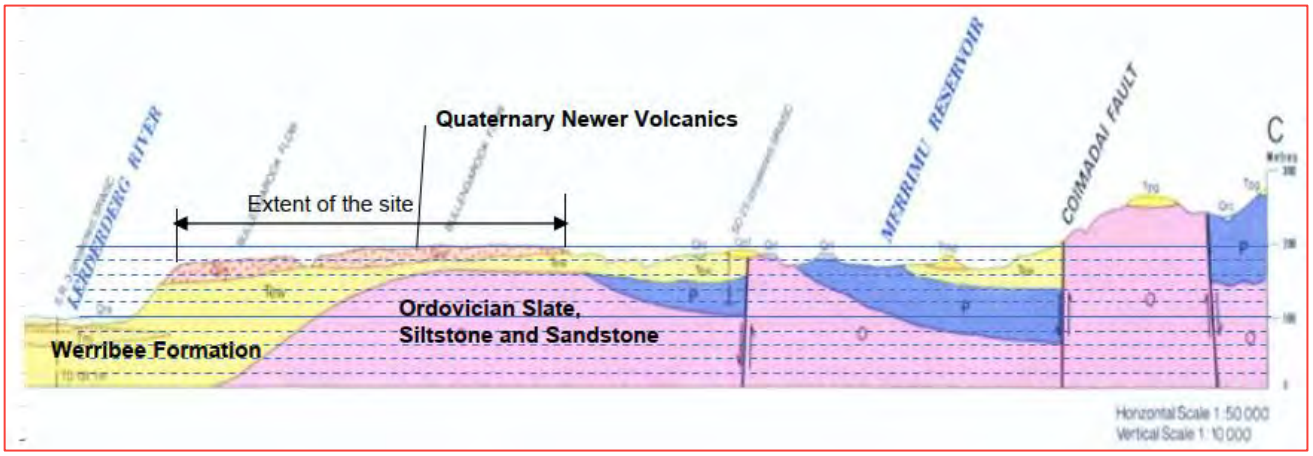


Figure 5.5 Cross section showing geological units within the site.

5.1.6.2 SURFACE AND SUBSURFACE CONDITIONS

The plateau was described as being relatively flat with a gentle decline moving north to south. Erosional features were present in a gully present at the southern end of the site falling into Flanagans Drive, which included channel, rill, and gully erosion. Several of these features were over 5 m deep.

The ground surface was observed across the plateau to be covered in thick grass with basalt outcrops and boulders being noted in several locations. Old mature trees between 5 to 20 m high were scattered within the gully.

In relation to subsurface conditions, the investigations found the regional geology generally was consistent with the field observations. Typically, the subsurface profile consisted of a thin layer of topsoil (up to 0.2 m thick) followed by residual clayey soils underlying weathered basalt. The Werribee Formation was encountered beneath the Newer Volcanics basalt at depths between 8.95 m to 9.6 m.

5.1.6.3 SOIL SODICITY AND DISPERSIVENESS

Based on laboratory testing the soils formed from the weathering of the Newer Volcanics were interpreted to be moderately to highly sodic with variable dispersion. The ESP of 17 samples ranged from 2.0% (non-sodic) to 32.0% (very strongly sodic) and Emerson Class of the 17 samples ranged from 3 (dispersive after remoulding) to 6 (non-dispersive). The Werribee Formation was slightly to highly sodic and dispersive with ESP as measured in 10 samples ranging from 4.9% (non-sodic) to 32.0% (very strongly sodic) and Emerson Class in the 10 samples ranging from 2 (some dispersion) to 3 (dispersive after remoulding).

The distribution of soils within the site was determined to be predominantly Newer Volcanics across the plateau and Werribee Formation along the mid and lower slopes of the gully, and Coffey (2020a) commented that development should aim to limit the impact to the gully. Furthermore, the assessment noted that any development should have appropriate plans in place to ensure additional runoff is not discharged to areas where Werribee Formation soils are exposed (such as the gully).

A list of controls for reducing and managing the risk of erosion for activities such as excavations and construction of roads, dams or sewage and grey water systems was outlined by Coffey (2020a). Many of these options involved limiting

the exposure or disturbance of dispersive topsoils and subsoils. Other options included re-compaction of soils, sand blocks and barriers, and chemical amelioration (e.g. treating sodic soils with gypsum or lime).

In summary, Coffey (2020c) has succinctly outlined the issues related to sodic and dispersive soils in the Merrimu precinct. An extensive field investigation program was undertaken to provide evidence and support their conclusions. A key finding in the assessment was to highlight the need for stringent controls when undertaking development in the precinct, particularly in relation to the Werribee Formation. The recommendations to prevent and manage erosion are relatively broad, and many seem to advocate limiting the disturbance or exposure of potentially sodic and dispersive soils.

Though Melbourne Water expressed concern about the presence of likely tunnel erosion at two locations, as discussed in Coffey (2020b), specific discussion addressing those concerns was not presented within this assessment.

5.1.7 ALLUVIUM (2021) MERRIMU PCP IMPACT AND OPTIONS ASSESSMENT FOR MANAGING URBAN STORMWATER

This assessment by Alluvium (2021) for Melbourne Water was to determine the impact of development on the geomorphology, ecology, and hydrology of the Merrimu Plateau. The assessment included identifying a risk profile for the four stormwater management options which were outlined for the Merrimu PSP area. Erosion within the site was determined to exist where the sodic soils of the Werribee Formation were exposed along the plateau margin. The erosion was also found to be a product of surface runoff, and not attributed tunnel erosion from groundwater daylighting. Therefore, Alluvium (2021) commented that no additional runoff should be delivered to tributaries draining the plateau.

With surface runoff being a primary issue, a key risk was identified concerning the increase in impermeable surfaces, associated with development, leading to an increase in annual runoff volumes leading to erosion of the Werribee Formation. This was particularly relevant because under current, largely unpaved conditions, water balance modelling indicated that most of the annual rainfall that falls on the plateau is lost to evaporation, with little contributing to runoff.

Alluvium (2021) commented that the approach to stormwater management is likely to include a combination of options such as:

- Centralised and distributed infiltration (e.g. sub-surface infiltration systems distributed throughout the catchment); and
- Evaporation/evapotranspiration (e.g. evaporation basins and stormwater harvesting for irrigation distributed throughout the catchment); and
- Aquifer storage and recovery, and off-site disposal.

Major identified constraints regarding future stormwater management included the high susceptibility of erosion at plateau margins and adjacent drainage lines, and waterway sensitivity to erosion by surface runoff. It was noted that more detailed site investigations were needed to determine the volume of runoff generated during different rainfall events, and the storage or disposal capacity required to prevent additional runoff entering waterways in the precinct.

In summary, Alluvium (2021) noted that erosion on exposed soils of the Werribee Formation was a high risk, particularly along the plateau margins. It also concluded that surface runoff was a key issue, and that no additional runoff, above pre-development annual surface runoff volumes, should enter waterways within the precinct. This informed their recommendations concerning stormwater management in the Merrimu precinct, including that any stormwater management option considered needed to have the storage or disposal capacity to offset the volume of runoff generated by rainfall events to prevent additional runoff into waterways.

5.1.8 CDM SMITH (2021) HYDROGEOLOGICAL REVIEW

As part of the Alluvium (2021) assessment for managing urban stormwater, CDM Smith was engaged by Alluvium as a sub-consultant to assist in delivering the hydrogeological aspect of the project. CDM Smith was asked to undertake

several tasks to evaluate an aquifer recharge strategy for stormwater disposal. This included a review of all available geological and hydrogeological maps and reports to identify a suitably permeable and deep aquifer beneath the plateau, finding nearby groundwater monitoring bores to estimate regional and local groundwater levels, and to assess the suitability of the aquifer to receive the injected water.

Through their review it was found that the Newer Volcanics layer is likely less than 20 m thick in the Merrimu precinct and underlain by the Werribee Formation. The Werribee Formation was estimated to be up to 90 m thick in the southwest, thinning in an easterly direction. Via the observation of two unsaturated bores drilled into the Newer Volcanics it was concluded that the water table was likely lying within the Werribee Formation. Additionally, local bore data indicated an average salinity of approximately 1,900 mg/L TDS. CDM Smith (2021) commented that the Werribee Formation was a known candidate for aquifer storage and recovery in Victoria but recommended further investigation of the Werribee Formation in the Merrimu area before proceeding with this option for stormwater disposal.

In summary, CDM Smith (2021) was engaged by Alluvium to assist in delivering the hydrogeological framework for evaluating an aquifer recharge strategy for stormwater disposal. They provided a comprehensive review of the geology, hydrology, and hydrogeology of the region with a final comment on the Werribee Formation being a known candidate for aquifer storage and recovery in Victoria. Little to no mention was made about potential dispersive or sodic soils within the Merrimu precinct, or potential impacts at discharge points.

5.1.9 CDM SMITH (2022) MEMORANDUM FOR MERRIMU GROUNDWATER MODELLING PLAN

This memorandum was written in response to CDM Smith's previous hydrogeological review which assessed the possibility of disposing of stormwater via infiltration within the Merrimu Precinct. The memorandum outlined the proposed methodology in modelling the groundwater response to infiltrating stormwater. A risk map of the Merrimu plateau was produced showing the ideal locations for stormwater infiltration basins and areas to avoid in order to minimise the risk for groundwater mounding and erosion at the plateau margin. To complete the modelling CDM Smith did require two inputs from Alluvium including possible locations of infiltration basins and infiltration rates from the basins to the underlying aquifer.

In summary, CDM Smith (2022) presented a proposal to develop a groundwater model to assess the risk of groundwater mounding due to disposal of stormwater via infiltration. The mounding was a concern because of the erosion which may be caused due to groundwater expression along the scarp. To proceed with the modelling the proposal asks for additional information including the locations of infiltration basins and infiltration rates from the basins to the underlying aquifer. Simple conceptualisation and Darcy flux estimation was stated as an alternative if infiltration rates could not be provided by Alluvium.

5.1.10 RAIN (2021) MERRIMU INTEGRATED WATER MANAGEMENT OPPORTUNITIES

Rain (2021) presented this report to comment on integrated water management (IWM) opportunities which exist at the Merrimu Precinct. They prepared this report for Bacchus Marsh Developments Pty Ltd, who owned 46% of the developable land at the precinct (Rain, 2021). This report was at a high level looking at potential water sources and demands and aligning them to a number IWM objectives. This report was to help inform the Merrimu Precinct Structure Plan (PSP).

Possible water sources included potable water (from Western Water), stormwater runoff (from roads and other ground surfaces), captured roof water (into rainwater tanks), recycled wastewater, and groundwater. Some of the demands included onsite household reuse, onsite showering, active open space watering and other urban development related water usage. These sources and demands were ultimately compared to IWM objectives to determine the degree of alignment to the objective and any possible issues. The objectives included:

- Innovative and adaptive approaches in managing water for the benefit of the community and the natural environment into the future,

- Incorporating traditional owner values and views,
- Ensuring place-based planning and projects that would strengthen community knowledge and promote local values,
- Managing stormwater to improve or maintain the health and value of the receiving waterways, and
- Using alternative water to help provide safe, secure, and affordable, fit for purpose supplies, including agricultural supply and potable water supply in and around the Merrimu area.

Aside from meeting the objectives three rules were outlined by Rain (2021) which were meant to be used when moving forward with integrated water management on the site. These were:

- Understanding that supply is high and that the options presented for supplying water to the site (generally stormwater and recycled water) outweigh the likely onsite demands. This finding means various offsite water usage will be required to utilise the entire water supply,
- Understanding that the Bacchus Marsh IWM strategy is likely to recommend a 25-50% reduction in new impervious area runoff from the site. The solution is reuse on site thus stormwater reuse should be the priority water supply on site, and
- Recognising that peak demand doesn't occur at the time of peak supply. This was particularly relevant to the reuse of stormwater because supply of stormwater is driven by rainfall patterns. To ensure consistent supply to meet demands, large storage areas will be required.

In summary Rain (2021) was engaged by Bacchus Marsh Development Pty Ltd to present opportunities for integrated water management for the Merrimu Precinct Structure Plan. This report outlined potential water sources and demands for development and any potential issues which may arise. An important point was that the Bacchus Marsh IWM was likely to recommend a 25-50% reduction in new impervious area runoff from the site. Thus, stormwater reuse was noted as being the priority water supply to the site. This reduction in runoff requirement was assessed by Rain (2021) to be likely in response to concerns around erosion mitigation and minimising surface runoff towards potential dispersive soils on site.

5.1.11 STREAMOLOGY (2021) MERRIMU STORMWATER FEASIBILITY INVESTIGATION

Streamology was engaged by Bacchus Marsh Developments Pty Ltd. to provide a feasibility investigation into possible discharge points for receiving stormwater from conventional retention basins on the plateau to receiving waterways. The key question in the investigation was taking into consideration 1 in 100-year flood events and ensuring the discharge location options were suitable under these conditions.

A site walkover was conducted by Streamology on 25th and 26th November 2021 with 12 locations visited for assessment. Several locations were reportedly (Streamology, 2021) inaccessible during the site visit.

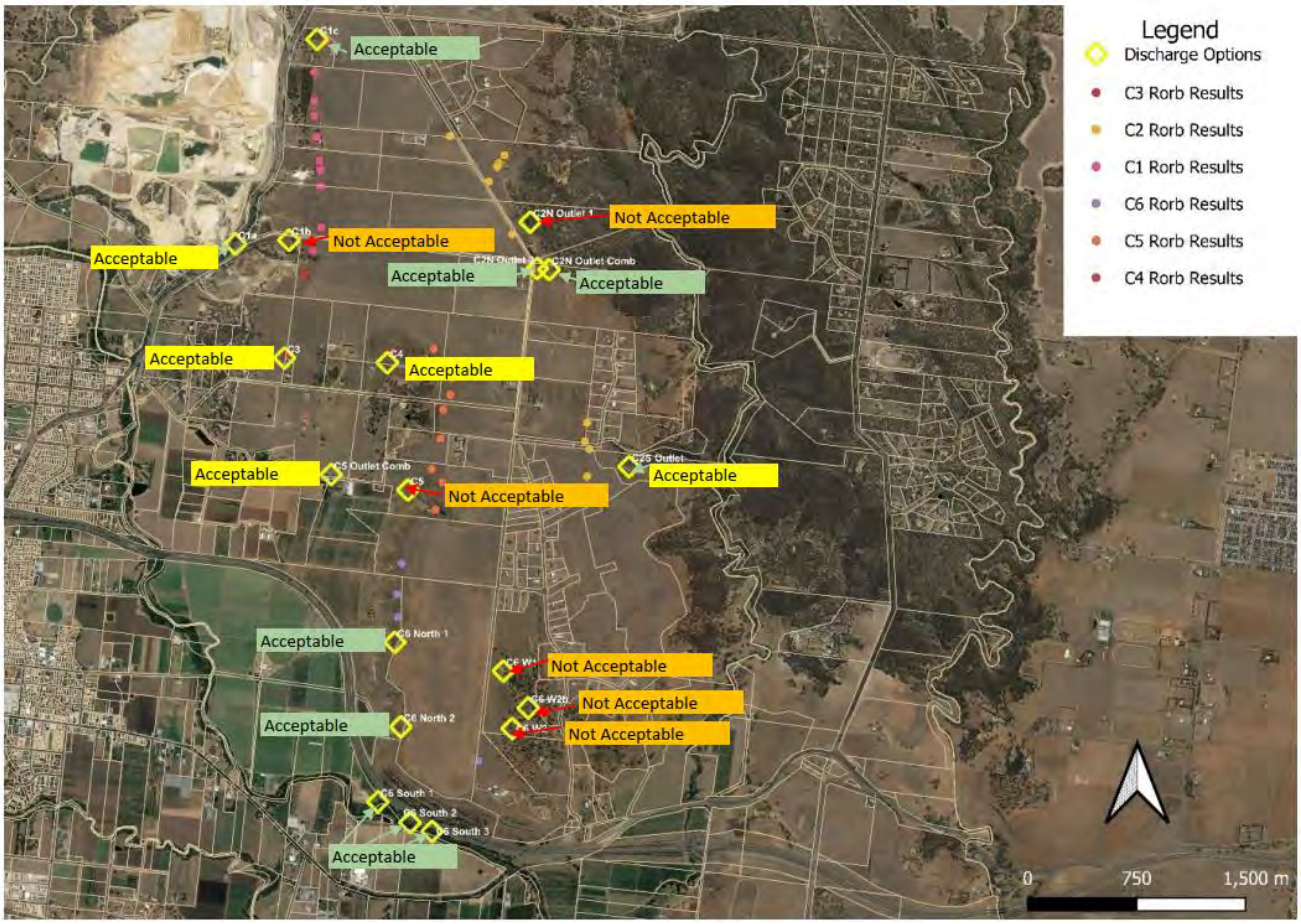


Figure 5.6 Location of possible discharge options with recommendations

Considering the three 'Not Acceptable' discharge locations in the southern section of the precinct (C6 W1, C6 W2b, C6 W2) all three were assessed as having disturbed sodic subsoils. It was determined that more frequent discharges would result in episodic erosion and increased sedimentation in downstream waterways. The discharge option in the centre of the precinct (C5) was deemed 'Not Acceptable' due to the observed erosional nature of the soils. Furthermore, terraced slope was present which appeared to have been undertaken to mitigate erosional processes. The northwest discharge option categorised as 'Not Acceptable' (C1b) was located within highly sodic dispersive soils within the Werribee Formation. Lastly the 'Not Acceptable' discharge option in the northeast corner of the precinct had a waterway comprising of a steep, incised gully with a cobble bed. It was concluded that discharges from the plateau would increase the incision processes which would widen the gully leading to a high potential of tree falls. Thus, this option was not recommended for discharge of water from the plateau.

For photos of the 'Not Acceptable' discharge location options with geological units outlined refer to Figure 6 in **Appendix A**.

In summary, Streamology (2021) identified unsuitable gullies which should not be used to drain stormwater from the plateau.

5.1.12 RAIN (2022) MERRIMU STORMWATER MANAGEMENT STRATEGY

Rain (2022) was engaged by Bacchus Marsh Development Pty Ltd to provide a high-level stormwater management strategy to inform the Merrimu Precinct Structure Plan (PSP). This report outlined the existing hydrologic and hydraulic conditions of the site and, considering the site's sensitivities to sodic and erosive soils, to determine a suitable strategy for managing stormwater runoff in the proposed development conditions.

Extensive modelling was undertaken by dividing the precinct into 6 different catchments and directing flows towards different retarding basins and outlets to determine best practice methods to manage stormwater. Hydraulic, hydrologic

and water quality modelling was first done to establish existing conditions on site. Soil conditions, surrounding vegetation, and existing waterway geomorphology were referred from Streamology's Merrimu Stormwater Feasibility Investigation report (Streamology, 2021), see Section 5.1.11 above. Modelled flows were directed into the basins using pipes or waterways which have been suitably modified to mitigate erosion.

Based on the modelling Rain (2022) made a range of conclusions including comments on further investigations into geomorphology around outlets, constructability assessments to determine outlet feasibility, and continual liaison with Melbourne Water in regard to future drainage schemes, outfall locations and erosion mitigation, and potential impacts on downstream receiving waterways.

In summary, Rain (2022) provided a high-level stormwater management strategy for treating and retarding stormwater runoff under the proposed development conditions. This report was written to address the sites sensitivities to sodic and erosive soils. Extensive surface water modelling was undertaken with stormwater runoff flows being directed through pipes and appropriate waterways towards retarding basins, and then to outlets. These models informed concept designs for water quality and hydraulic assets. This assessment highlights the need for robust stormwater runoff management due to sodic and erosive soils on site.

5.2 OTHER BACKGROUND DOCUMENTS

5.2.1 SOIL CONSERVATION AUTHORITY (1965) REPORT ON THE LAKE MERRIMU WATER SUPPLY CATCHMENT

An investigation to make a land-use determination was conducted by the Soil Conservation Authority, due to a Water Supply Catchment designation being made to a dam on Coimadai Creek. The Merrimu precinct falls within the catchment along with Coimadai and Bullengarook. The report states that present land-use on the basalt requires no significant modification to minimise the amount of silt reaching the proposed reservoir. However, on the sedimentary areas, believed to include the Werribee Formation, the report mentions that considerable work would need to be done to control the existing erosion, and to improve the general standard of management. Additionally, solodic soils (sodosols in the Australian Soil Classification) were described along the steep slopes dominating the northeast and central portions of the catchment.

In summary, the Soil Conservation Authority (1965) identified areas, within the catchment, where erosion and sodosols were considered limitations. The report noted work needed to be done to control existing erosion and to improve the general standard of management of the land.

5.2.2 SOIL CONSERVATION AUTHORITY (1981) LAND CAPABILITY STUDY IN THE SHIRE OF BANNOCKBURN

This study by the Soil Conservation Authority was intended to be used as an aid for broad-scale planning to advise planners on the physical characteristics of the land in Bannockburn. Bannockburn is located to the northwest of Geelong, 88 km southwest of Melbourne, and about 50 km south of Merrimu. See Figure 5.7 for the locality map. The major objectives of the report included examining the erosion risk associated with soil disturbance, constraints on construction, and effluent disposal by soil adsorption. The study divided the shire into forty-two map units describing the distinct land features such as topography, vegetation, and land use as well as the common soil types and geology.

A map unit which is useful for the Merrimu precinct is what Soil Conservation Authority (1981) calls Plains with Clay Soils on Quaternary Basalt and is similar to the conditions on the Merrimu plateau. The unit is described as a low erosion hazard, with the disturbed soil washing readily if exposed to storm runoff, but the wash in the form of fine aggregates is noted as being "easily settled".

Another notable map unit is Irregular Surfaces with Shallow Uniform Texture Soils on Tertiary Sedimentary Rock. This unit is described as being found on moderate to steep slopes and gorges associated with streams that have cut down through Tertiary sediments. It is noted that in some places the stream had cut through the basalt plain, and that basalt may

be found at the top of the scarp as a capping to the Tertiary sediments. This map unit would be analogous to the edges of the Merrimu precinct where steep slopes and gullies are present. A key comment with this unit is that it has a high erosion hazard if the soil is exposed.

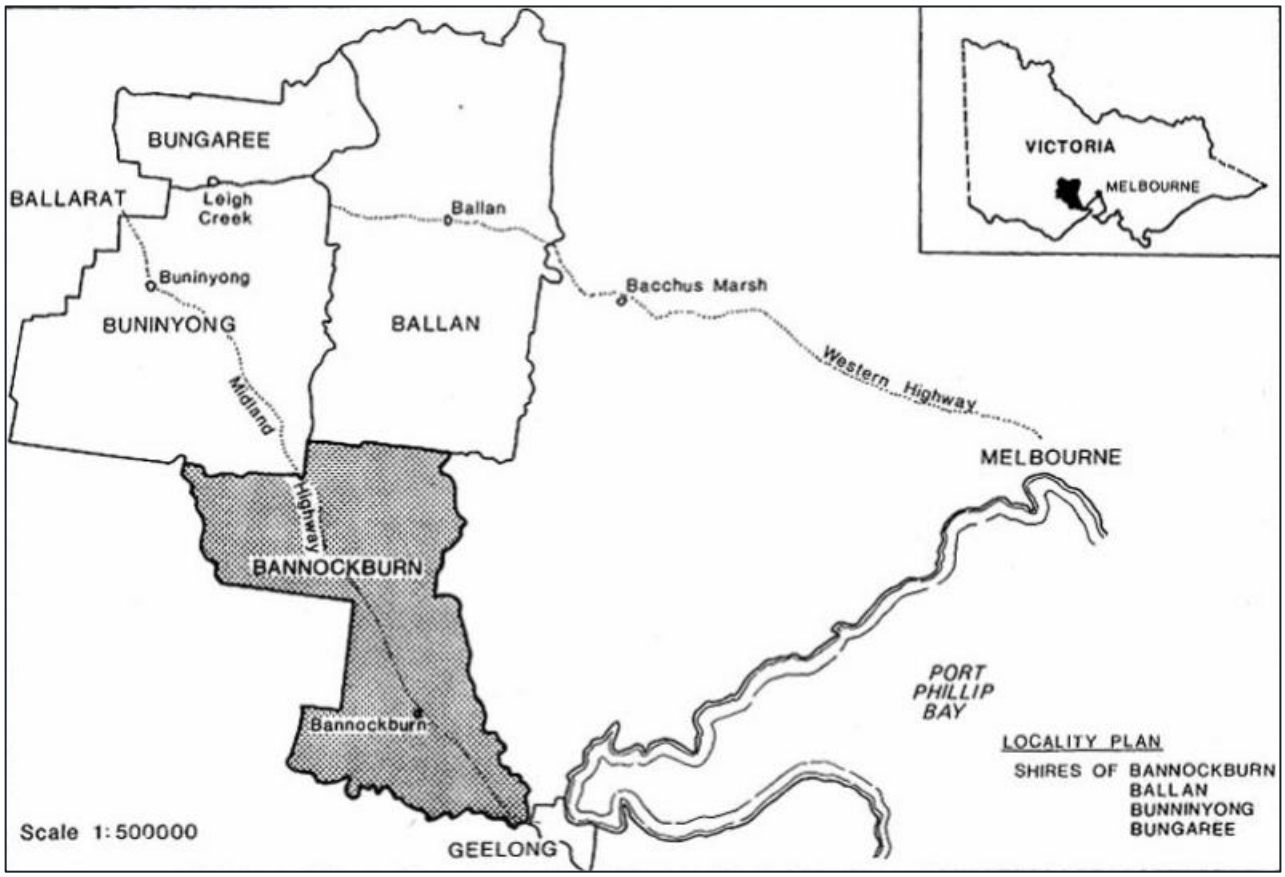


Figure 5.7 Locality map showing Bannockburn and surrounding areas.

In summary, the Soil Conservation Authority (1981) divided the Bannockburn shire into different distinct map units based on different land features such as topography, vegetation, and land use as well as the common soils and geology. Certain map units within this study are similar to the conditions found in the Merrimu precinct and provide insight into the natural erosion hazard present within the site. In particular, the basalt is described as a "low erosion hazard", whereas the exposed soils of the Tertiary sediments along the steep slopes and gorges are a "high erosion hazard".

5.2.3 VICTORIAN ONLINE RESOURCES (2015) SODICITY – UPPER SUBSOIL MAP

This map, referenced in the Department of Transport report on the Bacchus Marsh Eastern Link project, was created using soil observations within the Victorian Soil Information System (VSIS) and was part of DEDJTR (Department of Economic Development, Jobs, Transport, and Resources) Systems for Enhanced Farm Services program. It incorporates soil and land surveys over the past fifty years with the Victorian Online Resources site mentioning not to use the map as an indication of local subsoil sodicity, but more of as a general indication at regional to state-wide scale.

By comparing the sodicity map with the location of Merrimu precinct, the subsoil ESP seems to range from Sodic (6-15%) to Strongly Sodic (15-25%).

In summary, the Victorian Online Resources (2015) map provides a high-level overview of the likelihood of sodic soils in Victoria. By comparing the map with the location of Merrimu precinct sodic to strongly sodic soils seem to be present. However, the resource is intended for regional to state-wide scales so local investigations would be needed to confirm soil sodicity.

5.2.4 DEPARTMENT OF TRANSPORT (2021) BACCHUS MARSH EASTERN LINK PRELIMINARY INVESTIGATION REPORT

Department of Transport's Geotechnical Services were engaged by Department of Transport - Grampians Region in August 2021 to provide a comprehensive review of the geotechnical risks involved for the Bacchus Marsh Eastern Link Project. The report explored the four options proposed for the Bacchus Marsh Eastern Link Project via a desktop review, an updated geotechnical risk register, and a preliminary geotechnical investigation (three boreholes).

Two topographically distinct regions were identified; the alluvial flats comprising of soft sediments and shallow groundwater, and volcanic plains comprising high strength basalt and high plasticity clay.

Through the preliminary geotechnical investigation, where three boreholes were drilled, underlying materials in the Werribee Formation were tested and found to be high dispersive. All samples returned an Emerson Class 2 which is considered a very dispersive material. Furthermore, the report states that previous road projects which have used dispersive material have been problematic with major erosion or voids forming underneath the road. It is important to note that this refers to using dispersive material to construct roads, not in reference to building through or on dispersive materials.

In relation to sodic soils, Appendix B of the report (Geotechnical Risk Register) mentions that within the Bacchus Marsh area the sodicity ranges from Non-Sodic (ESP<6%) to Sodic (ESP 6-15%). This information was based on the Victorian Online Resource document 'Sodicity-Upper Subsoil' dated 9 June 2015. The report does detail that specific data from the study area was unavailable, so a detailed investigation was required.

See Figure 5.8 (following page) for the locations of the three boreholes drilled and the four different options explored for the Bacchus Marsh Eastern Link Project.

In summary, Department of Transport (2021) did identify that the Werribee Formation was highly dispersive, and that the Bacchus Marsh region had potentially sodic soils. However, in considering the route options for the Bacchus Marsh Eastern Link the predominant risk was associated with soft alluvial sediments and the deep cuts, necessary in some options, through the volcanic plains.

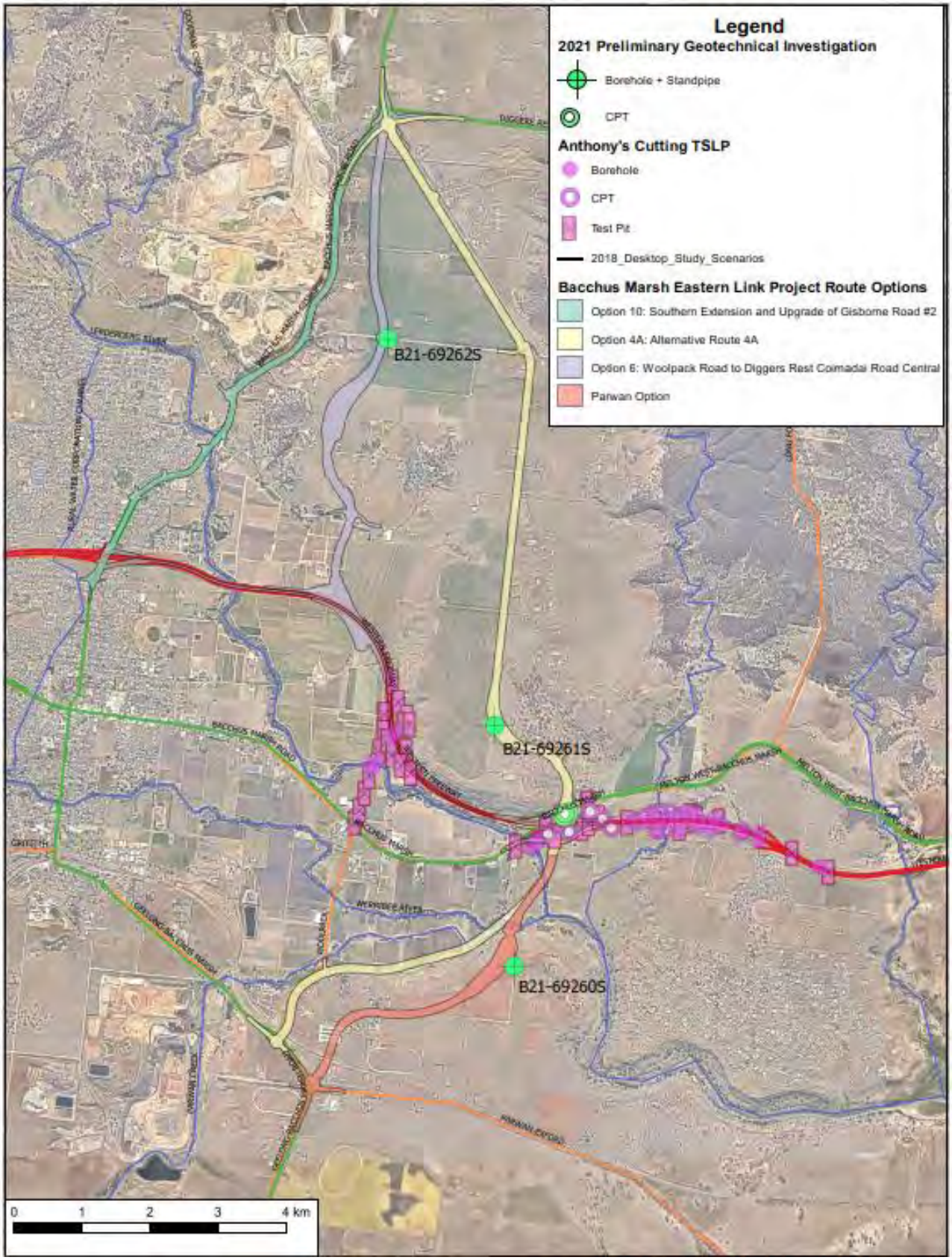


Figure 5.8 Map showing the three borehole locations and the four different options for the Bacchus Marsh Eastern Link Project.

5.3 SUMMARY OF LITERATURE REVIEW

The key points from each document reviewed are summarised below:

Site specific studies:

- The land capability study (Jacobs, 2018) provided an in-depth desktop assessment, however field observations and a discussion on potential sodic or dispersive soils were limited. The site inspection which was conducted involved assessing possible contamination presence within the project area.
- The original geotechnical investigation (Coffey, 2019) provides site specific data concerning the surface and subsurface conditions found in the project area. The report describes the regional stratigraphy as comprising thin topsoils underlain by stiff to very stiff, medium to high plasticity clay followed by Newer Volcanics, and possibly Werribee Formation at depth. Furthermore, the report provided recommendations on bearing pressure for footings, expected excavations conditions, and suitability of re-use of site soils as engineered fill. Limited discussion was present concerning the potential of sodic and dispersive soils within the project area.
- The original geomorphology and vegetation assessment (Alluvium, 2019) interpreted the landscape to be highly sensitive to changes in the flow regime of the tributary waterways, and in turn these changes were found to have a large influence on the geomorphology and vegetation found within the precinct. The report highlighted the challenges of mitigating against the impacts of development on stream flows. One of the management interventions proposed was the non-development of the plateau, which Alluvium (2019) notes is a challenging option but was argued as an option due to the sensitivity of the landscape. In lieu of this intervention Alluvium (2019) suggested higher requirements on engineering and water management standards than is currently applied to development.
- A desktop sodic soils assessment (Coffey, 2020a) used various references, in particular the Geomorphology and Vegetation Assessment by Alluvium (2019), to inform a proposed methodology for a soil sodicity and dispersiveness assessment. The regional geology, soil sodicity and dispersiveness, and geomorphological and vegetation information for the precinct was collated and an investigation methodology was devised. The proposed methodology was updated to include investigation of two possible occurrences of tunnel erosion reported by Melbourne Water (Coffey, 2020b). Coffey (2020b) undertook a site visit and based on the observations described the soils on the site to comprise basalt derived soils from weathered Newer Volcanics on the plateau with Werribee Formation soils visible in deeper gullies and on the scarp.
- The intrusive Soil Sodicity and Dispersiveness Assessment (Coffey, 2020c) was completed, and the report has succinctly outlined the issues related to sodic and dispersive soils in the Merrimu precinct. An extensive field investigation program was undertaken to provide evidence and support their conclusions. A key finding in the assessment was to highlight the need for stringent controls when undertaking development in the precinct, particularly in relation to the Werribee Formation. The recommendations to prevent and manage erosion are relatively broad, and many seem to advocate limiting the disturbance or exposure of potentially sodic and dispersive soils. Though Melbourne Water expressed concern about the presence of likely tunnel erosion at two locations, as discussed in Coffey (2020b), specific discussion addressing those concerns was not presented within this assessment.
- The first stormwater impact and management options assessment for the precinct (Alluvium, 2021) noted that erosion on exposed soils of the Werribee Formation was a high risk, particularly along the plateau margins. It also concluded that surface runoff was a key issue, and that no additional runoff, above pre-development annual surface runoff volumes, should enter waterways within the precinct. This informed Alluvium's (2021) recommendations concerning stormwater management in the Merrimu precinct, including that any stormwater management option considered needed to have the storage or disposal capacity to offset the volume of runoff generated by rainfall events to prevent additional runoff into waterways.
- Contributing to the stormwater impact and management options assessment (Alluvium, 2021), CDM Smith (2021) was engaged by Alluvium to assist in delivering the hydrogeological framework for evaluating an aquifer recharge strategy for stormwater disposal. They provided a comprehensive review of the geology, hydrology, and

hydrogeology of the region with a final comment on the Werribee Formation being a known candidate for aquifer storage and recovery in Victoria. Little to no mention was made about potential dispersive or sodic soils within the Merrimu precinct, or potential impacts at discharge points. The report's findings around geology of the precinct were consistent with previous reports.

- Subsequently, CDM Smith (2022) presented a proposal to develop a groundwater model to assess the risk of groundwater mounding due to disposal of stormwater via infiltration. The mounding was identified as a concern because of the erosion which may be caused due to groundwater expression along the scarp. To proceed with the modelling the proposal asks for additional information including the locations of infiltration basins and infiltration rates from the basins to the underlying aquifer. Simple conceptualisation and Darcy flux estimation was stated as an alternative if infiltration rates could not be provided by Alluvium.
- The first integrated water management (IWM) assessment for the Merrimu Precinct Structure Plan was undertaken by Rain (2021) on behalf of Bacchus Marsh Development Pty Ltd to identify opportunities for IWM at the precinct. This report outlined potential water sources and demands for development and any potential issues which may arise. An important point was that the Bacchus Marsh IWM was likely to recommend a 25-50% reduction in new impervious area runoff from the site. Thus, stormwater reuse was noted as being the priority water supply to the site. This reduction in runoff requirement was assessed by Rain (2021) to be likely in response to concerns around erosion mitigation and minimising surface runoff towards potential dispersive soils on site.
- A stormwater discharge feasibility investigation (Streamology, 2021) identified unsuitable gullies which should not be used to drain stormwater from the plateau.
- A groundwater management strategy (Rain, 2022) incorporating previous findings provided a high-level stormwater management strategy for treating and retarding stormwater runoff under the proposed development conditions. This report was written to address the site's sensitivities to sodic and erosive soils. Extensive surface water modelling was undertaken with stormwater runoff flows being directed through pipes and appropriate waterways towards retarding basins, and then to outlets. These models informed concept designs for water quality and hydraulic assets. This assessment highlighted the need for robust stormwater runoff management due to sodic and erosive soils on site.

Regional scale documents:

- The Soil Conservation Authority (1965) identified areas, within the Lake Merrimu catchment, where erosion and sodosols were considered limitations. The report noted work needed to be done to control existing erosion and to improve the general standard of management of the land.
- The Soil Conservation Authority (1981) assessment of the Bannockburn shire identified certain map units which are similar to the conditions found in the Merrimu precinct and provide insight into the natural erosion hazard present within the site. In particular, the basaltic soils are described as a "low erosion hazard", whereas the exposed soils of the Tertiary sediments along the steep slopes and gorges are a "high erosion hazard".
- State-wide soil sodicity mapping published by the Victorian Online Resources (2015) provides a high-level overview of the likelihood of sodic soils in Victoria. By comparing the map with the location of Merrimu precinct sodic to strongly sodic soils seem to be present. However, the resource is intended for regional to state-wide scales so local investigations would be needed to confirm soil sodicity.
- The Department of Transport (2021) identified that the Werribee Formation was highly dispersive, and that the Bacchus Marsh region had potentially sodic soils. However, in considering the route options for the Bacchus Marsh Eastern Link the predominant risk identified was associated with soft alluvial sediments and the deep cuts, necessary in some options, through the volcanic plains.

6 EXISTING DATA ANALYSIS

This section outlines the existing data from Coffey (2020c) Soil Sodicity and Dispersiveness Assessment. Emerson Class data from the Department of Transport (2021) Bacchus Marsh Eastern Link Preliminary Investigation Report has also been incorporated to add additional information concerning dispersiveness at depth within the Werribee Formation, although this data does not come from investigations on the site itself. This analysis aims to identify sodic and dispersive soils by geological unit and to align the literature review with the analytical results.

6.1 SUBSURFACE CONDITIONS

Coffey (2020c) conducted two field investigations, one between 4 and 6 August 2020 and another between 5 and 7 October 2020. Department of Transport (2021) conducted their investigation between 20 April 2021 and 10 May 2021. In total the Coffey investigations involved 25 test pits (depths ranging between 0.4 m to 3.1m), two deep boreholes (depths ranging between 11.1 m to 11.95 m) and 10 shallow samples (depths ranging between 0.2 m to 0.4 m). The Department of Transport investigation included three boreholes ranging in depth from 50 m to 60 m. Geological logs of boreholes are presented in **Appendix C**. A summary of the major geological units found in the Merrimu Precinct is presented in Table 6.1 below.

