

Report on the Soil Survey of Leases of the Warwick Limestone Quarry



Prepared for: Ausrocks

Revision 1.0 (Final report)

Revision date: 16/09/2022

Disclaimer

Horizon Soil Science and Engineering Pty. Ltd. (Horizon) have prepared this report for Ausrocks Consulting Mining Engineers (Ausrocks) (The Client) for the specific purpose for which it is supplied. Third parties may not rely on this report. Horizon waives all liability to any third party loss, damage, liability, or claim arising out of or incidental to a third party publishing, using or relying on the facts, content, opinions or subject matter contained in this report.

We have assumed that all information provided to us by the Client or other third parties which was relied upon, wholly or in part in reporting, was complete, current and accurate at the time of supply. Horizon waives all responsibility for any loss or damage relating to the accuracy, currency and completeness of information provided by the Client or other third parties.

Table of contents

Table of contents	iii
List of Tables	iv
List of Figures	iv
1. Scope and Deliverables	5
1.1 Scope	5
1.2 Deliverables	5
2. Desktop Review and Survey Design	6
2.1 Desktop Review	6
2.1.1 Geology	6
2.1.2 Land Resources and Soils	6
2.1.3 Grazing Land Management	6
2.2 Survey Design	7
2.2.1 Field Descriptions	7
2.2.2 Chemistry	8
3. Soil Survey Results	9
3.1 Soil Physical Characteristics Descriptions	9
3.2 Summary of Soil Chemistry	10
3.3 Stockpile material	13
4. Agricultural Land Evaluation	14
4.1 Strategic Cropping Land	14
4.2 Regional Land Suitability Frameworks	14
4.3 Agricultural Land Classification	15
5. Land Management and Amelioration	16
5.1 Soil Erosion	16
5.2 Soil Amelioration	16
6. Rehabilitation Soil Testing and Monitoring Metrics	18
6.1 Soil testing program/procedure	18
6.2 Metrics for Soil Rehabilitation Performance.	18
7. References	19
Appendix 1: Maps	20
Appendix 2: Detailed Descriptions	24
Appendix 3: Certificate of Analysis	55

List of Tables

Table 1: Sample numbers	7
Table 2: Soil chemistry analysis parameters	8
Table 3: Summary of soil type areal extent, number of sites described and sampled for chemistry	9
Table 4: Typical Physical Characteristics of Soil Types.....	9
Table 5: Soil chemistry sample location reference	10
Table 6: Chemical Characteristics of Soil Types	12
Table 7: Emerson Aggregate Scores by soil type and depth.....	13
Table 8: Stockpile material Soil Chemistry Summary	13
Table 9: Suitability Framework Score	14

List of Figures

Figure 1: Chemistry by soil type and depth (Salinity EC_{se} , pH, ESP and OC)	11
--	----

1. Scope and Deliverables

The Warwick Limestone Quarry (WLQ) is an open-pit mining development operated by Terrequip Environmental (Mining lease areas: ML50083, ML50146, ML50236, ML50237, ML50238 and ML50239), hereafter referred to as the “project area”. The locality of the lease areas are shown in Appendix 1 Maps: Mine Lease Boundaries. Limestone mined at site is used in various application including agricultural lime, decorative aggregates, crushed rock and road base.

Horizon Soil Science and Engineering (Horizon) were engaged by Ausrocks Consulting Mining Engineers (Ausrocks) to conduct a land assess survey in non-disturbed areas of the project area to provide background data of the existing landscape as a baseline for rehabilitation purposes.

1.1 Scope

The scope of work was to conduct a land assessment of the project area to:

- Assist Ausrocks devise and execute a land assessment survey (including chemistry sampling) in non-disturbed areas to provide background data of the existing landscape as a baseline for rehabilitation purposes;
- Conduct sampling of stockpiled topsoil samples and assess the suitability of stockpiled material for use in rehabilitation;
- Investigate the soil condition of any previously rehabilitated areas;
- Provide a report summarising the land assessment and stockpile characteristics across the project areas; and
- Assist Ausrocks to develop a soil rehabilitation methodology and topsoil amelioration procedure.

1.2 Deliverables

The key deliverables for the project included:

1. A soil survey report for the project area that:
 - o Maps the boundaries of soil types across the non-disturbed areas;
 - o Provides key physical and chemical characteristics of the mapped soils;
 - o Provides key physical and chemical characteristics of stockpiled material; and
 - o Classifies the project area agricultural land capability using an appropriate method.
2. Assist Ausrocks to develop:
 - o Soil rehabilitation methodology;
 - o Topsoil amelioration procedure;
 - o A soil testing program/procedure; and
 - o Metrics to measure future rehabilitation performance based on soil testing program results.

This report represents the Deliverable 1 – a soil survey report that provides advice on soil amelioration. Deliverable 2 will be developed in collaboration with Ausrocks and will be reported within a site rehabilitation plan.

2. Desktop Review and Survey Design

2.1 Desktop Review

A desktop review was completed to assist with defining landscape characteristics and soil boundaries. The desktop review included geology, land resource and land management data.

2.1.1 Geology

The surface geology of the survey area is shown in Appendix 1 Maps: Geology. The majority of the survey area surface geology is derived from Bald Hill formation (Early Devonian) with a mix of coarse and fine grained igneous rocks (Gabbroids and Mafites) and Carbonates (Limestone). Fringing the south of the project area are Stanthorpe Granites. Geological units display a high degree of spatial variability across the site due to the vertical orientation of geological units (Viriseff pers. comm)

2.1.2 Land Resources and Soils

The only soils mapping available for the site is the National scale (1:2,000,000) ASRIS mapping (<https://www.asris.csiro.au/>) which provides little detail at the scale of our investigation. The entire project area is classified under a single unit, Ub63. The primary soil associated with this unit are Sodosols. Further summary details of the unit are shown below.

Ub63	Strongly hilly to undulating: chief soils of the undulating to low hilly areas are hard-setting loamy soils with mottled yellow clayey subsoils (Dy3.42 and Dy3.43) and some (Dr2) soils. Associated are: hilly ridges of rock outcrops, (Uc) and (Um) soils with some shallow (Dy) and (Dr) soils; steep slopes of red earths (Gn2.14 and Gn2.15) with rock outcrops; and narrow valleys of undescribed soils some of which are affected by salinity
------	---

2.1.3 Grazing Land Management

The project area is mapped as grazing land management (GLM) unit BR07 - Granite plains and rises with mixed grassy woodlands (Source: Future Beef, 2018). Soils of this GLM unit are described as deep, bleached dark grey to yellowish brown sandy clay loam texture contrast soils (Kurosols, Sodosols).

The GLM is described as suitable for grazing on native and sown pastures. Minimal ground disturbance of the landscape is recommended as the dispersive soils erode easily, and grazing pressures should be managed to maximise ground cover and minimise soil loss.

The unit is considered to have land use limitation that include:

- Low fertility and very low to low water holding capacity.
- Poorly structured and drained subsoils that may cause waterlogging (particularly in winter).
- Rocky outcrops restrictive to cultivation opportunities.

2.2 Survey Design

The field survey was designed in accordance with sampling intensities recommended in the Australian Guidelines for Surveying Soil and Land Resources (McKenzie *et al*, 2008). The footprint area of the WLQ is approximately 172 ha with a proposed sample density of 6 ha /site for soil mapping at 1:25,000 scale giving a minimum of 30 observation sites.

The number of sites sampled for detailed analysis and chemistry are shown and exceed the percentage of sites criteria required by McKenzie *et al*. (2008).

Table 1: Sample numbers

	Mapping Observations	Detailed Description	Soil profile Chemistry sites
Recommended	15-29	10-20% (3-6)	5-10% (2-3)
Proposed	30	10	5
Actual	30	27	5

In addition to the survey sites, 3 stockpile sites were sampled (3 replicate samples per site), and one (1) site in a previously rehabilitated area was also sampled (including chemistry).

2.2.1 Field Descriptions

Field descriptions were undertaken in accordance with the Australian Soil Survey and Land Survey Field Handbook 3rd edition (The National Committee on Soil and Terrain, 2009) and classified using The Australian Soil Classification (Isbell, 2016). Field descriptions included a combination of mapping observations and detailed observations with a subset of detailed observations analysed for chemistry as described below:

1. Mapping observation are primarily used to identify land type boundaries. They include a description of:
 - Landform;
 - Vegetation;
 - Other distinguishing surface characteristics (e.g., gilgai and rockiness).
2. Detailed observations make up >20 % of the survey locations. The sample locations are provided in Appendix 2, profile logs and photographs are provided in Appendix 3. These sites were sampled using a soil rig include soil profile descriptions and observations of:
 - Horizon depths, designation and boundary distinctness;
 - Field texture;
 - Munsell Colour;
 - Mottles colour and abundance;
 - Coarse fragments size and abundance;
 - Structure;
 - Segregations and abundance.

2.2.2 Chemistry

Chemistry sites make up >10 % of the survey locations. 5 sample depths were analysed per site based on soil horizons; generally, this included the A1, upper and lower B2 and C horizon. The key parameters analysed are provided in Table 2. Analysis was conducted by the NATA accredited ALS Laboratory. The Certificate of Analysis is provided in Appendix 3.

Table 2: Soil chemistry analysis parameters

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/kg) (or as indicated)
Electrical Conductivity (1:5)	IN-4S	APHA 2510 B 1:5	1 $\square$ S/cm
pH (1:5)		APHA 4500 H B 1:5	0.1 pH Unit
CEC - Exchangeable Cations with pre-treatment (Ca, Mg, Na, K, Al)	ALS to determine based on pH and EC	calc	0.1
Exchangeable Sodium Percent (ESP) – base saturation calc		ALS to determine based on pH and EC	0.1 meq/100g
Ca:Mg ratio			0.10%
Chloride	ED045G	APHA 4500 Cl 1:5	10
Emerson Aggregate Test	EA058	AS1289.3.8.1	
Total Organic Carbon (OC) in Soil	EP003	ALS In house	0.02 %

Saturated extract soil salinity (EC_{se}) was estimated from $EC_{1:5}$ data using Shaw (1994) soil chloride and cation exchange method.

For reference the following acronyms are used for soil chemistry in this report:

- EC_{se} - Saturated extract soil salinity.
- CEC – Cation Exchange Capacity.
- ESP -Exchangeable sodium Percentage.
- Ca:Mg – Calcium: Magnesium ratio.
- EAT – Emerson Aggregate Test.
- OC - Organic Carbon

3. Soil Survey Results

A soil survey of the project area was conducted on the 22nd and 23rd March 2022. Sampling was conducted using a 4WD mounted push tube sampling rig with a 75 mm diameter push tube.

