Landloch

STRATEGIC GUIDANCE FOR REHABILITATED WASTE LANDFORMS: NOLANS RARE EARTHS PROJECT

Arafura Resources

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TOOWOOMBA
PO Box 57
HARLAXTON QLD 4350
Phone (07) 4613 1825

PERTH
PO Box 5175
SOUTH LAKE WA 6164
Phone (08) 9494 2835

NEWCASTLE
PO Box 7017
Redhead NSW 2290
Phone (02) 4965 7717

Landloch Pty Ltd
A.C.N. 011 032 803
A.B.N. 29011032803

Web site: www.landloch.com.au
Email: admin@landloch.com.au

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1 INTRODUCTION

1.1 Overview

Arafura Resources Limited (Arafura) is proposing to develop the Nolans Rare Earths Project (Nolans) located approximately 135km north-northwest of Alice Springs and 10km west of the Stuart Highway in the Northern Territory. The closest community is Aileron, situated ~13km south west of Nolans.

Nolans is targeting a mineral deposit hosted in fluorapatite and containing rare earths. Nolans comprises the mine site, a processing site, a borefield area, an accommodation village site, and interconnecting access roads and utility service corridors.

An open pit will be excavated and remain at closure.

Waste rock dumps (WRDs) will receive mineral wastes generated during the life of the mine (25 years measured and indicated). It is estimated that 91 million loose cubic metres (181 million tonnes) will need to be stored over the life of mine (based on 2015 pit model data provided to Landloch by Arafura), with 162Mt produced in the first 25 years. Current plans include two WRDs for the 25 years of mining (with a total of 38 years of ore processing), each with a total maximum height of 60m and constructed using a concave batter profile and no berms. The estimated footprint is 220ha (NT EPA 2019). Storage and infiltration of rainfall into the top surface of the WRDs is planned; discharge of runoff to the downslope batters is not planned.

A residue storage facility (RSF) is planned with a life of mine (LOM) footprint of 480ha and approximate height of 14m. The RSF is planned to be rehabilitated similar to WRDs.

Topsoil is to be stored for use in rehabilitation. Lower grade mined material will be stockpiled and may or may not require rehabilitation depending on future economics of the project.

Landloch Pty Ltd (Landloch) has considered issues related to the long-term erosional stability of the WRDs and RSF that may exist at Nolans post-closure. It is assumed that the lower grade mined materials can be treated the same as the other mineralised waste (though this assumption would need to be validated going forward). Other elements such as the processing plant, evaporation ponds, and ROM are not considered in this report.

Arafura is currently (as of June 2021) also considered WRD designs heights that exceed 60m (the target maximum dump height considered in this report). This is due to the potential increase in the size of the pit, developed in early 2021 based on the ore reserve update. As part of that update, it was simpler to add height to the current WRD locations rather than having to do a full re-design of all the surface water management infrastructure to locate an additional WRD within the mining lease. Arafura consider this an issue to be solved at a later date. Options to store the additional waste longer-term may include some or all of these:

- New dump location with surface water management adjustments;
- Expand the footprint of the current WRDs;
- Backfill parts of the open-pit; and/or
- Apply for a small increase to the WRD ceiling height.

The main objective of this report is to define appropriate WRD design concepts (i.e. batter shapes) for any volume of WRD material throughout the LOM, particularly in light of the fact that the project is very likely to continue on past the currently understood 38 year LOM, which will produce additional waste rock into the future.

The concepts provided in this report must necessarily be validated once mining has commenced and once samples of the extracted wastes and disturbed soils are available. Validation would include testing of the erodibility of the as-disturbed wastes and soils; this report uses estimations for erodibility based on available data to date. Field trials to further validate the suitability of the designs would then occur. This could include erosion and vegetation monitoring whereby measures of runoff and erosion are made for the proposed rehabilitation design. The results of this monitoring can then be fed back into the erosion modelling process to confirm the model predictions and provide additional confidence in the long-term suitability of the rehabilitation designs adopted for Nolans.

2 CONTEXT

2.1 Closure design shape and cost

The three dimensional (3D) shape and quality of rehabilitated mine waste landforms will be important for successful closure at Nolans. Their design must be consistent with constraints imposed them by material properties (soils and wastes), climate and other physical factors (e.g., topography). The constraints imposed by the properties of the soil and mineral wastes and the climate are for all intents and purposes fixed, with limited to no scope for Nolans to significantly alter their influence.

Preliminary rehabilitated landform parameters are often set early in the life of a mine (i.e., during the feasibility planning and/or approval's phases). These parameters include:

- The location of the landform;
- Landform footprint;
- Rehabilitated batter heights, gradients, and batter profile shapes; and
- Berm positions and capacity.