Table 6.1 Summary of the major geological units

GEOLOGICAL UNIT	APPARENT THICKNESS	FEATURES
Quaternary Sediments	<5m (CDM Smith, 2021)	- Discrete occurrences in the southern area of the precinct (CDM Smith, 2021). - Comprises of alluvial gravel, sand, and silt (CDM Smith, 2021).
Newer Volcanics	~20m (CDM Smith 2021)	- Tholeiitic to minor alkaline basaltic volcanic rocks (CDM Smith, 2021) - The unit is located at higher elevations in the precinct often forming a sheet like cover and escarpments due to erosion of underlying material (CDM Smith, 2021) - Commonly vesicular, with minor scoria, tuff, and agglomerate. Columnar jointing common (Department of Transport, 2021).
Darley Gravel	Ranging from 12.4m to 2.2m thickness (based on borehole logs from Department of Transport (2021))	- Gravel, sandy, silty, and clayey gravel, with lesser sand and clay. Local ferruginisation and silicification (Department of Transport, 2021) - Underlies, overlies, or interfingers with Newer Volcanics (Department of Transport, 2021)
Werribee Formation	Nearly 90m in the southern part of the precinct (CDM Smith, 2021) Depth to Werribee Formation in two boreholes was ~10m based on Coffey (2019)	- Comprises sand, gravel, clay, and coal (CDM Smith, 2021). - Clay, sandy and silty clay, white to grey, with sand and quartz gravel, minor tuff, brown coal, dolomite, pyritic and silica sand (Department of Transport, 2021).

GEOLOGICAL UNIT	APPARENT THICKNESS	FEATURES
Werribee Formation – Maddingley Coal Seam	Maximum thickness of over 43m (Department of Transport, 2021)	- Brown coal seam. Coal locally pyritic, plant remains common, minor clay (Department of Transport, 2021).
Castlemaine Group (bedrock)	Only encountered in one borehole (B21-69262S) at a depth of 56.50 mBGL and extending until the end of hole at 60.25 m (Department of Transport, 2021).	- Slate, shale, siltstone, sandstone, interbedded sequence of turbiditic character.

6.2 SODIC/DISPERSIVE SOILS

6.2.1 FIELD OBSERVATIONS

Key observations made by the geotechnical engineer for Coffey (2020c) included:

- A gully at the southern end of the Merrimu PSP which falls to Flanagans Drive. Burrowing was present as well as erosional features such as channel, rill, and gully erosion.
- Ground surface over the plateau was covered in thick grass. Basalt outcrops and boulders were noted in places.
- Old mature trees between 5 m and 20 m are scattered throughout the gully.
- In August 2020, the site was very dry with no surface water present.
- In October 2020 the investigation was carried out following rain. Parts of the site were inaccessible for 4WD vehicles due to surface water and basalt boulders. Surface water was present over Bences Road limiting access in parts.

Key observations made by the geotechnical engineer for Department of Transport (2021) included:

- Evidence of soil erosion on the cut faces of Geelong-Bacchus Marsh Road and Gisborne Road. Werribee Formation was the main geology along the cut batter faces. Some Ordovician Castlemaine Formation was visible on the faces along Gisborne Road.
- Steep rises in elevation including at the intersection of Bacchus Marsh Road and Flanagans Drive and descending west down Buckleys Road to get to Gisborne Road.
- Southern end of Woolpack Road in the alluvial flood plains showed flooding and soft ground.
- Terrain of the volcanic plains were undulating, and basalt boulders were at the surface.
- Cut faces on the western end of Buckleys Road and along Gisborne Road show the transition from the volcanic plains into the Ordovician Castlemaine Formation and then into the Quaternary (Pleistocene) aged alluvial deposits.

6.2.2 LABORATORY ANALYTICAL RESULTS

Locations for the samples taken for Coffey (2020c) and Department of Transport (2021) are shown in Figure 4 in **Appendix A**. A total of 35 samples were taken with 34 being analysed for Emerson Class testing, 24 tested for ESP, and 5 tested by the Pinhole Dispersion method.

Laboratory analytical results are provided in Table D1, Table D2 and Table D3 in **Appendix D**. Copies of the laboratory certificates of analysis are provided in **Appendix E**. Table 6.2 following page) summarises these results.

Table 6.2 Summary of laboratory test results

GEOLOGICAL UNIT	LOCATION	DEPTH (mBGL)	SAMPLE NUMBER	DESCRIPTION	EMERSON CLASS AND INTERPRETATION	ESP (%) AND SODICITY CLASS	PINHOLE DISPERSION TEST AND INTERPRETATION
Newer Volcanics	TP101	1.15 to 1.5	354	-	4 – Slaking, but no dispersion	18 – Strongly Sodic	-
Newer Volcanics	TP103	1 to 1.5	349	-	4 – Slaking, but no dispersion	23 – Strongly Sodic	D1 – Highly Dispersive
Newer Volcanics	TP104	0 to 0.5	367	-	4 – Slaking, but no dispersion	2.8 – Non-sodic	-
Newer Volcanics	TP105	0.4 to 0.5	355	-	4 – Slaking, but no dispersion	2 – Non-sodic	-
Newer Volcanics	TP105	1 to 1.5	351	-	4 – Slaking, but no dispersion	5 – Non-sodic	ND2 – Completely Non-dispersive
Newer Volcanics	TP108	0.5	365	-	4 – Slaking, but no dispersion	19 – Strongly Sodic	-
Newer Volcanics	TP108	2.5	356	-	5 – Slaking, initially non dispersive but becomes dispersive after remoulding and shaking	32 – Very Strongly Sodic	-
Newer Volcanics	TP109	1.5	357	-	4 – Slaking, but no dispersion	16 – Strongly Sodic	-
Newer Volcanics	TP110	0.5	358	-	3 – Slaking, initially non dispersive but becomes dispersive after remoulding	-	-
Newer Volcanics	TP114	2.5	359	-	4 – Slaking, but no dispersion	26 – Very Strongly Sodic	-
Newer Volcanics	TP115	1.5 to 1.6	360	-	4 – Slaking, but no dispersion	26 – Very Strongly Sodic	-
Newer Volcanics	TP116	0.5	361	-	3– Slaking, initially non dispersive but becomes dispersive after remoulding	-	-
Newer Volcanics	TP118	0 to 0.5	352	-	6 – Slaking, but no dispersion even after remoulding and shaking.	21 – Strongly Sodic	ND2 – Completely Non-dispersive
Newer Volcanics	TP120	1.5	362	-	4 – Slaking, but no dispersion	24 – Strongly Sodic	-
Newer Volcanics	TP122	1 to 1.4	363	-	-	4.7 – Non-sodic	-

GEOLOGICAL UNIT	LOCATION	DEPTH (mBGL)	SAMPLE NUMBER	DESCRIPTION	EMERSON CLASS AND INTERPRETATION	ESP (%) AND SODICITY CLASS	PINHOLE DISPERSION TEST AND INTERPRETATION
Newer Volcanics	TP122	1 to 1.5	350	-	4 – Slaking, but no dispersion	-	ND2 – Completely Non-dispersive
Newer Volcanics	TP123	1.1 to 1.5	353	-	4 – Slaking, but no dispersion	3.3 – Non-sodic	ND2 – Completely Non-dispersive
Newer Volcanics	TP125	1.2 to 1.5	364	-	6 – Slaking, but no dispersion even after remoulding and shaking.6	-	-
Newer Volcanics*	B21-69260S	11.0-11.45	57021-S1	Clayey SAND, fine to coarse, brown, fines of low plasticity, trace gravel	2 – Slaking with some dispersion	-	-
Werribee Fm	BH-1	10.5	M20-Oc24632	-	2 – Slaking with some dispersion	32 – Very Strongly Sodic	-
Werribee Fm	BH-1	11.5	M20-Oc24631	-	2 – Slaking with some dispersion	22 – Strongly Sodic	-
Werribee Fm	BH-4	9.7	M20-Oc24634	-	2 – Slaking with some dispersion	11 – Sodic	-
Werribee Fm	BH-4	10.7	M20-Oc24633	-	2 – Slaking with some dispersion	23 – Strongly Sodic	-
Werribee Fm	HA-1B	0.2	M20-Oc24625	-	2 – Slaking with some dispersion	6.1 – Sodic	-
Werribee Fm	HA-1C	0.3	M20-Oc24626	-	3– Slaking, initially non dispersive but becomes dispersive after remoulding	7.2 – Sodic	-
Werribee Fm	HA-2C	0.3	M20-Oc24627	-	2 – Slaking with some dispersion	6.5 – Sodic	-
Werribee Fm	HA-3B	0.4	M20-Oc24628	-	2 – Slaking with some dispersion	6.6 – Sodic	-
Werribee Fm	HA-3C	0.3	M20-Oc24629	-	3– Slaking, initially non dispersive but becomes dispersive after remoulding	9.6 – Sodic	-
Werribee Fm	HA-3D	0.3	M20-Oc24630	-	2 – Slaking with some dispersion	4.9 – Non-sodic	-
Werribee Fm*	B21-69260S	31.50-31.60	57021-S2	CLAY/SILT, low plasticity, grey, with sand	2 – Slaking with some dispersion	-	-

GEOLOGICAL UNIT	LOCATION	DEPTH (mBGL)	SAMPLE NUMBER	DESCRIPTION	EMERSON CLASS AND INTERPRETATION	ESP (%) AND SODICITY CLASS	PINHOLE DISPERSION TEST AND INTERPRETATION
Werribee Fm*	B21-69260S	44.80-45.00	57021-S3	SAND, fine to coarse, brown, with clay/silt	2 – Slaking with some dispersion	-	-
Werribee Fm*	B21-69261S	17.30-17.50	57021-S4	SAND, fine to coarse, grey, with clay/silt	2 – Slaking with some dispersion	-	-
Werribee Fm*	B21-69261S	38.80-39.00	57021-S5	SAND, fine to coarse, brown, with clay/silt	2 – Slaking with some dispersion	-	-
Werribee Fm*	B21-69262S	22.90-23.25	57021-S11	Sandy SILT, non-plastic, brown, sand fine to medium grained	2 – Slaking with some dispersion	-	-
Werribee Fm*	B21-69262S	46.90-47.20	57021-S10	SAND, fine to coarse, grey, with clay/silt	2 – Slaking with some dispersion	-	-

*From Department of Transport (2021) Bacchus Marsh Link Preliminary Investigation Report

Laboratory testing shows non-sodic to very strongly sodic soils are present across the precinct, with exchangeable sodium percentage ranging from 2.0% - 32%. Split by geology the ESP in the Werribee Formation ranges from 4.9% (Non-sodic) - 32% (Very strongly sodic) with the Newer Volcanics ranging from 2.0% (Non-sodic) - 32% (Very strongly sodic). The ESP varies considerably with no strong link between sodicity and depth or geological unit. However, only six samples out of 24 returned non-sodic (<5% ESP), hence it is likely that a majority of soils within the precinct will be classified sodic or higher.

In terms of Emerson Class the results range from Class 2 to Class 6, with eight samples out of ten in the Werribee Formation being Emerson Class 2. No samples in the Newer Volcanics returned a Class 2 with two samples out of seventeen returning an Emerson Class 3. Emerson Class 2 is considered a highly dispersive material, with a majority of samples showing some dispersion of air-dried crumbs, whereas Emerson Class 3 shows no dispersion, and the material is only dispersive when remoulded at the plastic limit. From these results the Werribee Formation is the primary risk for potential erosion due to its dispersiveness, whereas the Newer Volcanics is largely non-dispersive.

The Pinhole Dispersion Tests returned one highly dispersive designation (D1) and four completely non-dispersive (ND2) results. All five samples were taken from within the Newer Volcanics unit. This reinforces the Emerson Class data which indicates that the Newer Volcanics is generally non-dispersive.

Examining the results from Department of Transport (2021) laboratory testing shows Emerson Class 2 on all samples, with all but one sample being within the Werribee Formation. Again, these results are in line with previous data from Coffey (2020c) which indicate that the Werribee Formation is dispersive.

In summary, although the ESP in the Newer Volcanics is often elevated and within the sodic to very sodic range, the physical dispersity testing (Emerson aggregate and pin hole tests) typically shows this soil type to be non-dispersive or only dispersive following remoulding. In contrast, while the ESPs for Werribee Formation were generally lower than those in the Newer Volcanics (albeit still classifying as sodic soil), the physical dispersion testing (by Emerson aggregate only) showed the soil to be generally dispersive and representing a likely high risk of erosion.

Whilst the Newer Volcanics may be some metres thick in the centre of the plateau, they appear to thin on the margins and are incised in gully's and on the scarps.

6.3 ALIGNMENT WITH LITERATURE REVIEW

Bringing together the literature review and the analytical results, the exposed Werribee Formation, predominantly found along incised gullies bordering the precinct, appears to be the main concern. In terms of sodicity the values are quite varied with no clear distinction between geological unit and sodicity, although generally the Newer Volcanics had slightly higher ESPs that Werribee Formation soils. In each case most of the samples had an ESP which classified the soils as at least "sodic". Therefore, the soils of the Merrimu Precinct, including those formed from both Newer Volcanics and Werribee Formation are likely to be sodic soils which is consistent with the literature review.

Nevertheless, the soil of the Werribee Formation has a poor structure in places appearing apedal and massive (structureless) with little cohesion between the particles leading to a relatively high inherent risk of dispersion and therefore erosion potential as seen in the physical Emerson Aggregate test results.

The steep topography found between the elevated basalt plateau and the lower alluvial plains further increases the potential for erosion of this unit as surface water flows on the scarp will be faster, have a greater upgrading catchment (and therefore volume) than run-off generally flowing over the plateau.

With respect to site management, it is therefore critical to distinguish between the largely non-dispersive Newer Volcanics, which comprises the majority of the Merrimu Precinct, and the dispersive Werribee Formation which underlies the Newer Volcanics. This finding is consistent with the general recommendations of the literature reviewed as part of this study.

6.4 ADEQUACY OF EXISTING DATASET

Overall, the dataset provided was considered adequate for the purposes of this precinct level assessment of sodicity and erosion risk. When viewing the distribution of samples taken from the Newer Volcanics and the Werribee Formation the Newer Volcanics are well represented throughout the precinct. However, the Werribee Formation samples are mainly taken along the southern boundary of the precinct and so we have made assumptions on the risk presented by the Werribee Formation from this somewhat limited data. On making conclusions and recommendations on a precinct level scale this limitation should be considered.

Furthermore, mapping of the extents of the two main units (Newer Volcanics and Werribee Formation) is only available at broad scale (being based on the Geological Survey of Victoria, 1985 *1:50,000 Bacchus Marsh* geological map). We have assumed that the mapped units at this scale are a true reflection of the actual site conditions.

Field observations (e.g. Coffey (2020c) and Streamology (2021)) indicate variability in mapped geology (e.g. rocky vs clay, variable thickness of the capping Newer Volcanics) and erosion conditions at identified gullies along the escarpment (e.g. visible erosion vs well vegetated stable channels) within the same geological setting. At the precinct planning level, these variations can be integrated conservatively into the precinct planning process; however, at a development scale these variations may impact engineering controls required or the ability to construct particular infrastructure. This suggests that site specific detailed investigation (including intrusive assessment) is likely to be required to inform particular controls and constraints for individual development elements (e.g. stormwater infrastructure, works within steeply sloping land, etc.).

7 SITE VISIT FINDINGS

7.1 SITE FEATURES

A limited site walkover was undertaken on 15 November 2022 by two Contaminated Land Scientists from WSP. Figure 7.1 below shows Merrimu site area and the locations visited. See **Appendix B** for site photos.

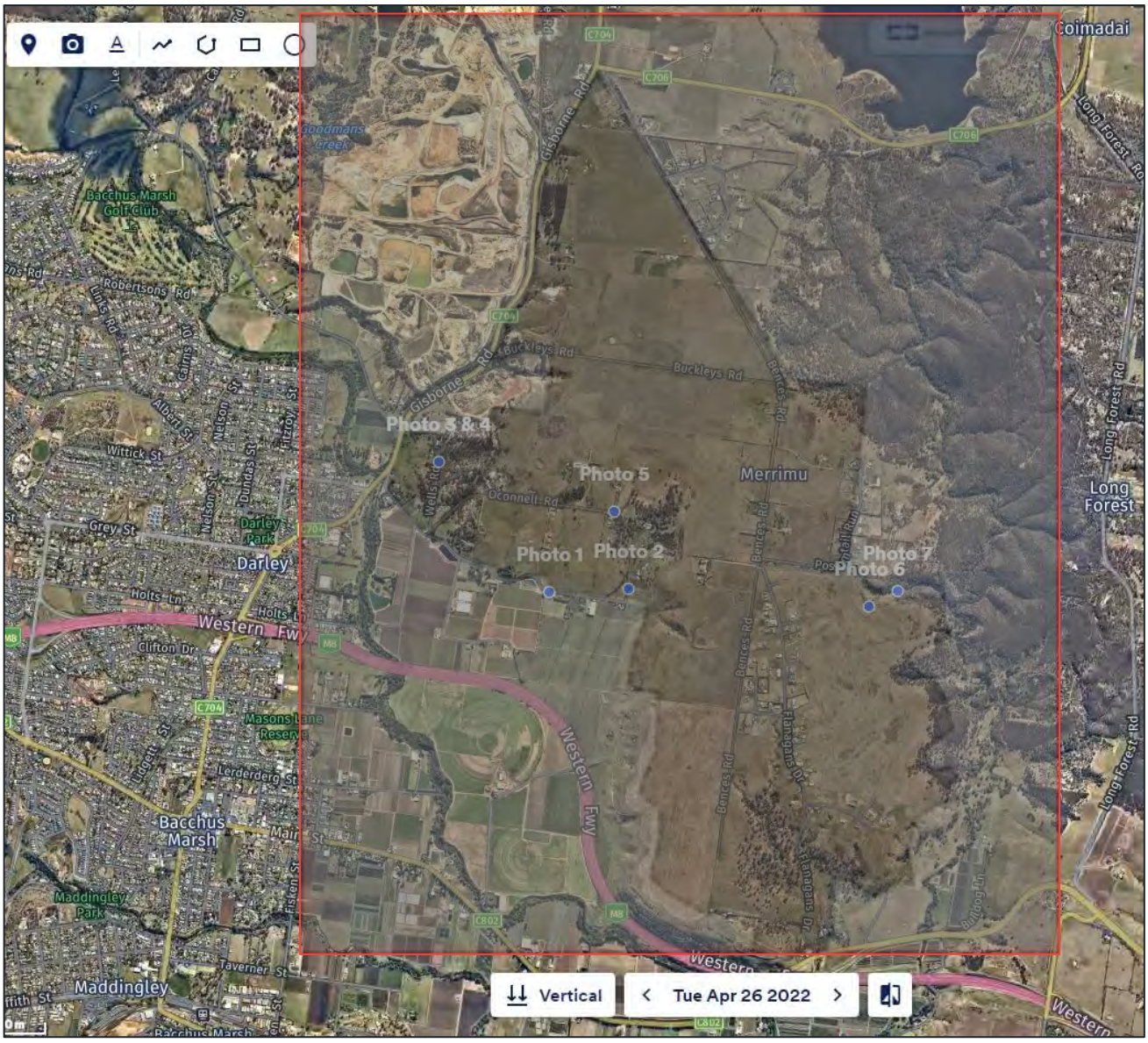


Figure 7.1 Merrimu site area and locations visited during site visit.

The following features were observed:

- Thin topsoil with unconsolidated gravel and rock across much of the Precinct,
- Agricultural land and winery in the southwestern and eastern portions of the Precinct. Terracing on slopes was observed (Photo 2),
- Several residential properties were observed along Possumtail Run, with many seemingly not permanently occupied.
- Residential properties were also observed along Flanagans Drive.

- The southern end of Bences Road, where Flanagans Drive starts, is unpaved and at the time of the site visit the ground was very soft, due to heavy rainfall during previous weeks, and was inaccessible with the 4WD utility vehicle.

7.2 SODIC/DISPERSIVE SOILS

7.2.1 SODIC SOIL SITE WALKOVER OBSERVATIONS

Observations were made during the site walkover of features which could be evidence of historical dispersion. Dispersion is often associated with sodic soils.

The following features were observed:

- Gully with steep valley sides observed (Photo 6, 7) just west of Pyrites Creek; stratigraphy is interpreted as Newer Volcanics overlying Werribee Formation.
- Gully with potentially exposed Werribee Formation near the southern end of the precinct at the Our Lady Ta' Pinu Shrine. The head of the gully is at the intersection of Flanagans Drive and Lindsay Avenue and runs north to south parallel to Flanagans Drive.

Photos of these features with descriptions are presented within **Appendix B**.

Based on site observations the basalt plateau has thin topsoils and sparse vegetation, but there were limited signs of erosion on this soil. However, gullying and exposure of Werribee Formation was observed in the east on Possumtail Run and in the south near the Our Lady Ta' Pinu Shrine. Site observations confirm the desktop reviewed data that the residual soils of the Newer Volcanics present an inherently lower erosion risk than the soils of the Werribee Formation.

8 DISCUSSION

8.1 INFLUENCE OF GEOLOGY ON EROSION RISK

Based on the review of previous studies in the Merrimu Precinct the geology and the soil type, coupled with the landscape are the key underlying factors when considering erosion risk for future development. In particular, the Werribee Formation underlying the Newer Volcanics, and which is predominantly exposed along incised gullies at the precinct edges has been found to be dispersive and being on the steeper parts of land this risk is heightened. These gullies are steep sitting atop a high basalt plateau draining to receiving waterways and areas of lower floodplains.

Management of surface runoff flowing over the erodible soils of the Werribee Formation should be the primary concern (from a soil erosion perspective), with any future development needing to minimise ground disturbance to minimise exposure of sodic and dispersive soils, and in particular the Werribee Formation soils along with managing runoff so that any increases in runoff volumes are controlled.

The main issue when considering the basalt plateau which comprise most of the precinct are the thin topsoils. Maintaining vegetative cover should be a priority particularly considering the geomorphic sensitivity of the gullies bordering the precinct and limiting the disturbance of those regions.

It is important to note that natural erosion is occurring currently in the precinct, however it is limited to localised areas generally where the Werribee Formation is exposed. Any risk management options should address control of surface water conveyance into existing gullies (or around via pipeline) and waterways (note: outside the precinct).

In summary, erosion risk is driven by exposed Werribee formation sediments along the escarpment, steep slopes (usually outside the precinct boundary), thin topsoils across all geologies, and degraded vegetation (as a result of thin topsoils and poor land management practices).

8.2 SOIL EROSION RISK SCHEME

The following methodology was adopted to assess the soil erosion risk to the precinct and assess the need for further investigation to inform precinct planning activities. This desktop assessment of erosion risk has been based on available guidance relating to sodic/dispersive soil risk, taking into consideration observations of the site inspection and the proposed land use at the precinct.

The assessment of erosion risk is based on the potential impacts associated with proposed development in both the short (i.e., during construction) and long term (i.e., topsoil conservation, channel instability), associated with soil erosion, and impacts to buildings, infrastructure, and waterways.

The risk level has been allocated based on likelihood of erosion, and the level of effort required to inform precinct planning activities and mitigate the risk. We consider that where immediate surface changes are relatively minor (e.g., construction of a stand-alone residential dwelling connected to services with topsoil reinstated on exposed surfaces), the risk of surface erosion is relatively low, especially if the landform is stable/flat. There may be a higher risk profile associated with main stormwater, sewer and potable water infrastructure, which is constructed as linear infrastructure, especially if this is built close to waterways and associated steeper landforms (banks) (e.g. entering the precinct along a hillside).

The risk level has also largely been allocated by considering slope, with the highest risk being observed on slopes greater than 15%. See Figures 6 and 7 in Appendix A for the terrain slope map and the high-risk slope map respectively. The high-risk slope map includes a 100 m buffer around the high-risk zone, which ensures the appropriate scrutiny is applied during construction for soil erosion risk. Additionally, Figure 7 includes Rain (2022) stormwater catchment boundaries and discharge locations. The focus of slope when considering soil erosion risk is partly due to the strong association of the Werribee Formation with steep slopes and the ease of stormwater runoff flow down steep slopes.

Separately, the risk ranking may be higher in consideration of:

- the quantum of works required (e.g. as part of an integrated water management plan for the precinct) to identify controls to manage changes to catchment hydrology; and
- the quantum of changes to precinct hydrology (e.g. higher peak flow, higher total discharge volumes, quality of inflows) requiring control by built infrastructure.

That is, the effort required to maximise water quality (e.g., bank stability and water clarity) may be significant, affecting the risk ranking.

Based on these considerations, and to support the identification of areas requiring further consideration, the recommended approach to assessing erosion risk has been aligned to the following:

- **Risk Level:** High risk, Medium risk, Low risk or Very low risk designations for detrimental erosion potential.
- **Precinct Context:** Range of precinct scenarios where development may be impacted by soil erosion risk.
- **Potential for Erosion:** Landforms within the precinct where erosion risk may be higher/lower, based on geological formation and topography.
- **Controls:** Ability to control/mitigate impact of erosion risk.

The resultant soil erosion risk scheme, as presented in Table 8.1 below, has been used in this assessment.

Table 8.1 Soil Erosion Risk Scheme and Precinct Context

RISK LEVEL	PRECINCT CONTEXT	POTENTIAL FOR EROSION	CONTROLS
Soil erosion			
High risk	**High risk** of significant erosion of surface soils leading to: — Inability to sustain vegetation — Unstable soils — Long term ongoing requirement for remedial works. Likely to affect all aspects of development, including residential dwelling construction.	Soil erosion more likely: — In areas where soil erosion is visible pre-development — Where extensive soil disturbance occurs — On sloping land — Sodicity/dispersiveness tests indicate higher likelihood — If topsoil is not appropriately retained during and post construction	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised — Topsoil layer (minimum 150 mm) to be retained/placed on all open areas — Protective matting to prevent erosion on slopes required until vegetation established — Ongoing maintenance to be programmed
Medium risk	**Medium risk** of significant erosion of surface soils leading to: — Inability to sustain vegetation — Unstable soils — Potential ongoing requirement for remedial works. Likely to affect most aspects of development, particularly deep/extensive excavations and sloping ground.	Soil erosion more likely: — In areas where soil erosion is visible pre-development — Where extensive soil disturbance occurs — On sloping land — Sodicity/dispersiveness tests indicate higher likelihood — If topsoil is not appropriately retained during and post construction	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised — Topsoil layer (minimum 150 mm) to be retained/placed on all open areas — Protective matting to prevent erosion on slopes required until vegetation established
Low risk	**Low risk** of significant erosion of surface soils leading to: — Inability to sustain vegetation — Unstable soils — Potential requirement for remedial works. Likely to affect some aspects of development, particularly deep/extensive excavations.	Soil erosion more likely: — In areas where soil erosion is visible pre-development — Where extensive soil disturbance occurs — On sloping land — Sodicity/dispersiveness tests indicate higher likelihood — If topsoil is not appropriately retained during and post construction	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised — Topsoil layer (minimum 150 mm) to be retained/placed on all open areas
Very low risk	**Negligible risk** of significant erosion of surface soils leading to: — Inability to sustain vegetation — Unstable soils — Remedial works. Unlikely to affect any aspects of development as erosion potential is low.	Soil erosion is unlikely: — In areas where soil erosion has not been observed pre-development — On flat ground — Where soil sodicity/dispersiveness tests indicate non-sodic — Where topsoil is appropriately retained during and post construction.	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised

RISK LEVEL	PRECINCT CONTEXT	POTENTIAL FOR EROSION	CONTROLS
Building and Infrastructure Impact			
High risk	**High risk** of significant erosion of subsurface soils leading to: — Tunnel erosion — Structural failure of infrastructure/foundations — Long term ongoing requirement for remedial works. Likely to affect all aspects of development, including residential dwelling construction.	Building and infrastructure impact is more likely: — In areas where soil erosion is visible pre-development — Where extensive soil disturbance occurs and exposes susceptible soils — Sodicity/dispersiveness tests indicate higher likelihood — If topsoil is not appropriately retained during and post construction	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised — Linear infrastructure backfill designed to minimise potential for tunnel erosion — Linear infrastructure avoided/above ground — Foundations designed to minimise soil disturbance
Medium risk	**Medium risk** of significant erosion of subsurface soils leading to: — Tunnel erosion — Structural failure of infrastructure/foundations — Potential ongoing requirement for remedial works. Likely to affect most aspects of development, particularly linear underground infrastructure and sloping ground.	Building and infrastructure impact is more likely: — In areas where soil erosion is visible pre-development — Where extensive soil disturbance occurs and exposes susceptible soils — Sodicity/dispersiveness tests indicate higher likelihood — If topsoil is not appropriately retained during and post construction	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised — Linear infrastructure backfill designed to minimise potential for tunnel erosion — Linear infrastructure avoided/above ground
Low risk	**Low risk** of significant erosion of subsurface soils leading to: — Tunnel erosion — Structural failure of infrastructure/foundations — Potential requirement for remedial works. Likely to affect some aspects of development, particularly linear underground infrastructure and sloping ground.	Building and infrastructure impact is more likely: — In areas where soil erosion is visible pre-development — Where extensive soil disturbance occurs and exposes susceptible soils — On sloping land — Sodicity/dispersiveness tests indicate higher likelihood — If topsoil is not appropriately retained during and post construction	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised — Linear infrastructure backfill designed to minimise potential for tunnel erosion
Very low risk	**Negligible risk** of significant erosion of subsurface soils leading to: — Tunnel erosion — Structural failure of infrastructure/foundations — Remedial works. Unlikely to affect any aspects of development as erosion potential is low.	Building and infrastructure impact is unlikely: — In areas where soil erosion has not been observed pre-development — Where susceptible soils are not exposed — Where soil sodicity/dispersiveness tests indicate non-sodic — Where topsoil is appropriately retained during and post construction.	Can be controlled with typical construction environment management techniques during construction phase, plus: — Topsoil disturbance to be minimised

RISK LEVEL	PRECINCT CONTEXT	POTENTIAL FOR EROSION	CONTROLS
Impact to Water Quality			
High risk	**High risk** of significant erosion of soils and stream channels leading to: — Undesirable impacts to protected Environmental Values (sediment loading, poor water quality) Likely to affect all aspects of development, including residential dwelling construction.	Soil and channel erosion more likely: — In areas where soil erosion is visible pre-development, and sodicity/dispersiveness tests indicate higher likelihood — Due to increased peak streamflow following development — Due to increased catchment discharge (reduced infiltration)	Can be controlled with typical riparian land management techniques[1], plus: — Stormwater treatment/settlement to minimise sedimentation — Stormwater retarding to manage peak and total flows within waterways — Treatment/management to prevent soil erosion within the catchment area — Engineered erosion control (such as grade control structures) to protect channels
Medium risk	**Medium risk** of significant erosion of soils and stream channels leading to: — Undesirable impacts to protected Environmental Values (sediment loading, poor water quality) Likely to significantly affect stormwater management infrastructure design/maintenance.	Soil and channel erosion more likely: — In areas where soil erosion is visible pre-development, and sodicity/dispersiveness tests indicate higher likelihood — Due to increased peak streamflow following development — Due to increased catchment discharge (reduced infiltration)	Can be controlled with typical riparian land management techniques[1], plus: — Stormwater treatment/settlement to minimise sedimentation — Stormwater retarding to manage peak and total flows within waterways — Treatment/management to prevent soil erosion within the catchment area
Low risk	**Low risk** of significant erosion of soils and stream channels leading to: — Undesirable impacts to protected Environmental Values (sediment loading, poor water quality) Likely to affect some aspects of stormwater management infrastructure design/maintenance.	Soil and channel erosion more likely: — In areas where soil erosion is visible pre-development, and sodicity/dispersiveness tests indicate higher likelihood — Due to increased peak streamflow following development — Due to increased catchment discharge (reduced infiltration)	Can be controlled with typical riparian land management techniques[1], plus: — Stormwater treatment/settlement to minimise sedimentation — Stormwater retarding to manage peak and total flows within waterways
Very low risk	**Negligible risk** of significant erosion of soils and stream channels leading to: — Undesirable impacts to protected Environmental Values (sediment loading, poor water quality) Unlikely to affect aspects of stormwater management infrastructure design.	Soil and channel erosion more likely: — In areas where soil erosion is visible pre-development, and sodicity/dispersiveness tests indicate higher likelihood — Due to increased peak streamflow following development — Due to increased catchment discharge (reduced infiltration)	Can be controlled with typical riparian land management techniques[1], plus: — Stormwater treatment/settlement to minimise sedimentation

(1) Port Phillip and Westernport CMA's Healthy Waterways Strategy (2018-2028) details typical riparian land management strategies, including stock exclusion fencing, planting of riparian vegetation, pest management and improving stormwater quality.

8.3 PRECINCT SOIL EROSION RISKS

An assessment of erosion risk was undertaken at a precinct planning level, on the basis of a literature review, review of previous laboratory analysis, and site walkover. The erosion risk has been divided between the relatively flat basaltic plateau and the escarpments found along the precinct boundary.

8.3.1 EROSION RISK (SOIL)

8.3.1.1 RISK ON PLATEAU

Based on the findings of the literature review and site walkover, in accordance with the adopted soil erosion risk scheme (Section 8.2), the Precinct soil erosion risk (surface soil) on the plateau was assessed as **Low- Medium Risk**. See Figure 8 in Appendix A for the erosion risk map (soil).

Undisturbed (and cropped land) on the plateau generally showed minimal evidence of surface erosion. The topsoil is very thin and efforts to maintain vegetative cover should be a priority during development.

The inherent soil risk appears relatively low on the Newer Volcanics, although the thickness of this unit is likely to decrease towards the precinct boundaries (i.e. medium risk). In general, the soil erosion risk presented by the development is likely to be most prevalent during the construction phase while soil surfaces are exposed, but once development is complete the risk across the developed portions is likely to be negligible with the surfaces covered by houses, roads and maintained gardens.

In addition to better informing the risk profile by undertaking intrusive investigations, controls during development may include protection of topsoil, placement of topsoil in scalped areas, and placement of matting to minimise erosion, in addition to maintaining vegetative cover and ensuring revegetation and stabilisation occur in a timely manner throughout the development works.

8.3.1.2 RISK ON ESCARPMENTS

Based on the findings of the literature review and site walkover, in accordance with the adopted soil erosion risk scheme (Section 8.2), the Precinct soil erosion risk (surface soil) along the escarpments was assessed as **High Risk**. See Figure 8 in Appendix A for the erosion risk map (soil).

Along most escarpments the underlying dispersive Werribee Formation is exposed making the soil susceptible to erosion. Currently, erosion is occurring at these locations, with channel, rill, and gullying being observed, and any development must avoid impacting the soils of the Werribee Formation. As with the plateau, maintenance of the topsoil and vegetative cover should be a priority.

Improving land management (e.g. fenced, destocked, weed management and regeneration) will likely lead to minimising erosion and stabilising the soils along the escarpments.

Development on the outer edges of the plateau near the escarpments (e.g. placement of retention basins, roadways and other infrastructure) may increase the soil erosion risk so controls should be implemented to minimise disturbing the subsoils. This may include matting and possibly creating a buffer zone or temporary barriers around the escarpments.

8.3.2 EROSION RISK (BUILDINGS AND INFRASTRUCTURE)

8.3.2.1 RISK ON PLATEAU

Based on the findings of the literature review and site walkover, in accordance with the adopted soil erosion risk scheme (Section 8.2), the Precinct soil erosion risk (buildings and infrastructure) was assessed as **Low – Medium Risk**. See Figure 9 in Appendix A for the erosion risk map (buildings and infrastructure).

The soils of the plateau are less dispersive and approximately 10m thick, however thickness will vary across the precinct. Therefore, it is possible that deep excavations may intersect underlying strata, which may be more reactive. Further assessment to understand the vertical soil profile may better inform the risk profile.

Infrastructure on the edges of the plateau may intersect more erodible soils or subsoils (i.e. medium risk), and detailed design of retention structures and discharge works down escarpments and into receiving waterways should consider these risks.

In addition to better informing the risk profile by undertaking intrusive investigations, controls may include backfill of linear infrastructure by methods designed to prevent tunnel erosion, avoidance (where possible) of installation of linear infrastructure underground, and minimisation of disturbance to topsoil.

8.3.2.2 RISK ON ESCARPMENTS

Based on the findings of the literature review and site walkover, in accordance with the adopted soil erosion risk scheme (Section 8.2), the Precinct soil erosion risk (surface soil) along the escarpments was assessed as **High Risk**. See Figure 9 in Appendix A for the erosion risk map (buildings and infrastructure).

The conditions of the escarpment or gully should be carefully considered when placing infrastructure such as piping for stormwater. The steepness, degree of vegetation, and level of erosion present should inform whether development would increase erosion and whether the gully is acceptable for development (e.g. diversion to a more suitable discharge pathway should be considered).

The increase in impermeable surfaces due to development leading to increased surface runoff is a high risk to the escarpments. Controls should be in place to capture and re-use or dispose of additional volumes of stormwater. Methods as such re-use of stormwater for watering vegetation in public spaces should be considered. This in turn will also help maintain topsoil cover. Other controls such as piping stormwater into retention basins and then into downstream waterways may be considered as long as gullies are properly assessed for suitability or engineered to minimise erosion.

8.3.3 EROSION RISK (WATER QUALITY)

8.3.3.1 RISK ON PLATEAU

Based on the findings of the literature review and site walkover, in accordance with the adopted soil erosion risk scheme (Section 8.2), the Precinct soil erosion risk (surface soil) on the plateau was assessed as **Low – Medium Risk**. See Figure 10 in Appendix A for the erosion risk map (water quality).

The risks on the plateau to the water quality will largely involve increases in surface runoff which may impact waterways. This is likely to be low post-construction and away from the escarpment (maintained exposed soil surfaces, impermeable roadways, etc.).

The risk to water quality is higher during construction (i.e. medium risk), where topsoils are disturbed, and sediment transport potential is increased. Application of best practice stormwater management during construction will be important, and may include consideration of staging of works, early reinstatement of topsoils, stabilisation of exposed soils (e.g. spray seeding, matting, filter socks, etc.), and ensuring stormwater controls are in place prior to commencement of lot-scale development.

Post construction, good management of surface runoff involving water sensitive urban design (e.g., re-use on site, retention storage and infiltration where appropriate) will assist in improving downstream water quality. Understanding the stormwater flow directions and expected volumes will be important in managing stormwater within the precinct.

8.3.3.2 RISK ON ESCARPMENTS

Based on the findings of the literature review and site walkover, in accordance with the adopted soil erosion risk scheme (Section 8.2), the Precinct soil erosion risk (surface soil) along the escarpments was assessed as **High Risk**. See Figure 10 in Appendix A for the erosion risk map (water quality).

As mentioned above, controlling the increased surface runoff to minimise the increase of erosion and sediment load into downstream waterways should be a priority. Due to the dispersive soils present along the escarpments and gullies increases in stormwater runoff will likely negatively impact water quality in downstream waterways.

Controls may include typical riparian land management (exclusion of stock, establishment, and protection of riparian vegetation, weed and pest control), stormwater treatment/settlement to minimise sedimentation, and stormwater retarding to manage peak and total flows within waterways.

8.4 ASSUMPTIONS AND LIMITATIONS OF THE ASSESSMENT

This soil erosion risk and assessment has been based upon a literature review and site visit. The risk ranking is general in nature and has been assessed at a Precinct scale.

Overall, the dataset provided was considered adequate for the purposes of this precinct level assessment of sodicity and erosion risk:

- The Werribee Formation samples are mainly taken along the southern boundary of the precinct and so we have made assumptions on the risk presented by the Werribee Formation from this somewhat limited data.
- Mapping of the extents of the two main units (Newer Volcanics and Werribee Formation) is only available at broad scale (being based on the Geological Survey of Victoria, 1985 *1:50,000 Bacchus Marsh* geological map). We have assumed that the mapped units at this scale are a true reflection of the actual site conditions.
- At the precinct planning level, variations in geological conditions and erosion conditions can be integrated conservatively into the precinct planning process; however, at a development scale these variations may impact engineering controls required or the ability to construct particular infrastructure.

Further works have been recommended based on the findings of this assessment (see Section 9.5), which will further inform the risk profile at the Precinct and enable appropriate control of planning/design of infrastructure to meet the objectives of the Precinct Planning process underway.