3.1 Soil Physical Characteristics Descriptions

Four soil types were described within the project area using the Australian Soil Classification (ASC) system (Isbell, 2021). A summary of the soils, the areal extent and number of sites described and sampled for chemistry are given in Table 3. The most common soil type across the project area were Brown and Red Sodosol and cover > 80% of the project area.

Table 3: Summary of soil type areal extent, number of sites described and sampled for chemistry

Australian Soil Classification	Mapped area (ha)	Number of Site Descriptions	Number of Soil Chemistry sites
Brown and Red Sodosol	143.3	16	3
Brown Tenosol	10.4	5	1
Red Dermosol	5.1	11	1
Brown Vertosol	13.1		

Sodosols are texture contrast soils, typically characterised by sandy loam or clay loam surfaces over light to medium clay sub-soils that are sodic in the upper portion of the B-horizon. Minor areas of Tenosol (deep sands) were associated with the Stanthorpe granite geology, and minor areas of Dermosol/Vertosol (uniform clay soils) were described. Example soil profiles for the ASC are given in [Error! Not a valid bookmark self-reference..](#) All full site descriptions are given in Appendix 2.

Table 4: Typical Physical Characteristics of Soil Types

Soil Description
Australian Soil Classification: Red Sodosol A1 Very dark brown (7.5YR 2.5/3) clay loam with weak granular structure, a few medium pebbles on surface, to 0.3m, clear change to; B2 Yellowish red (5YR 4/6) medium clay with moderate polyhedral structure, many manganese concretions, to 1.0m, diffuse change to; B3 Dark reddish brown (5YR 3/4) silty light clay (siltstone) with moderate polyhedral structure, with abundant yellow mottles and common carbonates, to 1.4m. 
Australian Soil Classification: Brown Tenosol A1 Brown (10YR 4/3) loamy sand, non-coherent structure, abundant small gravel on surface and common through horizon, to 0.35m, clear change to; B2 Brown (10YR 5/3) loamy sand, non-coherent structure, common small gravel, to 0.6m, diffuse change to; C Brown (7.5YR 5/3) clayey sand, non-coherent structure, abundant small gravel, to 1.5m. 

Soil Description
Australian Soil Classification: Brown Vertosol A1 Very dark brown (7.5YR 2.5/3) heavy clay with strong angular blocky structure, a few large pebbles on surface, to 0.1m, gradual change to; B21 Brown (7.5YR 4/2) heavy clay with moderate angular blocky structure, a few carbonates, to 0.8m, gradual change to; B22 Brown (7.5YR 4/3) heavy clay with weak angular blocky structure, many medium gravel, with a few dark mottles, common carbonates and manganese concretions, to 1.3m, clear change to; C Brown (7.5YR 4/3) silty light clay (siltstone), massive structure, with many yellow and red mottles, to 1.4m. 
Australian Soil Classification: Red Dermosol A1 Reddish brown (5YR 4/4) silty light clay with weak polyhedral structure, to 0.2m, clear change to; B21 Yellowish red (5YR 4/6) medium clay with moderate polyhedral structure, with many yellow and black mottles, common manganese, to 0.65m, diffuse change to; B22 Brownish Yellow (10YR 6/8) silty medium clay with weak polyhedral structure, with many red mottles, to 0.95m, diffuse change to; C Brownish Yellow (10YR 6/8) silty light clay with weak polyhedral structure, to 1.5m. 

3.2 Summary of Soil Chemistry

Five baseline and one rehabilitation location were selected for soil chemistry sampling. Site numbers, soil classification and sample locations are given in Table 5. The survey reference number can be cross referenced with the Appendix 1 Map: Soil Classification and Sample Locations, and the soil chemistry sample number with the Certificate of analysis in Appendix 3.

Table 5: Soil chemistry sample location reference

Survey reference	Australian Soil Classification	Soil chemistry sample number
TW_05	Brown Tenosol	Site 1
TW_10	Brown Sodosol	Site 2
TW_12	Brown Vertosol	Site 3
TW_22	Red Sodosol	Site 4
TW_34	Grey Anthroposol	Site 5
TW_40	Brown Sodosol	Site 6

Soil chemistry profiles of the key characteristics are shown in Figure 1. Table 6 shows the classification of the profiles based on Hazelton and Murphy (2016). Emerson Aggregate Test (EAT) scores are given in Table 7. Note that for the Brown and Red Sodosol sites (TW_10, TW_12 and TW_22) an average profile soil chemistry is presented.

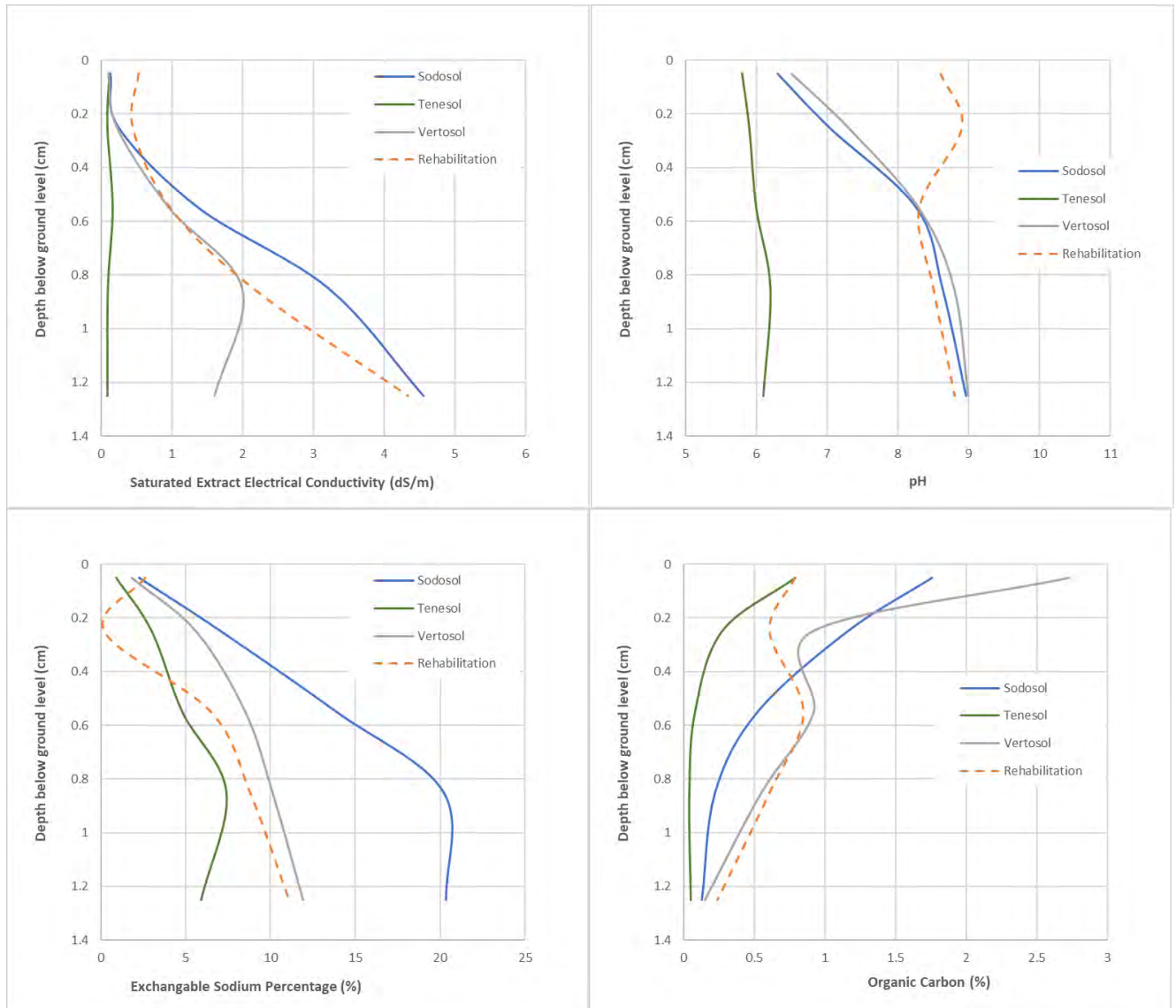


Figure 1: Chemistry by soil type and depth (Salinity EC_{se}, pH, ESP and OC)

Summarising soil chemistry by soil type the soils were found to be:

- Brown and Red Sodosol;
 - pH profiles slightly acid at surface to strongly alkaline at depth;
 - Non-saline at surface to moderately saline to depth;
 - High organic carbon in the surface declining to low at depth, with
 - Low to very low CEC, non-sodic at surface increasing to strongly sodic at depth with low Ca:Mg ratio;
 - EAT scores suggest non-dispersive topsoils with dispersive subsoils.

- Brown Tenesol;
 - pH profiles moderately acid at surface increasing to slightly acid to depth;
 - Non-saline throughout;
 - Moderate organic carbon in the surface declining to low at depth;
 - Very low CEC, non-sodic at surface to marginally sodic to depth with low Ca:Mg ratio;
 - EAT scores suggest non-dispersive topsoils with dispersive subsoils.
- Black and Brown Vertosol;
 - pH profiles slightly acid at surface to strongly alkaline at depth;
 - Non-saline throughout;
 - High organic carbon in the surface declining to low at depth.
 - Low CEC at surface increasing to moderate at depth, non-sodic at surface increasing sodic at depth with low Ca:Mg ratio;
 - EAT scores suggest dispersive topsoils and subsoils.
- Rehabilitated soil;
 - pH profiles slightly acid at surface to strongly alkaline at depth;
 - Non-saline throughout;
 - High organic carbon in the surface declining to low at depth.
 - Low CEC at surface increasing to moderate at depth, non-sodic at surface increasing sodic at depth with low Ca:Mg ratio;
 - EAT scores suggest slaking but non-dispersive topsoils and sub-soils.