Landloch regularly observes that the parameters set at this stage of mining (and in particular footprint and height) have a large bearing on the scope of rehabilitation options available later in the mine life. Landloch has observed situations where, for example, had more footprint been available, more flexibility and potentially more cost effective rehabilitation options could have been adopted.

One example of this is a Pilbara (WA) operation that placed a WRD containing erodible materials too close to an ore conveyor. This limited the ability to increase footprint, meaning that more erosion resistant materials had to be sourced and hauled from a distant pit to achieve successful rehabilitation.

The way in which a waste landform is built also has significant cost implications. For example, Landloch is aware of one site in the northern WA Goldfields that by constructing WRDs to a shape consistent with the rehabilitation shape rather than constructing to a generic shape based on ease of construction, the cost of rehabilitation was reduced by 75%. Failure to adequately plan for the rehabilitation WRD design requirements within the operations phase on another site in the Pilbara region saw rehabilitation costs for one WRD reach to in excess of $300,000 per hectare (2013 costs) because reshaping required the use of truck and shovel techniques rather than dozer push. Based on the operator's review of costs, truck and shovel was 6-10 times more costly than dozer push.

It is also important to note that bulk earthworks required as part of waste landform rehabilitation is a significant component of a mine site's closure liability. Kumari and Cooper (2019) presented closure cost data for the Mogalakwena platinum mine in South Africa. They stated that waste landform rehabilitation, "*made up about 70% of the total closure liability in [the] case of premature or immediate closure and almost 90% in [the] case of planned or LoM closure.*" They also stated that a major contributor to rehabilitation cost was, "*suboptimal placement of waste rock (i.e., restricted footprint, smaller bench widths, steeper side slopes and high dump heights)*", and acknowledged that, "*suboptimal waste placement could also contribute to other environmental issues—such as dust, erosion and groundwater impacts—leading to increased post-closure costs due to active care and maintenance requirements.*" Similar closure cost estimates are presented by AusIMM (2012), where the cost of reshaping can be as much as 80% of the total landform closure cost. Loch and Lowe (2008) illustrated via a simple example that constructing to a design guided by final landform design requirements could reduce bulk earthworks costs by ~35%. Combining these examples, a 35% reduction in reshaping costs could translate into savings of several millions of dollars (AUD), or a 20-30% reduction in the total closure cost for an entire mine (Howard 2019).

Significant savings can be realised through early inclusion of rehabilitated landform shapes into mine planning. This document aims to provide a broad understanding of landform design requirements that can be used by Arafura to develop informed preliminary rehabilitation landform shapes for Nolans.

2.2 Regulator expectations

2.2.1 Guidance documents

The Northern Territory Department of Mines and Energy published guidelines on mine closure and completion and mine rehabilitation in November 2006. Landloch understands that these documents have been withdrawn and are being updated. In the absence of these documents, guidance documents from Western Australia are commonly used. The Western Australian mining regulators involved with waste landforms and closure include the Department of Mines, Industry Regulation and Safety (DMIRS) and the Environmental Protection Authority of Western Australia (WA EPA). They have provided a range of guidance documents that are relevant to landform design.

In addition, the Australian Government has produced a range of handbooks in the Leading Practice Sustainable Development Program for the Mining Industry. The Mine Closure (LPSDP 2016a) and Mine Rehabilitation (LPSDP 2016b) handbooks are relevant for rehabilitation of waste facilities.

The NT EPA also provided information specific for Nolans in the terms of reference (NT EPA 2015) for the preparation of the Environmental Impact Statement for Nolans. This is discussed below.

2.2.2 DMIRS and WA EPA

DMIRS (formerly Department of Mines and Petroleum (DMP)) and WA EPA take an objective-based, non-prescriptive approach to assessing the suitability of waste landform closure designs. It is their expectation that mining proponents provide detail about how their project will meet their stated broad objectives. These objectives are clearly stated in the completion criteria framework document endorsed by DMIRS (Young *et al.* (2019), drawing from DMP & WA EPA (2015)):

> *"The Department of Mines and Petroleum's (DMP) principle (sic) closure objectives are for rehabilitated mines to be (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting/ non-contaminating, and capable of sustaining an agreed post-mining land use."*
>
> *"The Environmental Protection Authority's (EPA) objective for Rehabilitation and Decommissioning is to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner."*

Based on these objectives, land with a post mining land use consistent with 'Conservation and Natural Environments'[1] or 'Production from Relatively Natural Environments'[2] as defined using the Australian Land Use and Management classification (ABARES 2016) would require the development of vegetation consistent with the end land use (e.g., rangeland species) and would need to be non-polluting.