8.5 KEY CONSIDERATIONS FOR THE VPA PLANNING PROCESS FOR MERRIMU

8.5.1 PRECINCT SCALE

Waterway and gully management: Ongoing control and maintenance steep slopes (particularly waterways/gullies and easement where infrastructure is built) along the escarpment, and outside of the precinct boundary may be implemented at the **statutory level** by applying an environmental overlay (or equivalent) to require/encourage particular management in these areas (e.g. enforce riparian land management controls, minimise disturbance to native vegetation, etc.). At the **strategic level**, this land could be incorporated into the precinct to enable developer control over greenspace development/establishment.

Topsoil and urban run-off management: To minimise the risks during and post construction, **strategic controls** may include implementing water sensitive urban design in the precinct, and **statutory controls** may include specifying conservative stormwater retention and discharge parameters to reduce impact to waterways to acceptable levels (as established by others).

Greenspace and buffer zones: The **strategic** implementation of a green corridor along the escarpment has the dual benefit of improving land management (e.g. vegetation, minimise disturbance of topsoils) along the highest risk part of the precinct, and preventing the construction of housing too close to the edge of the plateau (risk of future structural damage).

8.5.2 DEVELOPMENT OR LOT SCALE

Erosion risk is highest along the escarpment and in steeply sloping areas (note: mostly outside the precinct boundary), is impacted by the generally thin topsoil across the precinct, and the nature of the infrastructure to be built.

Planning permit conditions may be considered for stages/tranches of the development to ensure appropriate consideration of soil erosion risk management, protection of topsoil and water quality, and appropriate design of engineered structures that take into consideration erosion risks and impact on future maintenance requirements.

Strategic controls may include:

- Staging release of development to reduce compounding risks arising from multiple development fronts across the precinct resulting in large areas of exposed soils and disturbed vegetation. This may be mitigated by careful construction controls informed by intrusive testing and appropriate runoff and sedimentation control.
- Consideration of development that is sympathetic to the landform – avoiding terracing, minimising cut-and-fill, selection of less intrusive foundation systems – particularly on the margins of the plateau (where capping Newer Volcanics is expected to be thin), on steep slopes, and within the Werribee formation.

Statutory conditions may include:

- Requirement for an erosion control management plan addressing risks and providing best-practice mitigations and which has been endorsed by a suitably qualified professional (e.g. a certified professional in erosion and sediment control or soil science).
- Requirement for intrusive (physical) soil investigations where constructions are deemed medium to high risk (e.g. along the escarpment, steep slopes, or where infrastructure is likely to be placed within the Werribee formation) to confirm soil conditions and erosion risk (driven by dispersivity).
- A general condition for a minimum thickness of topsoil to be retained or placed in exposed soil areas (nature strips, yards, parks, etc.) to provide a suitable depth of growing media to support vegetation growth and cover.

9 CONCLUSIONS

9.1 PRECINCT CONTEXT

The Merrimu precinct is located northeast of Bacchus Marsh town centre approximately 46 km northwest of Melbourne and covers an area of approximately 1,016 hectares. The precinct is bounded by the existing Darley neighbourhood and Gisborne Road to the west, Bences Road to the north, Possumtail Run and Pyrites Creek to the east, and Lerderderg Park Road and the Western Freeway to the south. The precinct is proposed to provide accommodation for approximately 5,900 to 6,700 households and up to 1,800 jobs, requiring extensive development to occur.

Most of the precinct is situated on a plateau, understood to comprise Newer Volcanics (3.5 to 4 million years old) clay and basalt, which acts as a cap over the underlying (and surrounding) alluvial white to grey clays, sands and gravels of the Werribee Formation (5.3 to 56 million years old). Beneath the Werribee Formation is the Ordovician aged (444 to 488 million years old) Castlemaine Group which comprises of slate, shale, siltstone, and sandstone and outcrops predominantly in the lowest slopes of the escarpment, particularly along Pyrites Creek but also at the western boundary of the precinct.

The thickness of the Newer Volcanics is likely less than 20 m in the Merrimu precinct and has been eroded away on the scarps surrounding the plateau where the Werribee Formation can be seen at the surface.

9.2 PREVIOUS STUDIES

A large number of assessments have been completed for the Merrimu precinct, focussing on geotechnical constraints, extent of sodic and dispersive soils, impacts of development on stormwater and options for managing discharge to within likely constraints (flow volumes).

The work completed identified risks associated with the presence of sodic and dispersive soils (particularly of the Werribee formation), gully erosion (existing and potential impact resulting from development) and thin topsoils.

The work identified erosion risks were particularly associated with stormwater discharge and steep slopes along the escarpment, and that stringent controls would be required to control risk posed by the development.

Recommendations ranged from non-development of the plateau (due to stormwater run-off restrictions) to infiltration and aquifer recharge solutions, to identifying suitable discharge pathways where gully condition was acceptable.

Regional studies indicated that while sodic, newer volcanics clay soils tend to settle quickly if eroded, reducing risk to water quality, and Werribee formation soils were identified as of particular concern on steep slopes.

A site visit undertaken by WSP aligned with previous findings and confirmed the desktop reviewed data that the residual soils of the Newer Volcanics present an inherently lower erosion risk than the soils of the Werribee Formation.

9.3 FINDINGS OF EXISTING DATA ANALYSIS

A re-analysis of laboratory results found that although the ESP in the Newer Volcanics is often elevated and within the sodic to very sodic range, the physical dispersity testing (Emerson aggregate and pin hole tests) typically shows this soil type to be non-dispersive or only dispersive following remoulding. In contrast, while the ESPs for Werribee Formation were generally lower than those in the Newer Volcanics (albeit still classifying as sodic soil), the physical dispersion testing (by Emerson aggregate only) showed the soil to be generally dispersive and representing a likely high risk of erosion.

Whilst the Newer Volcanics may be some metres thick in the centre of the plateau, they appear to thin on the margins and are incised in gully's and on the scarps.

Overall, the dataset provided was considered adequate for the purposes of this precinct level assessment of sodicity and erosion risk. On making conclusions and recommendations on a precinct level scale the limitation of sample distribution should be considered.

Field observations (e.g. Coffey (2020c) and Streamology (2021)) indicate variability in mapped geology (e.g. rocky vs clay, variable thickness of the capping Newer Volcanics) and erosion conditions at identified gullies along the escarpment (e.g. visible erosion vs well vegetated stable channels) within the same geological setting. At the precinct planning level, these variations can be integrated conservatively into the precinct planning process; however, at a development scale these variations may impact engineering controls required or the ability to construct particular infrastructure.

This suggests that site specific detailed investigation (including intrusive assessment) is likely to be required to inform particular controls and constraints for individual development elements (e.g. stormwater infrastructure, works within steeply sloping land, etc.).

9.4 PRECINCT SOIL EROSION CONSIDERATIONS

Under the adopted risk scheme, taking into consideration the findings of the literature review and reanalysis of available data, the soil erosion risk at the precinct was assessed as follows:

- In the context of **soil erosion:**
  - Low – Medium risk on the plateau
  - High risk on escarpment slopes
- In the context of **buildings and infrastructure:**
  - Low – Medium risk on the plateau
  - High risk on escarpment slopes
- In the context of **water quality:**
  - Low – Medium risk on the plateau
  - High risk on the escarpment slopes

The soil erosion risk and assessment has been based upon a literature review and site visit. The risk ranking is general in nature and has been assessed at a Precinct scale.

Erosion risk is highest along the escarpment and in steeply sloping areas (note: mostly outside the precinct boundary), is impacted by the generally thin topsoil across the precinct, and the nature of the infrastructure to be built.

Planning permit conditions may be considered for stages/tranches of the development to ensure appropriate consideration of soil erosion risk management, protection of topsoil and water quality, and appropriate design of engineered structures that take into consideration erosion risks and impact on future maintenance requirements.

9.5 FURTHER ASSESSMENT WORK (EROSION RISK)

Overall, the dataset provided was considered adequate for the purposes of this precinct level assessment of sodicity and erosion risk:

- The Werribee Formation samples are mainly taken along the southern boundary of the precinct and so we have made assumptions on the risk presented by the Werribee Formation from this somewhat limited data.

- Mapping of the extents of the two main units (Newer Volcanics and Werribee Formation) is only available at broad scale (being based on the Geological Survey of Victoria, 1985 *1:50,000 Bacchus Marsh* geological map). We have assumed that the mapped units at this scale are a true reflection of the actual site conditions.
- At the precinct planning level, variations in geological conditions and erosion conditions can be integrated conservatively into the precinct planning process; however, at a development scale these variations may impact engineering controls required or the ability to construct particular infrastructure.

Further works are recommended based on the findings of this assessment, which will further inform the risk profile at the Precinct and enable appropriate control of planning/design of infrastructure to meet the objectives of the Precinct Planning process underway.

1 Precinct-scale Erosion risk plans

Precinct-scale plans which highlight areas of high risk, medium risk and low risk in relation to erosion potential, were prepared as part of the assessment, to inform strategic and statutory controls.

The maps were developed based on:

- Agreed buffers from edge of plateau
- Existing gullies
- Known/inferred mapping of Werribee formation geology, and
- Slope.

WSP considers that any intrusive investigation to further refine the resolution of the maps may be better deferred to the proponent as this enables scoping to be suited to the proposed development (e.g. deep vs shallow, structural vs vegetation, etc.).

VPA should seek agreement and approval of the prepared figures (Figure 8, Figure 9 and Figure 10, **Appendix A**) to formalise these as the Precinct-scale Erosion Risk Plans for the PSP.

2 Precinct scale erosion controls

The erosion control component of the precinct structure plan (PSP) should include the following precinct scale considerations:

- **Waterway and gully management:** Ongoing control and maintenance steep slopes (particularly waterways/gullies and easement where infrastructure is built) along the escarpment, and outside of the precinct boundary may be implemented at the **statutory level** by applying an environmental overlay (or equivalent) to require/encourage particular management in these areas (e.g. enforce riparian land management controls, minimise disturbance to native vegetation, etc.). At the **strategic level**, this land could be incorporated into the precinct to enable developer control over greenspace development/establishment.
- **Topsoil and urban run-off management:** To minimise the risks during and post construction, **strategic controls** may include implementing water sensitive urban design in the precinct, and **statutory controls** may include specifying conservative stormwater retention and discharge parameters to reduce impact to waterways to acceptable levels (as established by others).
- **Greenspace and buffer zones:** The **strategic** implementation of a green corridor along the escarpment has the dual benefit of improving land management (e.g. vegetation, minimise disturbance of topsoils) along the highest risk part of the precinct, and preventing the construction of housing too close to the edge of the plateau (risk of future structural damage).

3 Development or Lot scale erosion controls

To control erosion risk during and post development, the PSP may specify strategic controls for development, or require proponents to demonstrate appropriate controls are in place as part of the planning application process (statutory conditions).

- **Strategic** controls may include:
  - Staging release of development to reduce compounding risks arising from multiple development fronts across the precinct resulting in large areas of exposed soils and disturbed vegetation. This may be mitigated by careful construction controls informed by intrusive testing and appropriate runoff and sedimentation control.
  - Consideration of development that is sympathetic to the landform – avoiding terracing, minimising cut-and-fill, selection of less intrusive foundation systems – particularly on the margins of the plateau (where capping Newer Volcanics is expected to be thin), on steep slopes, and within the Werribee formation.
- **Statutory** conditions may include:
  - Requirement for an erosion control management plan addressing risks and providing best-practice mitigations and which has been endorsed by a suitably qualified professional (e.g. a certified professional in erosion and sediment control or soil science) (i.e., control to be applied at lot or tranche level, irrespective of risk ranking).
  - Requirement for intrusive (physical) soil investigations where constructions are deemed medium to high risk (e.g. along the escarpment, steep slopes, or where infrastructure is likely to be placed within the Werribee formation) to confirm soil conditions and erosion risk (driven by dispersivity) (i.e., control to be applied in conjunction with geotechnical testing, at lot or tranche level).
  - A general condition for a minimum thickness of topsoil to be retained or placed in exposed soil areas (nature strips, yards, parks, etc.) to provide a suitable depth of growing media to support vegetation growth and cover (i.e., irrespective of risk ranking).

10 LIMITATIONS

This Report is provided by WSP Australia Pty Limited (WSP) for the Victorian Planning Authority (VPA) (Client) in response to specific instructions from the Client and in accordance with WSP's communicated scope of works dated 26 April 2022 and written agreement with the Client (Agreement) dated 7 November 2022 (Ref No: COR\22\5961).

PERMITTED PURPOSE

This Report is provided by WSP for the purpose described in the Agreement and no responsibility is accepted by WSP for the use of the Report in whole or in part, for any other purpose (Permitted Purpose).

QUALIFICATIONS AND ASSUMPTIONS

The services undertaken by WSP in preparing this Report were limited to those specifically detailed in the Report and are subject to the scope, qualifications, assumptions and limitations set out in the Report or otherwise communicated to the Client.

Except as otherwise stated in the Report and to the extent that statements, opinions, facts, conclusion and / or recommendations in the Report (Conclusions) are based in whole or in part on information provided by the Client and other parties identified in the report (Information), those Conclusions are based on assumptions by WSP of the reliability, adequacy, accuracy and completeness of the Information and have not been verified. WSP accepts no responsibility for the Information.

The Conclusions are reflective of the current Site conditions and cannot be regarded as absolute without further extensive intrusive investigations, outside the scope of the services set out in the Agreement and are indicative of the environmental condition of the Site at the time of preparing the Report. As a general principle, vertical and horizontal soil or groundwater conditions are not uniform. No monitoring, common or intrusive testing or sampling technique can eliminate the possibility that monitoring or testing results or samples taken, are not totally representative of soil and / or groundwater conditions encountered at the Site. It should also be recognised that Site conditions, including subsurface conditions can change with time due to the presence and concentration of contaminants, changing natural forces and man-made influences.

Within the limitations imposed by the scope of the services undertaken by WSP, the monitoring, testing (intrusive or otherwise), sampling for the preparation of this Report has been undertaken and performed in a professional manner in accordance with generally accepted practices, using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

WSP has prepared the Report without regard to any special interest of any person other than the Client when undertaking the services described in the Agreement or in preparing the Report.

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This Report can only be relied upon for the Permitted Purpose and may not be relied upon for any other purpose. The Report does not purport to recommend or induce a decision to make (or not make) any purchase, disposal, investment,

divestment, financial commitment or otherwise. It is the responsibility of the Client to accept (if the Client so chooses) the Conclusions and implement any recommendations in an appropriate, suitable and timely manner.

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APPENDIX A

FIGURES

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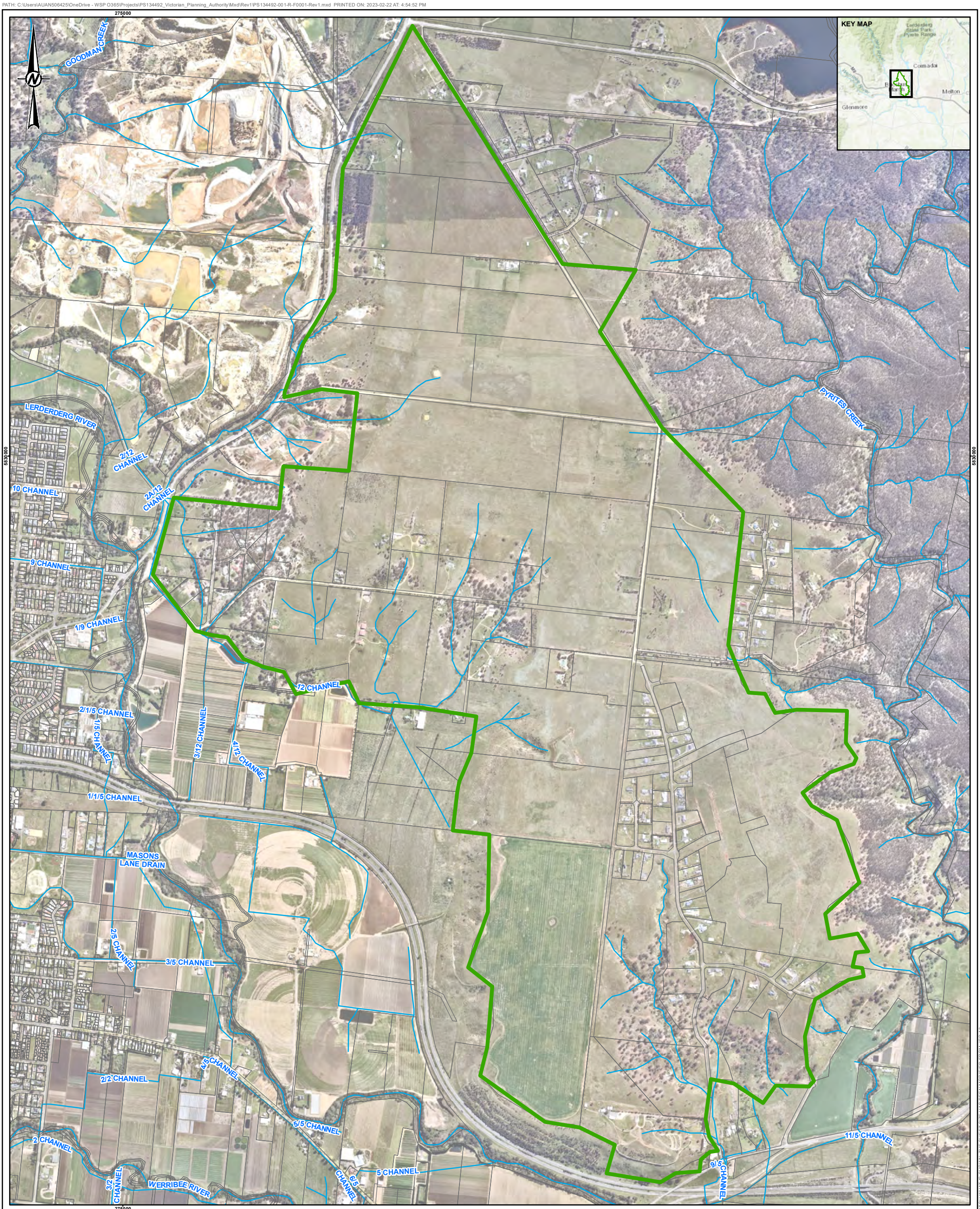

LEGEND

- Merrimu Precinct Boundary
- Parcel Boundary
- Watercourse

0 1,000

1:18,500 METRES

NOTE(S)

1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)

1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
3. Aerial imagery sourced from nearmap dated : 19/10/2022.

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TITLE
SITE LOCALITY

PROJECT NO.	CONTROL	REV.	FIGURE
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KEY MAP

DIGGERS REST-COIMADAI ROAD
BONNIE VALE ROAD
COCKATOO CREEK
DODEMAIDE CIRCUIT
MERRIMU TRACK
LONG POINT TRACK
STEEP TRACK
SALOOP TRACK
COIMADAI TRACK
COIMADAI CREEK TRACK
BUCKLEYS ROAD
BENCES ROAD
POSSUMTAIL RUN
HAPPY VALLEY TRACK
SPUR TRACK
DAVIES COURT
LINDSAY AVENUE
OLD HOUSE TRACK
OCONNELL ROAD
LERDERDERG PARK ROAD
GISBORNE ROAD
LERDERDERG GORGE ROAD
WELLS ROAD
LAWSON ROAD
HOLTS LANE
MASONS LANE
MASONS LANE DRAIN
LERDERDERG STREET
MAIN STREET
RYANS ROAD
BACCHUS MARSH ROAD
WESTERN FREEWAY
FLANAGANS DRIVE
TIPPERARY FLATS
STREETON DRIVE
CONDOR DRIVE
PYRITES CREEK
BULLDOG LANE
OLD WESTERN HIGHWAY
LERDERDERG RIVER
WERRIBEE RIVER
JODMAN CREEK
2/12 CHANNEL
2A/12 CHANNEL
1/9 CHANNEL
2/1/5 CHANNEL
3/12 CHANNEL
4/12 CHANNEL
12 CHANNEL
1/1/5 CHANNEL
1/5 CHANNEL
2/5 CHANNEL
3/5 CHANNEL
4/5 CHANNEL
2/2 CHANNEL
5/5 CHANNEL
5 CHANNEL
2 CHANNEL
9/5 CHANNEL
ALLAN DRIVE
RIVERBEND DRIVE
HARTOG GROVE
VICTORIA STREET
ALBERT STREET
BOURKE STREET
CAIN STREET
RAGLAN STREET
GREY STREET
VANCE CLOSE
DICKIE STREET
CROOK STREET
MANOR STREET
FISKEN STREET

LEGEND
- Merrimu Precinct Boundary
- Parcel Boundary
- Watercourse

Topographic surface elevation
- High : 218.185
- Low : 82.1826

0 1,000
1:18,500 METRES

NOTE(S)
1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)
1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
3. Aerial imagery sourced from nearmap dated : 19/10/2022.
4. DEM for topography is sourced from ELVIS (10M DEM).

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TITLE
TOPOGRAPHIC MAP

PROJECT NO.	CONTROL	REV.	FIGURE
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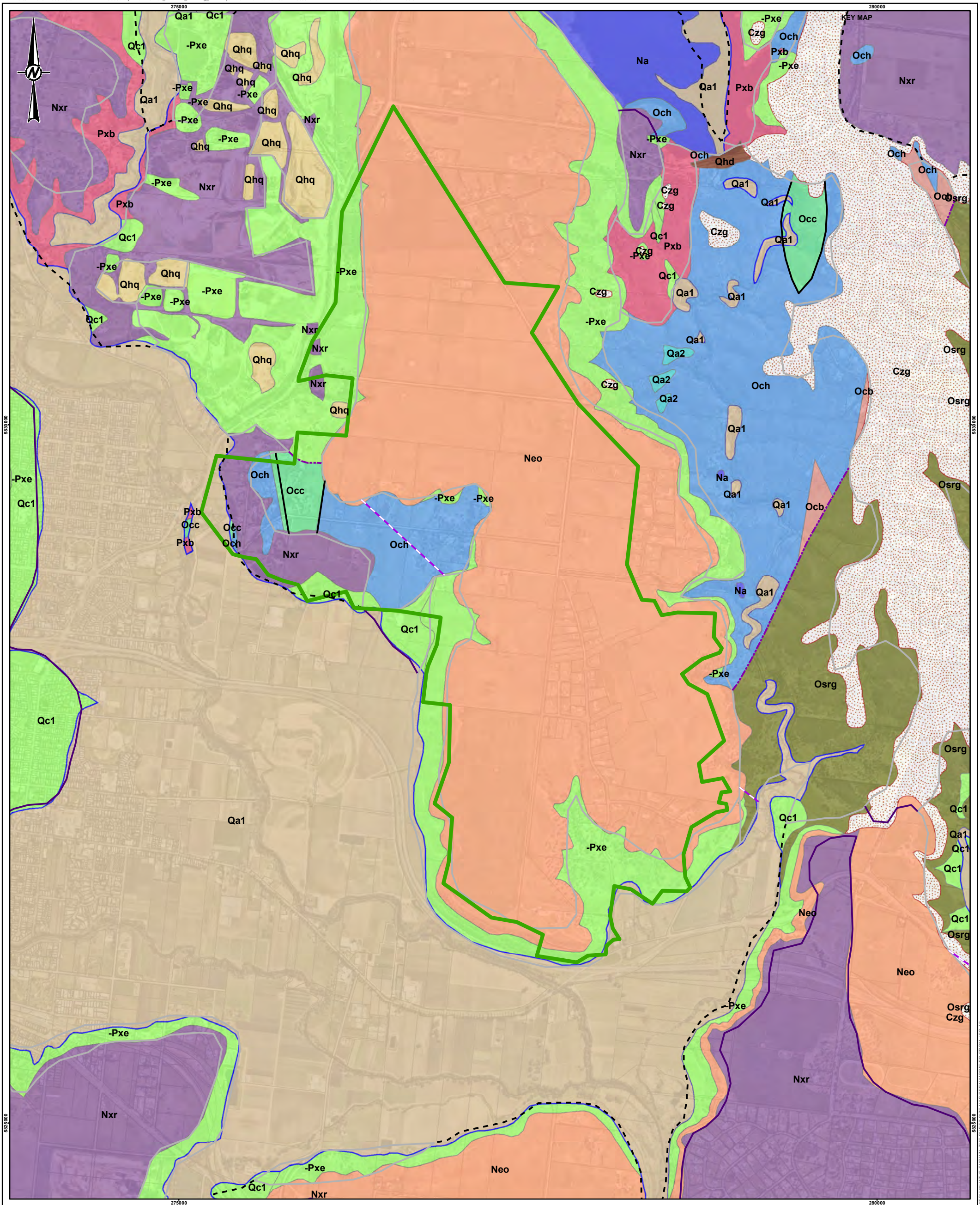

LEGEND

- Merrimu Precinct Boundary

Geology

- Werribee Formation (-Pxe)
- Altona Coal Seam (-Pxea)
- conglomerate and sandstone (Czg)
- Incised alluvium (Na): generic
- Newer Volcanic Group - basalt flows (Neo)
- Darley Gravel (Nxr)
- Castlemaine Group - Bendigonian(Ocb)
- Castlemaine Group - Castlemainian(Occ)
- Castlemaine Group - Chewtonian(Och)
- Riddell Sandstone Gisbornian(Osrg)
- Bacchus Marsh Formation (Pxb)
- Alluvium(Qa1)
- Colluvium(Qc1)
- Dam wall deposits (Qhd)
- Quarry waste deposits (Qhq)
- Alluvial terrace deposits(Qa2)

Geological Structure

- conformity
- disconformity
- fault
- faulted contact
- geological unit boundary
- unconformity

0 1,000

1:25,000 METRES

NOTE(S)

1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)

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2. Property and road data sourced from VIC Map.
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TITLE
GEOLOGICAL MAP

PROJECT NO.	CONTROL	REV.	FIGURE
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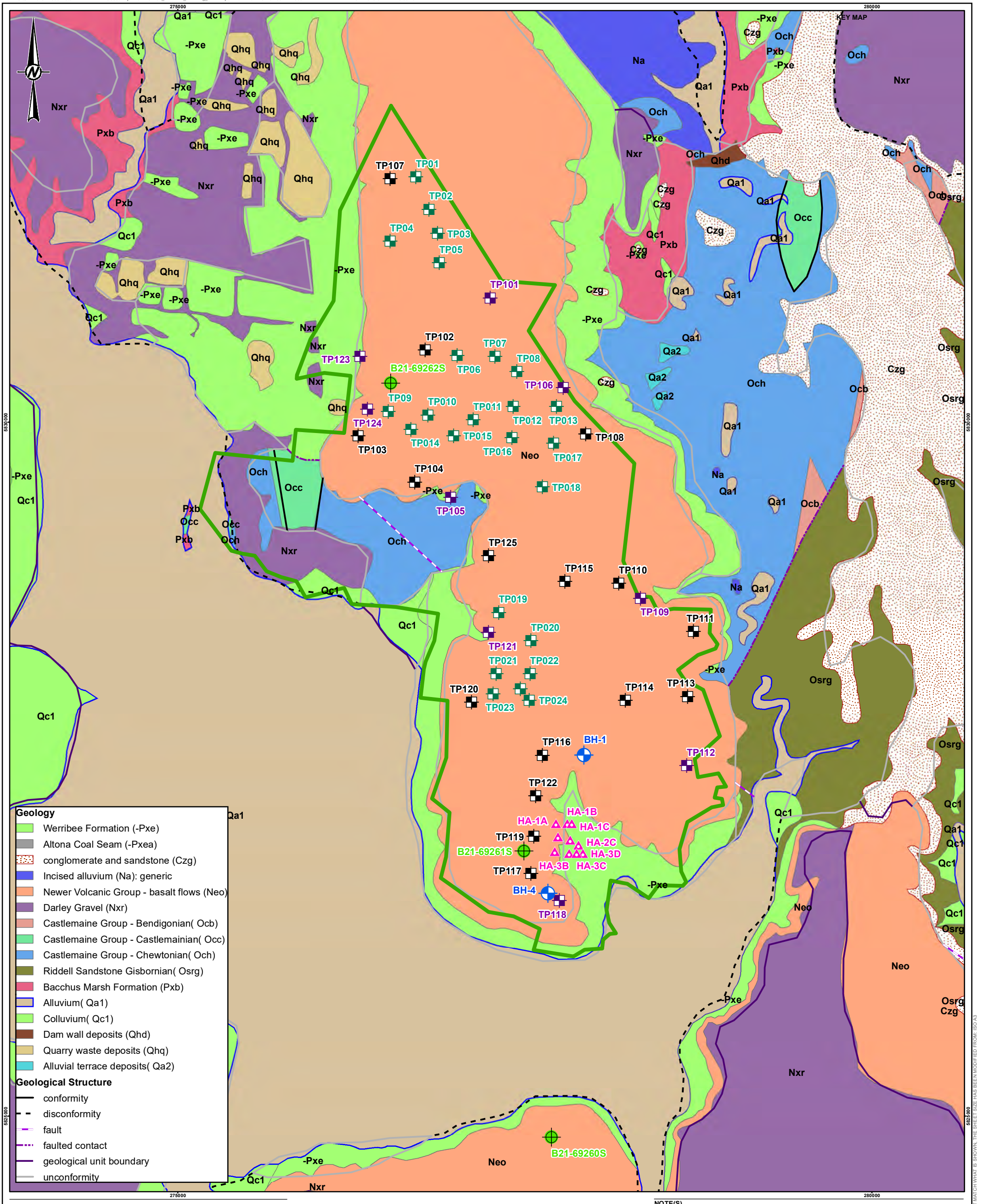

LEGEND

- Marrimu Precinct Boundary
- Borehole
- Borehole + Standpipe
- Previous Test Pit
- Shallow Sample
- Target Test Pit
- Test Pit

0 1,000

1:25,000 METRES

NOTE(S)

1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)

1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
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TITLE
SAMPLE LOCATIONS WITH GEOLOGY

PROJECT NO.	CONTROL	REV.	FIGURE
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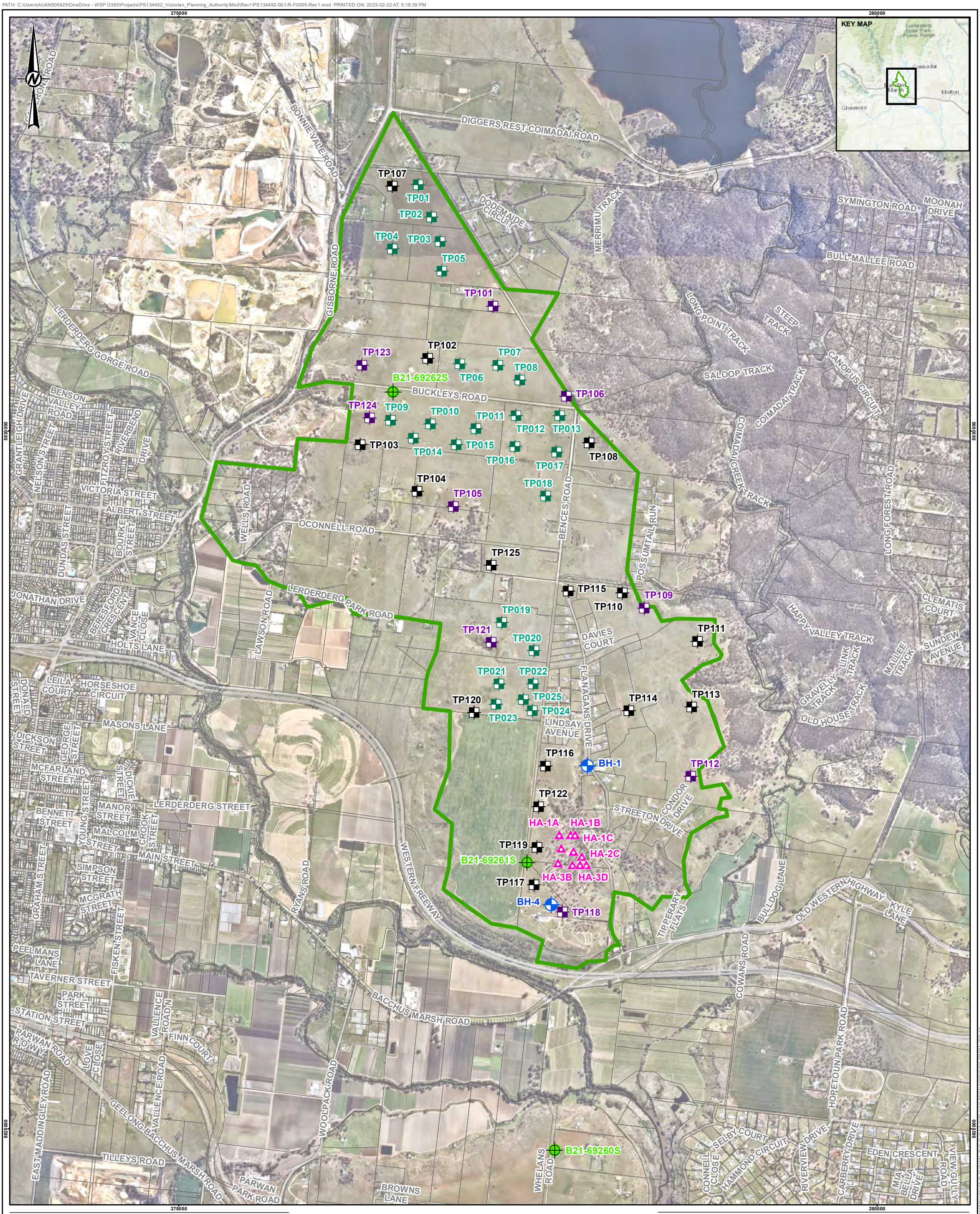

LEGEND

- Merrimu Precinct Boundary
- Parcel Boundary
- Previous Test Pit
- Shallow Sample
- Target Test Pit
- Test Pit
- Borehole
- Borehole + Standpipe

0 1,000
1:25,000 METRES

NOTE(S)
1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)
1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
3. Aerial imagery sourced from nearmap dated : 19/10/2022.

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TITLE
SAMPLE LOCATIONS WITH AERIAL IMAGE

PROJECT NO.	CONTROL	REV.	FIGURE
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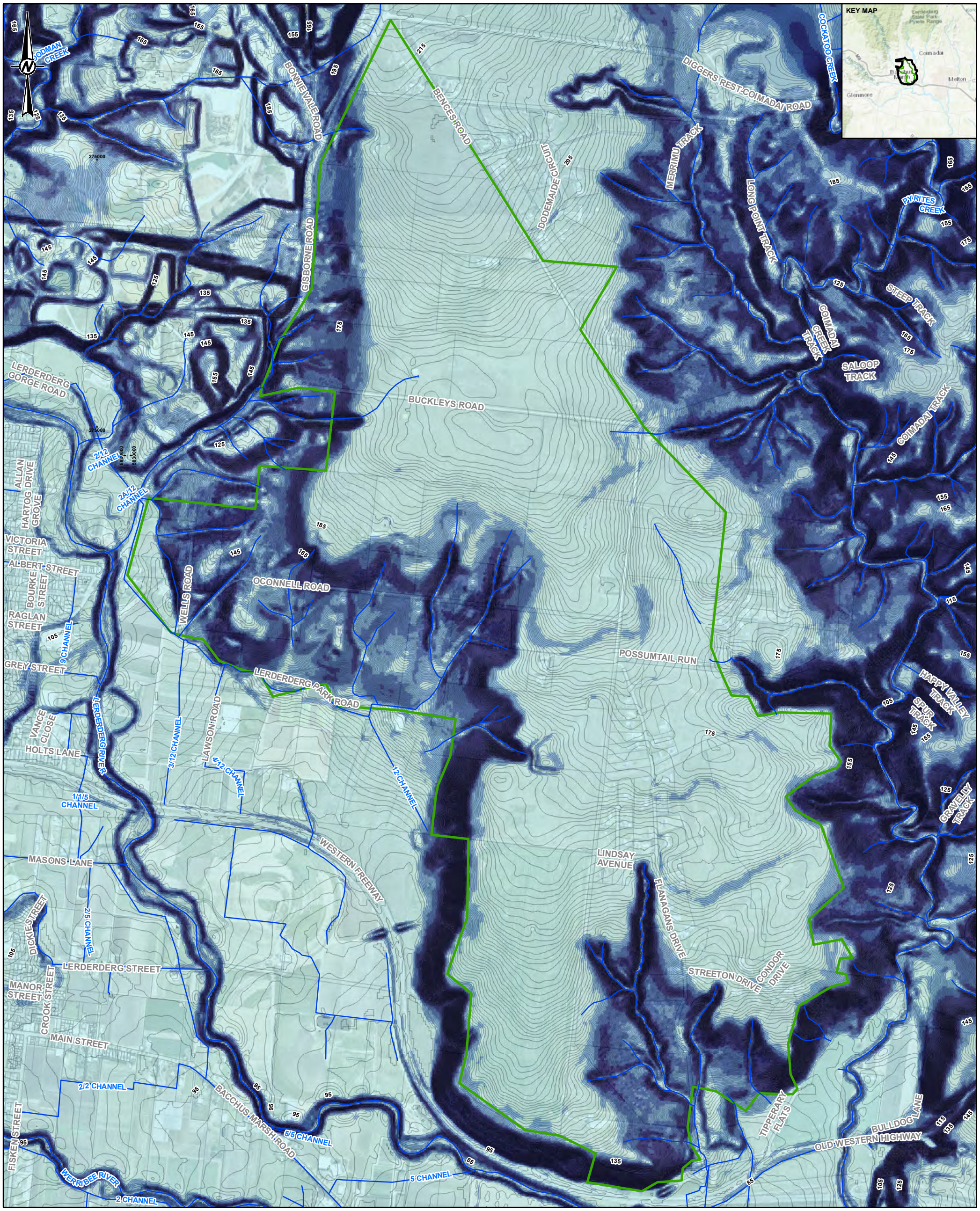

LEGEND

- Merrimu Prrecinct Boundary
- Parcel Boundary
- Watercourse
- Topographic Contours (1m)

Slope

- 0 - 5%
- 5 - 10%
- 10 - 15%
- >15%

0 1,000

1:18,500 METRES

NOTE(S)

1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)

1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
3. Aerial imagery sourced from nearmap dated : 19/10/2022.
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TITLE
TERRAIN SLOPE MAP

PROJECT NO.	CONTROL	REV.	FIGURE
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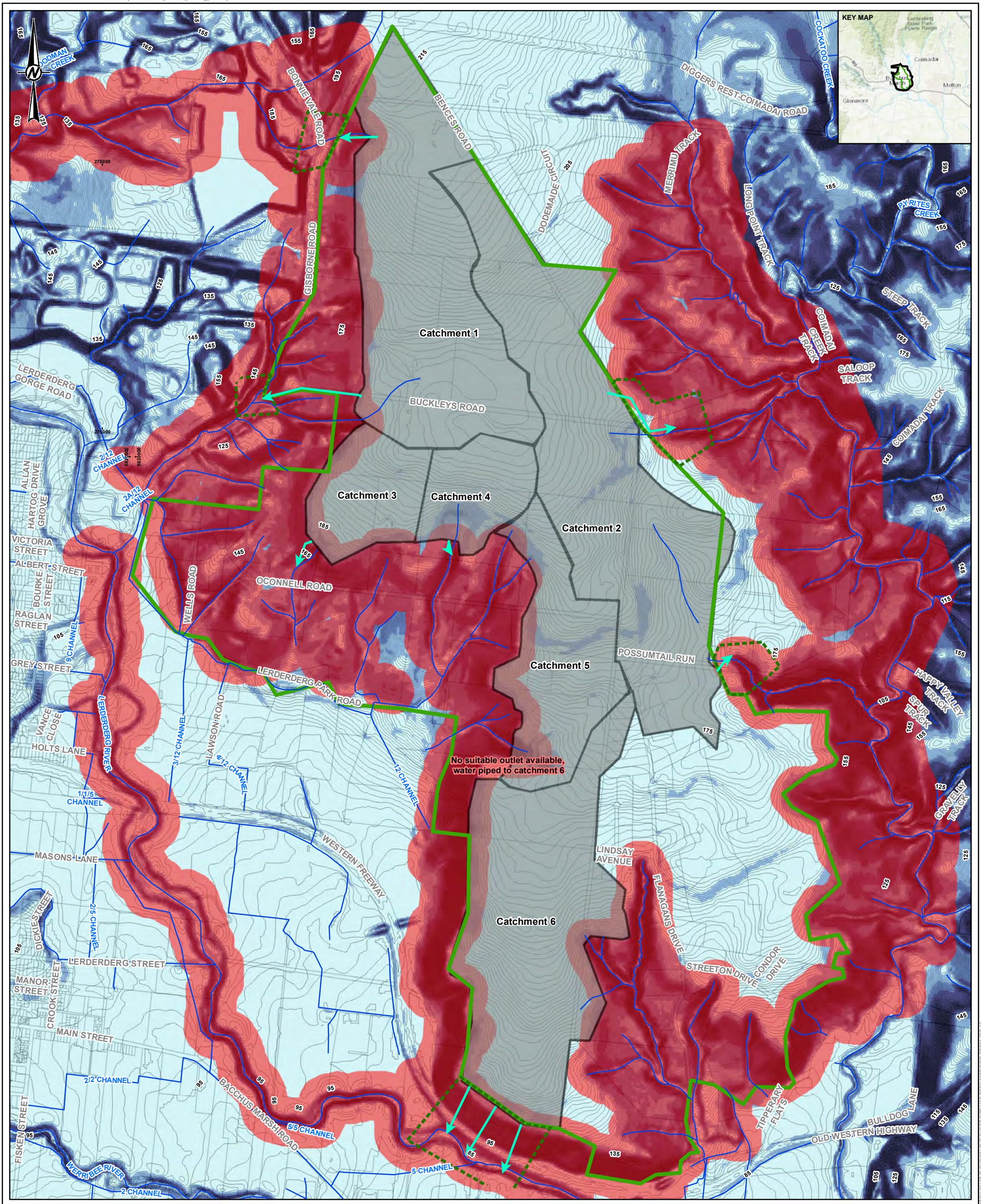

LEGEND

- Merrimu Precinct Boundary
- Parcel Boundary
- Watercourse
- Topographic Contours (1m)

Slope

- 0 - 5%
- 5 - 10%
- 10 - 15%
- >15%
- High risk slopes, escarpment, and steep banks (slope > 15%, plus 100 meter buffer)

- Potential stormwater discharge outlets (Rain, 2022)
- Proposed Stromwater Catchments (Rain,2022)
- Indicative Stormwater Infrastructure Footprint

0 1,000

1:18,500 METRES

NOTE(S)
1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)
1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
3. DEM for topography is sourced from ELVIS (10M DEM).