Table 6: Chemical Characteristics of Soil Types

Australian Soil Classifications	Profile	pH	EC _{se}	CEC	ESP (%)	OC (%)
Brown and Red Sodosol	Topsoil	Slightly acid	Non-saline	Low	Non-sodic	High
	Sub-soil	Neutral to moderately acid	Non-saline	Very low to low	Sodic	Moderate
	Sediment	Strongly alkaline	Moderately saline	Low	Strongly sodic	Low
Brown Tenesol	Topsoil	Moderately acid	Non-saline	Very low	Non-sodic	Moderate
	Sub-soil	Moderately acid	Non-saline	Very low	Non-sodic	Low
	Sediment	Slightly acid	Non-saline	Very low	Non-sodic to sodic	Low
Black and Brown Vertosol	Topsoil	Slightly acid	Non-saline	Low	Non-sodic	High
	Sub-soil	Neutral to moderately acid	Non-saline	Low to moderate	Sodic	Moderate
	Sediment	Strongly alkaline	Non-saline	Moderate	Sodic	Low
Rehabilitation area	Topsoil	Slightly acid	Non-saline	Low	Non-sodic	Moderate
	Sub-soil	Neutral to moderately acid	Non-saline	Low to moderate	Sodic	Moderate
	Sediment	Strongly alkaline	Non-saline	Moderate	Sodic	Low

Table 7: Emerson Aggregate Scores by soil type and depth

Emerson Class Number	Soil Type			
Soil depth (mm)	Sodosol	Tenosol	Vertosol	Rehabilitation
0 -100	7	7	3	4
200- 300	2	7	3	4
500- 600	2	2	2	5
800- 900	2	2	2	4
1200 – 1300	2	2	2	4

3.3 Stockpile material

Three (3) stockpiles of topsoil across the project area were randomly sampled (0-100 mm depth). 3 replicate samples were taken per stockpile and Table 8 gives the average chemistry. The physical characteristics of the stockpiles were:

- Stockpile 1 and 3 were similar, with brown to reddish brown medium to heavy clay texture, a few brown mottle and common medium gravel, chemistry described as:
 - Neutral pH;
 - Non-saline ;
 - Moderate to high organic carbon;
 - Moderate CEC, non-sodic with low Ca:Mg ratio;
 - EAT scores suggest slaking but non-dispersive soils.
- Stockpile 2 was a light yellowish brown silty sand, chemistry described as:
 - Moderately acid;
 - Non-saline;
 - Moderate organic carbon;
 - Low CEC, non-sodic with balanced Ca:Mg ratio;
 - EAT scores suggest slaking but non-dispersive soils.

Table 8: Stockpile material Soil Chemistry Summary

Site	ECse	pH	ESP (%)	CEC	Ca:Mg ratio	OC (%)	EAT
SP1	0.1	6.9	1.8	16.3	3.0	1.1	3
SP2	0.1	5.8	1.7	2.8	1.4	0.9	4
SP3	0.1	6.9	0.3	19.7	5.5	2.0	3

4. Agricultural Land Evaluation

A number of frameworks and references are referred to establish the agricultural land evaluation for the project area.

4.1 Strategic Cropping Land

None of the area was defined as Strategic cropping land (SCL) on the trigger maps. Queensland Globe (2022) (last access 10/5/2022). Therefore, no further assessment is required under this framework.

4.2 Regional Land Suitability Frameworks

Five land suitability classes are defined for use in Queensland (DNRM and DSITIA, 2013), with land suitability decreasing progressively from Class 1 to Class 5. These classes are used to describe an area of land in terms of suitability for a particular land use which allows optimum, sustainable production with current technology while minimising degradation to the land resource in the short, medium or long-term. The five land suitability classes are defined below:

- **Class 1** Suitable land with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.
- **Class 2** Suitable land with minor limitations which either reduce production or require more than the simple management practices of class 1 land to maintain economic production.
- **Class 3** Suitable land with moderate limitations which either further lower production or require more than those management practices of class 2 land to maintain economic production.
- **Class 4** Marginal land, which is presently considered unsuitable due to severe limitations. The long term significance of these limitations on the proposed land use is unknown or not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production.
- **Class 5** Unsuitable land with extreme limitations that preclude its use.

The first three classes of land are considered suitable for the specified land use, as the benefits from using the land for that land use in the long term should outweigh the inputs required to initiate and maintain production.

Class 4 land is regarded as marginal land, currently unsuitable for a particular land use due to the severity of one or a number of limiting factors. It is doubtful that the inputs required to achieve and maintain production outweigh the benefits in the long-term.

Class 5 land is regarded as unsuitable for a particular land use because it has limitations that singularly or in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain sustainable production in the long term.

An overall suitability class for each land use is then determined on a scale of 1 to 5.

Using the Suitability framework for the Eastern Downs area (DNRM and DSITIA, 2013) Regional Land Suitability Frameworks for Queensland we have assessed the suitability of the site for various dryland crops in aggregate. We have made this assessment for the Brown Red Sodosol soil unit only, as neither other soil units (Tenosol or Dermosol) represent sufficient area as to be suitable for any form of dryland cropping activity.

Table 9: Suitability Framework Score

Suitability Framework Category	Suitability Score Range	Most common Score
E - Water erosion	2 - 4	3
Es - Erosion hazard, subsoil erodibility	3 - 5	4
M – Soil water availability	2 - 4	3
Pm - Narrow moisture range	3 - 4	4
Ps - Surface condition	1 - 3	2
R - Rockiness	3 - 5	2
Tm - Microrelief	1 - 2	1
W - Wetness	2 - 4	2
Overall class		4

The overall classification was a suitability score of 4, Marginal land, which considered unsuitable due to severe limitations

4.3 Agricultural Land Classification

Agricultural land classification in Queensland follows a simple hierarchical scheme that is applicable across the state (DSITI & DNRM, 2015). It allows the presentation of interpreted land evaluation data to indicate the location and extent of agricultural land that can be used sustainably for a wide range of land uses with minimal land degradation. Three broad classes of agricultural land and one non-agricultural land class are identified:

- **Class A** – Crop land
- **Class B** – Limited crop land
- **Class C** – Pasture land
- **Class D** – Non-agricultural land.

A review of the Agricultural Land Classification . Queensland Globe (2022) (last access 10/5/2022) define the project area as either C1 or C2 class. C1 land is the higher fertility grazing land typically used for beef cattle fattening and lands that are not suitable for cropping. C2 land is more typically suited to sheep and cattle breeding, while C3 is restricted to grazing with low stocking rates.

Based on the mapping unit of C1 or C2 class, and including outcomes from Section 4.2 where the suitability assessment classed the site overall as Class 4, the site would be defined as C2 classification (DSITI & DNRM, 2015). The site is considered suitable for livestock fattening where stock can be removed as required to maintain vegetative cover, protecting the soils from erosion risk.

5. Land Management and Amelioration

5.1 Soil Erosion

Erosion can have an adverse effect on soil productivity and the associated agricultural value. Additional effects can include downstream sedimentation, and decline in fertility through loss of soil structure, and increased dust generation and poor rehabilitation.

Dispersive clay subsoils with high ESPs, low Ca:Mg ratios are susceptible to tunnel and gully erosion which is particularly difficult to manage once initiated. The subsoils of the WLQ have clay subsoils that have a low erosion rating when undisturbed. However, as the subsoils can be sodic to strongly sodic, these soils will erode due to clay dispersion where soil is exposed to rainfall or runoff. Management options involve minimising exposure, careful management of overland flow, maintaining vegetation cover, and where appropriate, the use of soil ameliorants such as gypsum and lime (to reduce the degree of dispersion).

While site practices will be guided by site specific Erosion and Sediment Control plans. Where applicable, the following general erosion and sediment control measures are recommended:

- Contour banks should be used at intervals appropriate to the slope and soil type to control the flow of surface water.
- Diversion and erosion and sediment control devices should be fully implemented to provide effective erosion control prior to land disturbance activities, and kept in place and maintained until the area has been effectively rehabilitated.
- Where diversion of runoff water around a construction/rehabilitation site is required, design will need to be mindful of possible erosion effects due to concentration of flow.

5.2 Soil Amelioration

Soil amelioration will vary for different soils depending on soil chemistry. Lower cation exchange capacity soils (i.e., sandy soils) generally have a lower amendment requirement due less exchange sites for cation transfer. The guiding principles for choosing chemical amendments, i.e., to use lime, gypsum, or sulphur ameliorants, depends on both pH, ESP and Ca:Mg ratio.

A summary of the topsoil stockpile characteristics and implications for their use in rehabilitation include:

- In general, the soils were observed to be weakly-structured and possibly hardsetting.
- Salinity (0.1 dS/m) was low and is not considered to be an issue for use of the material.
- Current pH (5.8 – 6.9) is unlikely to impact on vegetation growth. We do not recommend any treatment for soil pH.
- Cation Exchange Capacity was very low (stockpile 2) to moderate (stockpiles 1 and 3).
- Sodicity was low (0.3 – 1.8 %) but The EAT scores suggest most soils are slaking, but non-dispersive. Some of the stockpiled topsoil had low organic content.
- Give these characterises, the primary issues around use of the material in rehabilitation will not be due soil chemistry, but more likely be due to poor aggregation, a lack of root aeration and poor water and nutrient holding capacity. Remediation of these soils needs to therefore focus on improving aggregate stability and building organics within the soil.
- Total organic carbon across the stockpiles varies, but recommend that an increase in OC will be useful for long term viability of vegetation. Initial establishment is paramount to start the site

off on the right trajectory, and therefore we recommend rehabilitation areas have 10-20 t/ha of pasture hay applied, ideally the hay has seeding in the grass cut, and an application of a broad-based fertilizer (containing N,P,K and S). We suggest contacting a local fertiliser supplier for a recommendation of available product.

- Following the application of the pasture hay and fertilizer, the site should have a light offset disking to anchor the material into the surface.

If the sub-soil material (Sodosol soils) is used for rehabilitation, we recommend amendment application to manage the sodicity.

- Gypsum should be applied at a rate of 5 kg/m³ of soil to be treated, or 15 t/ha if broadcast as a surface ameliorant to treat the top 30 cm of material.
- Alternatively, Lime may be used were soil pH permits (not recommended for material where pH is >8.4) at a rate of 2.5 kg/m³ , or 7.5 t/ha if broadcast as a surface ameliorant to treat the top 30 cm of material.

6. Rehabilitation Soil Testing and Monitoring Metrics

Horizon were requested to provide:

- A soil testing program/procedure; and
- Metrics to measure future rehabilitation performance based on soil testing program results.