These objectives are further detailed in DMIRS (2020) (red underlining is Landloch's emphasis):

- *From the project approval stage throughout mine life, the mine closure plan should demonstrate that ecologically sustainable mine closure can be achieved consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the State.*
- *Materials characterisation needs to be carried out prior to project approval to a sufficient level of detail to develop a workable closure plan. This is fundamental to effective closure planning. For existing operations, this work should start as soon as possible. Materials characterisation should include the identification of materials with potential to produce acid, metalliferous or saline drainage, dispersive materials, erosive rock, fibrous and asbestiform materials, and radioactive materials, as well as benign materials intended for use in mine rehabilitation activities. The identification of good quality rehabilitation material (e.g., benign, fresh rock) should also be carried out.*

[1] Conservation purposes based on maintaining the essentially natural ecosystems present.

[2] Primary production with limited change to the native vegetation.

Specific guidance provided for WRDs (DMP 2009) includes (red underlining is Landloch's emphasis):

> *Design the profile of the dump (e.g., height and slope angles) to ensure that the final structure is safe, stable and not prone to significant erosion. Factors that should be considered in the design are material types, proposed vegetation cover, natural topography and climate. Generally, more dispersive material, poorer topsoil and high dumps will require flatter outer slopes. Only the best conditions and stable materials would justify slopes approaching 20 degrees.*
>
> *A major cause of serious erosion on newly created landforms is the lack of adequate drainage control. It is therefore essential to design and construct drainage control measures that will handle expected rainfall events. In arid regions, it is preferable to design the dump profile to be water retaining. This means that the top surface, berms and batters need to be constructed so that they hold the maximum expected rainfall event. The construction of suitably engineered impoundments on the flat surfaces and deep ripping at suitable intervals on the sloping surfaces will generally achieve the necessary control. Minimising slope lengths will help reduce water velocity and therefore reduce erosion potential.*

Specific to RSFs (similar to Tailings Storage Facilities (TSFs), the DMIRS's Code of Practice for TSFs in Western Australia (DMP 2013) states that the primary function of a TSF, "*is the safe and economical storage of tailings in an erosion-resistant, non-polluting structure that minimises environmental impacts*". This requirement for erosional resistance exists both during operations and after tenement relinquishment. Successful relinquishment requires that the TSF be left such that it is able to, *"maintain an acceptable impact on the environment, remain structurally stable, resist deterioration through erosion or decay, prevent loss of containment, and be functionally compatible with the agreed post-mining land use"*. There is to be no requirement for ongoing maintenance for relinquishment to occur.

2.2.3 Leading practice sustainable development program

The Australian Government's Mine Closure handbook (LPSDP 2016a) usefully defines a functional ecosystem (that is implicit in the DMIRS and WA EPA objectives) as, *"an ecosystem that is stable (not subject to high rates of erosion), is effective in retaining water and nutrients, and is self-sustaining"*.

It also provides these useful guiding thoughts:

> *"The difficulties faced in the restoration of functioning ecosystems on such landforms, often under extreme ranges in temperature and rainfall, are often exacerbated by the properties of the waste material. The physical, chemical and geochemical characterisation of mine waste materials is used to identify potentially problematic waste—for example, potentially acid-forming, sodic or saline waste—or waste units suitable for use as near-surface growth medium, water-holding material or surface armour.*

Identification of these characteristics—viewed in conjunction with local climatic conditions, the effects of climate change, the way waste materials are likely to weather and develop over time, and target closure objectives and completion criteria—is paramount to appropriate landform design.

…

The nature of the landform surface directly affects critical long-term objectives, such as resistance to erosion, the integrity of encapsulation of hostile wastes, the capacity to accept and store rainfall, and the ability to support plant growth. Ultimately, slope configuration, and the nature of surface material on those slopes, should be interdependent, with slope angle and length being constrained by the relative capacity of the surface material to resist erosion. Vegetation communities are typically one of the most visible outcomes of mine rehabilitation and thus are a logical focus of rehabilitation planning; however, success in establishing the community depends on creating an appropriate soil environment that forms a stable, functional cover.

The Australian Government's Mine Rehabilitation handbook (LPSDP 2016b) clearly includes landform design as an integral part of rehabilitation. It outlines the following aspects of mine rehabilitation:

1. Rehabilitation objectives and targets
2. Rehabilitation planning
3. Rehabilitation techniques
    a. Landform design and construction
    b. Reconstruction of the soil profile
    c. Selection of suitable species
    d. Establishment of vegetation
    e. Fauna recolonisation
4. Completion criteria
5. Rehabilitation management and monitoring

It also defines the characteristics of high and low risk landforms. These are summarised in Table 1 below, are a guide only, and are not absolutely prescriptive.