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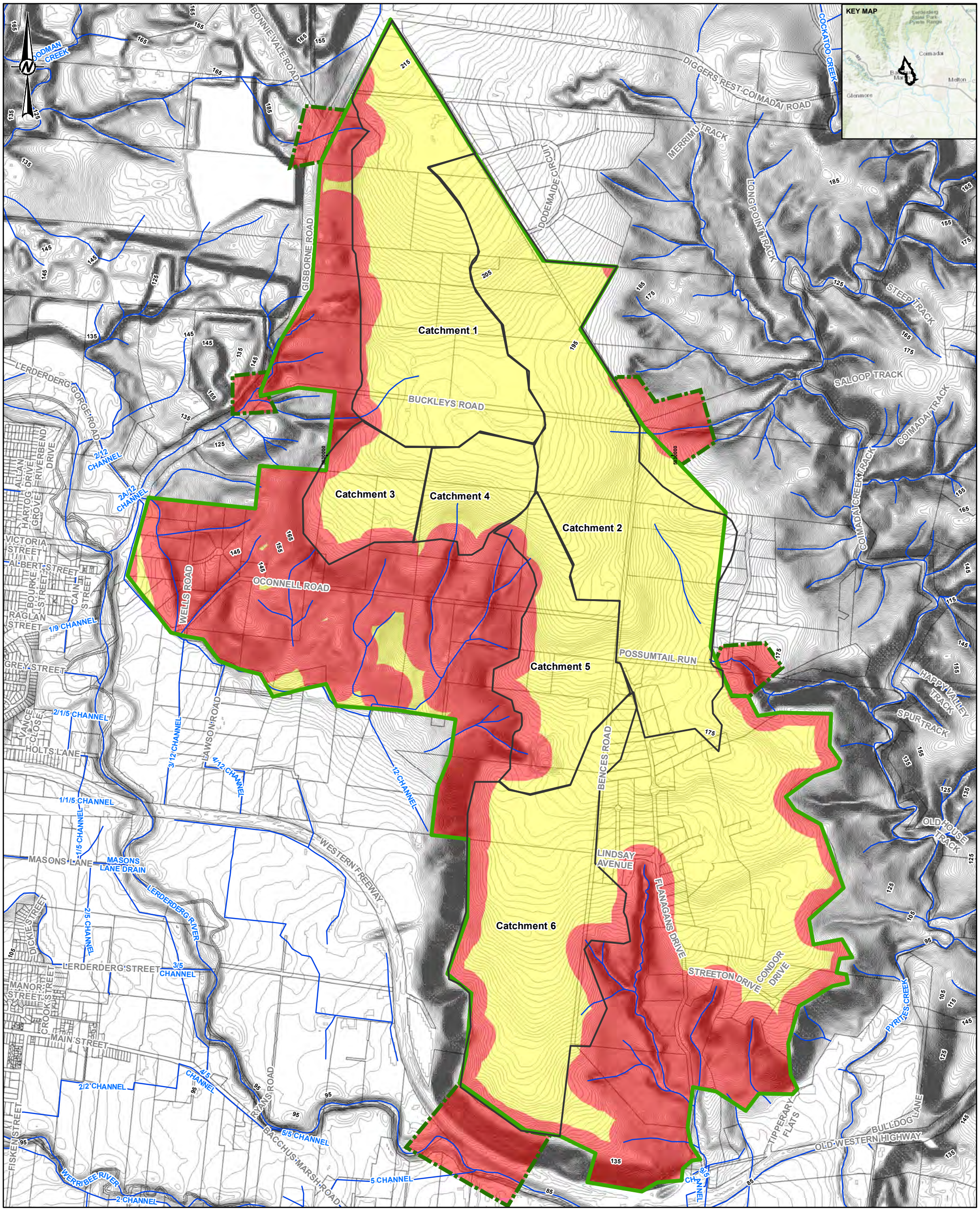
TITLE
HIGH RISK SLOPE MAP (INCLUDING 100 METER BUFFER, KEY WATER-WAYS)

PROJECT NO.	CONTROL	REV.	FIGURE
PS134492	001	1	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
0 25mm



LEGEND

- Merrimu Precinct Boundary
- Parcel Boundary
- Watercourse
- Topographic Contours (1m)
- Proposed Stormwater Catchments (Rain, 2022)
- Indicative Stormwater Infrastructure Footprint
- Low to medium risk
- High risk

0 1,000
1:18,500 METRES

NOTE(S)
1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)
1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.

CLIENT
VICTORIAN PLANNING AUTHORITY (VPA)

CONSULTANT
wsp

YYYY-MM-DD	2023-02-23
DESIGNED	AN
PREPARED	AN
REVIEWED	SG
APPROVED	SG

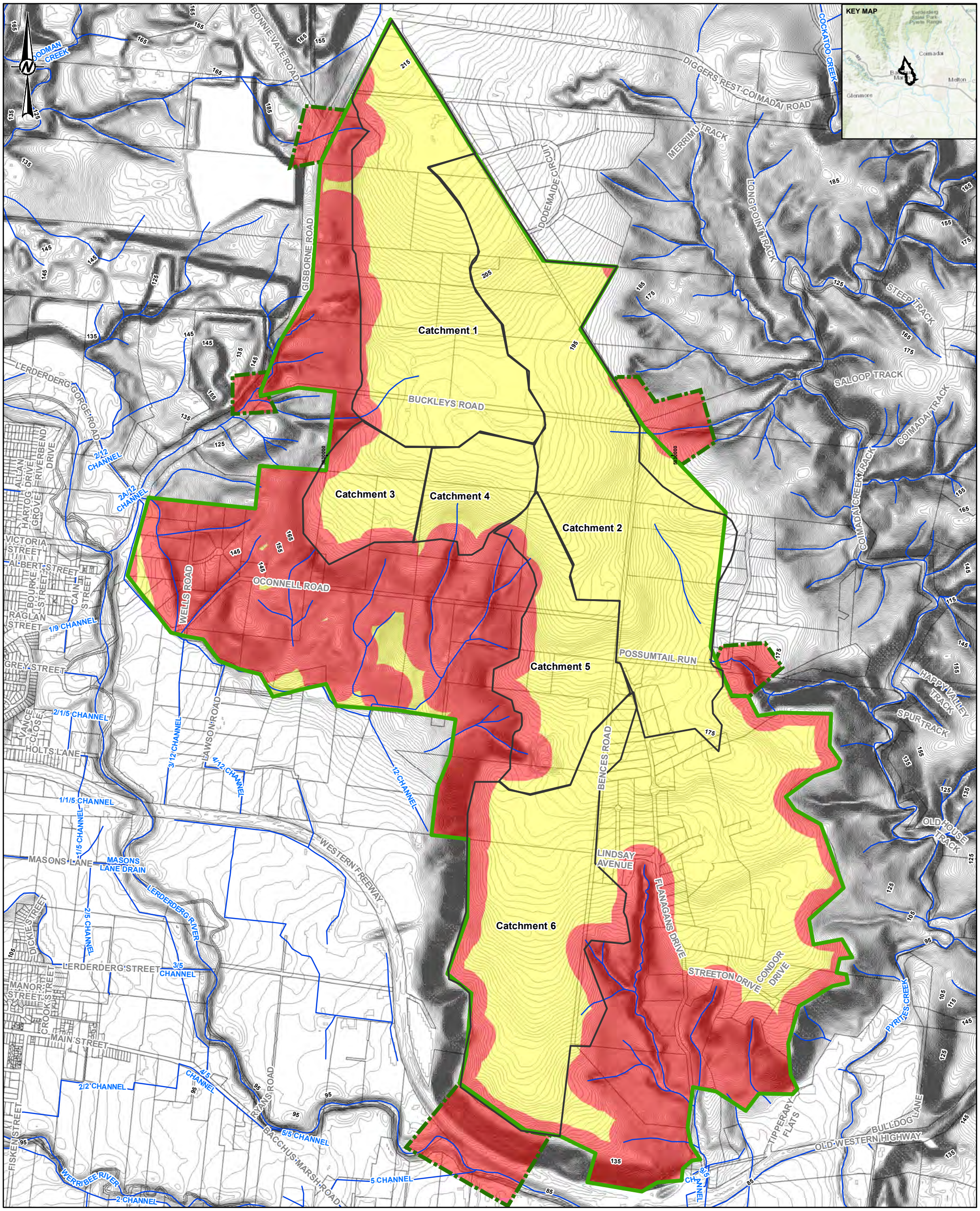
PROJECT
VICTORIAN PLANNING AUTHORITY (VPA)

TITLE
EROSION RISK MAP : SOIL

PROJECT NO.	CONTROL	REV.	FIGURE
PS134492	001	1	8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
0 25mm

PATH: C:\Users\AUAN506425\OneDrive - WSP O365\Projects\PS134492_Victorian_Planning_Authority\Mxd\Rev1\PS134492-001-R-F0009-Rev1.mxd PRINTED ON: 2023-02-23 AT: 12:23:41 PM



LEGEND

- Merrimu Precinct Boundary
- Parcel Boundary
- Watercourse
- Topographic Contours (1m)
- Proposed Stormwater Catchments (Rain, 2022)
- Indicative Stormwater Infrastructure Footprint
- Low to medium risk
- High risk

0 1,000

1:18,500 METRES

NOTE(S)
1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)
1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.

CLIENT
VICTORIAN PLANNING AUTHORITY (VPA)

PROJECT
VICTORIAN PLANNING AUTHORITY (VPA)

CONSULTANT
wsp

YYYY-MM-DD	2023-02-23
DESIGNED	AN
PREPARED	AN
REVIEWED	SG
APPROVED	SG

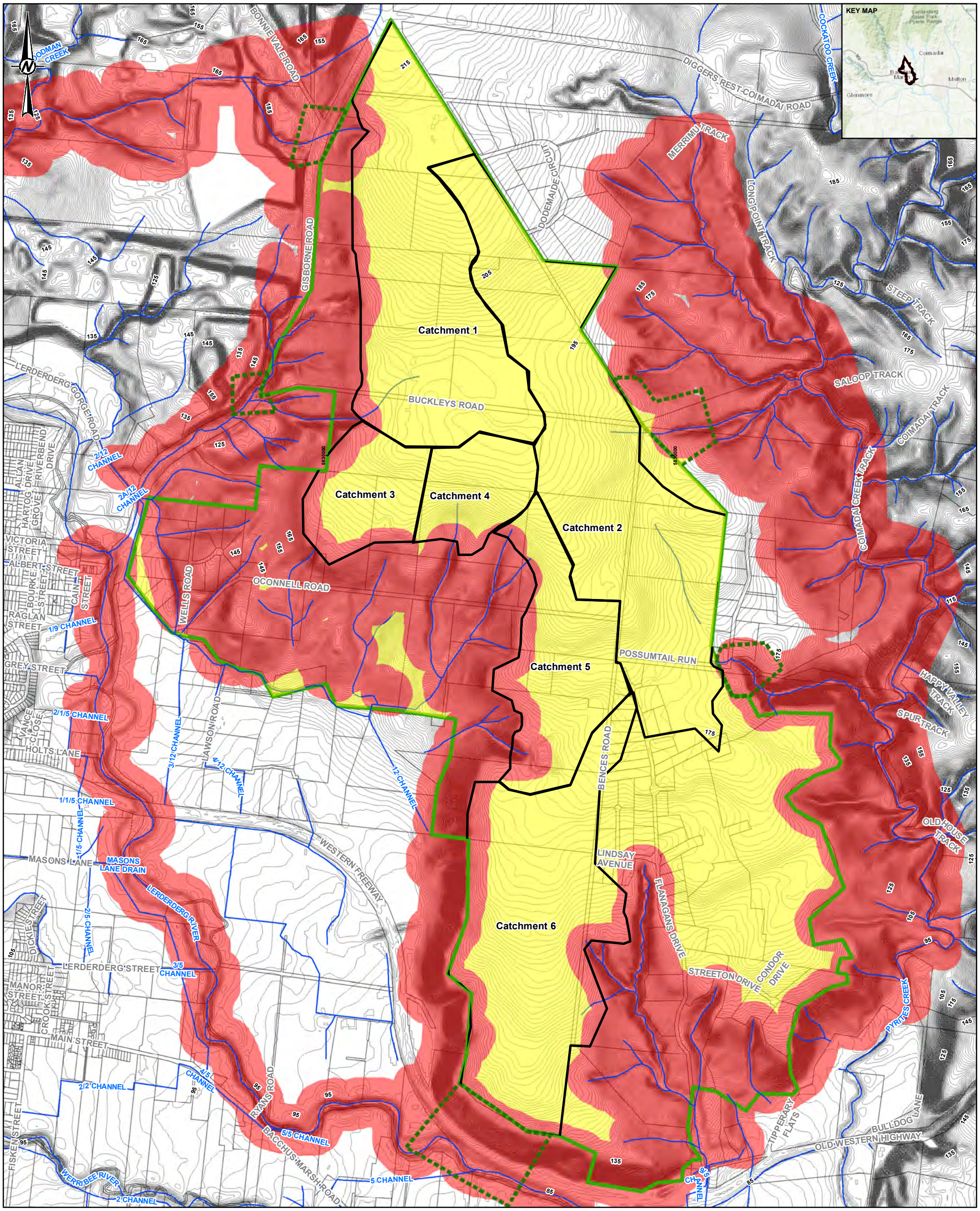
TITLE
EROSION RISK MAP : BUILDING AND INFRASTRUCTURE

PROJECT NO.	CONTROL	REV.	FIGURE
PS134492	001	1	9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

0 25mm

PATH: C:\Users\AUAN506425\OneDrive - WSP O365\Projects\PS134492_Victorian_Planning_Authority\Mxd\Rev1\PS134492-001-R-F00010-Rev1.mxd PRINTED ON: 2023-02-23 AT: 12:22:38 PM



LEGEND

- Merrimu Precinct Boundary
- Parcel Boundary
- Watercourse
- Topographic Contours (1m)
- Proposed Stromwater Catchments (Rain,2022)
- Indicative Stormwater Infrastructure Footprint
- Erosion risk: Low to medium risk
- Erosion risk : High risk

0 1,000

1:18,500 METRES

NOTE(S)
1. Projection: GDA2020 MGA Zone 55

REFERENCE(S)
1. Key map sourced from ESRI online Basemap.
2. Property and road data sourced from VIC Map.
3. DEM for topography is sourced from ELVIS (10M DEM).

CLIENT
VICTORIAN PLANNING AUTHORITY (VPA)

CONSULTANT
wsp

YYYY-MM-DD	2023-02-23
DESIGNED	AN
PREPARED	AN
REVIEWED	SG
APPROVED	SG

PROJECT
VICTORIAN PLANNING AUTHORITY (VPA)

TITLE
EROSION RISK MAP : WATER QUALITY

PROJECT NO.	CONTROL	REV.	FIGURE
PS134492	001	1	10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

0 25mm

APPENDIX B

PHOTOGRAPHS

wsp	**PHOTOGRAPHIC LOG – Site Visit (Appendix B)**

Client Name	**Site Location**	**Project No.**
Victorian Planning Authority	Merrimu Precinct	PS134492

Photo No.	**Date**
1	15 November 2022

Description

Looking northeast from Lerderderg Park Road.
Thin topsoil and erodible sediments visible in dam cutting.

Photo No.	**Date**
2	15 November 2022

Description

Looking east from Lerderderg Park Road to escarpment in distance.
Evidence of major erosion control plantings on escarpment, terracing.

	PHOTOGRAPHIC LOG – Site Visit (Appendix B)	
Client Name Victorian Planning Authority	**Site Location** Merrimu Precinct	**Project No.** PS134492

Photo No.	**Date**
3	15 November 2022

Description

Photo taken on Wells Road, showing erodible road treatment and gully erosion in underlying sediments.

Photo No.	**Date**
4	15 November 2022

Description

Photo taken on Wells Road, showing erodible road treatment and gully erosion in underlying sediments. Rudimentary engineering controls show some success in stabilizing sediments.

	PHOTOGRAPHIC LOG – Site Visit (Appendix B)	
Client Name Victorian Planning Authority	**Site Location** Merrimu Precinct	**Project No.** PS134492

Photo No.	**Date**
5	15 November 2022

Description

Looking east from the east end of Oconnel Road.
Exposed sediments show erosion where vegetation is absent. Further up and down gradient, gully appears stabilized with vegetation (trees, grass, scrub).
This area not fenced, stock not excluded, no riparian management visible.

Photo No.	**Date**
6	15 November 2022

Description

View of gully from driveway east of Possumtail Run.
Upper unit interpreted to be Newer Volcanics, lower unit (not exposed) is inferred to be Werribee formation.

wsp	**PHOTOGRAPHIC LOG – Site Visit (Appendix B)**

Client Name	**Site Location**	**Project No.**
Victorian Planning Authority	Merrimu Precinct	PS134492

Photo No.	**Date**
7	15 November 2022

Description

View of same gully from driveway east of Possumtail Run.
Upper unit interpreted to be Newer Volcanics, lower unit (exposed) is inferred to be Werribee formation.
Highly dispersive zone appears to be close to base of Newer Volcanics, given base of gully is well vegetated.

APPENDIX C

BOREHOLE LOGS – COFFEY AND DEPARTMENT OF TRANSPORT

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Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
		SILTS & CLAYS Liquid limit less than 50	**DRY STRENGTH**	**DILATANCY**	**TOUGHNESS**			
			None to Low	Quick to slow	None		ML	SILT
			Medium to High	None	Medium		CL	CLAY
			Low to medium	Slow to very slow	Low		OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium		MH	SILT
			High	None	High		CH	CLAY
			Medium to High	None	Low to medium		OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit W_L less than 35%. • Modium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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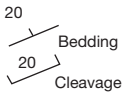
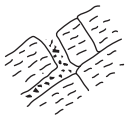
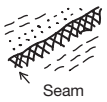
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS	
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS	
Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS	
Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS	
Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

72710 / 07-06

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Engineering Log - Borehole

Borehole ID.	**BH-1**
sheet:	1 of 3
project no.	**754-MELGE233440.1**
client:	**Creo Consultants**
date started:	**05 Oct 2020**
principal:	
date completed:	**05 Oct 2020**
project:	**Merrimu Precinct**
logged by:	**FR**
location:	**Refer to Figure 1**
checked by:	**MJ**

position: E: 277920; N: 5827607 (Datum Not Specified) surface elevation: 161.40 m (Datum Not Specified) angle from horizontal: 90°

drill model: Hanjin D&B, Track mounted drilling fluid: Polymer hole diameter : 110 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description **SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD N		Not Encountered		161	1.0		CH	**CLAY**: high plasticity, brown, with coarse grained basalt, and cobbles and boulders.	M	VSt		**NEWER VOLCANICS**
				160	2.0			Borehole BH-1 continued as cored hole				
				159	3.0							
				158	4.0							
				157	5.0							
				156	6.0							
				155	7.0							
				154								

CDF_0_9_07_LIBRARY.GLB rev:AU Log COF BOREHOLE: NON CORED 754-MELGE233440.1 MJ.GPJ <<DrawingFile>> 04-11-2020 10:38

method
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- HQ3 HQ3 core barrel (61.1mm)

* bit shown by suffix
e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH-1**
sheet:	2 of 3
project no.	**754-MELGE233440.1**
client: **Creo Consultants**	date started: **05 Oct 2020**
principal:	date completed: **05 Oct 2020**
project: **Merrimu Precinct**	logged by: **FR**
location: **Refer to Figure 1**	checked by: **MJ**

position: E: 277920; N: 5827607 (Datum Not Specified) surface elevation: 161.40 m (Datum Not Specified) angle from horizontal: 90°
drill model: Hanjin D&B, Track mounted drilling fluid: Polymer hole diameter : 110 mm

drilling information				material substance					rock mass defects			
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular	general
		161	1.0		started coring at 1.20m							
HQ	Not Encountered	160	2.0		**BASALT**: grey, 1-5% vesicular, vesicles up to 15 mm.	SW		a=6.02 d=1.34	50% 64%		JT, 70°, IR, RO, SN SM, 20°, Clay, 10 mm	
		159						a=6.73 d=9.06				
		158	3.0		**NO CORE:** 0.40 m				0%		SM, 10°, Clay, 10 mm SM, 60°, Clay, 30 mm	
		157	4.0		**BASALT**: as above.	SW		a=7.75 d=6.72	0%			
		156	5.0		**NO CORE:** 0.30 m **BASALT**: as above. becoming grey and brown, with weathered joints	SW DW			0% 0%			
		155	6.0		**NO CORE:** 0.10 m **BASALT**: grey and brown, with weathering on joints. **NO CORE:** 0.10 m **BASALT**: as above. **NO CORE:** 0.10 m **BASALT**: as above.	DW DW DW		a=1.88	0% 0% 0%		Defects are: JT, 0 - 30°, IR, RO - VR, CN - CO, unless otherwise described	
		154	7.0					a=8.22	0%			

CDF_0_9_07_LIBRARY.GLB rev:AU Log COF BOREHOLE: CORED 754-MELGE233440.1 MJ.GPJ <<DrawingFile>> 04-11-2020 10:39

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
RR rock roller
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
HQ3 HQ3 core barrel (61.1mm)

support
C casing M mud N none

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SS shear surface
SZ shear zone
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
VR very rough
RO rough
SO smooth
POL polished
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating

coffey
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Engineering Log - Cored Borehole

Borehole ID.	**BH-1**
sheet:	3 of 3
project no.	**754-MELGE233440.1**
client:	**Creo Consultants**
date started:	**05 Oct 2020**
principal:	
date completed:	**05 Oct 2020**
project:	**Merrimu Precinct**
logged by:	**FR**
location:	**Refer to Figure 1**
checked by:	**MJ**

position: E: 277920; N: 5827607 (Datum Not Specified) surface elevation: 161.40 m (Datum Not Specified) angle from horizontal: 90°

drill model: Hanjin D&B, Track mounted drilling fluid: Polymer hole diameter : 110 mm

drilling information				material substance						rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
HQ	Not Encountered	153	9.0		**BASALT**: grey-brown, some brecciation.	DW	X	a=0.56 d=0.70	100%		
					NO CORE: 0.90 m				15%		
		152			**BASALT**: grey-brown, some brecciation.	DW	X O	a=0.04 d=0.29	11%		
					NO CORE: 0.20 m				0%		**WERRIBEE FORMATION**
W			10.0		**Sandy GRAVEL (GP)**: fine to coarse grained, red-orange, fine to coarse grained sand, moist, very dense.			SPT 25/10mm, 5/mm N*=R			
		151	11.0		**Sandy CLAY (CH)**: high plasticity, red-orange, fine grained sand, moist, hard.			SPT 7, 18, 22 N*=40			
		150			**SAND (SP)**: fine to medium grained, red-orange, moist, very dense.			SPT 20, 28, 27 N*=55			
			12.0		Borehole BH-1 terminated at 11.95 m Target depth						
		149	13.0								
		148	14.0								
		147	15.0								
		146									

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method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
RR rock roller
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
HQ3 HQ3 core barrel (61.1mm)

support
C casing M mud N none

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SS shear surface
SZ shear zone
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
VR very rough
RO rough
SO smooth
POL polished
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating

drawn	**MJ**		client:	**Creo Consultants Pty Ltd**
approved		coffey A TETRA TECH COMPANY	project:	**Merrimu Precinct** **Additional Geotechnical Investigation** **Soil Sodicity and Dispersiveness Assessment**
date	**27 Oct 2020**		title:	**Core Photographs – BH-1**
scale	**NTS**		project no: **754-MELGE233440.1**	figure no:
original size	**A4**			

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Engineering Log - Borehole

Borehole ID.	***BH-4***
sheet:	1 of 3
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date started: ***06 Oct 2020***
principal:	date completed: ***06 Oct 2020***
project: ***Merrimu Precinct***	logged by: ***FR***
location: ***Refer to Figure 1***	checked by: ***MJ***

position: E: 277667; N: 5826610 (Datum Not Specified) surface elevation: 142.20 m (Datum Not Specified) angle from horizontal: 90°
drill model: Hanjin D&B, Track mounted drilling fluid: Polymer hole diameter : 110 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD N		Not Encountered		142			CH	**CLAY**: high plasticity, red-brown, with fine to coarse grained gravel, cobbles and boulders.	M	VSt		**NEWER VOLCANICS**
								BASALT: grey, with clay.				
				141	1.0			Borehole BH-4 continued as cored hole				
				140	2.0							
				139	3.0							
				138	4.0							
				137	5.0							
				136	6.0							
				135	7.0							

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method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
HQ3 HQ3 core barrel (61.1mm)

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud
C casing
N nil

penetration
1 2 3
no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Cored Borehole

Borehole ID.	**BH-4**
sheet:	2 of 3
project no.	**754-MELGE233440.1**
client: **Creo Consultants**	date started: **06 Oct 2020**
principal:	date completed: **06 Oct 2020**
project: **Merrimu Precinct**	logged by: **FR**
location: **Refer to Figure 1**	checked by: **MJ**

position: E: 277667; N: 5826610 (Datum Not Specified) surface elevation: 142.20 m (Datum Not Specified) angle from horizontal: 90°
drill model: Hanjin D&B, Track mounted drilling fluid: Polymer hole diameter : 110 mm

drilling information				material substance					rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
		142			started coring at 1.00m						
HQ3	Not Encountered	141	1.0		**BASALT**: grey-brown, with iron-staining.	DW		a=0.16 d=0.29	57%		SM, 10 - 40°, Clay, 120 mm
		140	2.0		**BASALT**: grey, 1-2% vesicular, vesicles up to 2 mm.	SW		a=8.18 d=9.40	56%		
		139	3.0		**NO CORE:** 1.40 m				0%		
		138	4.0		**BASALT**: as above.	SW					recovered as 2-10 mm gravel
					NO CORE: 0.10 m				0%		
					BASALT: as above.	SW			0%		JT, 80°, CU, RO, SN
		137	5.0		becoming grey and brown, weathering on joints	DW		a=9.82 d=7.96			
		136	6.0					a=2.70 d=4.15			JT, 40°, IR, VR, CN
		135	7.0		**BRECCIATED BASALT**: basalt is medium to high strength in a hard clay matrix, 3-40 mm clasts, grey and red.	HW					Defects are: JT, 0 - 30°, IR, RO - VR, CN - CO, unless otherwise described

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
RR rock roller
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
HQ3 HQ3 core barrel (61.1mm)

support
C casing M mud N none

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SS shear surface
SZ shear zone
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
VR very rough
RO rough
SO smooth
POL polished
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating

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Engineering Log - Cored Borehole

Borehole ID.	**BH-4**
sheet:	3 of 3
project no.	**754-MELGE233440.1**
client: **Creo Consultants**	date started: **06 Oct 2020**
principal:	date completed: **06 Oct 2020**
project: **Merrimu Precinct**	logged by: **FR**
location: **Refer to Figure 1**	checked by: **MJ**

position: E: 277667; N: 5826610 (Datum Not Specified) surface elevation: 142.20 m (Datum Not Specified) angle from horizontal: 90°

drill model: Hanjin D&B, Track mounted drilling fluid: Polymer hole diameter : 110 mm

drilling information				material substance					rock mass defects		
method & support	water	RL (m)	depth (m)	graphic log	material description **ROCK TYPE**: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
HQ3	Not Encountered	134			**BRECCIATED BASALT**: basalt is very low strength in a hard clay matrix, pale brown and orange. *(continued)*	HW		a=0.06 d=0.06			
		133	9.0		**Sandy CLAY (CH)**: high plasticity, pale brown, yellow, mottled grey, fine to medium grained sand, moist, very dense.			SPT 15, 32, 21/80mm N=R			**WERRIBEE FORMATION**
		132	10.0		becoming pale brown, mottled red, mottled grey			SPT 13, 21, 30/100mm N=R			
		131	11.0		Borehole BH-4 terminated at 11.10 m Target depth						
		130	12.0								
		129	13.0								
		128	14.0								
		127	15.0								

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
RR rock roller
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
HQ3 HQ3 core barrel (61.1mm)

support
C casing M mud N none

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SS shear surface
SZ shear zone
CO contact
CS crushed seam
SM seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
VR very rough
RO rough
SO smooth
POL polished
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating

Photograph 10: Erosion feature in gully

drawn	**MJ**		client:	**Creo Consultants Pty Ltd**
approved		coffey A TETRA TECH COMPANY	project:	**Merrimu Precinct** **Additional Geotechnical Investigation** **Soil Sodicity and Dispersiveness Assessment**
date	**27 Oct 2020**		title:	**Core Photographs – BH-4**
scale	**NTS**		project no: **754-MELGE233440.1**	figure no:
original size	**A4**			

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Engineering Log - Excavation

Excavation ID.	***TP101***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277385; N: 5830894 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered	B		0.5		ML	**TOPSOIL: Clayey SILT**: low liquid limit, brown with sand and roots.	M	Fb			**TOPSOIL**
								CH	**CLAY**: high plasticity, dark brown, trace rootlets, trace medium grained gravel.		F			**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming pale grey, mottled cream, white, trace calcareous pockets		VSt - H			R
						1.5			Refusal on weathered rock Test pit TP101 terminated at 1.5 m Refusal					
						2.0								
						2.5								
						3.0								
						3.5								

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HT hand tools

support
N none
S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
D disturbed sample
B bulk disturbed sample
E environmental sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Test pit

Excavated spoil

drawn	**RP**		client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP101**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

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Engineering Log - Excavation

Excavation ID.	***TP102***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 276772; N: 5830531 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.0		ML / CH	**TOPSOIL: Clayey SILT**: low liquid limit, brown with sand and roots.	M	Fb			**TOPSOIL**
									CLAY: high plasticity, dark brown, mottled grey, trace rootlets.		F - St			**RESIDUAL SOIL - NEWER VOLCANICS**
						0.5			becoming brown-orange, mottled grey, trace calcareous pockets		VSt - H			
						1.0			becoming pale grey, mottled white					
						1.5								
						2.0			Test pit TP102 terminated at 2.0 m Target depth					
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

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client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP102**
project no: 754-MELGE233440.1	fig no: / rev:

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Engineering Log - Excavation

Excavation ID.	***TP103***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 27693; N: 5829912 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	B		0.5		CH	**CLAY**: high plasticity, dark brown, with fine to coarse graiend sand, trace rootlets, trace calcareous pockets.	M	Fb			**TOPSOIL**
											VSt - H			**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming brown-orange, mottled grey					
						1.5								
						2.0								
						2.5			Test pit TP103 terminated at 2.4 m Target depth					
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

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client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP103**
project no: 754-MELGE233440.1	fig no: / rev:

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Engineering Log - Excavation

Excavation ID.	***TP104***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 276698; N: 5829569 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, brown-red, with coarse grained gravel, trace rootlets.	M				**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS** calcareous R
						1.0			Refusal on weathered rock Test pit TP104 terminated at 1.0 m Refusal					
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Test pit

Excavated spoil

drawn	**RP**	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP104**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

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Engineering Log - Excavation

Excavation ID.	***TP105***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 276966; N: 5829460 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, brown-red, trace rootlets.	M	Fb VSt - H			**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS**
								CH	**Sandy CLAY**: high plasticity, orange, mottled pale grey, fine to coarse grained sand.	D				calcareous R
				B		1.0		SC	**SAND**: fine to coarse grained, pale brown and orange brown, mottled pale grey.		VD			
						1.5								
						2.0								
						2.5			Refusal on weathered rock Test pit TP105 terminated at 2.5 m Refusal					
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil (calcareous soil)

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP105**
project no: 754-MELGE233440.1	fig no: / rev:

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Engineering Log - Excavation

Excavation ID.	***TP106***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277775; N: 5830264 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered			0.5		ML CH	**TOPSOIL: Clayey SILT**: low liquid limit, brown with sand, trace rootlets. **CLAY**: high plasticity, dark brown,, with fine to coarse grained gravel, trace boulders. becoming pale brown	M	Fb H			**TOPSOIL** boulder found between 0.0m-0.7m **RESIDUAL SOIL - NEWER VOLCANICS** R
						1.0 1.5 2.0 2.5 3.0 3.5			Refusal on weathered rock / boulders Test pit TP106 terminated at 0.8 m Refusal					

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP106**
project no: 754-MELGE233440.1	fig no: / rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP107***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 276530; N: 5831764 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		ML	**TOPSOIL: Clayey SILT**: low liquid limit, brown with sand, trace rootlets.	M	Fb			**TOPSOIL**
								CH	**CLAY**: high plasticity, dark brown, mottled dark grey, trace rootlets.		F - St			**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming pale brown-pale grey, mottled cream, with fine to coarse grained sand and fine to medium grained gravel		H			calcareous
						1.5			Refusal on weathered rock / boulder Test pit TP107 terminated at 1.4 m Refusal					
						2.0								
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
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client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT** **PHOTOGRAPHS TP107**
project no: 754-MELGE233440.1	fig no: / rev:

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Engineering Log - Excavation

Excavation ID.	***TP108***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277926; N: 5829925 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, dark grey, dark brown, trace rootlets.	M	Fb / F			**TOPSOIL** / **RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming dark brown, dark grey and red brown		VSt - H			
						1.5								
						2.0								
						2.5								
						3.0			Test pit TP108 terminated at 3.0 m Target depth					
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP108**
project no: 754-MELGE233440.1	fig no: / rev:

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Engineering Log - Excavation

Excavation ID.	***TP109***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 278321; N: 5828732 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered			0.0		CH	**CLAY**: high plasticity, dark brown, trace rootlets, trace fine to coarse grained sand.	M	VSt - H			**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS**
						0.5			becoming pale grey, trace fine to coarse grained gravel, trace calcareous pockets	D				R
				D		1.0			becoming pale grey- yellow brown					side wall full of rocks and boulders
						1.5								
						2.0			Refusal on weathered rock Test pit TP109 terminated at 1.9 m Refusal					
						2.5								
						3.0								
						3.5								

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

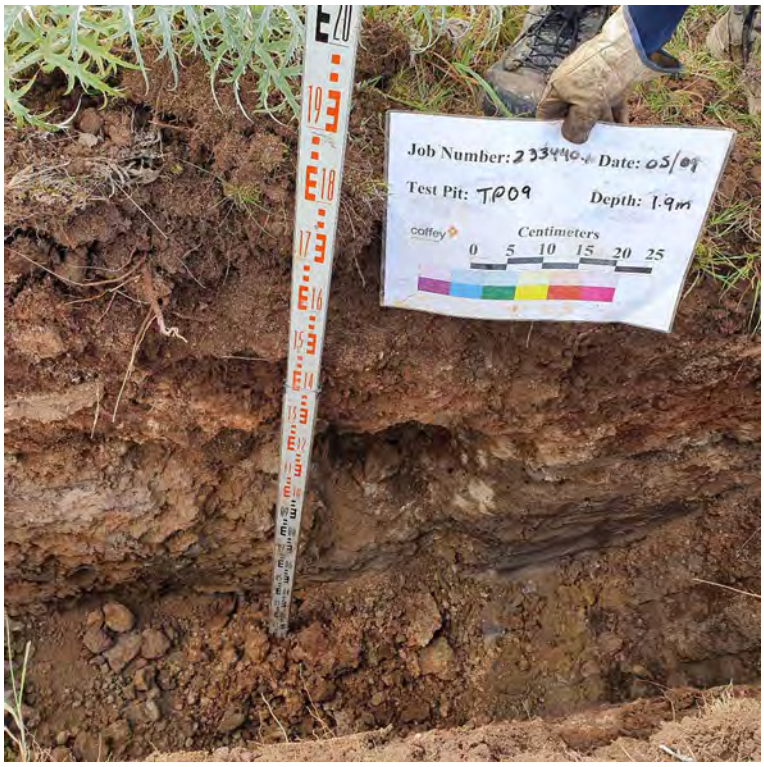
water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense



Test pit

Excavated spoil

drawn	**RP**	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP109**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

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Engineering Log - Excavation

Excavation ID.	***TP110***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 278191; N: 5828852 (Datum Not Specified) | surface elevation: Not specified | pit orientation: E-W | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, dark brown, mottled orange, trace rootlets, trace fine to coarse grained sand.	M	VSt - H			**TOPSOIL**
									becoming orange brown and grey-brown, calcareous	D				**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			increasing boulders					calcareous below 0.7 m depth
						1.5			Refusal on weathered rock / boulder Test pit TP110 terminated at 1.6 m Refusal					R
						2.0								
						2.5								
						3.0								
						3.5								

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

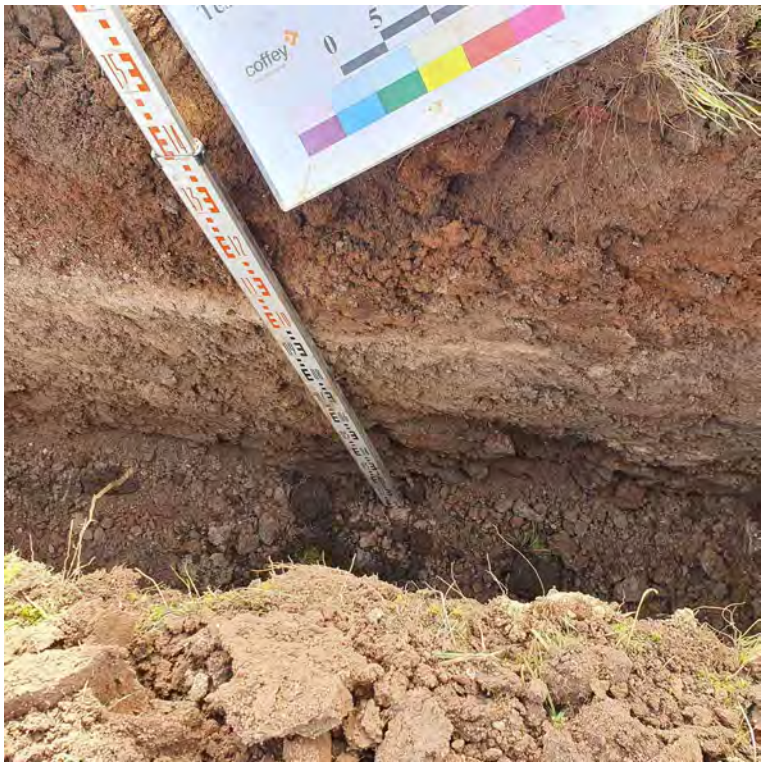
water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense



Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP110**
project no: 754-MELGE233440.1	fig no: / rev:

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Engineering Log - Excavation