Our proposed methodology is provided below:

6.1 Soil testing program/procedure

The following steps detail the proposed sampling program:

1. The testing program plan for each uniform rehabilitation area should be at a density of:
 - Minimum of 1 sample site per 6 hectares of rehabilitation: and
 - Have a minimum of 3 sample sites per rehabilitation area.
2. At each site, samples should be taken at a maximum of 100 mm increments to a depth not less than the topsoil capping depth. Sampling should ensure that soil from different depths does not mix.
3. Minimum sample size should 250 g. Samples to be labelled with sampler name, site, sample number, sample depth and date of sample.
4. Photograph to be taken of the samples, and surrounding area, with a hole identifier label and date visible.
5. Samples to be submitted to a NATA accredited laboratory for analysis of:
 - a. Moisture Content @ 40°C.
 - b. Electrical Conductivity (1:5).
 - c. pH (1:5).
 - d. Exchangeable Cations (Ca, Mg, Na, K, Al). With Ca:Mg ratio, and Exchangeable Sodium Percent (ESP) derived.
 - e. Chloride.
 - f. Total Organic Carbon (TOC) in Soil.

Soil salinity to be estimated as Saturated Extract Electrical Conductivity (EC_{se}) using the methods outlined in Shaw (1994).

6.2 Metrics for Soil Rehabilitation Performance.

The metrics for soil rehabilitation performance should be estimated using a minimum of three (3) samples for each uniform rehabilitation area. The measurement being expressed as a mean measurement with standard error of measurement presented.

The metric for success of the soil rehabilitation should be assessed against the following criteria:

1. The pH is between 5 and 8.4 pH units; and
2. The Exchangeable Sodium Percentage is less than six percent (< 6%); and
3. The soil salinity, expressed as EC_{se} is less than 5.5 dS/m; and
4. The organic carbon percentage (OC %) is greater than 1.0 %.
5. The site should be stable and not exhibiting evidence of rilling.

7. References

Department of Natural Resources and Mines and the Department of Science, Information Technology, Innovation and the Arts (DNRM and DSITIA) (2013) Regional Land Suitability Frameworks for Queensland

DSITI & DNRM (2015). Guidelines for agricultural land evaluation in Queensland (2nd edn). Queensland Government (Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines), Brisbane, Queensland.

Future Beef (2018) *Queensland Land Types*. Accessed 10th May 2022. <https://futurebeef.com.au/knowledge-centre/grazing-land-management/land-types-of-queensland/>

Globe.information.qld.gov.au, (2022) Queensland Globe User Guide - Featured Globes. [online] Available at: <http://globe.information.qld.gov.au/GlobeInformation/qldglobeUserGuide/featured-globes.htm> [Accessed 10 May. 2022].

Hazelton, P. and Murphy, B. (2016) Interpreting Soil Test Results. What do all the numbers mean? Third Edition CSIRO Publishing, Collingwood. Victoria.

Isbell, R.F. (2021) The Australian Soil Classification, Third Edition. CSIRO Publishing, Collingwood Victoria.

McDonald, R. (1998). Australian soil and land survey field handbook. Canberra: Australian Collaborative Land Evaluation Program.

McKenzie, N.J., Grundy, M.J., Webster, R. and Ringrose-Voase, A.J. (2007) Guidelines for Surveying Soil and Land Resources. CSIRO Publishing, Melbourne.

Milligan, E.N., Exon, N.F., Burger, D., Basey, D.J. (1971). Roma 1:250 000 Geology Sheet SG 55-12.

Rayment, G. and Lyons, D. (2011) Soil Chemical Methods. CSIRO Publishing, Collingwood, Victoria.

Shaw, R.J. (1994) Estimation of the electrical conductivity of saturation extracts from the electrical conductivity of 1:5 soil:water suspensions and various soil properties, Project report Q094025,