Excavation ID.	***TP111***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 278737; N: 5828499 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered			0.0		CH	**CLAY**: high plasticity, dark grey-dark brown, trace fine grained sand, trace rootlets.	D	VSt - H			**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS**
						0.5		CH	**CLAY**: high plasticity, pale brown-orange, mottled grey-red, with fine to coarse grained sand, trace fine to coarse grained gravel and boulder.	D				R calcareous
						1.0			Refusal on weathered rock Test pit TP111 terminated at 1.1 m Refusal					
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

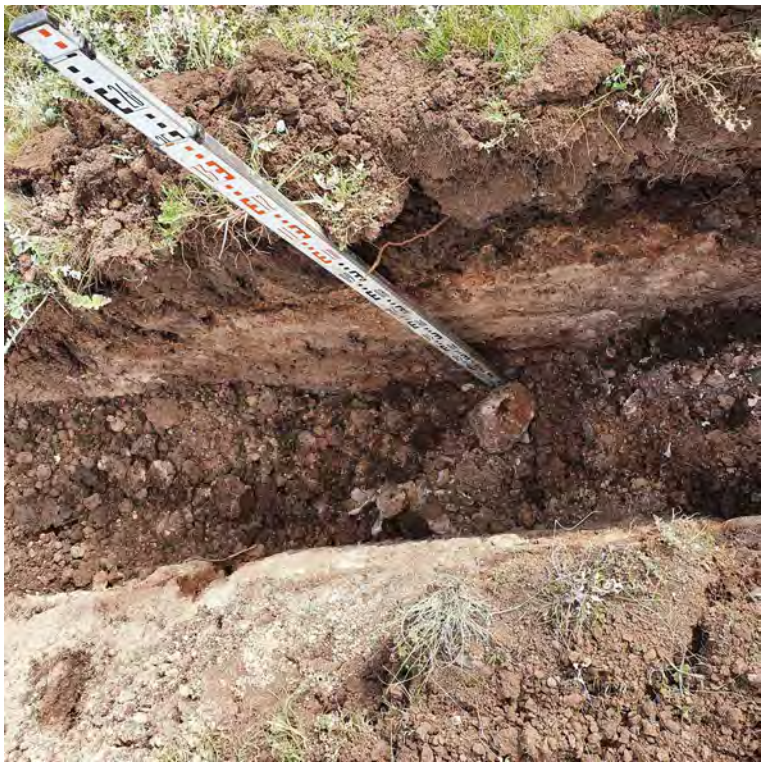
water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense



Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP111**
project no: 754-MELGE233440.1	fig no: / rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP112***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 278683; N: 5827533 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered			0.5		CH	**CLAY**: high plasticity, dark brown, trace rootlets, trace fine to coarse grained gravel, trace fine to coarse grained sand, trace rootlets.	M	VSt - H			**TOPSOIL**
														RESIDUAL SOIL - NEWER VOLCANICS
						1.0			becoming pale brown, dark grey, mottled white, calcareous with boulders up to 500mm in size	D				R
						1.5			Refusal on weathered rock Test pit TP112 terminated at 1.1 m Refusal					
						2.0								
						2.5								
						3.0								
						3.5								

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client: Creo Consultants

project: Merrimu Precinct
Merrimu

title: **TEST PIT PHOTOGRAPHS**
TP112

project no: 754-MELGE233440.1 | fig no: | rev:

coffey
A TETRA TECH COMPANY

Engineering Log - Excavation

Excavation ID.	***TP113***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 278686; N: 5828030 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.5		CH	**CLAY**: high plasticity, brown, trace fine grained sand, trace rootlets.	D	VSt - H			**TOPSOIL**
								CH	**CLAY**: high plasticity, yellow brown, mottled grey, with fine to coarse grained gravel, trace fine to coarse grained sand, calcareous mottling.					**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			Refusal on weathered rock Test pit TP113 terminated at 0.9 m Refusal					R
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

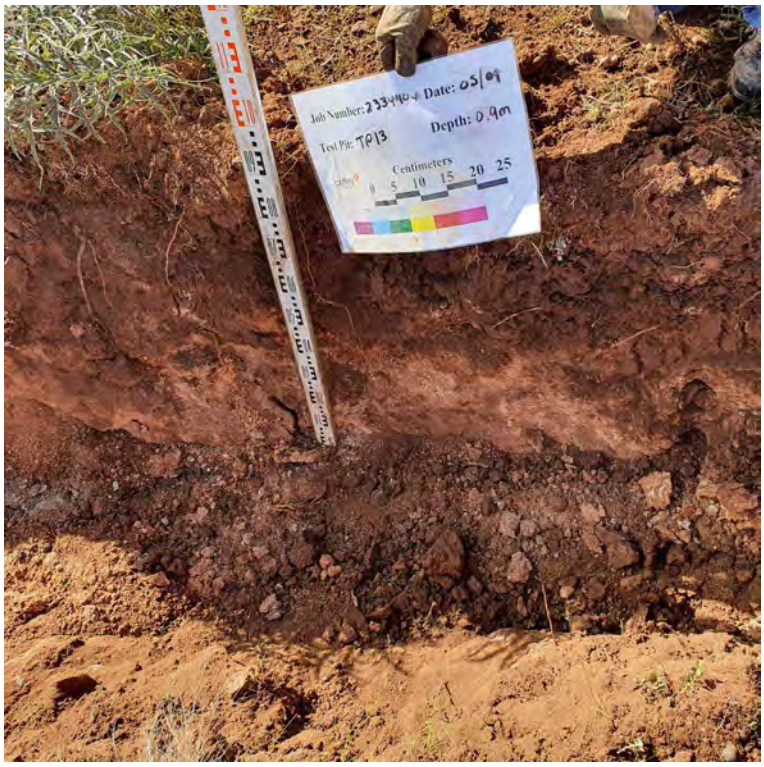
water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense



Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client: Creo Consultants

project: Merrimu Precinct
Merrimu

title: **TEST PIT PHOTOGRAPHS**
TP113

project no: 754-MELGE233440.1 | fig no: | rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP114***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 278234; N: 5828001 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, brown-orange, trace rootlets.	M				**TOPSOIL**
									calcareous between 0.5 m and 1.3 m depth					**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming mottled pale grey-orange brown, trace calcareous pockets					
						1.5								
						2.0								
						2.5								
						3.0								
						3.5			Test pit TP114 terminated at 3.2 m Target depth					

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

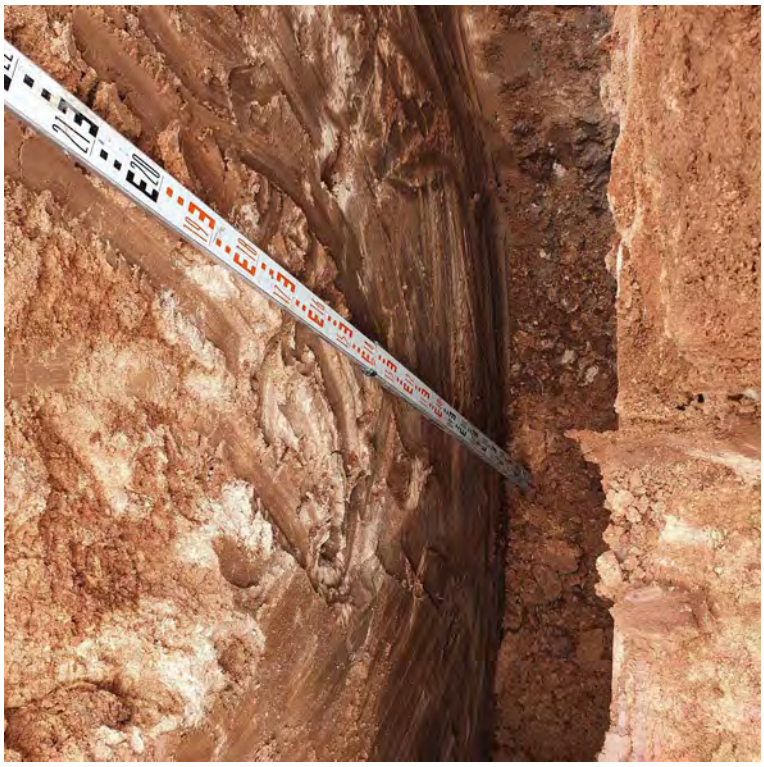
water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense



Test pit

Backfilled test pit location

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
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client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP114**
project no: 754-MELGE233440.1	fig no: / rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP115***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277806; N: 5828870 (Datum Not Specified) | surface elevation: Not specified | pit orientation: E-W | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, brown-orange, mottled grey, trace rootlets, trace fine to coarse grained sand.	D	Fb VSt - H			**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming pale grey, mottled pale brown					R
						1.5								
						2.0			Test pit TP115 terminated at 2.0 m Target depth					
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client: Creo Consultants

project: Merrimu Precinct
Merrimu

title: **TEST PIT PHOTOGRAPHS**
TP115

project no: 754-MELGE233440.1 | fig no: | rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP116***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277610; N: 5827616 (Datum Not Specified) | surface elevation: Not specified | pit orientation: E-W | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, dark brown, with fine to coarse grained gravel, trace rootlets.	M	Fb H			**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS**
						1.0		GC	**CLAYEY GRAVEL**: fine to coarse grained, pale brown, pale grey, mottled dark grey, calcareous. with boulders	D	VD			R encountered big boulders, grey-dark grey mottled white
						1.5								
						2.0			Refusal on weathered rock Test pit TP116 terminated at 1.8 m Refusal					
						2.5								
						3.0								
						3.5								

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HT hand tools

support
N none
S shoring

penetration
1 2 3 — no resistance ranging to refusal

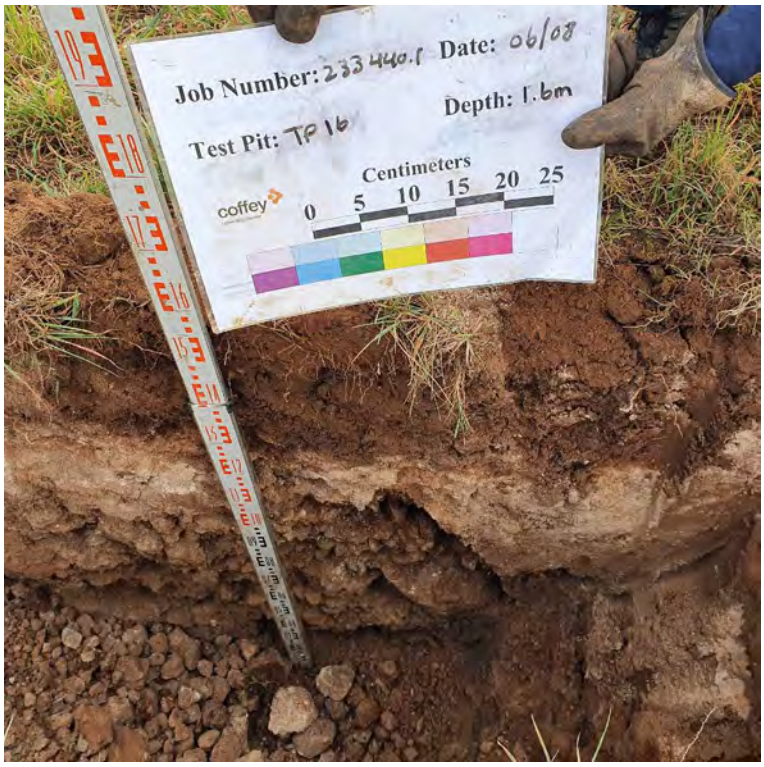
water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
D disturbed sample
B bulk disturbed sample
E environmental sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense



TP116

Excavated spoil

drawn	RP	coffey A TETRA TECH COMPANY	client:	Creo Consultants
approved	SS		project:	Merrimu Precinct Merrimu
date	09-Sep-20		title:	**TEST PIT PHOTOGRAPHS** **TP116**
scale	N.T.S.		project no: 754-MELGE233440.1	fig no: / rev:
original size	A4			

coffey
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Engineering Log - Excavation

Excavation ID.	***TP117***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***06 Aug 2020***
principal:	date completed: ***06 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277539; N: 5826762 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.0		CH	**CLAY**: high plasticity, dark brown, trace rootlets.	M	Fb / H			
						0.5		GC	**CLAYEY GRAVEL**: fine to coarse grained, pale grey-grey, low plasticity clay, with calcareous fragments. calcareous	D	VD			boulders on side wall, white to pale grey R
						1.0			Refusal on weathered rock Test pit TP117 terminated at 1.1 m Refusal					
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HT hand tools

support
N none
S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
D disturbed sample
B bulk disturbed sample
E environmental sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT** **PHOTOGRAPHS TP117**
project no: 754-MELGE233440.1	fig no: / rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP118***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***06 Aug 2020***
principal:	date completed: ***06 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: Not Specified | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 3.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	DCP (blows/100 mm) 2 4 6 8 10	structure and additional observations
E	N		Not Encountered	B		0.0		CH	**CLAY**: high plasticity, dark brown-red brown, trace rootlets.	M	H			**TOPSOIL**
														RESIDUAL SOIL - NEWER VOLCANICS
						0.5			**CLAYEY GRAVEL**: fine to coarse grained, grey, mottled white, high plasticity clay, calcareous.	D				
											VD			**EXTREMELY WEATHERED BASALT**
														R
						1.0			Refusal on weathered rock Test pit TP118 terminated at 0.8 m Refusal					
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP118**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

coffey
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Engineering Log - Excavation

Excavation ID.	***TP119***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***06 Aug 2020***
principal:	date completed: ***06 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: Not Specified | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.0		CH	**CLAY**: high plasticity, dark brown-brown, trace rootlets.	M	H			**TOPSOIL** **RESIDUAL SOIL - NEWER VOLCANICS**
						0.5		GC	**CLAYEY GRAVEL**: fine to coarse grained, grey-dark grey, mottled white, calcareous.	D	VD			**EXTREMELY WEATHERED BASALT** boulders seen on side walls R
						1.0			Refusal due to weathered rock Test pit TP119 terminated at 1.3 m Refusal					
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HT hand tools

support
N none
S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
D disturbed sample
B bulk disturbed sample
E environmental sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Test pit

Excavated spoil

drawn	RP	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	SS		project:	Merrimu Precinct Merrimu	
date	09-Sep-20		title:	**TEST PIT PHOTOGRAPHS TP119**	
scale	N.T.S.		project no: 754-MELGE233440.1	fig no:	rev:
original size	A4				

coffey
A TETRA TECH COMPANY

Engineering Log - Excavation

Excavation ID.	***TP120***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***06 Aug 2020***
principal:	date completed: ***06 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277168; N: 5827987 (Datum Not Specified) | surface elevation: Not specified | pit orientation: E-W | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	D		0.5		CH	**CLAY**: high plasticity, dark brown, trace rootlets.	M	Fb			**TOPSOIL**
											F - St			**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			becoming pale grey-yellow brown, mottled orange		H			
						1.5								
						2.0			Test pit TP120 terminated at 2.1 m Target depth					
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client: Creo Consultants

project: Merrimu Precinct
Merrimu

title: **TEST PIT PHOTOGRAPHS**
TP120

project no: 754-MELGE233440.1 | fig no: | rev:

coffey
A TETRA TECH COMPANY

Engineering Log - Excavation

Excavation ID.	***TP121***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***06 Aug 2020***
principal:	date completed: ***06 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277234; N: 5828492 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.5 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.5		CH	**CLAY**: high plasticity, dark brown, trace rootlets.	M	Fb			**TOPSOIL**
											H			**RESIDUAL SOIL - NEWER VOLCANICS**
									encountered big boulders, pale grey-white	D				
						1.0			Refusal on weathered rock Test pit TP121 terminated at 0.8 m Refusal					R
						1.5								
						2.0								
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
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client:	Creo Consultants
project:	Merrimu Precinct Merrimu
title:	**TEST PIT PHOTOGRAPHS** **TP121**
project no: 754-MELGE233440.1	fig no: / rev:

coffey
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Engineering Log - Excavation

Excavation ID.	***TP122***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***06 Aug 2020***
principal:	date completed: ***06 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277569; N: 5827317 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.5		CH	**CLAY**: high plasticity, dark brown, trace rootlets.	M	Fb			**TOPSOIL**
											H			**RESIDUAL SOIL - NEWER VOLCANICS**
										D				Boulders on side wall
				B		1.0		GC	**CLAYEY GRAVEL**: fine to coarse grained, pale brown-pale grey, mottled grey, calcareous mottling with boulders.		VD			**EXTREMELY WEATHERED BASALT**
														R
						1.5			Refusal due to weathered rock Test pit TP122 terminated at 1.4 m Refusal					
						2.0								
						2.5								
						3.0								
						3.5								

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HT hand tools

support
N none
S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
D disturbed sample
B bulk disturbed sample
E environmental sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TP122

Excavated spoil

drawn	**RP**
approved	**SS**
date	**09-Sep-20**
scale	**N.T.S.**
original size	**A4**

coffey
A TETRA TECH COMPANY

client: Creo Consultants

project: Merrimu Precinct
Merrimu

title: **TEST PIT PHOTOGRAPHS**
TP122

project no: 754-MELGE233440.1 | fig no: | rev:

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Engineering Log - Excavation

Excavation ID.	***TP123***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 276318; N: 5830483 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
			Not Encountered	B		0.5			**TOPSOIL**: low liquid limit, brown with sand, trace rootlets.	M	Fb			**TOPSOIL**
								CH	**CLAY**: high plasticity, dark brown-pale brown, trace rootlets, trace fine to coarse grained gravel.		H			**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0			grading gravelly becoming pale brown-orange mottled grey					R
						1.5		GP	**GRAVEL**: fine - coarse grained, pale brown, with fines, trace cobbles.		VD			**EXTREMELY WEATHERED BASALT**
						2.0			Refusal due to boulders and weathered rock Test pit TP123 terminated at 1.7 m Refusal					
						2.5								
						3.0								
						3.5								

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator
HT hand tools

support
N none
S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
D disturbed sample
B bulk disturbed sample
E environmental sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Test pit

Excavated spoil

drawn	**RP**	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP123**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

coffey
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Engineering Log - Excavation

Excavation ID.	***TP124***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***04 Aug 2020***
principal:	date completed: ***04 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 276346; N: 5830103 (Datum Not Specified) | surface elevation: Not specified | pit orientation: | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered			0.0		ML	**TOPSOIL**: low liquid limit, brown with sand, trace rootlets.	M	Fb			**TOPSOIL**
								CH	**CLAY**: high plasticity, dark grey, mottled white, trace rootlets.		F - St			**RESIDUAL SOIL - NEWER VOLCANICS**
						0.5			becoming pale brown-orange, mottled pale grey		VSt - H			
						1.0			becoming pale grey, trace calcareous pockets					R
						1.5			Refusal on weathered rock Test pit TP124 terminated at 1.4 m Refusal					
						2.0								
						2.5								
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP124**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

coffey
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Engineering Log - Excavation

Excavation ID.	***TP125***
sheet:	1 of 1
project no.	***754-MELGE233440.1***
client: ***Creo Consultants***	date excavated: ***05 Aug 2020***
principal:	date completed: ***05 Aug 2020***
project: ***Merrimu Precinct***	logged by: ***MZ***
location: ***Merrimu***	checked by: ***SS***

position: E: 277235; N: 5829046 (Datum Not Specified) | surface elevation: Not specified | pit orientation: N-S | DCP id.: 8

equipment type: 15t Excavator | excavation method: E | excavation dimensions: 2.0 m long 0.5 m wide

excavation information | **material substance**

method	support	penetration (1 2 3)	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) (100 200 300 400)	DCP (blows/100 mm) (2 4 6 8 10)	structure and additional observations
E	N		Not Encountered	B		0.5		CH	**CLAY**: high plasticity, dark brown-red brown, trace rootlets.	M	F - St			**TOPSOIL**
									becoming brown-red brown		H			**RESIDUAL SOIL - NEWER VOLCANICS**
						1.0		CH	**CLAY**: high plasticity, grey, mottled orange.					R
						1.5								
						2.0								
						2.5			Refusal on weathered rock Test pit TP125 terminated at 2.6 m Refusal					
						3.0								
						3.5								

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method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator
- HT hand tools

support
- N none
- S shoring

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- D disturbed sample
- B bulk disturbed sample
- E environmental sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- VS vane shear peak/remouded (kPa)

soil group symbol & soil description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Test pit

Excavated spoil

drawn	**RP**	coffey A TETRA TECH COMPANY	client:	Creo Consultants	
approved	**SS**		project:	Merrimu Precinct Merrimu	
date	**09-Sep-20**		title:	**TEST PIT PHOTOGRAPHS TP125**	
scale	**N.T.S.**		project no: 754-MELGE233440.1	fig no:	rev:
original size	**A4**				

TEST SITE SYMBOLS

- Cored and/or washbored borehole (B) (Suffix 'I' for borehole with inclinometer casing)
- Auger hole (B) (Suffix 'A' after borehole number)
- Borehole with standpipe (Suffix 'S' after borehole number) Borehole with piezometer (Suffix 'P' after borehole number)
- Inclined borehole
- Friction cone penetration test (C) (Suffix 'P' for piezo-friction cone penetration test)
- Dynamic cone penetration test (DCPT)
- Test pit (TP) Dozer pit (DP)
- Pavement Dipping (PD)

FIELD TEST METHODS

Standard Penetration Test (SPT)

Refer AS 1289.6.3.1

The blow counts are recorded on the borehole log as one of:

(i) 10,10,25 — 35 blows required for 300mm penetration after seating drive of 10 blows

(ii) 30/110* — 30 blows undertaken for 110mm penetration in seating drive

(iii) 10, 30/110 — 30 blows undertaken for 110mm penetration after seating drive of 10 blows

(iv) 10, 20/10 (hammer bouncing) — 20 blows undertaken for 10mm penetration before test ended due to hammer bounce after seating drive of 10 blows

The penetration resistance is recorded on the borehole log as one of:

(i) N25 — 25 blows required for 300mm penetration after seating drive

(ii) N<1 — Shoe penetrates 450mm under rod or rod and hammer weight

(iii) N>60 — More than 60 blows required to penetrate 300mm after seating drive

Cone Penetration Test (CPT)

Refer AS 1289.6.5.1

Where soil descriptions are shown on the CPT plots have been inferred from the measured resistances and cannot be guaranteed. Tenderers are advised to draw their own conclusions as to the character of the materials penetrated.

Dynamic Cone Penetration Test (DCPT)

Refer AS 1289.6.3.2

SOIL DESCRIPTION

Basic Soil Types

Term	Size range	Term	Size range
BOULDERS	>200mm	Coarse SAND	0.6-2.36mm
COBBLES	63-200mm	Medium SAND	0.2-0.6mm
Coarse GRAVEL	20-63mm	Fine SAND	0.075-0.2mm
Medium GRAVEL	6-20mm	SILT & CLAY see A-Line chart	
Fine GRAVEL	2.36-6mm		

Organic soils include organic sands, organic silts, organic clays and peats. Size range varies.

Descriptive Terms for Material Proportion

Coarse grained soils	
% Fines	Modifier
≤ 5	Omit, or use 'trace'
> 5 ≤ 12	Described as with 'clay/silt' as applicable
>12	Prefix soil as 'silty/clayey' as applicable

Fine grained soils	
% Coarse	Modifier
≤ 15	Omit, or use 'trace'
>15 ≤ 30	Described as with 'sand/gravel' as applicable
>30	Prefix soil as 'sandy/gravelly' as applicable

Consistency - Non-Cohesive Soils

Term	SPT N Value	Relative Density (%)
Very loose	< 4	< 15
Loose	> 4 ≤ 10	> 15 ≤ 35
Medium dense	> 10 ≤ 30	> 35 ≤ 65
Dense	> 30 ≤ 50	> 65 ≤ 85
Very dense	> 50	> 85

Consistency - Cohesive Soils

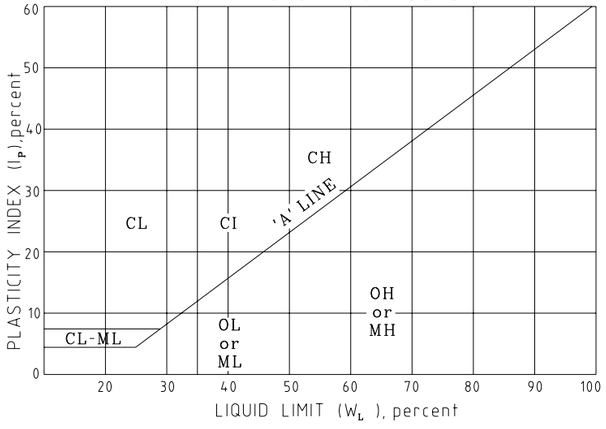
Term	Undrained shear strength (kPa)	Field Guide to Consistency
Very soft	≤ 12	Exudes between fingers when squeezed in hand
Soft	>12 ≤25	Can be moulded by light finger pressure
Firm	>25 ≤50	Can be moulded by strong finger pressure
Stiff	>50 ≤100	Cannot be moulded by fingers Can be indented by thumb
Very stiff	>100 ≤200	Can be indented by thumb nail
Hard	> 200	Can be indented with difficulty by thumb nail

Classification Symbols

Where laboratory tests are not used to classify soils letter symbols are shown in brackets e.g (CH).

		Description name	Letter Symbol
Coarse Components	Main terms	GRAVEL	G
		SAND	S
	Qualifying terms	Well graded	W
		Poorly graded	P
Fine Components	Main terms	SILT	M
		CLAY	C
	Qualifying terms	Of low plasticity	L
		Of medium plasticity	I
		Of high plasticity	H
Organic Components	Main terms	PEAT	P_t
		ORGANICS	O

A-Line Chart for Classification of Fine Grained Soils



Soil Moisture

Term	Field Guide to Soil Moisture
Dry (D)	Cohesive soils, hard or friable or powdery, well dry of plastic limit Granular soil, cohesionless and free-running
Moist (M)	Soil feels cool, darkened in colour Cohesive soil can be moulded Granular soil tends to cehere
Wet (W)	Soil feels cool, darken in colour Cohesive soil usually weaken and free water forms on hands when handling Granular soil tends to cohere

SYMBOLS USED ON BOREHOLE LOGS

- Undisturbed Sample
- Continuous Sample
- Core
- Core loss
- 3-11-89 — Water table level and date of observation
- Inflow of groundwater during drilling
- Water loss during drilling
- N25 — Standard Penetration Test (SPT) and N value
- 5.6 — Is(50) test location and result (MPa)

GRAPHIC SYMBOLS FOR SOIL AND ROCK

- Fill
- Cobbles Boulders
- Gravel
- Sand
- Silt
- Clay or undifferentiated soil
- Peat or organic soil
- Coal
- Cemented soil
- Mudstone (siltstone & claystone)
- Shale
- Sandstone
- Conglomerate
- Limestone
- Tuff Scoria
- Granite, Granodiorite & other coarse grained igneous
- Basalt
- Other fine-medium grained igneous
- Slate, phyllite or schist
- Gneiss
- Hornfels
- Quartzite
- Breccia
- Crushed or shear zone
- Clay Seam

LAST UPDATED MAY 2009

FOR DETAILED DESCRIPTION SEE AUSTRALIAN STANDARD AS 1726

TECHNICAL CONSULTING

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CHECKED: J SLATER

APPROVED: N FOK, GROUP MANAGER

CAT: GEOTECHNICAL SERVICES
PROJ: GEOLOGY
FILE: 396223.dgn

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GEOTECHNICAL INVESTIGATION

SUMMARY OF GEOTECHNICAL TERMS AND SYMBOLS

FILE NO.	CONTRACT NO.	SHEET NO.	DRAWING NO.	ISSUE
		1 OF 2	396223	

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ROCK DESCRIPTION

Rock Material

Strength

Letter Symbol	Colour Code	Term	Point Load Index (MPa) I_{s50}
EL		Extremely low	≤ 0.03
VL		Very low	>0.03 ≤0.1
L		Low	> 0.1 ≤0.3
M		Medium	> 0.3 ≤1.0
H		High	> 1.0 ≤3.0
VH		Very high	> 3.0 ≤10
EH		Extremely high	>10

Core Fractures

The fracture state is described by the Rock Quality Designation (RQD)

$$RQD\ (\%) = \frac{\text{Sum of core pieces} > 100\text{mm in length(mm)}}{\text{Length of core run (mm)}} \times 100$$

NOTES: 1. Breaks produced by drilling or handling are ignored in the summation.
2. Length of core run includes any core losses.

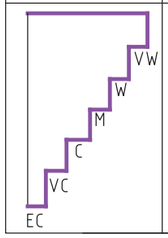
Rock Weathering

Term	Symbol	Colour Code	Description
Residual Soil	RS		Soil developed on extremely weathered rock; the mass structure and substancwe fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported
Extremely weathered rock	XW		Rock is weathered to such an extent that it has 'soil' properties, i.e. either disintegrates or can be remoulded, in water
Distinctly weathered rock	DW		Rock strength usually changed by weathering. The rock may be highly discoloured, usually be ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores
Slightly weathered rock	SW		Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh rock	FR		Rock shows no sign of decomposition or staining

Rock Mass

Discontinuity Spacing in One Dimension (e.g. joints, shear zones etc.)

Term		Spacing
Very thick	All Rock Types	> 2m
Thick	All Rock Types	> 600mm ≤ 2m
Medium	All Rock Types	> 200mm ≤ 600mm
Thin	All Rock Types	> 60mm ≤200mm
Very Thin	All Rock Types	> 20mm ≤60mm
Thickly laminated (Sedimentary) Narrow (Igneous & Metamorphic)		> 6mm ≤ 20mm
Thinly laminated (Sedimentary) Very narrow (Igneous & Metamorphic		≤ 6mm

Graphic	Letter Symbol	Term	Spacing
	VW	Very widely spaced	> 2m
	W	Widely spaced	> 600mm ≤ 2m
	M	Medium spaced	> 200mm ≤ 600mm
	C	Closely spaced	> 60mm ≤ 200mm
	VC	Very closely spaced	> 20mm ≤ 60mm
	EC	Extremely closely spaced	≤ 20mm

Planar Structures and Discontinuities

Symbol	Term
S_O	Bedding plane joint
S_V	Sub-vertical joint
S_H	Sub-horizontal joint
xJTy	x No of Joints each at y mm ave thickness
xCSy	x No of Clay Seam each at y mm ave. thickness
FZ/y XX	Fractured Zone at y mm thickness @ spacing
CZ/y	Crushed Zone at y mm thickness
SZ/y	Shear Zone at y mm thickness

Discontinuity Spacing in Three Dimensions (not applicable to rock core)

First term	Spacing
Very large	> 2m
Large	> 600mm ≤ 2m
Medium	> 200mm ≤ 600mm
Small	> 60mm ≤ 200mm
Very small	≤ 60mm
Second Term	**Nature of Block**
Blocky	Equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greater than cross section

Seismic Refraction Testing Symbols

Seismic traverse location in section

Seismic traverse location in plan

Interface plotted from complete data coverage

Interface plotted from partial data coverage

Seismic velocity interface (Seismic velocity, m/sec.)

Lateral velocity change

LAST UPDATED OCTOBER 2012

FOR DETAILED DESCRIPTION SEE AUSTRALIAN STANDARD AS 1726

TECHNICAL CONSULTING

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APPROVED N. FOK
GROUP MANAGER

CAT: GEOTECHNICAL SERVICES
PROJ: GEOLOGY
FILE: 396224.dgn

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GEOTECHNICAL INVESTIGATION

SUMMARY OF GEOTECHNICAL TERMS AND SYMBOLS

FILE NO.	CONTRACT NO.	SHEET NO.	DRAWING NO.	ISSUE
		2 OF 2	396224	

10/10/2012 3:13:30 PM Default 396224.dgn

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling				Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SW FR)	Spacing RQD (EC VC C M W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HWT Casing Auger	135	1	0.00	clayey SAND, red brown, loose, dry, fine to medium grained sand					1.00	N49 SPT 16, 22, 27
	134	2							1.45	
	133	3	2.40	BASALT, dark blue, highly vesicular, trace iron staining and fractured zones		68%		2.50 FZ100-EC 2.55 1JT/SH, RF-Ud, SN/ Fe 2.65 1JT/SH, RF-Ud, SN/ Fe 2.80 1JT/SH, RF-Ud, SN/ Fe 2.90 2JT/30°, RF-Ud, SN/ Fe 3.10 1JT/30°, RF-Ud, SN/ Fe 3.20 1JT/SH, RF-Ud, SN/ Fe 3.33 1JT/SH, RF-Ud, SN/ Fe 3.40 1JT/SH, RF-Ud, SN/ Fe		
	100%		3.40			74%		3.50 CZ100 3.58 1JT/SH, RF-Ud, SN/ Fe clay 3.62 1JT/SH, RF-Ud, SN/ Fe 3.90 1JT/SH, RF-Ud, SN/ Fe 4.00 FZ100-EC clay 4.10 1JT/30°, RF-Ud, SN/ Fe clay 4.30 1JT/SH, RF-Ud, SN/ Fe clay 4.40 FZ100-EC 4.55 1JT/SH, RF-Ud, SN/ Fe		
	132	4								
	131	5	5.00			90%		5.00 1JT/SH, RF-Ud, SN/ Fe 5.32 1JT/SH, RF-Ud, SN/ Fe 5.39 1JT/SH, RF-Ud, SN/ Fe 5.57 1JT/30°, RF-Ud, SN/ Fe 5.65 1JT/SH, RF-Ud, SN/ Fe 5.80 1JT/SH, RF-Ud, SN/ Fe 5.90 1JT/30°, RF-Ud, SN/ Fe 6.12 1JT/SH, RF-Ud, SN/ Fe		
HQ Casing HMLC, MUD	130	6	6.00	slightly vesicular						
			6.50			95%		6.50 1JT/SH, RF-Ud, SN/ Fe 6.63 1JT/SH, RF-Ud, SN/ Fe 6.80 1JT/SH, RF-Ud, SN/ Fe 6.90 1JT/SH, RF-Ud, SN/ Fe 7.27 1JT/SH, RF-Ud, SN/ Fe 7.34 2JT/SH, RF-Ud, SN/ Fe 7.74 1JT/SH, RF-Ud, SN/ Fe 7.85 1JT/SH, RF-Ud, SN/ Fe		
	129	7								
	128	8	8.00	silty SAND with gravel, pale brown, dense to very dense, wet, fine to coarse grained sand and quartz gravel, trace clay				8.00 1JT/SH, RF-Ud, SN/ Fe		
			8.50							
	127	9								
			9.50							
	126	10								

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: W. Anderson
Date Drilled: 20/04/2021

Logged By: Katerina Irwin
Date Logged: 20/04/2021
Checked By: Andrew Wilson
Date Checked: 25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00
Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling / Material / Rock Mass Discontinuities / Sampling and Testing

Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SlW FR)	Spacing RQD (EC VC C W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	125	11.00							11.00	N>60 SPT 17, 35, 25
		11.50		silty CLAY, pale grey mottled pale brown, stiff to very stiff, moist, high plasticity					11.45	Ground Science Sample Number #: 57021-S1 11.00 to 11.45m Emerson Class 2
	124	12.00							12.00	N=20 SPT 6, 9, 11
		12.80		sandy CLAY with gravel, dark brown mottled orange, hard, moist, low to medium plasticity, fine to medium grained sand, fine to medium grained basalt gravel, trace organic matter; XW BASALT					12.45	
	123	13.00								
	122	14.00				35%		14.40 SAND_CLAY		
		14.40		BASALT, dark blue, highly weathered, low strength, moderately vesicular				14.57 1JT/SH, RF-Ud, SN/ Fe 14.64 CZ70		
		14.80		14.80-15.00 XW BASALT band				14.80 FZ160-EC		
	121	15.00						15.00 SAND_CLAY 15.05 1JT/SH, RF-Ud, SN/ Fe		
		15.05		Becoming highly weathered to moderately weathered, medium strength, increased fractured zones				15.20 1JT/SH, RF-Ud, SN/ Fe 15.30 2JT/30°, RF-Ud, SN/ Fe		
		15.50						15.50 1JT/SH, RF-Ud, SN/ Fe		
						57%		15.70 FZ200-EC		
	120	16						15.90 4JT/SH, RF-Ud, SN/ Fe 16.08 1JT/SV, RF-Ud, SN/ Fe		
								16.25 1JT/SH, RF-Ud, SN/ Fe 16.35 1JT/SH, RF-Ud, SN/ Fe 16.45 1JT/SH, RF-Ud, SN/ Fe 16.50 1JT/SH, RF-Ud, SN/ Fe		
								16.70 1JT/SV, RF-Ud, SN/ Fe 16.77 1JT/SH, RF-Ud, SN/ Fe		
								16.90 FZ130-EC		
	119	17						17.00 1JT/SV, RF-Ud, SN/ Fe		
		17.00		SANDSTONE, dark blue, moderately weathered, medium strength		23%		17.10 1JT/30°, RF-Ud, SN/ Fe 17.17 1JT/SH, RF-Ud, SN/ Fe 17.24 1JT/SV, RF-Ud, SN/ Fe		
								17.37 1JT/SV, RF-Ud, SN/ Fe 17.42 1JT/SH, RF-Ud, SN/ Fe 17.52 2JT/SH, RF-Ud, SN/ Fe 17.59 FZ70-EC 17.67 1JT/SH, RF-Ud, SN/ Fe		
								17.83 FZ160-VC 17.90 1JT/30°, RF-Ud, SN/ Fe		
	118	18						18.05 FZ150-EC 18.15 2JT/SV, RF-Ud, SN/ Fe 18.26 1JT/SH, RF-Ud, SN/ Fe		
								18.40 FZ140-EC		
		18.50						18.50 2JT/SH, RF-Ud, SN/ Fe		
						34%		18.70 FZ200-EC		
	117	19						18.86 1JT/SH, RF-Ud, SN/ Fe 18.92 1JT/SH, RF-Ud, SN/ Fe 18.96 1JT/SH, RF-Ud, SN/ Fe 19.05 1JT/SV, RF-Ud, SN/ Fe		
								19.20 FZ150-VC 19.25 1JT/SV, RF-Ud, SN/ Fe		
								19.40 1JT/SV, RF-Ud, SN/ Fe 19.48 1JT/SH, RF-Ud, SN/ Fe 19.53 1JT/SH, RF-Ud, SN/ Fe 19.57 CZ40 19.65 1JT/SH, RF-Ud, SN/ Fe		
	116	20						19.85 1JT/SH, RF-Ud, SN/ Fe		
		20.00								

This Log shall be read in conjunction with VicRoads - Dwg Nos. 396223, 396224 & 684947 which provide a summary of the Geotechnical Terms and Symbols used.

Drilling Contractor:	Star Drilling	Logged By:	Katerina Irwin
Rig Type:	SANDVIK 650	Date Logged:	20/04/2021
Driller:	W. Anderson	Checked By:	Andrew Wilson
Date Drilled:	20/04/2021	Date Checked:	25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00
Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling				Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SW FR)	Spacing RQD (EC VC C W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	115	21		sandy SILT, grey, dense, wet, fine to medium grained sand						
				sandy SILT, grey mottled pink, very dense, wet, fine to medium grained sand; XW SILTSTONE						
	114	22		becoming grey mottled orange						
	113	23								
	112	24								
	111	25								
	110	26		silty SAND, grey mottled orange, very dense, wet, fine to medium grained, trace fine to medium sandstone gravel, trace clay and iron staining; XW SANDSTONE						
	109	27								
	108	28								
	107	29		silty SAND, pale brown mottled orange, wet, very dense, fine to medium grained sand; XW SANDSTONE						
	106	30		sandy SILT, grey mottled orange, very dense, wet, fine to medium grained sand, trace clay; XW SILTSTONE						

20.00
20.60
21.50
21.70
23.00
23.50
24.50
26.00
27.50
29.00
29.40

This Log shall be read in conjunction with VicRoads - Dwg Nos. 396223, 396224 & 684947 which provide a summary of the Geotechnical Terms and Symbols used.