Appendix 1: Maps



Mining Lease Boundaries

Project:
Warwick Limestone Quarry

Version Number: 1.0
Date: 10/05/2022

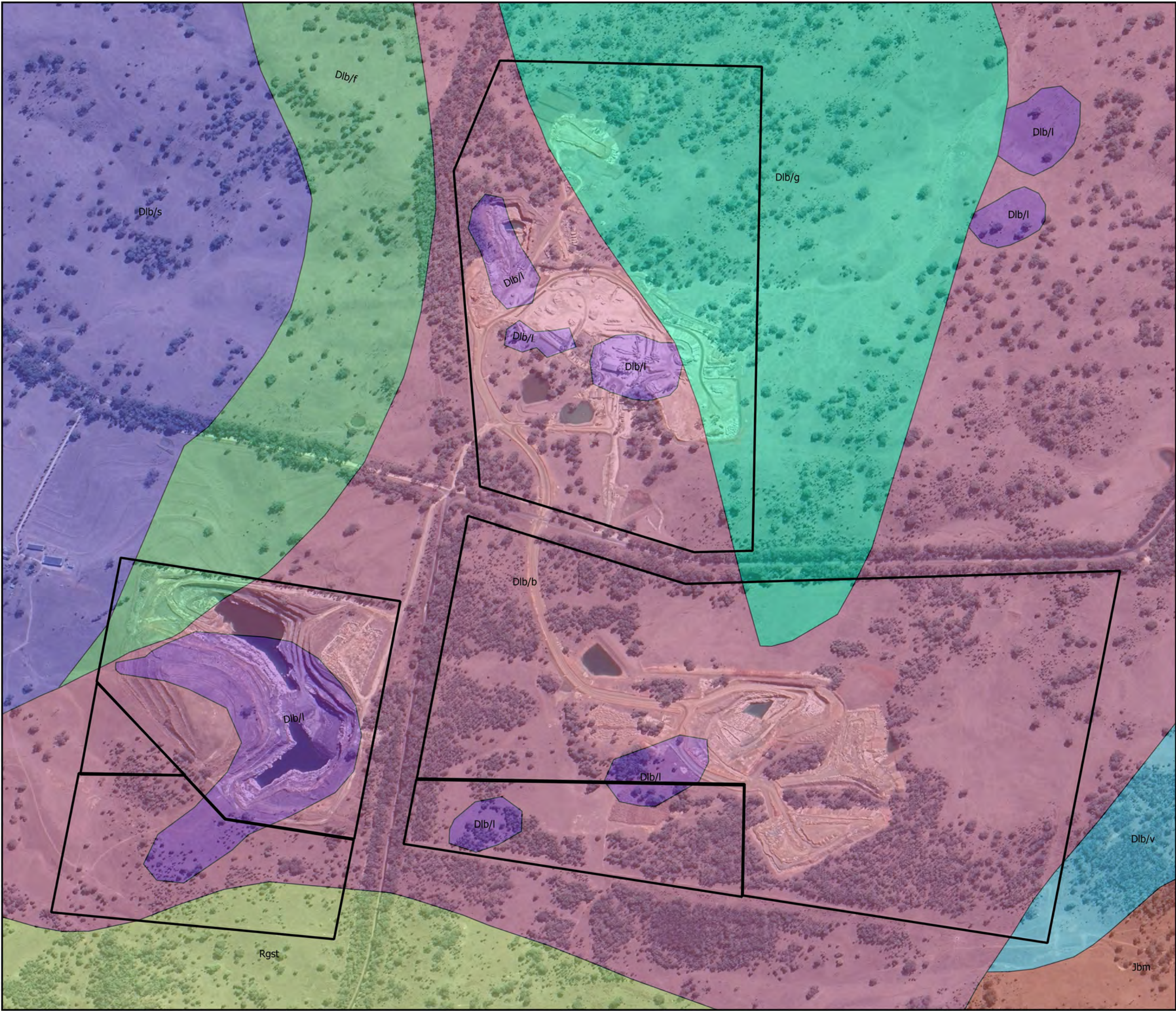
0 0.2 0.4 km

Legend

 Mining Lease Boundaries
Google Satellite



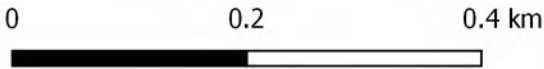
Horizon
Soil Science and Engineering



Geology

Project:
Warwick Limestone Quarry

Version Number: 1.0
Date: 10/05/2022



Legend

Mining Lease Boundaries

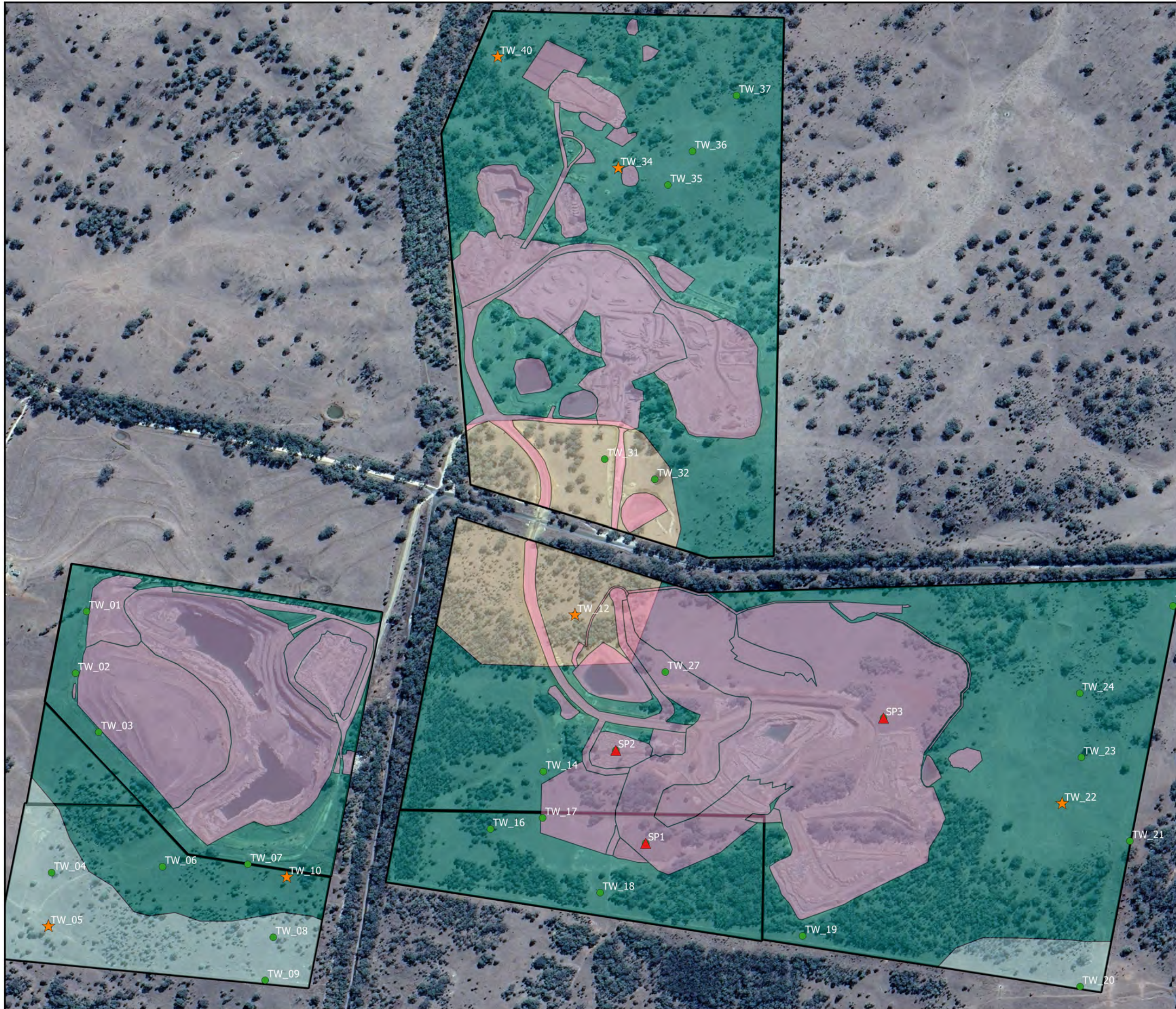
QLD Geology

- Bald Hill Formation/b (Dlb/b)
- Bald Hill Formation/f (Dlb/f)
- Bald Hill Formation/g (Dlb/g)
- Bald Hill Formation/l (Dlb/l)
- Bald Hill Formation/s (Dlb/s)
- Bald Hill Formation/v (Dlb/v)
- Marburg Subgroup (Jbm)
- Stanthorpe Granite (Rgst)

Google Satellite



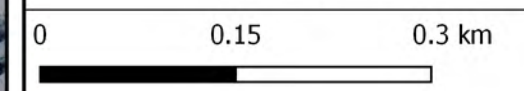
Horizon
Soil Science and Engineering



Soil Boundaries and Sample Locations

Project:
Terraquip Warwick

Version Number: 1.0
Date: 29/03/2022



Legend

- Sample locations
- ★ Chemistry locations
- ▲ Stockpile locations
- ▭ Mining Lease Boundaries
- ▭ Future disturbance Areas

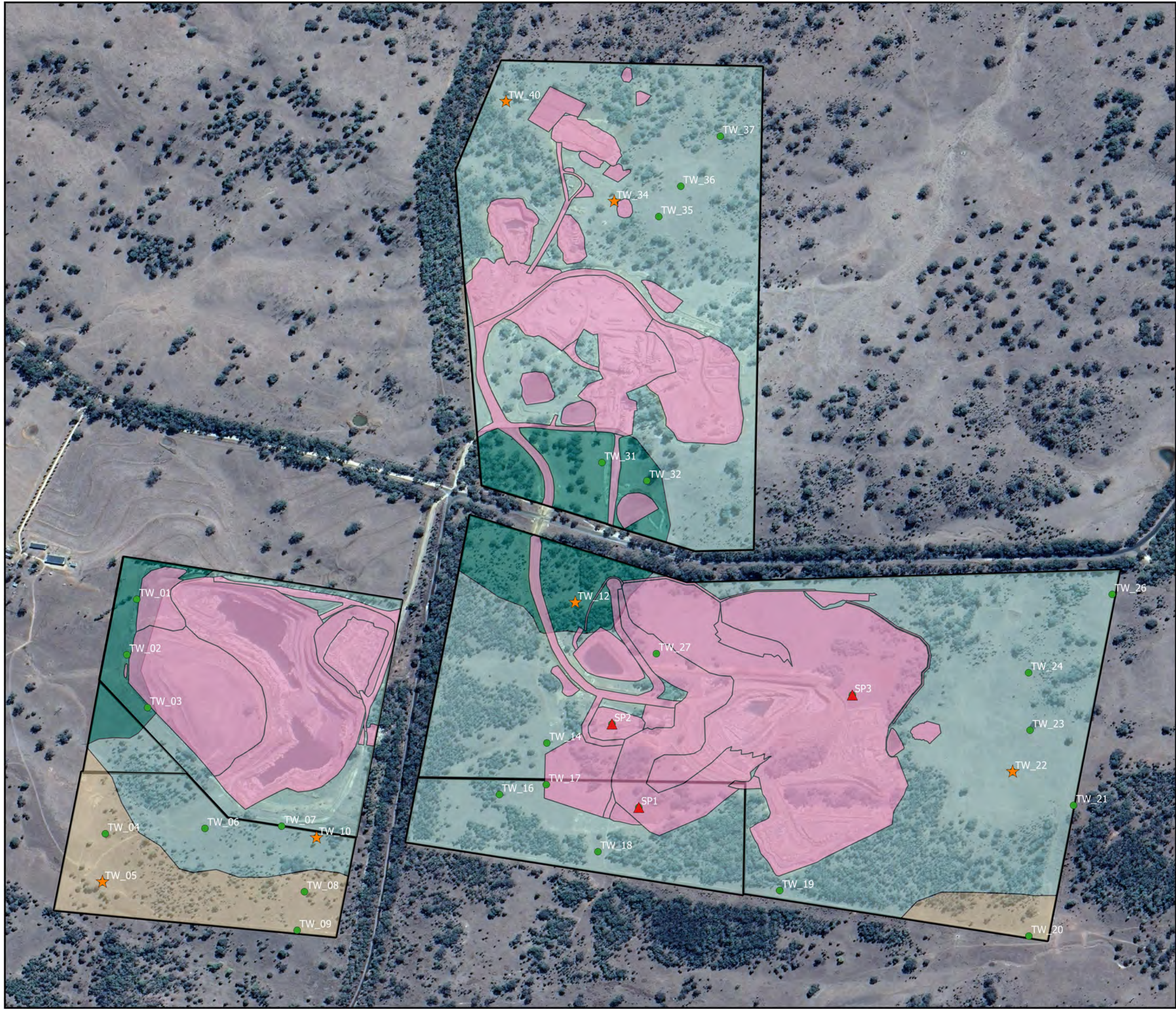
Soil boundaries

- Chromosol
- Tenesol
- Vertosol

Google Satellite



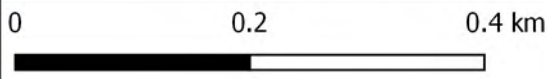
Horizon
Soil Science and Engineering



Soils Classification and Sample Locations

Project:
Warwick Limestone Quarry

Version Number: 1.1
Date: 16/05/2022



Legend

- Detailed Description
- ★ Chemistry locations
- ▲ Stockpile locations
- Future disturbance Areas
- Mining Lease Boundaries

Soil boundaries

- Dermosol
- Sodosol
- Tenesol

Google Satellite



Horizon
Soil Science and Engineering

Appendix 2: Detailed Descriptions

Site number	Description	Photos
Site ID: TW01 Location: S28.39514° E152.10617° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Well drained Rock outcrop: Slightly rocky Surface coarse fragments: Nil Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	Australian Soil Classification (ASC): Red Dermosol A1 Reddish brown (5YR 4/4) silty light clay with weak polyhedral structure, to 0.2m, clear change to; B21 Yellowish red (5YR 4/6) medium clay with moderate polyhedral structure, with many yellow and black mottles, common manganese, to 0.65m, diffuse change to; B22 Brownish Yellow (10YR 6/8) silty medium clay with weak polyhedral structure, with many red mottles, to 0.95m, diffuse change to; C Brownish Yellow (10YR 6/8) silty light clay with weak polyhedral structure, to 1.5m.	
		

Site number	Description	Photos
Site ID: TW02 Location: S28.39620° E152.10601° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Slowly permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Slightly rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Dermosol A1 Very dark greyish brown (2.5Y 3/2) silty light clay with moderate polyhedral structure, many small gravel on surface, to 0.15m, clear change to; B2 Oliver brown (2.5Y 4/4) medium clay with weak polyhedral structure, common medium gravel, with many yellow and grey mottles, a few manganese, to 0.45m, clear change to; B3 Dark grey (2.5Y 4/1) light clay with massive nil structure, with many yellow and red mottles, to 0.6m, gradual change to; C Dark grey (2.5Y 4/1) fine sandy light clay, to 1.5m.	
		

Site number	Description	Photos
Site ID: TW03 Location: S28.39717° E152.10642° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Well drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Red Dermosol A1 Very dark greyish brown (2.5Y 3/2) silty light clay with moderate polyhedral structure, many small gravel on surface, to 0.15m, clear change to; B2 Yellowish red (5YR 4/6) medium clay with weak polyhedral structure, common medium gravel, with many yellow and black mottles, a few manganese, to 0.45m, clear change to; B3 Dark grey (2.5Y 4/1) light clay with massive nil structure, with many yellow mottles, to 0.6m, gradual change to; C Dark grey (2.5Y 4/1) fine sandy light clay, to 1.5m.	
		

Site number	Description	Photos
Site ID: TW04 Location: S28.39957° E152.10568° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Slowly permeable Microrelief: None Drainage: Poorly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Grey Tenosol A1 Dark brown (10YR 3/3) loamy sand with massive nil structure, common small gravel, to 0.15m, clear change to; B2 Light brownish grey (10YR 6/2) loamy sand with massive nil structure, common small gravel, to 0.6m, diffuse change to; B31 Light yellowish brown (10YR 6/4) coarse sandy clay with massive nil structure, many small gravel, to 0.9m, clear change to; B32 Yellowish brown (10YR 5/6) clayey sand with massive nil structure, common small gravel, with abundant grey and a few black mottles, common iron-manganese, to 1.2m.	
		

Site number	Description	Photos
Site ID: TW05 Location: S28.40045° E152.10563° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Moderately permeable Microrelief: None Drainage: Well drained Rock outcrop: No bedrock exposed Surface condition: Loose Disturbance: Extensive clearing Sample site: SITE 1	ASC: Brown Tenosol Description A1 Brown (10YR 4/3) loamy sand, non-coherent structure, abundant small gravel on surface and common through horizon, to 0.35m, clear change to; B2 Brown (10YR 5/3) loamy sand, non-coherent structure, common small gravel, to 0.6m, diffuse change to; C Brown (7.5YR 5/3) clayey sand, non-coherent structure, abundant small gravel, to 1.5m.	 
		