Drilling Contractor:	Star Drilling	Logged By:	Katerina Irwin
Rig Type:	SANDVIK 650	Date Logged:	20/04/2021
Driller:	W. Anderson	Checked By:	Andrew Wilson
Date Drilled:	20/04/2021	Date Checked:	25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling				Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results
HQ, Casing HMLC, MUD	105	31		clayey SILT with gravel, grey , very dense, wet, fine to medium grained sand and quartz gravel						
		30.50								
		31.50								Ground Science Sample Number #: 57021-S2 31.50 to 31.60m Emerson Class 2
	104	32		silty CLAY, grey mottled yellow, hard, wet, moderate to high plasticity						
		32.00								
		32.40		32.40-32.60 trace fine to medium grained sand						
	103	33		clayey SILT, pale grey mottled yellow, very dense, wet, trace fine grained sand						
		33.00								
		33.50								
	102	34								
	101	35								
		35.00								
		35.30								
	100	36								
		36.50								
	99	37								
	98	38							38.00	N>60 SPT 14, 35, 25
		38.00							38.45	
		38.80								
	97	39								
		39.50								
		39.90								
	96	40		silty CLAY, dark brown, hard, wet, low plasticity, trace organic matter						

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: W. Anderson
Date Drilled: 20/04/2021

Logged By: Katerina Irwin
Date Logged: 20/04/2021
Checked By: Andrew Wilson
Date Checked: 25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling				Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (VC, C, M, W)	Inferred Strength Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	95	41	41.00							
	94	42	42.00	silty SAND, brown, medium dense, wet, fine to medium grained sand						
			42.50							
	93	43	43.00						43.00	N13 SPT 12, 6, 7
									43.45	
	92	44	44.00	clayey SILT, dark brown, medium dense, wet, low plasticity, trace fine grained sand						
	91	45	45.00							Ground Science Sample Number #: 57021-S3 44.80 to 45.00m Emerson Class 2
			45.50	silty SAND, pale brown, dense, wet, fine to medium grained sand						
	90	46	46.20							
	89	47	47.00	clayey SILT, dark brown-clack, very dense, wet, low plasticity; Brown coal						
	88	48	48.50							
			48.80							
	87	49	49.00	Becoming very hard; XW SILTSTONE						
	86	50	50.00							

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: W. Anderson
Date Drilled: 20/04/2021

Logged By: Katerina Irwin
Date Logged: 20/04/2021
Checked By: Andrew Wilson
Date Checked: 25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SW FR)	Spacing RQD (EC VC C M W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	85 / 51 84 / 52 83 / 53 82 / 54	50.00 50.40 51.50 52.80 54.30							

End of Bore 54.30 m

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: W. Anderson
Date Drilled: 20/04/2021

Logged By: Katerina Irwin
Date Logged: 20/04/2021
Checked By: Andrew Wilson
Date Checked: 25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log / Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength / Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: W. Anderson
Date Drilled: 20/04/2021

Logged By: Katerina Irwin
Date Logged: 20/04/2021
Checked By: Andrew Wilson
Date Checked: 25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69260S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Whelans Road, Parwan

Northing (m): 5,824,867.00
Easting (m): 277,663.00
AHD. R.L. (m): 136.00

Coordinate System: MGA94
Bearing:
Angle: 90°

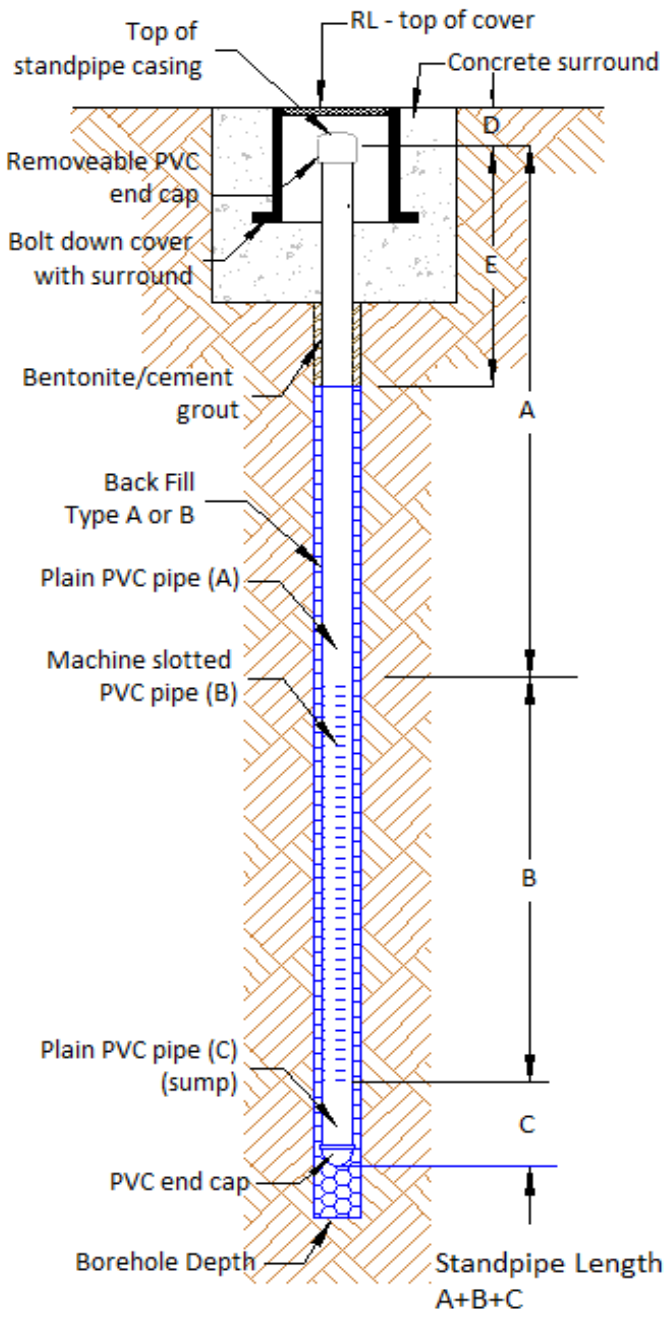
Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log / Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, W)	Inferred Strength / Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: W. Anderson
Date Drilled: 20/04/2021

Logged By: Katerina Irwin
Date Logged: 20/04/2021
Checked By: Andrew Wilson
Date Checked: 25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss



STANDPIPE CONSTRUCTION DETAILS

Western Region

Bacchus Marsh Eastern Link Desktop Study

Borehole No	Easting (m)	Northing (m)	RL (m)	Borehole Depth (m)	Standpipe Length (m)	A (m)	B (m)	C (m)	D (m)	E (m)	BackFill type
B21-69260S	277663	5824867	136.00	54.30	31.00	15	15	0.5	0.5	4.5	A

Notes:

1. Coordinates are MGA. RL is AHD
2. Borehole depth is measured from top of cover
3. Cover details (i) rubber ring between cover and surround. (ii) Cover shall be bolted down with 2 no. 5/16" hexhead bolts
4. Back Fill Type: (A) 5mm aggregate; (B) Washed coarse grained sand

BOREHOLE LOG

Borehole No:	B21-69261S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Bences Road, Merrimu

Northing (m): 5,826,949.00
Easting (m): 277,496.00
AHD. R.L. (m): 153.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling

Method: HWT Casing Auger; HQ Casing HMLC, MUD

RL (m) / Depth (m) / Graphic Log Core Recovery

Material

Description

0.00 clayey SAND with gravel, red brown, dense, dry, fine to medium grained sand, fine to medium grained basalt gravel

1.80 BASALT, dark blue mottled red, moderately vesicular, high amounts of iron staining

2.40 BASALT, dark blue, moderately vesicular

2.76 BASALT, dark blue mottle red, moderately vesicular, high amounts of iron staining

3.14 BASALT, dark blue, moderately vesicular, moderately fractured

3.30

3.50

4.10

4.50

6.00

7.50

9.00

9.76 becoming red brown; XW BASALT

10.00

Rock Mass Discontinuities

Weathering: XW | DW | MW | SW | SW | FR

Spacing RQD: EC | VC | C | M | W

Inferred Strength Classification: EL | VL | L | M | H | VH | EH

60%

13%

0%

47%

77%

37%

35%

Description, thickness, and inclination

2.00 FZ200-EC
2.40 8JT/SH, RF-Ud, SN/ Fe
2.76 1JT/SH, RF-Ud, SN/ Fe
3.14 1JT/SH, RF-Ud, SN/ Fe
3.30 1JT/SH, RF-Ud, SN/ Fe
4.00 FZ700-EC
4.10 1JT/SV, RF-Ud, SN/ Fe
4.30 2JT/SH, RF-Ud, SN/ Fe
4.34 1JT/30°, RF-Ud, SN/ Fe
4.40 1JT/SH, RF-Ud, SN/ Fe
4.44 1JT/270°, RF-Ud, SN/ Fe
4.50 1JT/SH, RF-Ud, SN/ Fe
4.60 1JT/SH, RF-Ud, SN/ Fe
4.65 1JT/SH, RF-Ud, SN/ Fe
4.75 1JT/SH, RF-Ud, SN/ Fe
4.88 1JT/20°, RF-Ud, SN/ FeCA
4.92 1JT/SH, RF-Ud, SN/ FeCA
5.00 FZ80-EC
5.08 1JT/SH, RF-Ud, SN/ Fe
5.10 1JT/SH, RF-Ud, SN/ FeCA
5.15 1JT/20°, RF-Ud, SN/ Fe
5.25 1JT/SH, RF-Ud, SN/ Fe
5.32 1JT/270°, RF-Ud, SN/ Fe
5.35 1JT/SH, RF-Ud, SN/ Fe
5.50 1JT/SH, RF-Ud, SN/ Fe
5.56 FZ60-EC
5.65 1JT/SH, RF-Ud, SN/ Fe
5.70 1JT/60°, RF-Ud, SN/ Fe
5.82 1JT/SH, RF-Ud, SN/ Fe
5.87 FZ50-EC
5.91 1JT/30°, RF-Ud, SN/ Fe clay
6.00 1JT/SH, RF-Ud, SN/ Fe
6.05 1JT/SV, RF-Ud, SN/ Fe
6.50 1JT/SH, RF-Ud, SN/ Fe
6.65 1JT/270°, RF-Ud, SN/ Fe
6.82 1JT/SH, RF-Ud, SN/ Fe
6.87 1JT/SV, RF-Ud, SN/ Fe
6.93 1JT/SH, RF-Ud, SN/ Fe
7.00 1JT/SV, RF-Ud, SN/ Fe
7.05 1JT/SH, RF-Ud, SN/ Fe
7.15 1JT/SH, RF-Ud, SN/ Fe
7.33 1JT/SH, RF-Ud, SN/ Fe
7.40 1JT/30°, RF-Ud, SN/ Fe
7.50 1JT/270°, RF-Ud, SN/ Fe
7.60 1JT/SH, RF-Ud, SN/ Fe
7.65 1JT/SH, RF-Ud, SN/ Fe
7.69 1JT/SH, RF-Ud, SN/ Fe
7.79 1JT/SH, RF-Ud, SN/ Fe
7.89 1JT/SH, RF-Ud, SN/ Fe
7.97 1JT/SH, RF-Ud, SN/ Fe
8.03 1JT/SH, RF-Ud, SN/ Fe
8.03 1JT/SH, RF-Ud, SN/ Fe
8.30 FZ270-EC/90° CA
8.40 1JT/SH, RF-Ud, SN/ Fe
8.49 1JT/270°, RF-Ud, SN/ Fe
8.57 FZ80-EC
8.65 1JT/SH, RF-Ud, SN/ Fe
8.81 1JT/SH, RF-Ud, SN/ Fe
9.00 FZ190-EC
9.30 FZ300-EC
9.48 FZ180-VC
9.76 1JT/SH, RF-Ud, SN/ Fe

Sampling and Testing

Type / **Results**

1.00 – 1.45: N30 SPT 9, 13, 17

Ground Science
Job No. #: GS5702/1
7.15 to 7.33 m Is(50) 6.2 MPa, Is(50) 3.4 MPa

This Log shall be read in conjunction with VicRoads - Dwg Nos. 396223, 396224 & 684947 which provide a summary of the Geotechnical Terms and Symbols used.

Drilling Contractor:	Star Drilling	Logged By:	Katerina Irwin
Rig Type:	SANDVIK 650	Date Logged:	26/04/2021
Driller:	Simon B.	Checked By:	Andrew Wilson
Date Drilled:	25/05/2021	Date Checked:	25/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

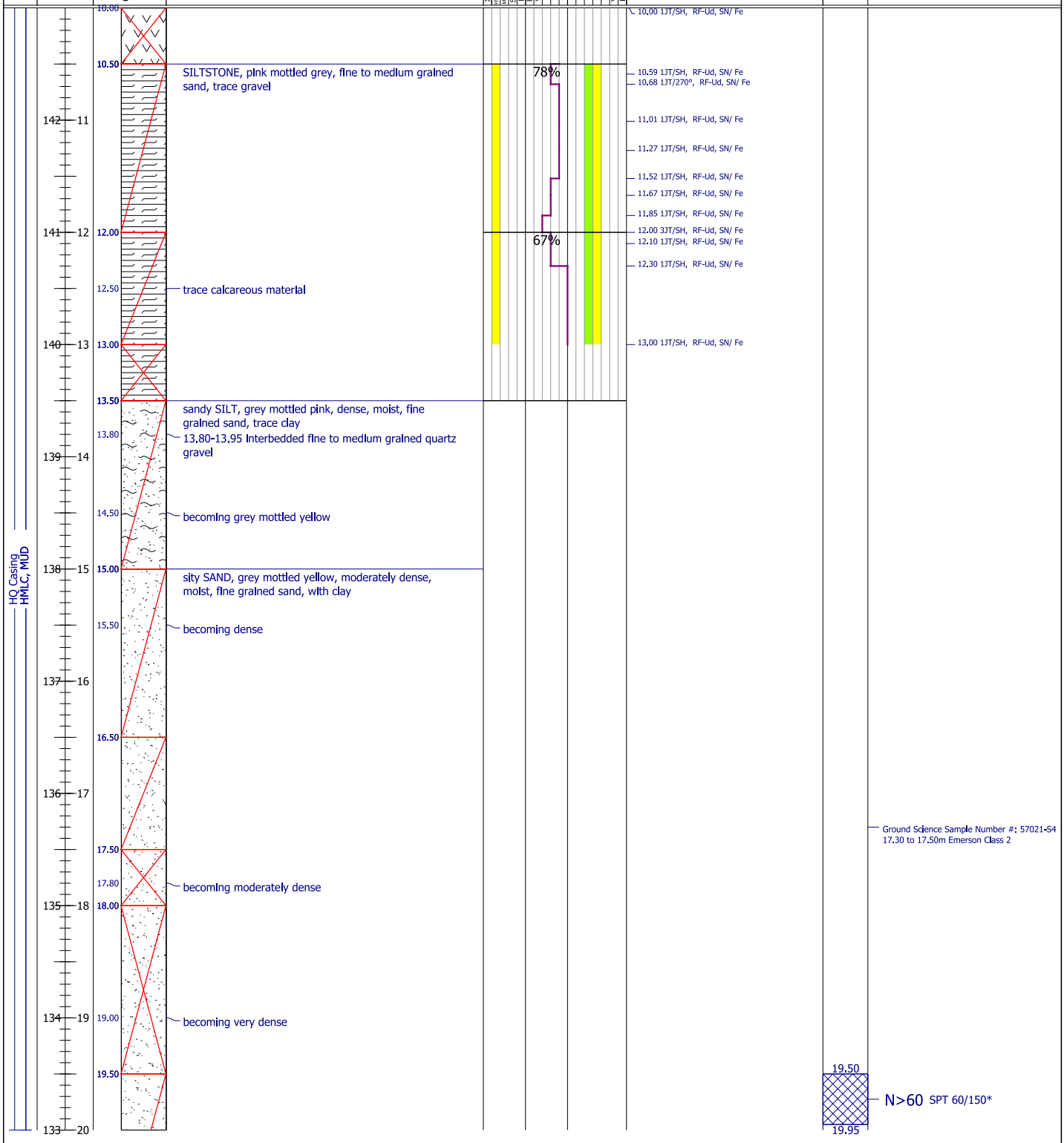
BOREHOLE LOG

Borehole No:	B21-69261S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section:
Location: Bences Road, Merrimu

Northing (m): 5,826,949.00
Easting (m): 277,496.00
AHD. R.L. (m): 153.00

Coordinate System: MGA94
Bearing:
Angle: 90°



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Drilling				Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	132	21	21.00	silty CLAY, grey, hard, moist, high plasticity					21.00	N>60 SPT 60/150*
									21.45	
	131	22	22.00							
			22.50						22.50	N>60 SPT 60/150*
	130	23							22.95	
			70%							
	129	24	24.00						24.00	N>60 SPT 8, 30/150*
			24.60						24.45	
	128	25								
			25.50						25.50	U50 Ground Science Job No. #: GS5702/1 Cohesion 64 (kPa) Angle of Friction 25°
	127	26							25.95	
	126	27	27.00							
			27.30	silty SAND, grey, very dense, moist, fine to medium grained sand						
	125	28								
			28.30							
			28.50	silty CLAY, grey, hard, moist, high plasticity, trace fine to medium grained sand						
	124	29	29.20							
	123	30	30.00							

Drilling Contractor: Star Drilling
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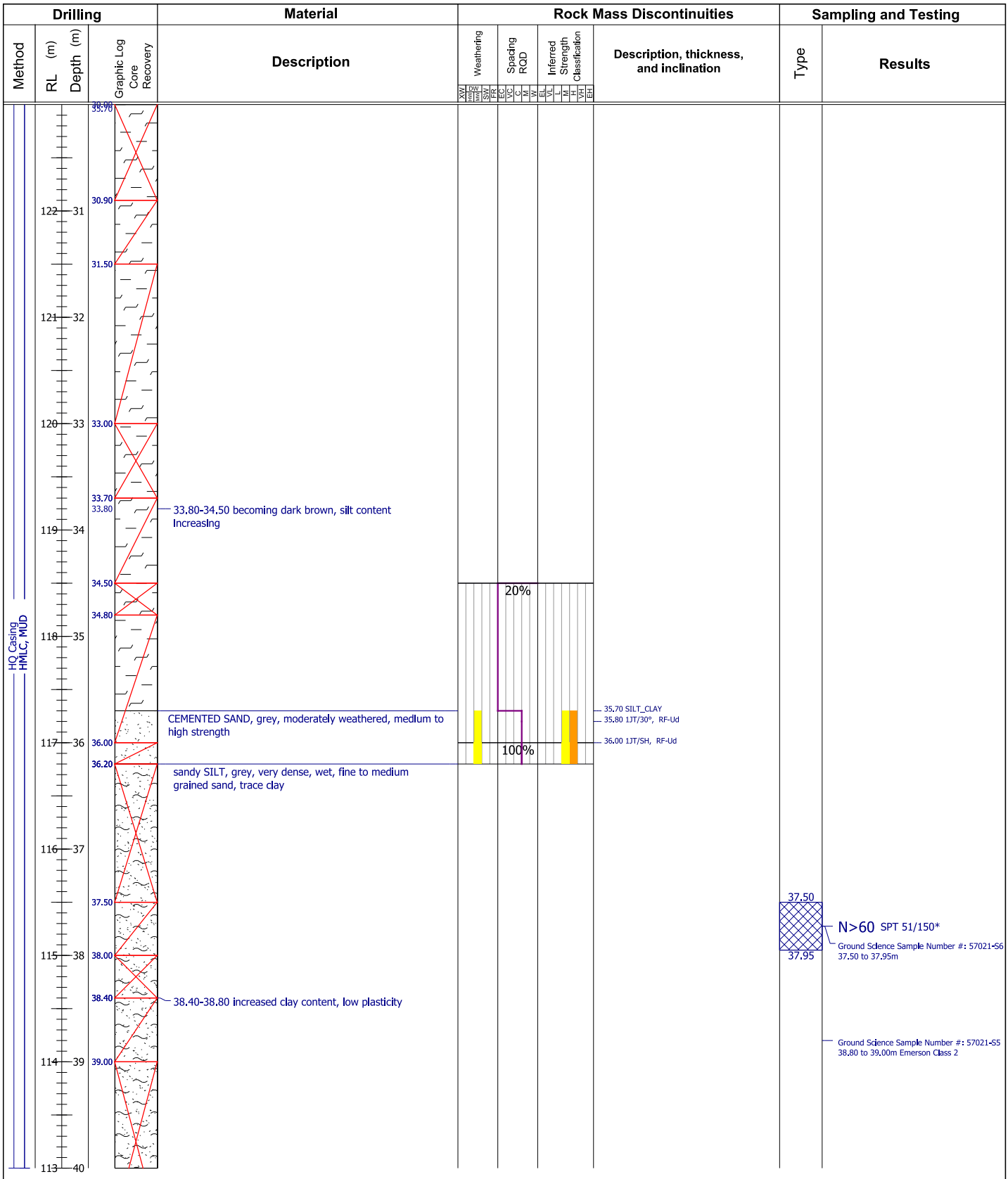

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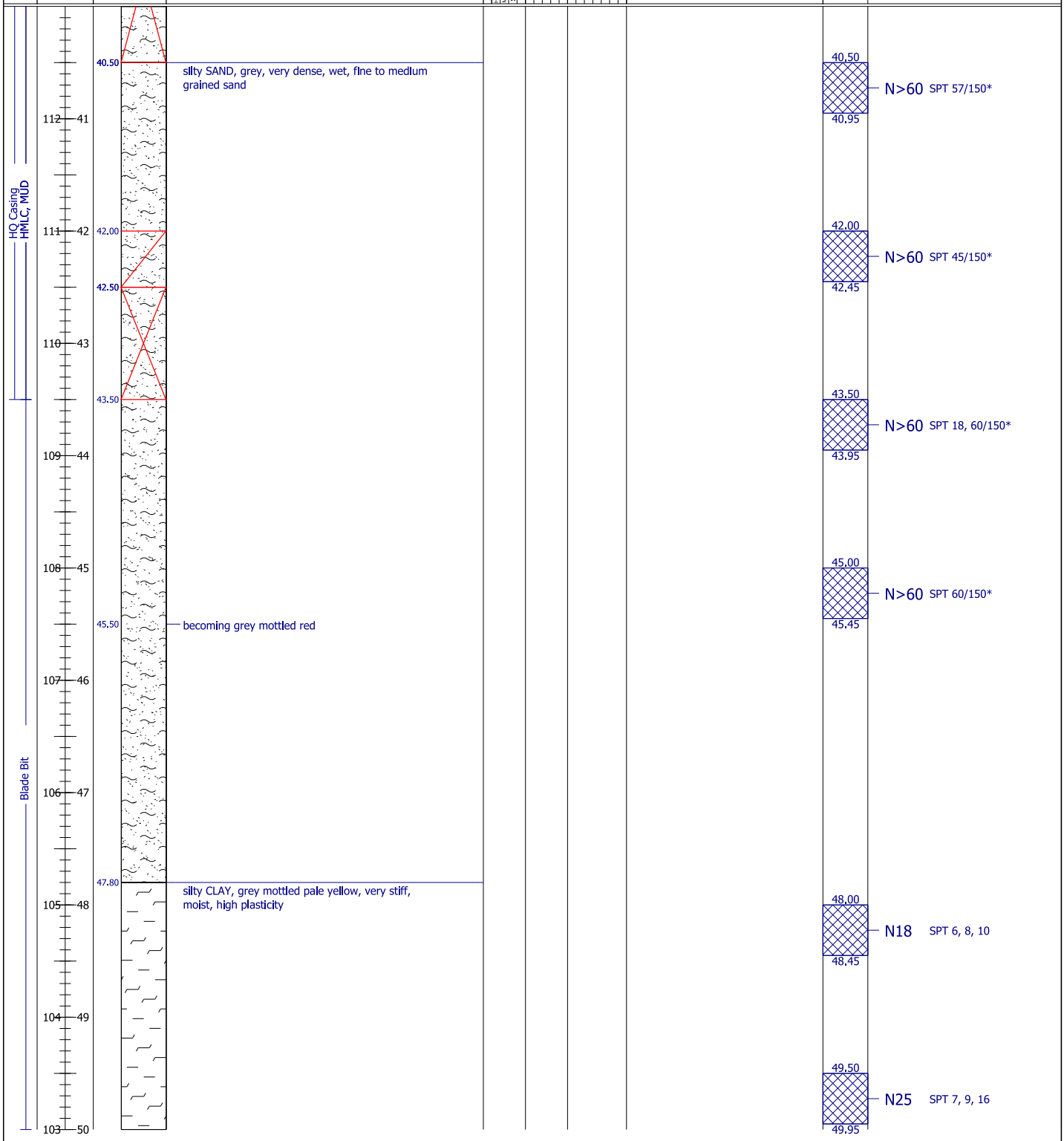

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Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW FR)	Spacing RQD (EC VC C W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
Blade Bit	102 — 51 101 — 52	52.00	silty SAND, grey, very dense, wet, fine grained sand					52.50	N>60 SPT 20, 50/150*
			End of Bore 52.95 m					52.95	

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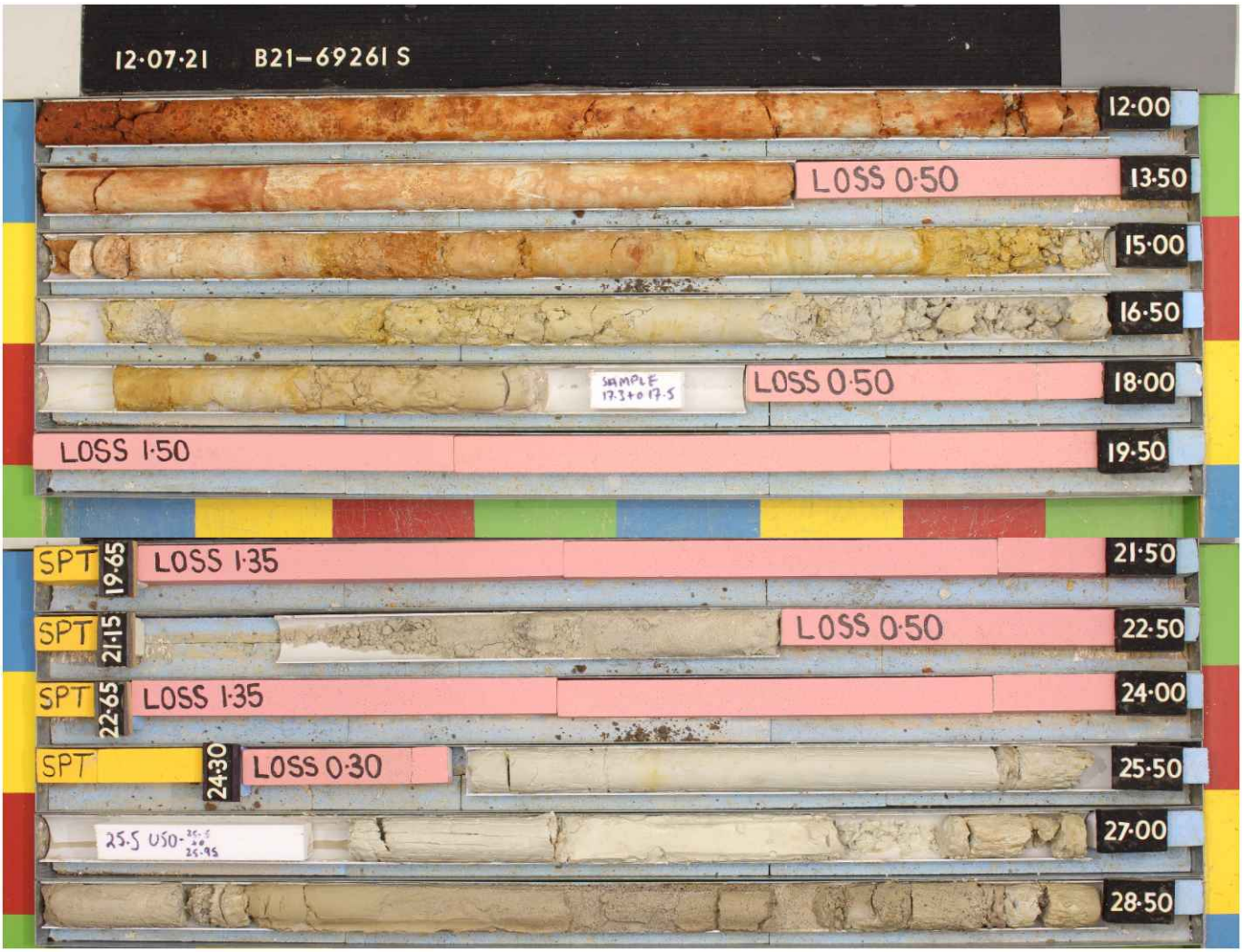
Method	RL (m) / Depth (m)	Graphic Log / Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength / Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results



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Rig Type: SANDVIK 650
Driller: Simon B.
Date Drilled: 25/05/2021

Logged By: Katerina Irwin
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Method	RL (m) / Depth (m)	Graphic Log / Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength / Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results

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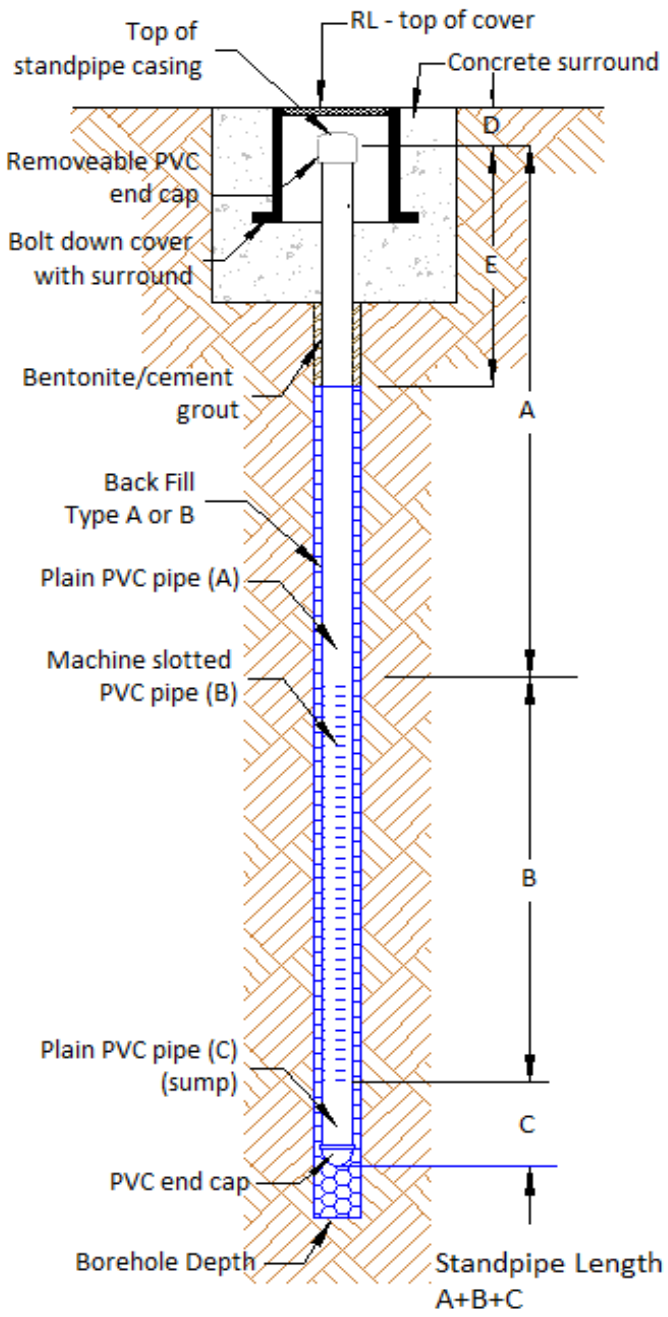

STANDPIPE CONSTRUCTION DETAILS

Western Region

Bacchus Marsh Eastern Link Desktop Study

Borehole No	Easting (m)	Northing (m)	RL (m)	Borehole Depth (m)	Standpipe Length (m)	A (m)	B (m)	C (m)	D (m)	E (m)	BackFill type
B21-69261S	277496	5826949	153.00	52.95	31.00	15	15	0.5	0.5	4.5	A

Notes:

1. Coordinates are MGA. RL is AHD
2. Borehole depth is measured from top of cover
3. Cover details (i) rubber ring between cover and surround. (ii) Cover shall be bolted down with 2 no. 5/16" hexhead bolts
4. Back Fill Type: (A) 5mm aggregate; (B) Washed coarse grained sand

BOREHOLE LOG

Borehole No:	B21-69262S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section: Buckleys Road
Location: Buckleys Road, Merrimu

Northing (m): 5,830,298.00
Easting (m): 276,572.00
AHD. R.L. (m): 194.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m)	Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SW FR)	Spacing RQD (EC VC C M W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HWT Casing Auger	193	1	0.00	silty CLAY, dark grey-brown, stiff, moist, high plasticity					1.00	N12 SPT 4, 6, 6
			1.60	silty CLAY, dark blue, hard, moist, medium to high plasticity, fine to medium grained basalt gravel; XW BASALT					1.45	
	192	2	1.90			74%		2.10 CLAY_SILT 2.16 1JT/SH, RF-Ud, SN/ Fe 2.26 1JT/SH, RF-Ud, SN/ Fe 2.48 1JT/SH, RF-Ud, SN/ Fe 2.54 1JT/SH, RF-IR, SN/ Fe 2.61 FZ70-EC		
			2.10	BASALT, red-brown mottled dark blue						
	191	3						3.10 1JT/45°, RF-Ud, SN/ Fe 3.25 1JT/SH, RF-Ud, SN/ Fe		
			3.40			63%		3.40 1JT/SH, RF-Ud, SN/ Fe 3.50 1JT/SH, RF-Ud, SN/ Fe 3.56 FZ60-EC 3.63 1JT/SH, RF-Ud, SN/ Fe		
			3.80	BASALT, dark blue, slightly vesicular, moderately to highly fractured				3.78 1JT/SH, RF-Ud, SN/ Fe		
	190	4						3.95 1JT/SH, RF-Ud, SN/ Fe 4.05 1JT/SV, RF-Ud, SN/ FeCA 4.18 1JT/SV, RF-Ud, SN/ FeCA 4.26 1JT/SV, RF-Ud, SN/ FeCA 4.40 FZ140-EC CA 4.50 1JT/SH, RF-Ud, SN/ FeCA 4.60 1JT/SH, RF-Ud, SN/ FeCA 4.70 FZ100-EC CA 4.80 1JT/SH, RF-Ud, SN/ FeCA		
			4.90			22%		4.90 2JT/SH, RF-Ud, SN/ FeCA 5.20 FZ300-EC CA 5.30 1JT/SH, RF-Ud, SN/ FeCA 5.37 1JT/SH, RF-Ud, SN/ FeCA 5.38 CS10 5.42 1JT/SH, RF-Ud, SN/ FeCA 5.50 1JT/30°, RF-Ud, SN/ FeCA 5.58 1JT/SH, RF-Ud, SN/ FeCA 5.68 2JT/SH, RF-Ud, SN/ FeCA 5.78 1JT/SH, RF-Ud, SN/ FeCA		
HQ Casing HMLC, WATER	189	5						5.92 FZ140-VC CA 6.00 1JT/SH, RF-Ud, SN/ FeCA 6.05 1JT/SH, RF-Ud, SN/ Fe 6.13 1JT/SH, RF-Ud, SN/ Fe 6.26 1JT/SH, RF-Ud, SN/ Fe 6.30 1JT/SH, RF-Ud, SN/ Fe 6.40 2JT/SH, RF-Ud, SN/ Fe		
			6.40			31%		6.75 FZ350-VC 6.84 1JT/SH, RF-Ud, SN/ Fe 6.88 FZ40-EC 6.94 1JT/SH, RF-Ud, SN/ Fe 7.01 1JT/30°, RF-Ud, SN/ Fe 7.02 CS10 7.12 1JT/SH, RF-Ud, SN/ Fe 7.18 1JT/SH, RF-Ud, SN/ Fe 7.40 FZ220-VC 7.50 2JT/SH, RF-Ud, SN/ Fe 7.61 1JT/SH, RF-Ud, SN/ Fe 7.65 FZ40-EC 7.76 1JT/SH, RF-Ud, SN/ Fe		
	188	6						7.90 1JT/SH, RF-Ud, SN/ Fe		
			7.90			14%		8.07 FZ170-EC 8.17 2JT/SH, RF-Ud, SN/ Fe 8.41 FZ240-VC CA 8.52 1JT/30°, RF-Ud, SN/ FeCA 8.62 2JT/30°, RF-Ud, SN/ FeCA 8.72 2JT/30°, RF-Ud, SN/ FeCA 8.83 FZ110-EC 8.89 1JT/SH, RF-Ud, SN/ Fe 8.92 FZ30-EC 8.97 1JT/SH, RF-Ud, SN/ Fe 9.00 FZ30-EC 9.10 1JT/SH, RF-Ud, SN/ Fe 9.15 1JT/SH, RF-Ud, SN/ Fe 9.21 1JT/SH, RF-Ud, SN/ Fe 9.24 1JT/30°, RF-Ud, SN/ Fe 9.28 1JT/SH, RF-Ud, SN/ Fe 9.33 1JT/80°, RF-Ud, SN/ Fe 9.40 1JT/SH, RF-Ud, SN/ Fe		
	187	7								
	186	8								
	185	9								
			9.40			21%				
	184	10								

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

Logged By: Katerina Irwin
Date Logged: 3/05/2021
Checked By: Andrew Wilson
Date Checked: 26/05/2021

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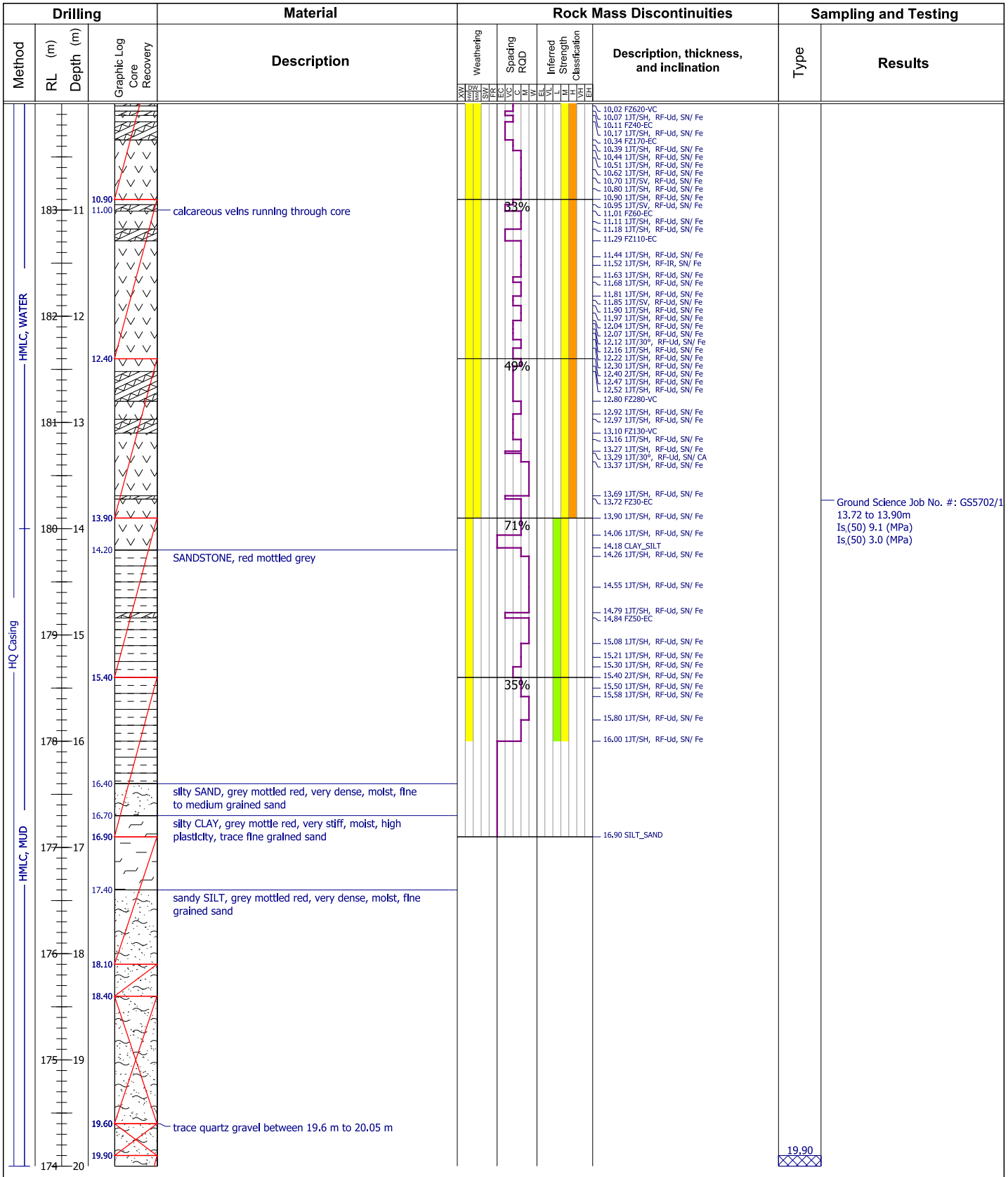
BOREHOLE LOG