Site number	Description	Photos
Site ID: TW06 Location: S28.39923° E152.10736° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Limestone Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained R Rock outcrop: Rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Dermosol A1 Very dark greyish brown (10YR 3/2) heavy clay with strong polyhedral structure, a few small and medium gravel, to 0.2m, clear change to; B2 Dark brown (10YR 3/3) heavy clay with moderate polyhedral structure, with a few red mottles, to 0.5m, clear change to; B3 Olive brown (2.5Y 4/3) heavy clay with weak polyhedral structure, many small gravel, with common dark mottles, a few manganese, to 0.9m. Refusal on rock	
		

Site number	Description	Photos
Site ID: TW07 Location: S28.39933° E152.10901° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Red Dermosol A1 Very dark greyish brown (10YR 3/2) loam with weak polyhedral structure, to 0.15m, abrupt change to; B21 Reddish brown (5YR 4/4) medium clay with moderate polyhedral structure, with common grey mottles, to 0.45m, gradual change to; B22 Dark yellowish brown (10YR 4/4) medium clay with moderate polyhedral structure, many medium gravel, a few manganese, to 0.7m, clear change to; R Grey (10YR 5/1) basalt.	
		

Site number	Description	Photos
Site ID: TW08 Location: S28.40059° E152.10947° Described by: Dan Rattray Date: 22/03/2022 Geology: Stanthorpe Granite Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Well drained Rock outcrop: Rocky Surface condition: Loose Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Tenosol A11 Dark brown (10YR 3/3) loamy sand with massive nil structure, common medium gravel, to 0.25m, clear change to; A12 Yellowish brown (10YR 5/6) loamy sand with massive nil structure, many medium gravel, to 0.5m, abrupt change to; R White (7.5YR 8/1) granite.	 
		

Site number	Description	Photos
Site ID: TW09 Location: S28.40133° E152.10933° Described by: Dan Rattray Date: 22/03/2022 Geology: Standthorpe Granite Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Well drained Rock outcrop: No bedrock exposed Surface condition: Loose Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Tenosol A1 Dark brown (10YR 3/3) loamy sand with massive nil structure, common medium gravel, to 0.15m, abrupt change to; B2 Yellowish brown (10YR 5/4) loamy sand with massive nil structure, many medium gravel, to 0.4m, clear change to; C Reddish yellow (7.5YR 6/8) clayey sand with massive nil structure, abundant medium gravel, to 0.9m.	
		

Site number	Description	Photos
Site ID: TW10 Location: S28.39955° E152.10967° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: SITE 2	ASC: Brown Sodosol A1 Very dark brown (10YR 2/2) sandy loam with weak polyhedral structure, a few small gravel, to 0.2m, abrupt change to; B2 Yellowish brown (10YR 5/6) medium heavy clay with weak polyhedral structure, many small gravel, with common dark mottles, a few manganese, to 1.3m.	
		

Site number	Description	Photos
Site ID: TW012 Location: S28.39507° E152.11448° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Drainage line Permeability: Slowly permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface coarse fragments: A few large pebbles Surface condition: Self mulching Disturbance: Extensive clearing Sample site: SITE 3	ASC: Brown Vertosol Description A1 Very dark brown (7.5YR 2.5/3) heavy clay with strong angular blocky structure, a few large pebbles on surface, to 0.1m, gradual change to; B21 Brown (7.5YR 4/2) heavy clay with moderate angular blocky structure, a few carbonates, to 0.8, gradual change to; B22 Brown (7.5YR 4/3) heavy clay with weak angular blocky structure, many medium gravel, with a few dark mottles, common carbonates and manganese concretions, to 1.3m, clear change to; C Brown (7.5YR 4/3) silty light clay (siltstone), massive structure, with many yellow and red mottles, to 1.4m.	
		

Site number	Description	Photos
Site ID: TW14 Location: S28.39759° E152.11390° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Slowly permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Slightly rocky Surface condition: Loose Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Brown (10YR 5/3) sandy clay with weak granular structure, common medium gravel, to 0.2m, abrupt change to; B2 Strong brown (7.5YR 5/8) medium clay with weak polyhedral structure, many medium gravel, with many grey mottles, a few carbonates, to 0.8m, clear change to; B3 Strong brown (7.5YR 5/8) medium clay with massive nil structure, abundant medium and large gravel, with many grey mottles, a few carbonates, to 1.2m, clear change to; C Yellowish brown (10YR 5/4) sandstone with massive nil structure, to 1.4m.	
		

Site number	Description	Photos
Site ID: TW15 Location: S28.39841° E152.11585° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Dermosol A1 Very dark brown (7.5YR 2.5/3) heavy clay with strong angular blocky structure, a few large gravel on surface, to 0.1m, gradual change to; B21 Brown (7.5YR 4/2) heavy clay with moderate angular blocky structure, a few carbonates, to 0.8m, gradual change to; B22 Brown (7.5YR 4/3) heavy clay with weak angular blocky structure, many medium gravel, with a few dark mottles, common carbonates, to 1.3m, clear change to; C Brown (7.5YR 4/3) silty light clay with massive angular blocky structure, with many yellow mottles, to 1.4m.	

Site number	Description	Photos
Site ID: TW16 Location: S28.39867° E152.11313° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Very dark brown (7.5YR 2.5/3) loamy sand with weak granular structure, common small gravel, to 0.25m, abrupt change to; B2 Strong brown (7.5YR 5/6) medium clay with weak polyhedral structure, many small and medium gravel, with a few grey mottles, to 0.6m, abrupt change to; R White (7.5YR 8/1) coarse grained rock.	
		

Site number	Description	Photos
Site ID: TW17 Location: S28.39849° E152.11398° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Slowly permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Slightly rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Brown (10YR 5/3) sandy loam with weak granular structure, common medium gravel, to 0.2m, abrupt change to; B2 Strong brown (7.5YR 5/8) medium clay with weak polyhedral structure, many medium gravel, common carbonates, to 1.2m.	
		

Site number	Description	Photos
Site ID: TW18 Location: S28.39973° E152.11497° Described by: Dan Rattray Date: 22/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Moderly drained Rock outcrop: No bedrock exposed Surface condition: Hardsetting Disturbance: Extensive clearing Sample site: Nil	ASC: Red Sodosol A1 Brown (7.5YR 5/4) clayey sand with weak granular structure, common medium gravel, to 0.3m, abrupt change to; B2 Red (2.5YR 4/6) medium clay with weak polyhedral structure, many small gravel, with many dark/grey mottles, common manganese, to 1.4m.	
		

Site number	Description	Photos
Site ID: TW19 Location: S28.40040° E152.11841° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Slightly rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Red Sodosol A1 Very dark brown (7.5YR 2.5/3) sandy loam with moderate polyhedral structure, a few medium gravel, to 0.15m, abrupt change to; B2 Dark Red (2.5YR 3/6) light clay with moderate polyhedral structure, a few medium gravel, with a few yellow mottles, to 0.7m, abrupt change to; B3 Strong brown (7.5YR 5/6) light clay with massive nil structure, many medium and large gravel, with abundant grey/yellow mottles, to 1.3m.	
		

Site number	Description	Photos
Site ID: TW20 Location: S28.40087° E152.12279° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Moderately permeable Microrelief: None Drainage: Poorly drained Rock outcrop: No bedrock exposed Surface condition: Loose Disturbance: Extensive clearing Sample site: Nil	ASC: Grey Tenosol A11 Dark greyish brown (10YR 4/2) loamy sand with weak granular structure, abundant small gravel on surface, to 0.3m, abrupt change to; A12 Pale brown (10YR 6/3) clayey sand with weak granular structure, many medium gravel, to 0.6m, clear change to; C Pale brown (10YR 6/3) medium clay with massive nil structure, abundant medium gravel, with abundant red mottles, to 1.2m.	
		

Site number	Description	Photos
Site ID: TW21 Location: S28.39871° E152.12395° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Rocky Surface condition: Hardsetting Disturbance: Extensive clearing Sample site: Nil	ASC: Red Sodosol A1 Dark reddish brown (5YR 3/4) silty light clay with weak granular structure, many small and medium gravel on surface, to 0.2m, abrupt change to; B2 Yellowish red (5YR 4/6) medium clay with moderate polyhedral structure, with a few yellow mottles, a few manganese, to 0.6m, clear change to; R Reddish yellow (5YR 6/8) ironstone.	
		

Site number	Description	Photos
Site ID: TW22 Location: S28.39809° E152.12277° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Broad valley Permeability: Slowly permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface coarse fragments: A few medium pebbles Surface condition: Firm Disturbance: Complete clearing Sample site: SITE 4	ASC: Red Sodosol Description A1 Very dark brown (7.5YR 2.5/3) clay loam with weak granular structure, a few medium pebbles on surface, to 0.3m, clear change to; B2 Yellowish red (5YR 4/6) medium clay with moderate polyhedral structure, many manganese concretions, to 1.0m, diffuse change to; B3 Dark reddish brown (5YR 3/4) silty light clay (siltstone) with moderate polyhedral structure, with abundant yellow and dark mottles and common carbonates, to 1.4m.	 
		

Site number	Description	Photos
Site ID: TW23 Location: S28.39726° E152.12283° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Poorly drained Rock outcrop: No bedrock exposed Surface condition: Loose Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Dark brown (7.5YR 3/4) loamy sand with weak granular structure, to 0.2m, abrupt change to; B2 Strong brown (7.5YR 5/6) medium clay with weak polyhedral structure, a few medium gravel, with common dark mottles, common manganese, to 0.5m, clear change to; R Grey (10YR 5/1) basalt.	
		

Site number	Description	Photos
Site ID: TW24 Location: S28.39622° E152.12287° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Very dark greyish brown (10YR 3/2) loam with weak granular structure, a very few medium gravel on surface, to 0.3m, abrupt change to; B2 Yellowish brown (10YR 5/6) light clay with weak polyhedral structure, with many grey/red mottles, a few manganese, to 0.8m, clear change to; R Very dark grey (10YR 3/1) basalt.	
		

Site number	Description	Photos
Site ID: TW26 Location: S28.39490° E152.12432° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Moderately permeable Microrelief: None Drainage: Poorly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Dermosol A1 Very dark brown (10YR 2/2) silty light clay with weak polyhedral structure, to 0.2m, clear change to; B2 Very dark greyish brown (10YR 3/2) medium clay with strong polyhedral structure, common small and medium gravel, a few manganese, to 0.4m, gradual change to; B3 Dark yellowish brown (10YR 4/6) medium clay with weak polyhedral structure, abundant medium gravel, with abundant dark/grey mottles, many manganese, to 0.8m, gradual change to; R Very dark greyish brown (10YR 3/2) basalt.	
		

Site number	Description	Photos
Site ID: TW27 Location: S28.39543° E152.11651° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Moderately permeable Microrelief: None Drainage: Well drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Sodosol	

Site number	Description	Photos
Site ID: TW31 Location: S28.39240° E152.11491° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Black Vertosol A1 Black (10YR 2/1) heavy clay with strong subangular blocky structure, a few medium gravel, to 0.1m, clear change to; B2 Black (10YR 2/1) heavy clay with strong subangular blocky structure, a few small gravel, common manganese, to 0.3m, clear change to; B3 Dark yellowish brown (10YR 4/4) heavy clay with strong subangular blocky structure, with many dark mottles, to 1.4m.	
		

Site number	Description	Photos
Site ID: TW32 Location: S28.39273° E152.11577° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Slightly rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Dermosol A1 Very dark brown (10YR 2/2) silty medium clay with moderate subangular blocky structure, common cobbles on surface, to 0.1m, clear change to; B2 Dark brown (7.5YR 3/3) heavy clay with moderate subangular blocky structure, with common dark mottles, a few manganese, to 0.4m, abrupt change to; R White (10YR 8/1) limestone.	
		

Site number	Description	Photos
Site ID: TW34 Location: S28.38752° E152.11503° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Gabbroid Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: SITE 6	ASC: Rehabilitation (Grey Anthroposol) A1 Dark brown (10YR 3/3) sandy clay with moderate polyhedral structure, many medium and large gravel on surface, to 0.4m, abrupt change to; B2 Dark greyish brown (10YR 4/2) heavy clay, to 0.85m, gradual change to; B3 Dark yellowish brown (10YR 4/6) heavy clay, common small gravel, to 1.5m.	
		

Site number	Description	Photos
Site ID: TW35 Location: S28.38775° E152.11591° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Red Sodosol A1 Very dark brown (7.5YR 2.5/3) clay loam with weak polyhedral structure, to 0.1m, clear change to; B2 Dark reddish brown (5YR 3/4) medium clay with moderate polyhedral structure, common small and medium gravel, with a few yellow mottles, to 0.6m, abrupt change to; B3 Yellowish brown (10YR 5/6) silty sand with massive nil structure, with many red/yellow mottles, many manganese, to 1.3m.	
		

Site number	Description	Photos
Site ID: TW36 Location: S28.38717° E152.11632° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Midslope Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Very dark brown (7.5YR 2.5/3) clay loam with weak polyhedral structure, to 0.15m, clear change to; B2 Dark brown (7.5YR 3/4) medium clay with moderate subangular blocky structure, with common dark mottles, a few manganese, to 0.5m, abrupt change to; R White (10YR 8/1) limestone.	
		

Site number	Description	Photos
Site ID: TW37 Location: S28.38623° E152.11707° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Bottom hill Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: Slightly rocky Surface condition: Firm Disturbance: Extensive clearing Sample site: Nil	ASC: Brown Sodosol A1 Very dark brown (7.5YR 2.5/3) clay loam with weak polyhedral structure, to 0.15m, clear change to; B2 Dark brown (7.5YR 3/4) medium clay with moderate subangular blocky structure, with common dark mottles, a few manganese, to 0.5m, abrupt change to; R White (10YR 8/1) limestone.	
		

Site number	Description	Photos
Site ID: TW40 Location: S28.38563° E152.11299° Described by: Dan Rattray Date: 23/03/2022 Geology: Bald hill formation, Mafites Landform pattern: Low Hills Element: Top Permeability: Moderately permeable Microrelief: None Drainage: Imperfectly drained Rock outcrop: No bedrock exposed Surface condition: Firm Disturbance: Extensive clearing Sample site: SITE 5	ASC: Brown Sodosol A1 Very dark greyish brown (10YR 3/2) silty light clay with weak polyhedral structure, many medium gravel on surface, to 0.1m, abrupt change to; B21 Dark yellowish brown (10YR 4/6) silty medium clay with weak polyhedral structure, a few medium gravel, common manganese, to 0.6m, gradual change to; B22 Yellowish brown (10YR 5/6) fine sandy medium clay with moderate polyhedral structure, a few medium gravel, common carbonates, to 1.05m, gradual change to; B3 Yellowish brown (10YR 5/6) clayey sand with massive nil structure, a few medium gravel, with many grey mottles, to 1.35m.	
		

Appendix 3: Certificate of Analysis

CERTIFICATE OF ANALYSIS

Work Order : **EB2208185**
Client : **Horizon Soil Science and Engineering**
Contact : MR DAN RATTRAY
Address : Condamine Alliance EcoHub 266 Margaret Street
 Toowoomba Toowoomba 4350
Telephone : ----
Project : Terraquip Warwick
Order number : ----
C-O-C number : ----
Sampler : DAN RATTRAY
Site : ----
Quote number : BN/158/21 V3
No. of samples received : 39
No. of samples analysed : 39

Page : 1 of 11
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 24-Mar-2022 13:28
Date Analysis Commenced : 28-Mar-2022
Issue Date : 06-Apr-2022 16:26



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED045G (Chloride): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED007 (Exchangeable Cations): Unable to calculate Magnesium/Potassium Ratio result as required Exchangeable Potassium results are less than the limit of reporting.
- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio results for some samples as required Exchangeable Potassium results are less than the limit of reporting.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity ($H^+ + Al^{3+}$).



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Site1_SOIL_0_20_2203231201	TW_Site1_SOIL_200_202203231202	TW_Site1_SOIL_500_202203231203	TW_Site1_SOIL_800_202203231204	TW_Site1_SOIL_1200_202203231205
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-001	EB2208185-002	EB2208185-003	EB2208185-004	EB2208185-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.8	5.9	6.0	6.2	6.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	3	<1	2	4
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	3.7	5.2	5.9	4.9	5.2
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Grayish Brown (10YR 3/2)	Dark Grayish Brown (10YR 4/2)	Brown (7.5YR 5/3)	Brown (7.5YR 5/3)	Brown (7.5YR 4/4)
Texture	----	-	-	Clay Loam Sandy	Sandy Clay Loam	Sandy Loam	Clayey Sand	Clayey Sand
Emerson Class Number	EC/TC	-	-	7	7	2	2	2
ED005: Exchange Acidity								
Ø Exchange Acidity	----	0.1	meq/100g	<0.1	0.2	0.3	----	----
Ø Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	0.1	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.9	0.4	0.1	0.2	0.6
Exchangeable Magnesium	----	0.1	meq/100g	0.3	0.2	0.2	0.3	0.4
Exchangeable Potassium	----	0.1	meq/100g	0.1	0.1	<0.1	0.1	0.1
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	1.0	0.8	----	----
Cation Exchange Capacity	----	0.1	meq/100g	1.4	----	----	1.0	1.3
Exchangeable Sodium Percent	----	0.1	%	0.9	3.0	4.8	7.4	5.9
Calcium/Magnesium Ratio	----	0.1	-	3.0	2.0	0.5	0.7	1.5
Magnesium/Potassium Ratio	----	0.1	-	2.2	1.8	----	2.8	3.0
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.79	0.27	0.08	0.04	0.05



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Site2_SOIL_0_20 2203231206	TW_Site2_SOIL_200_ 202203231207	TW_Site2_SOIL_500_ 202203231208	TW_Site2_SOIL_800_ 202203231209	TW_Site2_SOIL_1200_ _202203231210
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-006	EB2208185-007	EB2208185-008	EB2208185-009	EB2208185-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	7.2	7.9	8.3	8.7
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	39	93	232	524
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	22.3	21.6	10.7	7.8	14.4
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Gray (7.5YR 3/1)	Brown (10YR 4/3)	Brown (10YR 5/3)	Brown (10YR 4/3)	Brown (7.5YR 5/3)
Texture	----	-	-	Loam	Heavy Clay	Medium Heavy Clay	Medium Clay	Medium Heavy Clay
Emerson Class Number	EC/TC	-	-	7	2	1	1	1
ED006: Exchangeable Cations on Alkaline Soils								
∅ Exchangeable Calcium	----	0.2	meq/100g	----	----	2.2	2.7	4.0
∅ Exchangeable Magnesium	----	0.2	meq/100g	----	----	4.7	6.1	10.1
∅ Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	<0.2
∅ Exchangeable Sodium	----	0.2	meq/100g	----	----	1.4	2.1	3.8
∅ Cation Exchange Capacity	----	0.2	meq/100g	----	----	8.3	10.9	17.9
∅ Exchangeable Sodium Percent	----	0.2	%	----	----	16.8	19.2	21.1
∅ Calcium/Magnesium Ratio	----	0.2	-	----	----	0.4	0.4	0.4
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.9	4.6	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	1.7	9.7	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.2	1.7	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	7.1	16.2	----	----	----
Exchangeable Sodium Percent	----	0.1	%	2.6	10.5	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	2.9	0.5	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	6.6	55.9	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	50	120	270	790
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.21	0.42	0.31	0.20	0.11



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Site3_SOIL_0_20 2203231211	TW_Site3_SOIL_200_ 202203231212	TW_Site3_SOIL_500_ 202203231213	TW_Site3_SOIL_800_ 202203231214	TW_Site3_SOIL_1200_ _202203231215
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-011	EB2208185-012	EB2208185-013	EB2208185-014	EB2208185-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.5	7.3	8.3	8.8	9.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	15	31	130	330	296
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	20.8	26.2	23.0	18.7	17.4
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Black (5YR 2.5/1)	Dark Brown (7.5YR 3/2)	Brown (7.5YR 4/2)	Dark Brown (7.5YR 3/3)	Brown (7.5YR 4/3)
Texture	----	-	-	Medium Clay	Medium Heavy Clay	Medium Heavy Clay	Medium Heavy Clay	Medium Clay
Emerson Class Number	EC/TC	-	-	3	3	2	2	2
ED006: Exchangeable Cations on Alkaline Soils								
∅ Exchangeable Calcium	----	0.2	meq/100g	----	----	14.2	11.5	13.5
∅ Exchangeable Magnesium	----	0.2	meq/100g	----	----	10.2	9.3	10.3
∅ Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	<0.2
∅ Exchangeable Sodium	----	0.2	meq/100g	----	----	2.3	2.3	3.2
∅ Cation Exchange Capacity	----	0.2	meq/100g	----	----	26.7	23.1	27.0
∅ Exchangeable Sodium Percent	----	0.2	%	----	----	8.5	10.1	11.9
∅ Calcium/Magnesium Ratio	----	0.2	-	----	----	1.4	1.2	1.3
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	16.1	19.5	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	8.8	16.0	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.5	2.1	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	25.8	37.9	----	----	----
Exchangeable Sodium Percent	----	0.1	%	1.8	5.6	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	1.8	1.2	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	24.7	68.6	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	40	150	210	150
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.73	0.91	0.92	0.55	0.15