Borehole No:	B21-69262S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section: Buckleys Road
Location: Buckleys Road, Merrimu

Northing (m): 5,830,298.00
Easting (m): 276,572.00
AHD. R.L. (m): 194.00

Coordinate System: MGA94
Bearing:
Angle: 90°



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Coordinate System: MGA94
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Method	RL (m) / Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SW FR)	Spacing RQD (EC VC C W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	173 / 21	21.00	trace fine to medium grained quartz gravel					20.35	N>60 SPT 18, 27, 35
		21.40	becoming orange mottled red					21.40	
	172 / 22							21.85	N>60 SPT 35, 50/150*
	171 / 23	22.90						22.90	
								23.35	N>60 SPT 22, 38/150* Ground Science Sample Number #: 57021-S11 22.90 to 23.35m Emerson Class 2
	170 / 24	24.00	becoming grey						
		24.40						24.40	
	169 / 25	24.85						24.85	N>60 SPT 15, 35/150*
		25.30							
		25.60	fine to medium grained sand						
		25.90							
	168 / 26	26.00	silty CLAY, grey mottled yellow, hard, moist, high plasticity						
	167 / 27								
		27.40							
	166 / 28	28.00	sandy SILT, grey, very dense, moist, fine to medium grained sand						
		28.50							
		28.80							
	165 / 29	28.90							
	164 / 30								

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
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HQ Casing HMLC, MUD	163	31	30.40	silty SAND, grey, very dense, moist, fine to medium grained sand						
	162	32	31.90						31.90 – 32.35	N>60 SPT 24, 45, 150*
	161	33	33.40						33.40 – 33.85	N>60 SPT 30, 150*
	160	34	34.50	becoming orange						
	159	35	34.90							
	158	36	36.00							
			36.20	silty CLAY, grey, hard, moist, high plasticity						
	157	37	36.40							
	156	38	37.90							
			38.00	sandy SILT, grey, very dense, moist, fine grained sand, trace clay, trace medium grained sand						
	155	39	39.00							
			39.40	clayey SILT, grey, dense, moist, low to moderate plasticity						
	154	40								

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

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HQ Casing HMLC, MUD	153	41	100%	46.90						
				40.20 silty CLAY, grey, hard, moist, high plasticity						
				40.90						
	152	42		41.60						
				42.40						
	151	43		42.80						
				43.90 trace fine to medium grained sand 43.9 m to 44.05 m						
	150	44								
	149	45		45.40 sandy SILT, grey mottled yellow, dense, moist, trace fine to medium grained sand, trace clay						
	148	46		46.00						
				46.90 sandy SILT, grey, wet, dense, fine to medium grained sand						Ground Science Sample Number #: 57021-S10 46.90 to 47.20m Emerson Class 2
	147	47								
	146	48		48.10						
				48.40 increase in sand content between 48.4 m to 49 m						
				48.70						
	145	49								
	144	50		49.90						

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

Logged By: Katerina Irwin
Date Logged: 3/05/2021
Checked By: Andrew Wilson
Date Checked: 26/05/2021

Commonly Used Symbols

pp	Pocket Penetrometer	A	Auger Sample
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69262S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section: Buckleys Road
Location: Buckleys Road, Merrimu

Northing (m): 5,830,298.00
Easting (m): 276,572.00
AHD. R.L. (m): 194.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW DW MW SW SW FR)	Spacing RQD (EC VC C W)	Inferred Strength Classification (EL VL L M H VH EH)	Description, thickness, and inclination	Type	Results
HQ Casing HMLC, MUD	143 / 51	50.00	silty SAND, grey, very dense, wet, fine to medium grained sand						
		50.90							
		51.40							
	142 / 52	51.80	sandy SILT, grey mottled yellow, dense, wet, fine grained sand, trace medium grained sand						
		52.40	increased clay content						
	141 / 53	52.90	sandy SILT, dark brown mottled yellow, very dense, moist, fine grained sand, trace clay, trace lignite, trace medium grained sand, trace fine to medium grained gravel						
	140 / 54								
		54.40							
	139 / 55								
		55.50							
	138 / 56	55.90							
		56.50	silty SAND with cemented sand bands, grey, very dense, wet, fine to medium grained sand						
	137 / 57	57.05							
Blade Bit, MUD	136 / 58								
	135 / 59								
	134 / 60							59.80	

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

Logged By: Katerina Irwin
Date Logged: 3/05/2021
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BOREHOLE LOG

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File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section: Buckleys Road
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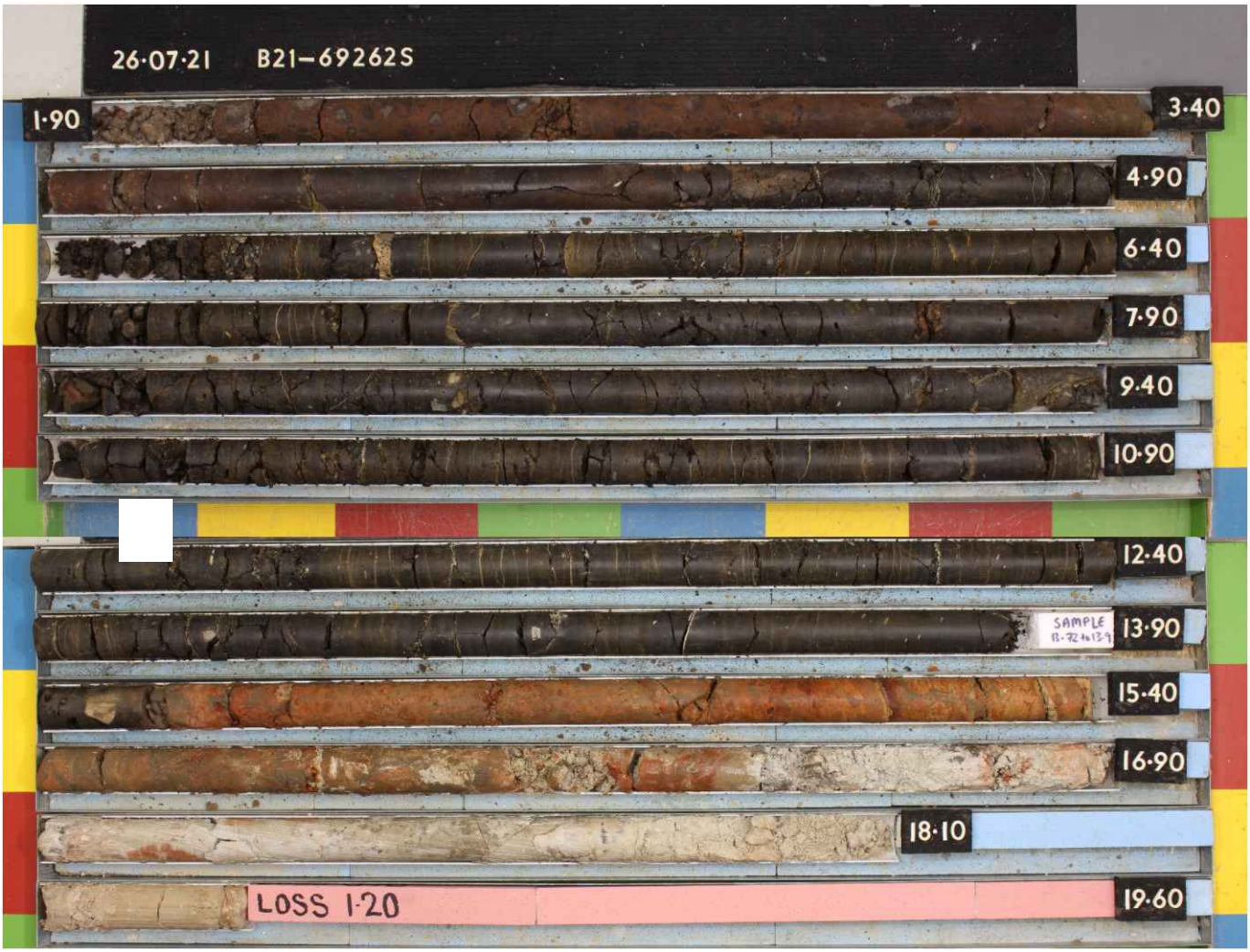
Northing (m): 5,830,298.00
Easting (m): 276,572.00
AHD. R.L. (m): 194.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log / Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results
Blade Bit, MUD									N>60 SPT 22, 25, 150*
			End of Bore 60.25 m					60.25	



This Log shall be read in conjunction with VicRoads - Dwg Nos. 396223, 396224 & 684947 which provide a summary of the Geotechnical Terms and Symbols used.
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Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

Logged By: Katerina Irwin
Date Logged: 3/05/2021
Checked By: Andrew Wilson
Date Checked: 26/05/2021

Commonly Used Symbols

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SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
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BOREHOLE LOG

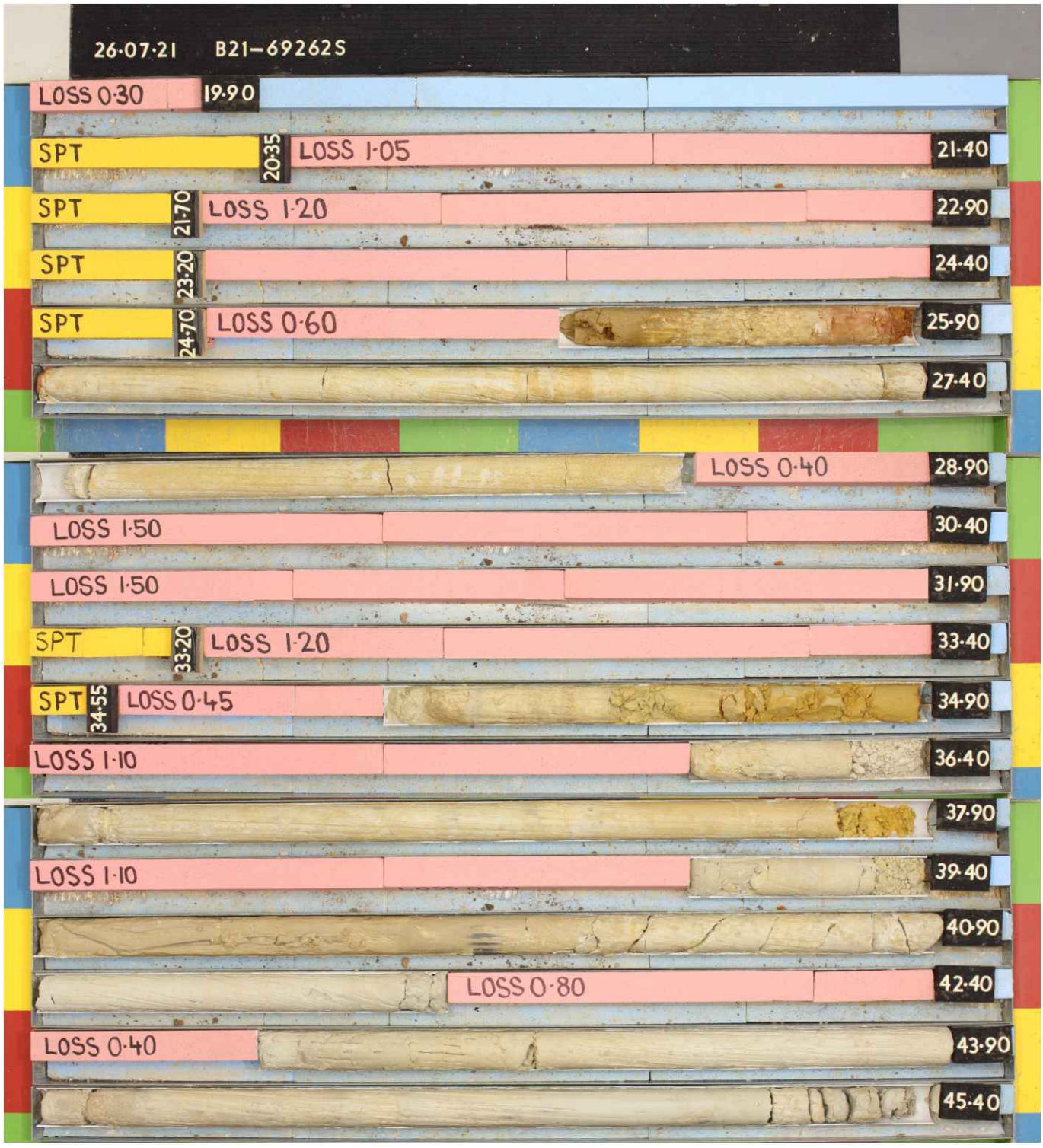
Borehole No:	B21-69262S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section: Buckleys Road
Location: Buckleys Road, Merrimu

Northing (m): 5,830,298.00
Easting (m): 276,572.00
AHD. R.L. (m): 194.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log / Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, M, W)	Inferred Strength / Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results



Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

Logged By: Katerina Irwin
Date Logged: 3/05/2021
Checked By: Andrew Wilson
Date Checked: 26/05/2021

Commonly Used Symbols

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SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
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MC	Moisture Content	▶	Water Inflow
		◀	Water Loss

BOREHOLE LOG

Borehole No:	B21-69262S
File No:	GE046-19

Client: Western Region
Road: Bacchus Marsh Eastern Link Desktop Study
Section: Buckleys Road
Location: Buckleys Road, Merrimu

Northing (m): 5,830,298.00
Easting (m): 276,572.00
AHD. R.L. (m): 194.00

Coordinate System: MGA94
Bearing:
Angle: 90°

Drilling			Material	Rock Mass Discontinuities				Sampling and Testing	
Method	RL (m) / Depth (m)	Graphic Log Core Recovery	Description	Weathering (XW, DW, MW, SW, FR)	Spacing RQD (EC, VC, C, W)	Inferred Strength Classification (EL, VL, L, M, H, VH, EH)	Description, thickness, and inclination	Type	Results

Drilling Contractor: Star Drilling
Rig Type: SANDVIK 650
Driller: S. Anderson
Date Drilled: 3/05/2021

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Commonly Used Symbols

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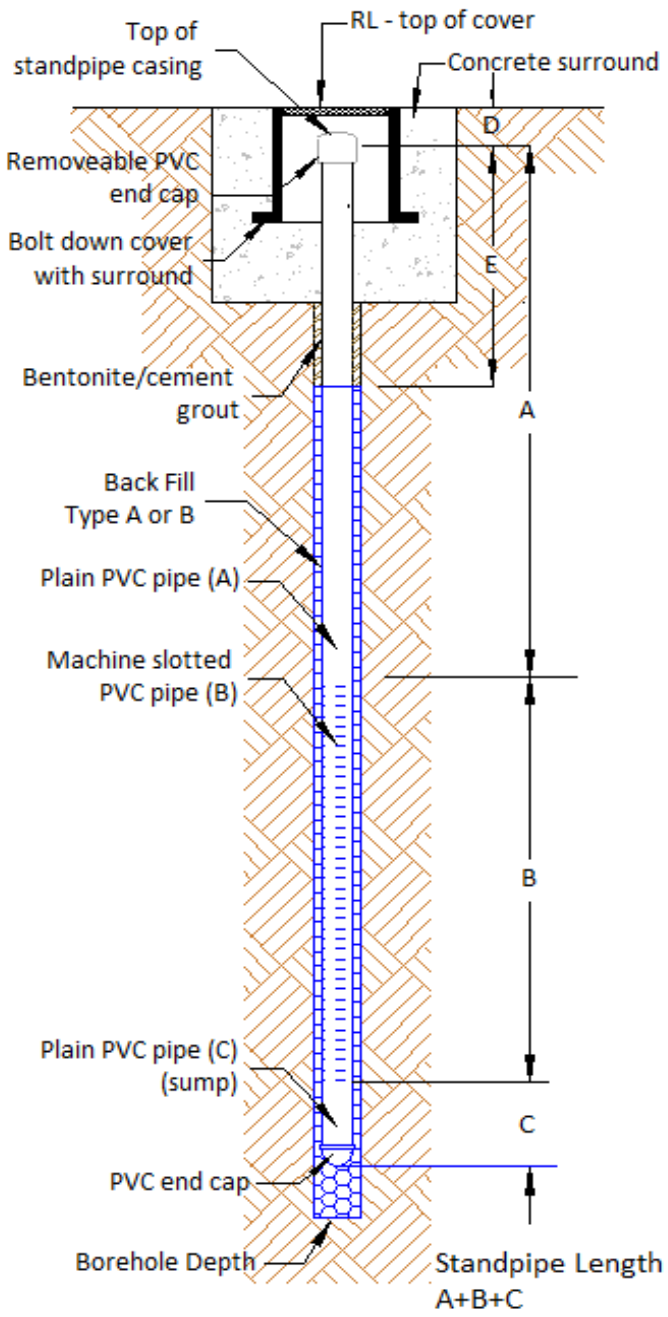
SPT	Standard Penetration Test	Ux	Undisturbed Sample (x mm dia)
$Is_{(50)}$	Point Load Strength Index	▼	Water Table
MC	Moisture Content	▶	Water Inflow
		◀	Water Loss



STANDPIPE CONSTRUCTION DETAILS

Western Region

Bacchus Marsh Eastern Link Desktop Study

Borehole No	Easting (m)	Northing (m)	RL (m)	Borehole Depth (m)	Standpipe Length (m)	A (m)	B (m)	C (m)	D (m)	E (m)	BackFill type
B21-69262S	276572	5830298	194.00	60.25	31.00	15	15	0.5	0.5	4.5	A

Notes:

1. Coordinates are MGA. RL is AHD
2. Borehole depth is measured from top of cover
3. Cover details (i) rubber ring between cover and surround. (ii) Cover shall be bolted down with 2 no. 5/16" hexhead bolts
4. Back Fill Type: (A) 5mm aggregate; (B) Washed coarse grained sand

APPENDIX D

RESULTS TABLES

Table D1: Coffey Pinhole Dispersion Test results

Location	Depth (mbgl)	Sample number	Particle Size Distribution (%)			Coefficient of Permeability* (m/s)	Emerson Class	Pinhole dispersion test - designation
			Gravel	Sand	Fines			
TP103 [1]	1 to 1.5	349	-	-	-	-	4	D1
TP105	1 to 1.5	351	7	32	61	$2x10^{-9}$	4	ND2
TP118	0 to 0.5	352	-	-	-	-	6	ND2
TP122	1 to 1.5	350	-	-	-	$3x10^{-9}$	4	ND2
TP123	1.1 to 1.5	353	-	-	-	$5x10^{-9}$	4	ND2

Where: * Remoulded at 95% maximum dry density and optimum moisture content; mbgl = metres below ground level; D1 - highly dispersive, ND2 - completely erosion resistant

Notes: [1] Sample could not be saturated. Considered to be impermeable

Table D2: Coffey Emerson/Exchangeable Sodium Test results

Location	Depth (mbgl)	Unit	Material	Sample Number	Emerson Class Number	ESP (%)	pH	EC (µS/cm)	Particle Size Distribution (%)		
									Gravel	Sand	Fines
BH-1	10.5	Werribee Fm		M20-Oc24632	2	32	9.4	67	-	-	-
BH-1	11.5	Werribee Fm		M20-Oc24631	2	22	9.4	47	-	-	-
BH-4	9.7	Werribee Fm		M20-Oc24634	2	11	9.4	370	-	-	-
BH-4	10.7	Werribee Fm		M20-Oc24633	2	23	8.6	360	-	-	-
HA-1B	0.2	Werribee Fm	SP Sand	M20-Oc24625	2	6.1	7.9	29	-	-	-
HA-1C	0.3	Werribee Fm	SP Sand	M20-Oc24626	3	7.2	7.4	10	-	-	-
HA-2C	0.3	Werribee Fm	SC Clayey Sand	M20-Oc24627	2	6.5	9.4	730	-	-	-
HA-3B	0.4	Werribee Fm	SP Sand	M20-Oc24628	2	6.6	7.3	17	-	-	-
HA-3C	0.3	Werribee Fm	SC Clayey Sand	M20-Oc24629	3	9.6	9.3	270	-	-	-
HA-3D	0.3	Werribee Fm	CH Sandy Clay	M20-Oc24630	2	4.9	9.5	110	-	-	-
TP101	1.15 to 1.5	Newer Volcanics	CH	354	4	18	9.3	1000	-	-	-
TP103	1 to 1.5	Newer Volcanics	CH	349	4	23	9.2	1600	-	-	-
TP104	0 to 0.5	Newer Volcanics	CH	367	4	2.8	8.6	210	1	4	95
TP105	0.4 to 0.5	Newer Volcanics	CH Sandy Clay	355	4	2	9.1	96	-	-	-
TP105	1 to 1.5	Newer Volcanics	SP Sand	351	4	5	9.2	280	7	32	61
TP108	0.5	Newer Volcanics	CH	365	4	19	8.8	1300	0	8	92
TP108	2.5	Newer Volcanics	CH	356	5	32	8.2	1700	-	-	-
TP109	1.5	Newer Volcanics	CH	357	4	16	9.2	1200	-	-	-
TP110	0.5	Newer Volcanics	CH	358	3	-	-	-	-	-	-
TP114	2.5	Newer Volcanics	CH	359	4	26	9	2000	-	-	-
TP115	1.5 to 1.6	Newer Volcanics	CH	360	4	26	8.7	2300	-	-	-
TP116	0.5	Newer Volcanics	CH	361	3	-	-	-	-	-	-
TP118	0 to 0.5	Newer Volcanics	CH	352	6	21	7.4	55	-	-	-
TP120	1.5	Newer Volcanics	CH	362	4	24	9	2400	0	8	92
TP122	1 to 1.4	Newer Volcanics	GC	363	-	4.7	8.8	290	-	-	-
TP122	1 to 1.5	Newer Volcanics	GC	350	4	-	-	-	-	-	-
TP123	1.1 to 1.5	Newer Volcanics	CH	353	4	3.3	9.1	79	-	-	-
TP125	1.2 to 1.5	Newer Volcanics	CH	364	6	-	-	-	-	-	-

Where: ESP = Exchangeable Sodium Percentage; EC = Electrical Conductivity (1:5 aqueous extract)

Location	Sample ID	Depth (mbgl)	Material	Emerson Class
B21-69260S	57021-S1	11.00-11.45	clayey SAND, fine to coarse, brown, fines of low plasticity, trace gravel	2
B21-69260S	57021-S2	31.50-31.60	CLAY/SILT, low plasticity, grey, with sand	2
B21-69260S	57021-S3	44.80-45.00	SAND, fine to coarse, brown, with clay/silt	2
B21-69261S	57021-S4	17.30-17.50	SAND, fine to coarse, grey, with clay/silt	2
B21-69261S	57021-S5	38.80-39.00	SAND, fine to coarse, brown, with clay/silt	2
B21-69262S	57021-S11	22.90-23.25	sandy SILT, non-plastic, brown, sand fine to medium grained	2
B21-69262S	57021-S10	46.90-47.20	SAND, fine to coarse, grey, with clay/silt	2

APPENDIX E

LABORATORY CERTIFICATES – COFFEY REPORT

Material Test Report

Ground Science Pty Ltd
Ground Science Laboratory
13 Brock Street Thomastown Victoria 3074
Phone: (03) 9464 4617
Email: chris@groundscience.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Chris Senserrick
Laboratory Manager
NATA Accredited Laboratory Number: 15055

Report Number: **GS5387/1-1**
Issue Number: 1
Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S1
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **HA1B (0.2m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	SILT, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

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Issue Number: 1
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Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S2
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **HA1C (0.3m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**3**		
Soil Description	SILT, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

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Issue Number: 1
Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S3
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **HA2C (0.3m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	CLAY, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

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Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S4
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **HA3B (0.4m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	SILT, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

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Report Number: **GS5387/1-1**
Issue Number: 1
Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S5
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **HA3C (0.3m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**3**		
Soil Description	SILT, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

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Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S6
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **HA3D (0.3m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	CLAY, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

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Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S7
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **BH1 (11.5m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	SILT, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

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Issue Number: 1
Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S8
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **BH1 (10.5m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	SILT, low to medium plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

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Phone: (03) 9464 4617
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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Chris Senserrick
Laboratory Manager
NATA Accredited Laboratory Number: 15055

Report Number: **GS5387/1-1**
Issue Number: 1
Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S9
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **BH4 (9.7m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	CLAY, medium to high plasticity, brown.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

Material Test Report

Ground Science Pty Ltd
Ground Science Laboratory
13 Brock Street Thomastown Victoria 3074
Phone: (03) 9464 4617
Email: chris@groundscience.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Chris Senserrick
Laboratory Manager
NATA Accredited Laboratory Number: 15055

Report Number: **GS5387/1-1**
Issue Number: 1
Date Issued: 19/10/2020
Client: Coffey Information
Level 1, 436 Johnston St, Abbotsford, Melbourne VIC 3067
Contact: Farid Khayyer
Project Number: GS5387/1
Project Name: Merrimu Precinct
Project Location: Various
Client Reference: GS5387/1
Work Request: 483
Sample Number: 53871-S10
Date Sampled: 15/10/2020
Dates Tested: 15/10/2020 - 19/10/2020
Sample Location: **BH4 (10.7m)**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	CLAY, medium to high plasticity, grey.		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		

ACN 31 105 704 078

13 Brock Street, Thomastown, VIC P 03 9464 4617 Email reception@groundscience.com.au

Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MA**
Sample number:	#349		
Sample identification:	TP103 @ 1 - 1.5m		

Start time :

does the sample slake

[ ] no → [ ] 7 sample swells

[X] yes [ ] 8 no swell

time dispersion commences

start :

end:

[ ] 1 complete dispersion

[ ] 2 partial dispersion

[X] no dispersion

remoulded sample

[ ] 3 dispersion

time dispersion commences

start :

end:

[X] no dispersion

calcite / gypsum present

[X] 4 present

[ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

[ ] 5 disperses (remains cloudy)

[ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *gravelly CLAY, medium to high plasticity, brown, fine to coarse*

EMERSON CLASS NUMBER

4

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Chris Senserrick
Approved Signatory

Date: 26/08/2020

ACN 31 105 704 078

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MB**
Sample number:	#350		
Sample identification:	TP122 @ 1 - 1.50m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start :

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *silty CLAY, low plasticity, brown*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MC**
Sample number:	#351		
Sample identification:	TP105 @ 1 - 1.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start :

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY, low to medium plasticity, brown*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MD**
Sample number:	#352		
Sample identification:	TP118 @ 0.0 - 0.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start :

end:

- [X] no dispersion

calcite / gypsum present

- [ ] 4 present
- [X] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [X] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY/ SILT, high plasticity, brown*

EMERSON CLASS NUMBER

6

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**ME**
Sample number:	#353		
Sample identification:	TP123 @ 1.1 - 1.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start :

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *clayey SILT, medium to high plasticity, brown.*

EMERSON CLASS NUMBER

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MF**
Sample number:	#354		
Sample identification:	TP101 @ 1.15 - 1.5m		

Start time :

does the sample slake

[ ] no → [ ] 7 sample swells

[X] yes [ ] 8 no swell

time dispersion commences

start :

end:

[ ] 1 complete dispersion

[ ] 2 partial dispersion

[X] no dispersion

remoulded sample

[ ] 3 dispersion

time dispersion commences

start :

[X] no dispersion

end:

calcite / gypsum present

[X] 4 present

[ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

[ ] 5 disperses (remains cloudy)

[ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *silty CLAY, medium to high plasticity, brown*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MG**
Sample number:	#355		
Sample identification:	TP105 @ 0.4 - 0.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start :

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *SILT, low to medium plasticity, brown*

EMERSON CLASS NUMBER

4

Chris Senserrick
Approved Signatory

Date: 26/08/2020

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MH**
Sample number:	#356		
Sample identification:	TP108 @ 2.5m		

Start time :

does the sample slake
- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences
start :
end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences
start :
end:

- [X] no dispersion

calcite / gypsum present

- [ ] 4 present
- [X] absent

5 :1 water: soil mix
10 mins of vigorous shaking

- [X] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*
water temp : *18"C*
description : *clayey SILT, medium to high plasticity, brown*

EMERSON CLASS NUMBER

5

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MI**
Sample number:	#357		
Sample identification:	TP109 @ 1.5m		

Start time :

does the sample slake

- [ ] no → [ ] 7 sample swells
- [X] yes → [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start :

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *gravelly clayey SILT, medium to high plasticity, brown, fine to coarse*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client: COFFEY INFORMATION (ABBOTSFORD)
Job No. **GS5116/1**
Project: MERRIMU PRECINCT - ADDITIONAL TESTING
Date: **20/08/2002**
Location: -
Report No. **MJ**
Sample number: #358
Sample identification: TP110 @ 0.5m

Start time :

does the sample slake
[ ] no → [ ] 7 sample swells
[X] yes [ ] 8 no swell

time dispersion commences
start :
end:

[ ] 1 complete dispersion
[ ] 2 partial dispersion
[X] no dispersion

remoulded sample
[X] 3 dispersion

time dispersion commences
start : 8.30
end: 10.30
[ ] no dispersion

calcite / gypsum present
[ ] 4 present
[ ] absent

5 :1 water: soil mix
10 mins of vigorous shaking
[ ] 5 disperses (remains cloudy)
[ ] 6 floculates (clear at surface)

water type: *distilled*
water temp : *18"C*
description : *clayey SILT, medium to plasticity, brown*

EMERSON CLASS NUMBER

3

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MK**
Sample number:	#359		
Sample identification:	TP114 @ 2.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start : 8.30

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY, medium to high plasticity, brown*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**ML**
Sample number:	#360		
Sample identification:	TP115 @ 1.5 - 1.6m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start : 8.30

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY, medium to high plasticity, grey*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client: COFFEY INFORMATION (ABBOTSFORD)

Job No. **GS5116/1**

Project: MERRIMU PRECINCT - ADDITIONAL TESTING

Date: **20/08/2002**

Location: -

Report No. **MM**

Sample number: #361

Sample identification: TP116 @ 0.5m

Start time :

does the sample slake

[ ] no → [ ] 7 sample swells

[X] yes [ ] 8 no swell

time dispersion commences

start :

end:

[ ] 1 complete dispersion

[X] 2 partial dispersion

[ ] no dispersion

remoulded sample

[X] 3 dispersion

time dispersion commences

start : 8.30

end:

[ ] no dispersion

calcite / gypsum present

[ ] 4 present

[ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

[ ] 5 disperses (remains cloudy)

[ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *silty CLAY, low to medium plasticity, brown.*

EMERSON CLASS NUMBER

3

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Date: 26/08/2020

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MN**
Sample number:	#362		
Sample identification:	TP120 @ 1.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start : 8.30

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY, medium to high plasticity, grey.*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MO**
Sample number:	#364		
Sample identification:	TP125 @ 1.2 - 1.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start : 8.30

end:

- [X] no dispersion

calcite / gypsum present

- [ ] 4 present
- [X] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [X] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY, medium to high plasticity, grey*

EMERSON CLASS NUMBER

6

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Approved Signatory

Date: 26/08/2020

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MP**
Sample number:	#365		
Sample identification:	TP108 @ 0.5m		

Start time :

does the sample slake

- [ ] no → 7 sample swells
- [X] yes
- [ ] 8 no swell

time dispersion commences

start :

end:

- [ ] 1 complete dispersion
- [ ] 2 partial dispersion
- [X] no dispersion

remoulded sample

- [ ] 3 dispersion

time dispersion commences

start : 8.30

end:

- [X] no dispersion

calcite / gypsum present

- [X] 4 present
- [ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

- [ ] 5 disperses (remains cloudy)
- [ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY, medium to high plasticity, brown*

EMERSON CLASS NUMBER

4

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Test Results - Emerson Dispersion - AS1289 3.8.1

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Date:	**20/08/2002**
Location:	-	Report No.	**MQ**
Sample number:	#367		
Sample identification:	TP104 @ 0.0 - 0.5m		

Start time :

does the sample slake

[ ] no → [ ] 7 sample swells

[X] yes → [ ] 8 no swell

time dispersion commences

start :

end:

[ ] 1 complete dispersion

[ ] 2 partial dispersion

[X] no dispersion

remoulded sample

[ ] 3 dispersion

time dispersion commences

start : 8.30

[X] no dispersion

end:

calcite / gypsum present

[X] 4 present

[ ] absent

5 :1 water: soil mix

10 mins of vigorous shaking

[ ] 5 disperses (remains cloudy)

[ ] 6 floculates (clear at surface)

water type: *distilled*

water temp : *18"C*

description : *CLAY/SILT, low to medium plasticity, brown*

EMERSON CLASS NUMBER

4

Chris Senserrick
Approved Signatory

Date: 26/08/2020

GroundScience
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PERMEABILITY - FALLING HEAD AS1289 6.7.2

Client :	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Report No.	MW
Location:	-	Test date:	31-Aug-20

Sample identification	TP103 @ 1 - 1.5m
Sample number	# 349
Source	-

Coefficient of permeability (m/sec)	SPECIMEN DID NOT SATURATE
Hydraulic Gradient	Various
Specimen compacted Density Ratio (%)	95
Specimen compacted Moisture ratio (%)	101
Surcharge applied to specimen (kPa)	3
Surcharge applied to specimen (kg)	5.5
Percentage of material retained (%)	1.1
Sieve Size used (mm)	19
specimen description	gravelly CLAY, medium to high plasticity, brown, fine to coarse

Notes:		Sample remoulded to a target of 98% SMDD @ OMC
Maximum Dry Density	t/m^3	1.36
Optimum Moisture Conten	%	33.0
Compaction test method		AS1289 5.1.1
Sampling Method		Sampled by client, tested as received
Comments		MDD and OMC obtained by standard compaction AS1289.5.1.1 Sample failed to saturate therefore deemed impermeable according to RC cop 500.16 4(e)

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NATA Accredited Laboratory No. 15055

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Date of issue
2/09/2020

Aaron Stuart
Approved Signatory

A C N 105 704 078
13 Brock Street Thomastown VIC, P 03 9464 4617 Email reception@groundscience.com.au

PERMEABILITY - FALLING HEAD AS1289 6.7.2

Client :	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Report No.	MV
Location:	-	Test date:	31-Aug-20

Sample identification	TP122 @ 1 - 1.50m
Sample number	# 350
Source	-

Coefficient of permeability (m/sec)	3E-09
Hydraulic Gradient	Various
Specimen compacted Density Ratio (%)	95
Specimen compacted Moisture ratio (%)	100
Surcharge applied to specimen (kPa)	3
Surcharge applied to specimen (kg)	5.5
Percentage of material retained (%)	7.4
Sieve Size used (mm)	19
specimen description	silty CLAY, low plasticity, brown

Notes:		Sample remoulded to a target of 95% SMDD @ OMC
Maximum Dry Density	t/m^3	1.43
Optimum Moisture Conten	%	28.0
Compaction test method		AS1289 5.1.1
Sampling Method		Sampled by client, tested as received

Comments

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Date of issue
7/09/2020

Aaron Stuart
Approved Signatory

A C N 105 704 078
13 Brock Street Thomastown VIC, P 03 9464 4617 Email reception@groundscience.com.au

PERMEABILITY - FALLING HEAD AS1289 6.7.2

Client :	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Report No.	MU
Location:	-	Test date:	31-Aug-20

Sample identification	TP105 @ 1 - 1.5m
Sample number	#351
Source	-

Coefficient of permeability (m/sec)	2E-09
Hydraulic Gradient	Various
Specimen compacted Density Ratio (%)	95
Specimen compacted Moisture ratio (%)	99
Surcharge applied to specimen (kPa)	3
Surcharge applied to specimen (kg)	5.5
Percentage of material retained (%)	0
Sieve Size used (mm)	19
specimen description	sandy SILT/CLAY, low to medium plasticity, brown, sand fine to coarse, trace gravel.

Notes: Sample remoulded to a target of 95% SMDD @ OMC

Maximum Dry Density	t/m^3	1.80
Optimum Moisture Conten	%	15.5
Compaction test method		AS1289 5.1.1
Sampling Method		Sampled by client, tested as received

Comments

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Date of issue 7/09/2020

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PERMEABILITY - FALLING HEAD AS1289 6.7.2

Client :	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PRECINCT	Report No.	MT
Location:	-	Test date:	02-Sep-20

Sample identification	TP23 @ 1.1 - 1.5m
Sample number	# 353
Source	-

Coefficient of permeability (m/sec)	5E-09
Hydraulic Gradient	Various
Specimen compacted Density Ratio (%)	95
Specimen compacted Moisture ratio (%)	98
Surcharge applied to specimen (kPa)	3
Surcharge applied to specimen (kg)	5.5
Percentage of material retained (%)	26
Sieve Size used (mm)	19
specimen description	gravelly CLAY, medium to high plasticity, brown, fine to coarse

Notes:		Sample remoulded to a target of 98% SMDD @ OMC
Maximum Dry Density	t/m^3	1.72
Optimum Moisture Conten	%	20.0
Compaction test method		AS1289 5.1.1
Sampling Method		Sampled by client, tested as received

Comments

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Test Results - Pinhole Dispersion

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PROJECT	Report No.	MZ
Location	-	Test Date	01-Sep-20

Sample Number		#349
Sample Id		TP03
Depth		1 - 1.5m
Test Method		AS1289 3.8.3 - 2014
Soil Description		CLAY, medium plasticity, dark brown
Maxiumum Dry Density	t/m3	1.36
Optimum Moisture Content	%	33.0
Natural Moisture Content	%	32.7
Specimen Moisture Content	%	33.0
Bulk Density of Specimen	t/m3	1.718
Rate of Flow	mL/s	0.4
PINHOLE DISPERSION		
DESCRIPTION		D1
DESIGNATION		Highly Dispersive
Specimen cure period		> 48 HOURS
Water type		potable water
Note		Sample remoulded to a target of 98% SMDD @ OMC Specimen is based on material passing 2.36mm sieve only

Comments: Sampled by client, tested as received.
MDD & OMC tested in accordance with AS1289 5.1.1

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date: 8/09/2020

Approved Signatory: Ernie Gmehling

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Test Results - Pinhole Dispersion

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PROJECT	Report No.	NA
Location	-	Test Date	01-Sep-20

Sample Number		#350
Sample Id		TP22
Depth		1.0 - 1.5m
Test Method		AS1289 3.8.3 - 2014
Soil Description		clayey SILT, low to medium plasticity, dark brown
Maxiumum Dry Density	t/m3	1.43
Optimum Moisture Content	%	28.0
Natural Moisture Content	%	26.0
Specimen Moisture Content	%	27.9
Bulk Density of Specimen	t/m3	1.739
Rate of Flow	mL/s	3.8
PINHOLE DISPERSION		
DESCRIPTION		ND2
DESIGNATION		Completely Erosion Resistant
Specimen cure period		> 48 HOURS
Water type		potable water
Note		Sample remoulded to a target of 98% SMDD @ OMC Specimen is based on material passing 2.36mm sieve only
Comments		Sampled by client, tested as received. MDD & OMC tested in accordance with AS1289 5.1.1

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Test Results - Pinhole Dispersion

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PROJECT	Report No.	NB
Location	-	Test Date	01-Sep-20

Sample Number		#351
Sample Id		TP05
Depth		1.0 - 1.5m
Test Method		AS1289 3.8.3 - 2014
Soil Description		silty CLAY, medium plasticity, brown, trace gravel.
Maxiumum Dry Density	t/m3	1.80
Optimum Moisture Content	%	15.5
Natural Moisture Content	%	15.0
Specimen Moisture Content	%	14.9
Bulk Density of Specimen	t/m3	1.975
Rate of Flow	mL/s	2.5
PINHOLE DISPERSION		
DESCRIPTION		ND2
DESIGNATION		Completely Erosion Resistant
Specimen cure period		> 48 HOURS
Water type		potable water
Note		Sample remoulded to a target of 98% SMDD @ OMC Specimen is based on material passing 2.36mm sieve only

Comments: Sampled by client, tested as received.
MDD & OMC tested in accordance with AS1289 5.1.1

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Test Results - Pinhole Dispersion

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PROJECT	Report No.	NC
Location	-	Test Date	01-Sep-20

Sample Number		#352
Sample Id		TP18
Depth		0.0 - 0.5m
Test Method		AS1289 3.8.3 - 2014
Soil Description		silty CLAY, low to medium plasticity, brown
Maxiumum Dry Density	t/m3	1.41
Optimum Moisture Content	%	24.5
Natural Moisture Content	%	25.2
Specimen Moisture Content	%	24.3
Bulk Density of Specimen	t/m3	1.668
Rate of Flow	mL/s	2.3
PINHOLE DISPERSION		
DESCRIPTION		ND2
DESIGNATION		Completely Erosion Resistant
Specimen cure period		> 48 HOURS
Water type		potable water
Note		Sample remoulded to a target of 98% SMDD @ OMC Specimen is based on material passing 2.36mm sieve only

Comments: Sampled by client, tested as received.
MDD & OMC tested in accordance with AS1289 5.1.1

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Test Results - Pinhole Dispersion

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	GS5116/1
Project:	MERRIMU PROJECT	Report No.	ND
Location	-	Test Date	01-Sep-20

Sample Number		#353
Sample Id		TP23
Depth		1.1 - 1.5m
Test Method		AS1289 3.8.3 - 2014
Soil Description		silty CLAY, low to medium plasticity, brown
Maxiumum Dry Density	t/m3	1.72
Optimum Moisture Content	%	20.0
Natural Moisture Content	%	19.6
Specimen Moisture Content	%	20.0
Bulk Density of Specimen	t/m3	1.961
Rate of Flow	mL/s	4.5
PINHOLE DISPERSION		
DESCRIPTION		ND2
DESIGNATION		Completely Erosion Resistant
Specimen cure period		> 48 HOURS
Water type		potable water
Note		Sample remoulded to a target of 98% SMDD @ OMC Specimen is based on material passing 2.36mm sieve only

Comments: Sampled by client, tested as received.
MDD & OMC tested in accordance with AS1289 5.1.1

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Particle Size Distribution & Atterberg Limits Test Report

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Test Date:	**18-Aug-20**
Location:	-	Report No.	**LW**
Lab Reference No.	**#351**	Sample Identification:	**TP105 @ 1 - 1.5m**

Laboratory Specimen Classification: sandy SILT/CLAY, low to medium plasticity, brown, sand fine to coarse, trace gravel.