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Site4_SOIL_0_20 2203231216	TW_Site4_SOIL_200_ 202203231217	TW_Site4_SOIL_500_ 202203231218	TW_Site4_SOIL_800_ 202203231219	TW_Site4_SOIL_1200_ _202203231220
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-016	EB2208185-017	EB2208185-018	EB2208185-019	EB2208185-020
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.1	6.7	8.0	8.2	9.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	12	103	522	764
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	20.2	17.2	20.7	21.2	18.2
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown (7.5YR 3/2)	Very Dark Brown (7.5YR 2.5/2)	Reddish Brown (5YR 4/4)	Reddish Brown (5YR 4/4)	Brown (7.5YR 4/3)
Texture	----	-	-	Light Clay	Light Medium Clay	Medium Heavy Clay	Heavy Clay	Medium Clay
Emerson Class Number	EC/TC	-	-	7	3	2	2	2
ED006: Exchangeable Cations on Alkaline Soils								
∅ Exchangeable Calcium	----	0.2	meq/100g	----	----	5.7	5.0	5.9
∅ Exchangeable Magnesium	----	0.2	meq/100g	----	----	8.2	9.8	12.3
∅ Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	<0.2
∅ Exchangeable Sodium	----	0.2	meq/100g	----	----	1.8	3.2	4.6
∅ Cation Exchange Capacity	----	0.2	meq/100g	----	----	15.7	18.1	22.9
∅ Exchangeable Sodium Percent	----	0.2	%	----	----	11.8	17.5	20.1
∅ Calcium/Magnesium Ratio	----	0.2	-	----	----	0.7	0.5	0.5
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	7.0	6.9	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	3.8	5.2	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.1	0.3	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	11.6	12.6	----	----	----
Exchangeable Sodium Percent	----	0.1	%	1.0	2.6	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	1.8	1.3	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	6.1	26.4	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	10	110	870	1060
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.89	2.17	0.67	0.41	0.15



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Site5_SOIL_0_20 2203231221	TW_Site5_SOIL_200_ 202203231222	TW_Site5_SOIL_500_ 202203231223	TW_Site5_SOIL_800_ 202203231224	TW_Site5_SOIL_1200 _202203231225
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-021	EB2208185-022	EB2208185-023	EB2208185-024	EB2208185-025
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	7.2	8.9	9.4	9.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	23	33	357	406	430
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	15.0	21.9	17.6	7.7	15.9
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Grayish Brown (10YR 3/2)	Dark Brown (10YR 3/3)	Brown (10YR 4/3)	Brown (10YR 4/3)	Brown (10YR 4/3)
Texture	----	-	-	Medium Clay	Medium Heavy Clay	Light Medium Clay	Sandy Clay Loam	Clay Loam Sandy
Emerson Class Number	EC/TC	-	-	7	2	2	2	2
ED006: Exchangeable Cations on Alkaline Soils								
∅ Exchangeable Calcium	----	0.2	meq/100g	----	----	6.2	5.8	5.8
∅ Exchangeable Magnesium	----	0.2	meq/100g	----	----	9.0	7.4	7.3
∅ Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	<0.2
∅ Exchangeable Sodium	----	0.2	meq/100g	----	----	2.3	4.1	3.2
∅ Cation Exchange Capacity	----	0.2	meq/100g	----	----	17.6	17.3	16.4
∅ Exchangeable Sodium Percent	----	0.2	%	----	----	13.1	23.9	19.8
∅ Calcium/Magnesium Ratio	----	0.2	-	----	----	0.7	0.8	0.8
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	11.2	10.2	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	9.9	16.4	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.7	2.4	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	22.0	29.2	----	----	----
Exchangeable Sodium Percent	----	0.1	%	3.2	8.2	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	1.1	0.6	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	44.6	101	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	50	230	280	340
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.18	0.89	0.59	0.06	0.13



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Site6_SOIL_0_20 2203231226	TW_Site6_SOIL_200_ 202203231227	TW_Site6_SOIL_500_ 202203231228	TW_Site6_SOIL_800_ 202203231229	TW_Site6_SOIL_1200_ _202203231230
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-026	EB2208185-027	EB2208185-028	EB2208185-029	EB2208185-030
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.6	8.9	8.3	8.5	8.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	119	92	207	356	553
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	7.8	11.0	26.1	23.5	18.9
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Brown (7.5YR 4/2)	Brown (7.5YR 4/2)	Dark Grayish Brown (10YR 4/2)	Brown (7.5YR 4/2)	Brown (7.5YR 4/3)
Texture	----	-	-	Medium Clay	Medium Clay	Medium Heavy Clay	Medium Heavy Clay	Medium Heavy Clay
Emerson Class Number	EC/TC	-	-	4	4	5	4	4
ED006: Exchangeable Cations on Alkaline Soils								
∅ Exchangeable Calcium	----	0.2	meq/100g	6.6	5.1	15.2	9.5	6.4
∅ Exchangeable Magnesium	----	0.2	meq/100g	1.7	1.0	13.4	12.8	11.1
∅ Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
∅ Exchangeable Sodium	----	0.2	meq/100g	0.2	<0.2	2.0	2.1	2.2
∅ Cation Exchange Capacity	----	0.2	meq/100g	8.5	6.1	30.6	24.4	19.7
∅ Exchangeable Sodium Percent	----	0.2	%	2.6	<0.2	6.5	8.8	11.1
∅ Calcium/Magnesium Ratio	----	0.2	-	3.9	5.2	1.1	0.7	0.6
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	70	240	670
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.79	0.61	0.85	0.61	0.24



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Stock1_SOIL_Re p1_202203231231	TW_Stock1_SOIL_Re p2_202203231232	TW_Stock1_SOIL_Re p3_202203231233	TW_Stock2_SOIL_Re p1_202203231234	TW_Stock2_SOIL_Re p2_202203231235
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-031	EB2208185-032	EB2208185-033	EB2208185-034	EB2208185-035
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.2	7.9	6.7	5.8	6.3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	21	27	10	11	12
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	11.5	20.3	19.2	6.8	5.6
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown (7.5YR 3/2)	Dark Reddish Brown (5YR 3/3)	Dark Reddish Brown (5YR 3/3)	Very Dark Grayish Brown (10YR 3/2)	Brown (7.5YR 4/2)
Texture	----	-	-	Medium Clay	Medium Heavy Clay	Medium Heavy Clay	Light Clay	Light Medium Clay
Emerson Class Number	EC/TC	-	-	3	4	3	7	3
ED005: Exchange Acidity								
Ø Exchange Acidity	----	0.1	meq/100g	----	----	----	0.2	----
Ø Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	<0.1	----
ED006: Exchangeable Cations on Alkaline Soils								
Ø Exchangeable Calcium	----	0.2	meq/100g	----	7.8	----	----	----
Ø Exchangeable Magnesium	----	0.2	meq/100g	----	2.4	----	----	----
Ø Exchangeable Potassium	----	0.2	meq/100g	----	<0.2	----	----	----
Ø Exchangeable Sodium	----	0.2	meq/100g	----	<0.2	----	----	----
Ø Cation Exchange Capacity	----	0.2	meq/100g	----	10.2	----	----	----
Ø Exchangeable Sodium Percent	----	0.2	%	----	<0.2	----	----	----
Ø Calcium/Magnesium Ratio	----	0.2	-	----	3.3	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	7.0	----	19.8	1.8	1.0
Exchangeable Magnesium	----	0.1	meq/100g	6.4	----	4.2	0.8	0.8
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	0.2	0.4	<0.1
Exchangeable Sodium	----	0.1	meq/100g	0.7	----	0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	3.2	----
Cation Exchange Capacity	----	0.1	meq/100g	14.2	----	24.4	----	1.9
Exchangeable Sodium Percent	----	0.1	%	4.8	----	0.5	0.4	3.8
Calcium/Magnesium Ratio	----	0.1	-	1.1	----	4.7	2.2	1.2
Magnesium/Potassium Ratio	----	0.1	-	33.0	----	18.4	2.0	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	<10	<20	<10	<10



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Stock1_SOIL_Re p1_202203231231	TW_Stock1_SOIL_Re p2_202203231232	TW_Stock1_SOIL_Re p3_202203231233	TW_Stock2_SOIL_Re p1_202203231234	TW_Stock2_SOIL_Re p2_202203231235
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00
Compound	CAS Number	LOR	Unit	EB2208185-031	EB2208185-032	EB2208185-033	EB2208185-034	EB2208185-035
Result				Result	Result	Result	Result	Result
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.86	1.29	1.11	1.33	0.48



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Sample ID

				TW_Stock2_SOIL_Re p3_202203231236	TW_Stock3_SOIL_Re p1_202203231237	TW_Stock3_SOIL_Re p2_202203231238	TW_Stock3_SOIL_Re p3_202203231239	----
Sampling date / time				23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	23-Mar-2022 00:00	----
Compound	CAS Number	LOR	Unit	EB2208185-036	EB2208185-037	EB2208185-038	EB2208185-039	-----
				Result	Result	Result	Result	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.4	6.9	7.2	6.7	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	6	26	22	23	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	10.6	16.0	15.4	22.3	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Brown (7.5YR 4/3)	Dark Reddish Brown (5YR 3/2)	Dark Reddish Brown (5YR 3/3)	Very Dark Gray (5YR 3/1)	----
Texture	----	-	-	Clay Loam Sandy	Medium Heavy Clay	Medium Heavy Clay	Heavy Clay	----
Emerson Class Number	EC/TC	-	-	3	3	3	3	----
ED005: Exchange Acidity								
Ø Exchange Acidity	----	0.1	meq/100g	0.8	----	----	----	----
Ø Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	16.8	12.7	10.9	----
Exchangeable Magnesium	----	0.1	meq/100g	1.2	4.2	1.1	11.1	----
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.7	0.8	0.6	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	3.2	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	21.8	14.6	22.7	----
Exchangeable Sodium Percent	----	0.1	%	0.8	0.2	0.2	0.4	----
Calcium/Magnesium Ratio	----	0.1	-	0.7	4.0	11.5	1.0	----
Magnesium/Potassium Ratio	----	0.1	-	3.0	5.8	1.4	18.1	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<20	<10	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.88	2.66	2.02	1.44	----