Particle Size Distribution AS1289 3.6.1

Sieve Size	% Passing	Specification
150 mm	**100**	
75 mm	**100**	
53mm	**100**	
37.5 mm	**100**	
26.5 mm	**100**	
19.0 mm	**100**	
13.2 mm	**99**	
9.5 mm	**98**	
6.7 mm	**96**	
4.75 mm	**95**	
2.36 mm	**93**	
1.18 mm	**88**	
600 um	**84**	
425 um	**82**	
300 um	**80**	
150 um	**71**	
75 um	**61**	

Consistency Limits and Moisture Content

Test		Method	Result	Spec.
Liquid Limit	%	AS1289 3.1.2	**ND**	
Plastic Limit	%	AS1289 3.2.1	**ND**	
Plasticity Index	%	AS1289 3.3.1	**ND**	
Linear Shrinkage	%	AS1289 3.4.1	**ND**	
Moisture Content	%	AS1289 2.1.1	**8.3**	

Sample History:	Oven Dried
Preparation Method:	Dry sieved
Crumbling / Curling of linear shrinkage:	-
Linear shrinkage mould length:	250 mm

ND = not determined NO = not obtainable NP = non plastic

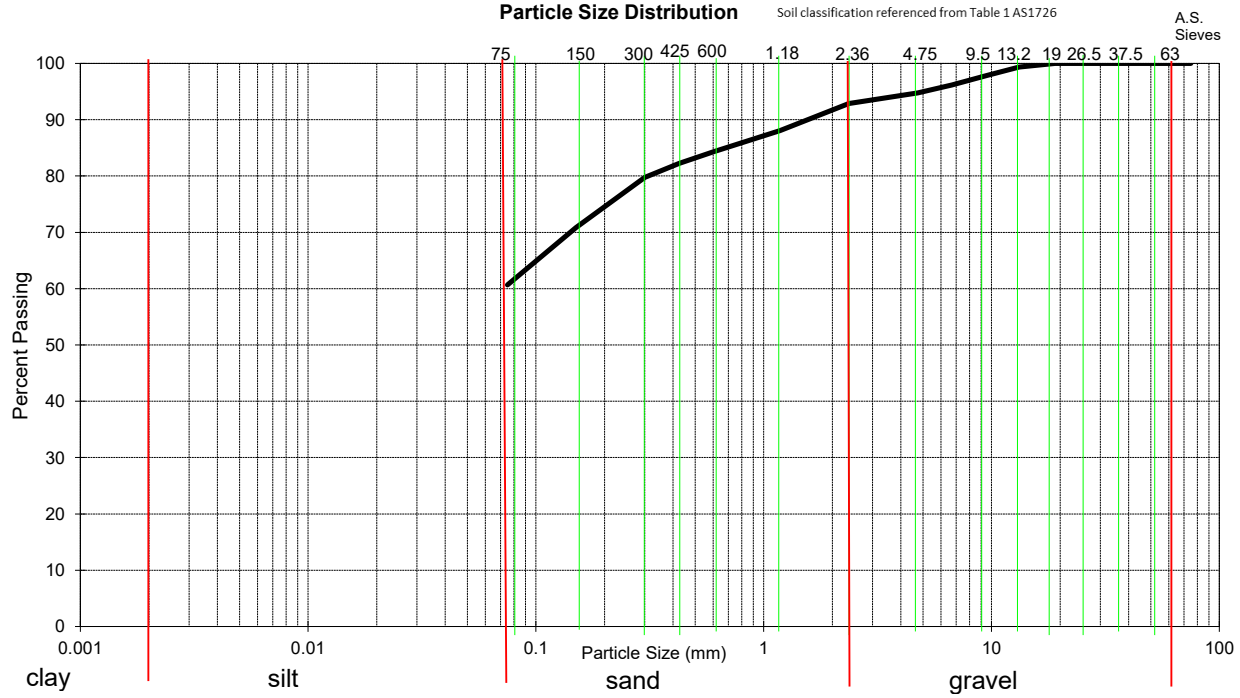
Moisture / Dry Density Relationship AS 1289 5.2.1

Maximum Dry Density: t/m^3

Optimum Moisture Content: %

Notes: Sampling Method Sampled by client, tested as received

Particle Size Distribution Soil classification referenced from Table 1 AS1726



Date: 26/08/2020

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Particle Size Distribution & Atterberg Limits Test Report

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Test Date:	**14-Aug-20**
Location:	-	Report No.	**LX**
Lab Reference No.	**#365**	Sample Identification:	**TP108 @ 0.5m**

Laboratory Specimen Classification: CLAY/SILT, medium to high plasticity, brown, trace sand.

Particle Size Distribution AS1289 3.6.1

Sieve Size	% Passing	Specification
150 mm	**100**	
75 mm	**100**	
53mm	**100**	
37.5 mm	**100**	
26.5 mm	**100**	
19.0 mm	**100**	
13.2 mm	**100**	
9.5 mm	**100**	
6.7 mm	**100**	
4.75 mm	**100**	
2.36 mm	**100**	
1.18 mm	**100**	
600 um	**99**	
425 um	**98**	
300 um	**97**	
150 um	**95**	
75 um	**92**	

Consistency Limits and Moisture Content

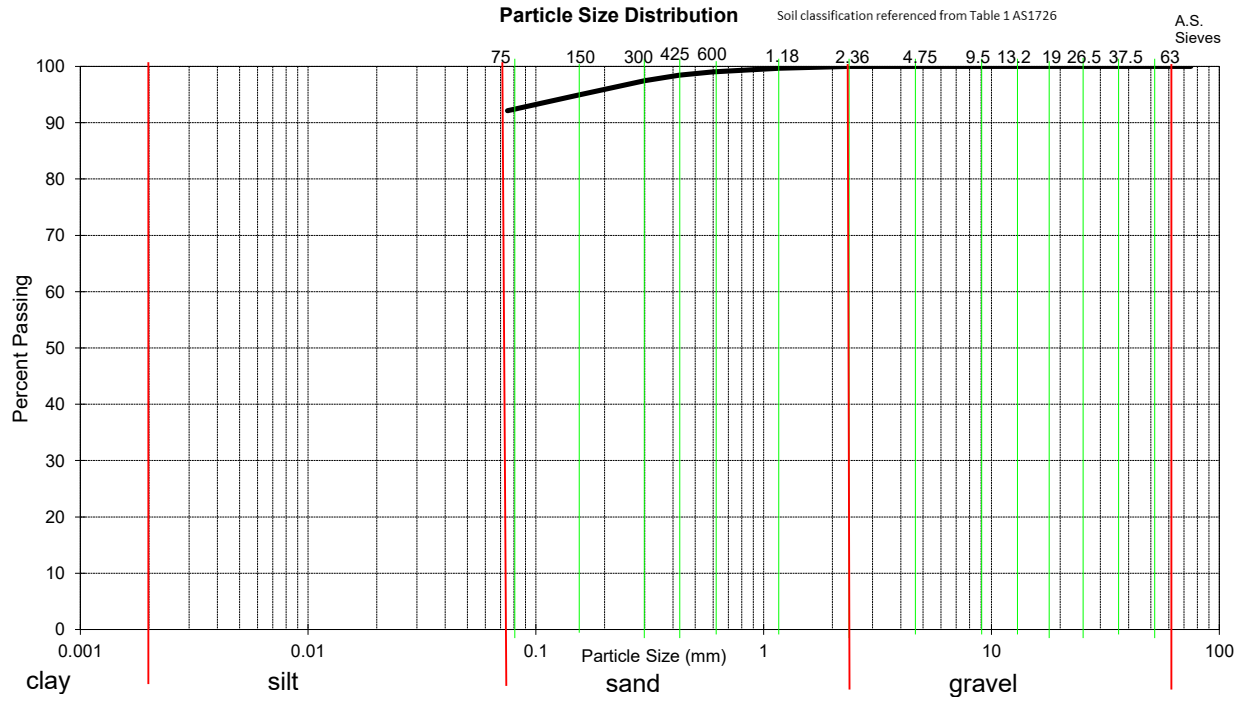
Test		Method	Result	Spec.
Liquid Limit	%	AS1289 3.1.2	**ND**	
Plastic Limit	%	AS1289 3.2.1	**ND**	
Plasticity Index	%	AS1289 3.3.1	**ND**	
Linear Shrinkage	%	AS1289 3.4.1	**ND**	
Moisture Content	%	AS1289 2.1.1	**27.9**	

Sample History:	Oven Dried
Preparation Method:	Dry sieved
Crumbling / Curling of linear shrinkage:	-
Linear shrinkage mould length:	250 mm

ND = not determined NO = not obtainable NP = non plastic

Moisture / Dry Density Relationship	AS 1289 5.2.1
Maximum Dry Density:	t/m^3
Optimum Moisture Content:	%

Notes: Sampling Method Sampled by client, tested as received



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Particle Size Distribution & Atterberg Limits Test Report

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Test Date:	**14-Aug-20**
Location:	-	Report No.	**LY**
Lab Reference No.	**#366**	Sample Identification:	**TP120 @ 1.5m**

Laboratory Specimen Classification: CLAY/SILT, medium to high plasticity, grey, trace sand.

Particle Size Distribution AS1289 3.6.1

Sieve Size	% Passing	Specification
150 mm	**100**	
75 mm	**100**	
53mm	**100**	
37.5 mm	**100**	
26.5 mm	**100**	
19.0 mm	**100**	
13.2 mm	**100**	
9.5 mm	**100**	
6.7 mm	**100**	
4.75 mm	**100**	
2.36 mm	**100**	
1.18 mm	**100**	
600 um	**99**	
425 um	**98**	
300 um	**98**	
150 um	**95**	
75 um	**92**	

Consistency Limits and Moisture Content

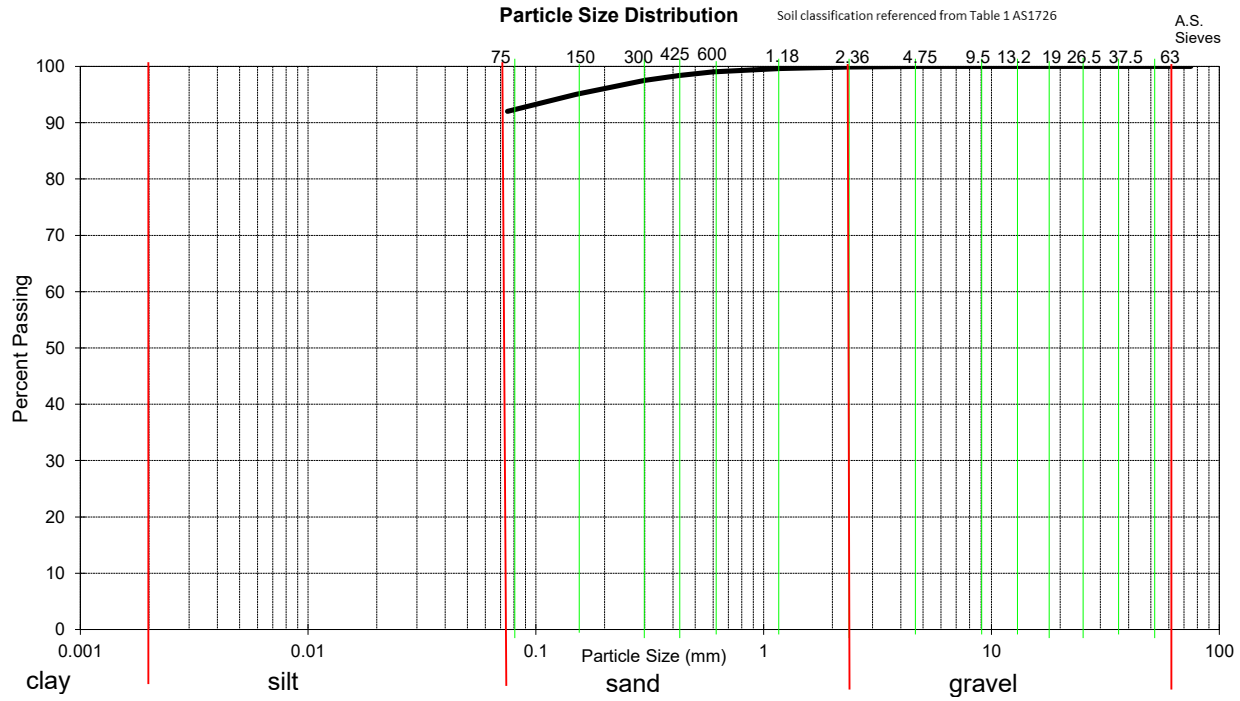
Test		Method	Result	Spec.
Liquid Limit	%	AS1289 3.1.2	**ND**	
Plastic Limit	%	AS1289 3.2.1	**ND**	
Plasticity Index	%	AS1289 3.3.1	**ND**	
Linear Shrinkage	%	AS1289 3.4.1	**ND**	
Moisture Content	%	AS1289 2.1.1	**34.6**	

Sample History:	Oven Dried
Preparation Method:	Dry sieved
Crumbling / Curling of linear shrinkage:	-
Linear shrinkage mould length:	250 mm

ND = not determined NO = not obtainable NP = non plastic

Moisture / Dry Density Relationship	AS 1289 5.2.1
Maximum Dry Density:	t/m^3
Optimum Moisture Content:	%

Notes: Sampling Method Sampled by client, tested as received



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Particle Size Distribution & Atterberg Limits Test Report

Client:	COFFEY INFORMATION (ABBOTSFORD)	Job No.	**GS5116/1**
Project:	MERRIMU PRECINCT - ADDITIONAL TESTING	Test Date:	**14-Aug-20**
Location:	-	Report No.	**LZ**
Lab Reference No.	**#367**	Sample Identification:	**TP104 @ 0.0 - 0.5m**

Laboratory Specimen Classification: CLAY/SILT, medium to high plasticity, brown, trace sand, trace gravel.

Particle Size Distribution AS1289 3.6.1

Sieve Size	% Passing	Specification
150 mm	**100**	
75 mm	**100**	
53mm	**100**	
37.5 mm	**100**	
26.5 mm	**100**	
19.0 mm	**100**	
13.2 mm	**100**	
9.5 mm	**99**	
6.7 mm	**99**	
4.75 mm	**99**	
2.36 mm	**99**	
1.18 mm	**98**	
600 um	**98**	
425 um	**97**	
300 um	**97**	
150 um	**95**	
75 um	**95**	

Consistency Limits and Moisture Content

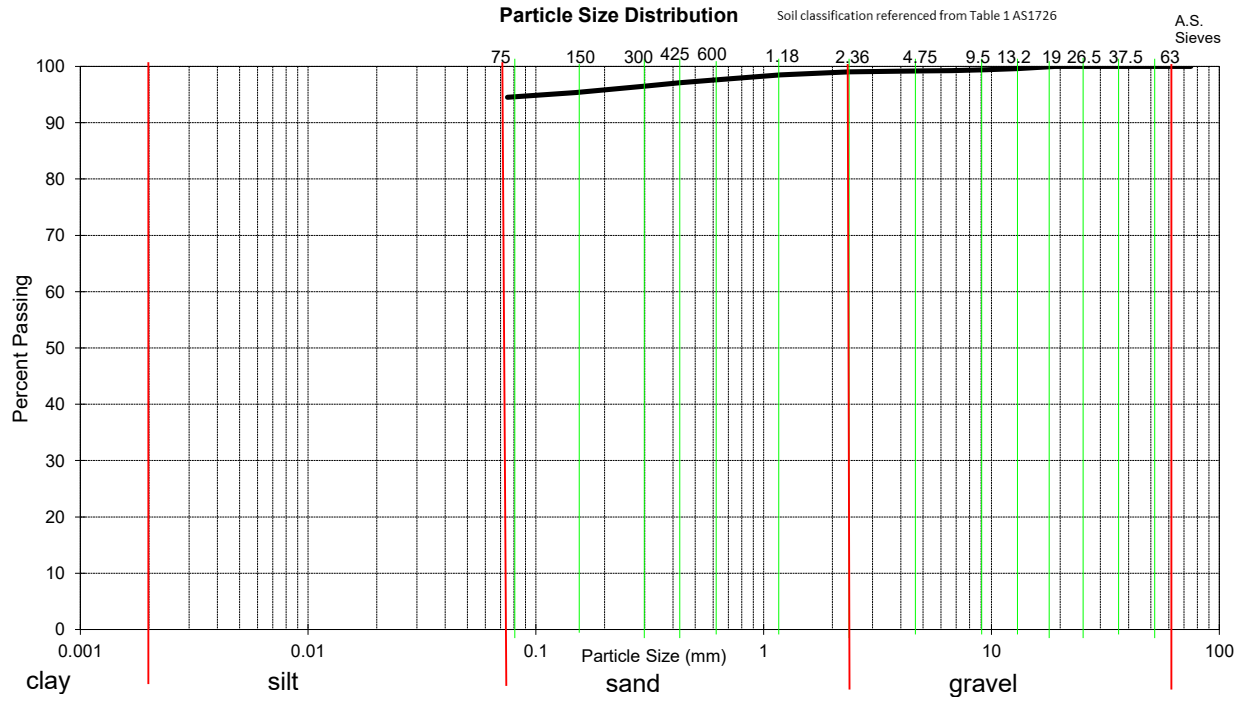
Test		Method	Result	Spec.
Liquid Limit	%	AS1289 3.1.2	**ND**	
Plastic Limit	%	AS1289 3.2.1	**ND**	
Plasticity Index	%	AS1289 3.3.1	**ND**	
Linear Shrinkage	%	AS1289 3.4.1	**ND**	
Moisture Content	%	AS1289 2.1.1	**22.7**	

Sample History:	Oven Dried
Preparation Method:	Dry sieved
Crumbling / Curling of linear shrinkage:	-
Linear shrinkage mould length:	250 mm

ND = not determined NO = not obtainable NP = non plastic

Moisture / Dry Density Relationship	AS 1289 5.2.1
Maximum Dry Density:	t/m^3
Optimum Moisture Content:	%

Notes: Sampling Method Sampled by client, tested as received



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Coffey Environments Pty Ltd VIC
Level 1, 436 Johnston Street
Abbotsford
VIC 3067

Attention: **Michael Jamieson**

Report **750523-S**
Project name
Project ID 754MELGE23340
Received Date Oct 13, 2020

Client Sample ID			**HA-1B_0.20**	**HA-1C_0.30**	**HA-2C_0.30**	**HA-3B_0.40**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Oc24625**	**M20-Oc24626**	**M20-Oc24627**	**M20-Oc24628**
Date Sampled			**Oct 07, 2020**	**Oct 07, 2020**	**Oct 07, 2020**	**Oct 07, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	29	10	730	17
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	7.9	7.4	9.4	7.3
Exchangeable Sodium Percentage (ESP)	0.1	%	6.1	7.2	6.5	6.6
% Moisture	1	%	4.2	7.3	12	2.7

Client Sample ID			**HA-3C_0.30**	**HA-3D_0.30**	**BH 1_11.5**	**BH 1_10.5**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Oc24629**	**M20-Oc24630**	**M20-Oc24631**	**M20-Oc24632**
Date Sampled			**Oct 07, 2020**	**Oct 07, 2020**	**Oct 07, 2020**	**Oct 07, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	270	110	47	67
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	9.3	9.5	9.4	9.4
Exchangeable Sodium Percentage (ESP)	0.1	%	9.6	4.9	22	32
% Moisture	1	%	12	13	9.3	11

Client Sample ID			**BH 4_9.7**	**BH 4_10.7**
Sample Matrix			**Soil**	**Soil**
Eurofins Sample No.			**M20-Oc24633**	**M20-Oc24634**
Date Sampled			**Oct 07, 2020**	**Oct 07, 2020**
Test/Reference	LOR	Unit		
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	360	370
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	8.6	9.4
Exchangeable Sodium Percentage (ESP)	0.1	%	23	11
% Moisture	1	%	13	12

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Conductivity (1:5 aqueous extract at 25°C as rec.)	Melbourne	Oct 16, 2020	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25°C as rec.)	Melbourne	Oct 16, 2020	7 Days
- Method: LTM-GEN-7090 pH in soil by ISE			
Exchangeable Sodium Percentage (ESP)	Melbourne	Oct 19, 2020	28 Days
- Method: LTM-MET-3060 - Cation Exchange Capacity (CEC) & Exchangeable Sodium Percentage (ESP)			
% Moisture	Melbourne	Oct 16, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

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New Zealand

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Phone : +64 9 526 45 51
IANZ # 1327

Christchurch
43 Detroit Drive
Rolleston, Christchurch 7675
Phone : 0800 856 450
IANZ # 1290

Company Name: Coffey Environments Pty Ltd VIC
Address: Level 1, 436 Johnston Street
Abbotsford
VIC 3067

Project Name:
Project ID: 754MELGE23340

Order No.:
Report #: 750523
Phone: 03 9290 7000
Fax:

Received: Oct 13, 2020 1:30 PM
Due: Oct 20, 2020
Priority: 5 Day
Contact Name: Michael Jamieson

Eurofins Analytical Services Manager : Harry Bacalis

Sample Detail						Conductivity (1:5 aqueous extract at 25°C as rec.)	Exchangeable Sodium Percentage (ESP)	pH (1:5 Aqueous extract at 25°C as rec.)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X
Sydney Laboratory - NATA Site # 18217									
Brisbane Laboratory - NATA Site # 20794									
Perth Laboratory - NATA Site # 23736									
Mayfield Laboratory									
External Laboratory									
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**				
1	HA-1B_0.20	Oct 07, 2020		Soil	M20-Oc24625	X	X	X	X
2	HA-1C_0.30	Oct 07, 2020		Soil	M20-Oc24626	X	X	X	X
3	HA-2C_0.30	Oct 07, 2020		Soil	M20-Oc24627	X	X	X	X
4	HA-3B_0.40	Oct 07, 2020		Soil	M20-Oc24628	X	X	X	X
5	HA-3C_0.30	Oct 07, 2020		Soil	M20-Oc24629	X	X	X	X
6	HA-3D_0.30	Oct 07, 2020		Soil	M20-Oc24630	X	X	X	X
7	BH 1_11.5	Oct 07, 2020		Soil	M20-Oc24631	X	X	X	X
8	BH 1_10.5	Oct 07, 2020		Soil	M20-Oc24632	X	X	X	X
9	BH 4_9.7	Oct 07, 2020		Soil	M20-Oc24633	X	X	X	X

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ABN: 50 005 085 521 web: www.eurofins.com.au email: EnviroSales@eurofins.com

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Contact Name: Michael Jamieson

Eurofins Analytical Services Manager : Harry Bacalis

Sample Detail						Conductivity (1:5 aqueous extract at 25°C as rec.)	Exchangeable Sodium Percentage (ESP)	pH (1:5 Aqueous extract at 25°C as rec.)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X
Sydney Laboratory - NATA Site # 18217									
Brisbane Laboratory - NATA Site # 20794									
Perth Laboratory - NATA Site # 23736									
Mayfield Laboratory									
External Laboratory									
10	BH 4_10.7	Oct 07, 2020		Soil	M20-Oc24634	X	X	X	X
Test Counts						10	10	10	10

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Conductivity (1:5 aqueous extract at 25°C as rec.)	uS/cm	< 10			10	Pass	
Exchangeable Sodium Percentage (ESP)	%	< 0.1			0.1	Pass	
LCS - % Recovery							
Conductivity (1:5 aqueous extract at 25°C as rec.)	%	97			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25°C as rec.)	M20-Oc24627	CP	uS/cm	730	630	15	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	M20-Oc24627	CP	pH Units	9.4	9.5	pass	30%	Pass	
% Moisture	M20-Oc24627	CP	%	12	12	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Harry Bacalis	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Scott Beddoes	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Ground Science
13 Brock St
Thomastown
VIC 3074

Attention: **Tim Senserrick**

Report **738426-S-V2**
Project name MERRIMU PRECINT-ADDITIONAL TESTING
Project ID GS5116/1 COFFEY MELBOURNE
Received Date Aug 18, 2020

Client Sample ID			**#359 SAMPLE TP114**	**#360 SAMPLE TP115**	**#362 SAMPLE TP120**	**#363 SAMPLE TP122**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au26035**	**M20-Au26036**	**M20-Au26037**	**M20-Au26038**
Date Sampled			**Aug 17, 2020**	**Aug 17, 2020**	**Aug 17, 2020**	**Aug 17, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	2000	2300	2400	290
Exchangeable Sodium Percentage (ESP)	0.1	%	26	26	24	4.7
% Moisture	1	%	27	26	26	14

Client Sample ID			**#365 SAMPLE TP108**	**#367 SAMPLE TP104**
Sample Matrix			**Soil**	**Soil**
Eurofins Sample No.			**M20-Au26039**	**M20-Au26040**
Date Sampled			**Aug 17, 2020**	**Aug 17, 2020**
Test/Reference	LOR	Unit		
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	-	210
Exchangeable Sodium Percentage (ESP)	0.1	%	19	2.8
% Moisture	1	%	23	18

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Conductivity (1:5 aqueous extract at 25°C as rec.)	Melbourne	Aug 19, 2020	7 Days
- Method: LTM-INO-4030 Conductivity			
Exchangeable Sodium Percentage (ESP)	Melbourne	Aug 19, 2020	28 Days
- Method: LTM-MET-3060 - Cation Exchange Capacity (CEC) & Exchangeable Sodium Percentage (ESP)			
% Moisture	Melbourne	Aug 18, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

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Company Name: Ground Science
Address: 13 Brock St
Thomastown
VIC 3074

Project Name: MERRIMU PRECINT-ADDITIONAL TESTING
Project ID: GS5116/1 COFFEY MELBOURNE

Order No.: ENG 146
Report #: 738426
Phone: 9464 4617
Fax: 9464 4618

Received: Aug 18, 2020 10:00 AM
Due: Aug 25, 2020
Priority: 5 Day
Contact Name: Tim Senserrick

Eurofins Analytical Services Manager : Savini Suduweli

Sample Detail						Conductivity (1:5 aqueous extract at 25°C as rec.)	Exchangeable Sodium Percentage (ESP)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X
Sydney Laboratory - NATA Site # 18217								
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Newcastle Laboratory								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	#359 SAMPLE TP14	Aug 17, 2020		Soil	M20-Au26035	X	X	X
2	#360 SAMPLE TP15	Aug 17, 2020		Soil	M20-Au26036	X	X	X
3	#362 SAMPLE TP20	Aug 17, 2020		Soil	M20-Au26037	X	X	X
4	#363 SAMPLE TP22	Aug 17, 2020		Soil	M20-Au26038	X	X	X
5	#365 SAMPLE TP8	Aug 17, 2020		Soil	M20-Au26039	X	X	X
6	#367 SAMPLE	Aug 17, 2020		Soil	M20-Au26040	X	X	X

eurofins | Environment Testing

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Company Name:	Ground Science	**Order No.:**	ENG 146	**Received:**	Aug 18, 2020 10:00 AM
Address:	13 Brock St Thomastown VIC 3074	**Report #:**	738426	**Due:**	Aug 25, 2020
		Phone:	9464 4617	**Priority:**	5 Day
		Fax:	9464 4618	**Contact Name:**	Tim Senserrick
Project Name:	MERRIMU PRECINT-ADDITIONAL TESTING				
Project ID:	GS5116/1 COFFEY MELBOURNE				

Eurofins Analytical Services Manager : Savini Suduweli

Sample Detail	Conductivity (1:5 aqueous extract at 25°C as rec.)	Exchangeable Sodium Percentage (ESP)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271	X	X	X
Sydney Laboratory - NATA Site # 18217			
Brisbane Laboratory - NATA Site # 20794			
Perth Laboratory - NATA Site # 23736			
TP4			
Test Counts	6	6	6

Internal Quality Control Review and Glossary

General

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2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
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6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
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Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre

ppm: Parts per million | **ppb:** Parts per billion | **%:** Percentage

org/100mL: Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
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COC	Chain of Custody
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CP	Client Parent - QC was performed on samples pertaining to this report
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QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

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2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
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10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25°C as rec.)	B20-Au03522	NCP	uS/cm	17	18	2.8	30%	Pass	
% Moisture	M20-Au25825	NCP	%	20	20	3.0	30%	Pass	

Comments

V2: Report updated with amended sample IDs as per client request.

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	No
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Savini Suduweli	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Scott Beddoes	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Ground Science
13 Brock St
Thomastown
VIC 3074

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Tim Senserrick**

Report **739362-S**
Project name COFFEY (MELBOURNE)
Project ID GS5116/1
Received Date Aug 21, 2020

Client Sample ID			**#349 SAMPLE TP103**	**#350 SAMPLE TP122**	**#351 SAMPLE TP105**	**#352 SAMPLE TP118**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au34034**	**M20-Au34035**	**M20-Au34036**	**M20-Au34037**
Date Sampled			**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	1600	-	280	-
Exchangeable Sodium Percentage (ESP)	0.1	%	23	-	-	-
% Moisture	1	%	24	16	7.8	21
Exchangeable Sodium Percentage (ESP)						
Exchangeable Sodium Percentage (ESP)	0.1	%	-	4.5	5.0	2.6

Client Sample ID			**#353 SAMPLE TP123**	**#354 SAMPLE TP101**	**#355 SAMPLE TP105**	**#356 SAMPLE TP108**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au34038**	**M20-Au34039**	**M20-Au34040**	**M20-Au34041**
Date Sampled			**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**
Test/Reference	LOR	Unit				
% Moisture	1	%	17	21	11	27
Exchangeable Sodium Percentage (ESP)						
Exchangeable Sodium Percentage (ESP)	0.1	%	3.3	18	2.0	32

Client Sample ID			**#357 SAMPLE TP9**
Sample Matrix			**Soil**
Eurofins Sample No.			**M20-Au34042**
Date Sampled			**Aug 19, 2020**
Test/Reference	LOR	Unit	
% Moisture	1	%	21
Exchangeable Sodium Percentage (ESP)			
Exchangeable Sodium Percentage (ESP)	0.1	%	16

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Conductivity (1:5 aqueous extract at 25°C as rec.)	Melbourne	Aug 25, 2020	7 Days
- Method: LTM-INO-4030 Conductivity			
Exchangeable Sodium Percentage (ESP)	Melbourne	Aug 25, 2020	28 Days
- Method: LTM-MET-3060 - Cation Exchange Capacity (CEC) & Exchangeable Sodium Percentage (ESP)			
Exchangeable Sodium Percentage (ESP)	Melbourne	Aug 25, 2020	28 Days
- Method: LTM-MET-3060 Cation Exchange Capacity (CEC) & Exchangeable Sodium Percentage (ESP)			
% Moisture	Melbourne	Aug 21, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

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Company Name: Ground Science
Address: 13 Brock St
Thomastown
VIC 3074

Project Name: COFFEY (MELBOURNE)
Project ID: GS5116/1

Order No.: ENG 148
Report #: 739362
Phone: 9464 4617
Fax: 9464 4618

Received: Aug 21, 2020 2:53 PM
Due: Aug 28, 2020
Priority: 5 Day
Contact Name: Tim Senserrick

Eurofins Analytical Services Manager : Savini Suduweli

Sample Detail						Moisture Set	Exchangeable Sodium Percentage (ESP)
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
Newcastle Laboratory							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	#349 SAMPLE TP03	Aug 19, 2020		Soil	M20-Au34034	X	X
2	#350 SAMPLE TP22	Aug 19, 2020		Soil	M20-Au34035	X	X
3	#351 SAMPLE TP05	Aug 19, 2020		Soil	M20-Au34036	X	X
4	#352 SAMPLE TP18	Aug 19, 2020		Soil	M20-Au34037	X	X
5	#353 SAMPLE TP23	Aug 19, 2020		Soil	M20-Au34038	X	X
6	#354 SAMPLE	Aug 19, 2020		Soil	M20-Au34039	X	X

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Sample Detail						Moisture Set	Exchangeable Sodium Percentage (ESP)
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
	TP1						
7	#355 SAMPLE TP5	Aug 19, 2020		Soil	M20-Au34040	X	X
8	#356 SAMPLE TP8	Aug 19, 2020		Soil	M20-Au34041	X	X
9	#357 SAMPLE TP9	Aug 19, 2020		Soil	M20-Au34042	X	X
Test Counts						9	9

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

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If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre

ppm: Parts per million | **ppb:** Parts per billion | **%:** Percentage

org/100mL: Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Conductivity (1:5 aqueous extract at 25°C as rec.)	uS/cm	< 10			10	Pass	
LCS - % Recovery							
Conductivity (1:5 aqueous extract at 25°C as rec.)	%	107			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	M20-Au34042	CP	%	21	20	4.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Savini Suduweli	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Scott Beddoes	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Ground Science
13 Brock St
Thomastown
VIC 3074

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Tim Senserrick**

Report **741006-S**
Project name MERRIMU PRECINCT
Project ID GS5116/1 COFFEY (MELBOURNE)
Received Date Aug 31, 2020

Client Sample ID			**#359 SAMPLE TP114**	**#360 SAMPLE TP115**	**#362 SAMPLE TP120**	**#363 SAMPLE TP122**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au50117**	**M20-Au50118**	**M20-Au50119**	**M20-Au50120**
Date Sampled			**Aug 17, 2020**	**Aug 17, 2020**	**Aug 17, 2020**	**Aug 17, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	-	-	-	-
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	9.0	8.7	9.0	8.8
% Moisture	1	%	26	25	24	15

Client Sample ID			**#365 SAMPLE TP108**	**#367 SAMPLE TP104**	**#349 SAMPLE TP103**	**#350 SAMPLE TP122**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au50121**	**M20-Au50122**	**M20-Au50123**	**M20-Au50124**
Date Sampled			**Aug 17, 2020**	**Aug 17, 2020**	**Aug 19, 2020**	**Aug 19, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	1300	-	-	-
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	8.8	8.6	9.2	-
% Moisture	1	%	24	18	22	-

Client Sample ID			**#351 SAMPLE TP5**	**#352 SAMPLE TP18**	**#353 SAMPLE TP23**	**#354 SAMPLE TP1**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au50125**	**M20-Au50126**	**M20-Au50127**	**M20-Au50128**
Date Sampled			**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**
Test/Reference	LOR	Unit				
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	280	55	79	1000
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	9.2	7.4	9.1	9.3
% Moisture	1	%	8.1	22	15	21

Client Sample ID			#355 SAMPLE TP105	#356 SAMPLE TP108	#357 SAMPLE TP109
Sample Matrix			**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Au50129**	**M20-Au50130**	**M20-Au50131**
Date Sampled			**Aug 19, 2020**	**Aug 19, 2020**	**Aug 19, 2020**
Test/Reference	LOR	Unit			
Conductivity (1:5 aqueous extract at 25°C as rec.)	10	uS/cm	96	1700	1200
pH (1:5 Aqueous extract at 25°C as rec.)	0.1	pH Units	9.1	8.2	9.2
% Moisture	1	%	10	26	20

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Conductivity (1:5 aqueous extract at 25°C as rec.)	Melbourne	Sep 01, 2020	7 Days
- Method: LTM-INO-4030 Conductivity			
pH (1:5 Aqueous extract at 25°C as rec.)	Melbourne	Aug 31, 2020	7 Days
- Method: LTM-GEN-7090 pH in soil by ISE			
% Moisture	Melbourne	Aug 31, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

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Company Name:	Ground Science	**Order No.:**	
Address:	13 Brock St Thomastown VIC 3074	**Report #:**	741006
		Phone:	9464 4617
		Fax:	9464 4618
Project Name:	MERRIMU PRECINCT		
Project ID:	GS5116/1 COFFEY (MELBOURNE)		

Received:	Aug 31, 2020 9:52 AM
Due:	Sep 7, 2020
Priority:	5 Day
Contact Name:	Tim Senserrick

Eurofins Analytical Services Manager : Savini Suduweli

Sample Detail						Conductivity (1:5 aqueous extract at 25°C as rec.)	pH (1:5 Aqueous extract at 25°C as rec.)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X
Sydney Laboratory - NATA Site # 18217								
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
Newcastle Laboratory								
External Laboratory								
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**			
1	#359 SAMPLE TP14	Aug 17, 2020		Soil	M20-Au50117	X	X	X
2	#360 SAMPLE TP15	Aug 17, 2020		Soil	M20-Au50118	X	X	X
3	#362 SAMPLE TP20	Aug 17, 2020		Soil	M20-Au50119	X	X	X
4	#363 SAMPLE TP22	Aug 17, 2020		Soil	M20-Au50120	X	X	X
5	#365 SAMPLE TP8	Aug 17, 2020		Soil	M20-Au50121	X	X	X
6	#367 SAMPLE	Aug 17, 2020		Soil	M20-Au50122	X	X	X

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Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X
Sydney Laboratory - NATA Site # 18217								
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
	TP4							
7	#349 SAMPLE TP3	Aug 19, 2020		Soil	M20-Au50123	X	X	X
8	#350 SAMPLE TP22	Aug 19, 2020		Soil	M20-Au50124	X	X	X
9	#351 SAMPLE TP5	Aug 19, 2020		Soil	M20-Au50125	X	X	X
10	#352 SAMPLE TP18	Aug 19, 2020		Soil	M20-Au50126	X	X	X
11	#353 SAMPLE TP23	Aug 19, 2020		Soil	M20-Au50127	X	X	X
12	#354 SAMPLE TP1	Aug 19, 2020		Soil	M20-Au50128	X	X	X
13	#355 SAMPLE TP5	Aug 19, 2020		Soil	M20-Au50129	X	X	X

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Priority: 5 Day
Contact Name: Tim Senserrick

Eurofins Analytical Services Manager : Savini Suduweli

Sample Detail						Conductivity (1:5 aqueous extract at 25°C as rec.)	pH (1:5 Aqueous extract at 25°C as rec.)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X
Sydney Laboratory - NATA Site # 18217								
Brisbane Laboratory - NATA Site # 20794								
Perth Laboratory - NATA Site # 23736								
14	#356 SAMPLE TP8	Aug 19, 2020		Soil	M20-Au50130	X	X	X
15	#357 SAMPLE TP9	Aug 19, 2020		Soil	M20-Au50131	X	X	X
Test Counts						15	15	15

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LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
Conductivity (1:5 aqueous extract at 25°C as rec.)			uS/cm	< 10			10	Pass	
LCS - % Recovery									
Conductivity (1:5 aqueous extract at 25°C as rec.)			%	97			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25°C as rec.)	M20-Au50122	CP	uS/cm	120	130	9.7	30%	Pass	
pH (1:5 Aqueous extract at 25°C as rec.)	M20-Au50122	CP	pH Units	8.6	8.6	pass	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	M20-Au50124	CP	%	15	13	16	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

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Glenn Jackson
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Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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