Table 1: Summary of high and low risk waste landform batter profiles

High-risk Landforms	Low-risk Landforms
• low vegetation cover (likely associated with low rainfall or with rainfall patterns) • high rainfall erosivity • high batter slopes (the definition of 'high' varies with climate and materials, but in many situations ≥60m is considered high) • highly erodible materials • limited capacity to reduce gradients to effective levels (i.e., footprint constraints).	• high and effective vegetation cover • low-moderate rainfall erosivity (associated with rain of low intensities but sufficient volume to grow vegetation) • low batter slopes (commonly ≤20 m) • materials of low erodibility, often with significant content of competent rock • capacity to reduce gradients to effective levels.

2.2.4 EIS terms of reference

The NT EPA terms of reference states that Nolans' Mine Rehabilitation and Closure Plan should include a description of measures to be taken that will ensure soil stabilisation against erosion to a level similar to comparable landforms in surrounding undisturbed areas.

From this it is concluded that erosion rates of rehabilitated WRDs and RSF batters should be consistent with rates from comparable undisturbed areas.

2.3 Landform design expectations

Landloch's understanding of rehabilitation landform design expectations is outlined below.

2.3.1 Need for erosion modelling

Mining regulators often request that there be a clear link between the waste landform design and material properties. Results of erosion modelling and landform evolution modelling are often requested, with an increasing expectation for these tasks to have been completed as materials become available and as a site nears closure. This is done as a means of demonstrating that the risk posed by erosion in the long-term is addressed.

2.3.2 Design life

Design of mine waste facility batters based on long-term erosion does not commonly consider erosion from individual storm events. Rather, it considers long-term erosion rates. This is because available erosion benchmarks against which erosion can be assessed are almost always measures of long-term rates. These benchmarks include naturally occurring erosion rates and rates of soil formation, both of which are measured over decades or centuries. Also, it is important to note that elevated erosion of a batter during a single large rainfall event does not necessarily cause irreversible changes to the batter surface condition such that all subsequent events yield higher erosion rates. Because of this, batter slopes (excluding engineered runoff control structures) can be considered 'resilient' to a variety of rainfall/runoff events when their erosion rates are consistent with long-term benchmark erosion rates for the area.

Assuming that batter shapes are designed to produce rates consistent with long-term benchmark rates, it is then the engineered runoff control structures that represent points in the design that can fail and irreversibly change the erosion potential of a batter. These structures include crest bunds, mid-batter berms, rock drains, and toe drains. These features introduce a 'brittleness' to a design. For this reason, it is important to determine an appropriate design storm for use in designing these structures for closure. The design storms adopted for closure will be much larger than those adopted for operations.

To consider an appropriate design storm, it is useful to first consider the required design life of these engineered structures. The Western Australian DMP & EPA (2015) provides a reference point that is helpful in setting a design life for mining landforms.

It states:

> *"In developing completion criteria, the proponent/operator should identify criteria that lead to the design and construction of final landforms, voids and ecosystems, and upon being met, will demonstrate achievements of closure objectives of the mine being closed. The final landforms, voids, and ecosystems must be designed and constructed in the context of the agreed land use and closure objectives. The completion criteria should include performance indicators to demonstrate that rehabilitation trends are following the predicted performance, particularly where mathematical modelling is utilised to predict any long-term environmental impact (usually 300 years or longer)".*

Therefore, it seems appropriate to design any engineered structures for closure using a design life of ~300 years and also adopting an acceptable risk of failure within that period (it is impossible to design an engineered structure that poses no risk at closure).

2.3.3 Design storms for engineered structures

To inform what is an acceptable risk, Landloch considered the relationship between design storm events and risk outlined in the Guidelines on Tailings Dams (ANCOLD 2012) for structures with a shorter design life and then applied that risk to closure designs with a 300 year design life. The ANCOLD Guidelines are a commonly used engineering guidance document used to establish appropriate engineering design storms based on risk. These storms are defined by their Annual Exceedance Probabilities (AEP)[3]. Adopting the Guideline's approach for designing a tailings dam's spillway or freeboard in a location where the consequence of failure is minor or medium[4], and the population at direct risk would be less than 10, the resultant risk rating is "very low" to "significant", and the recommended AEP is between 0.01 and 0.001. Assuming an operational design life of 50 years for the TSF, there is a 5-40% probability of the design storm being exceeded once in 50 years.

If a probability of failure of 10% is adopted (i.e., within the range currently accepted during operations for a TSF but towards the lower end of the range), for a design life of 300 years, this equates to an AEP of 0.0004, equivalent to an Annual Recurrence Interval (ARI) of 2,500 years. Adoption of a design storm event with an AEP of 0.0004 seems reasonable for design of engineered runoff control structures for closure landforms at

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[3] AEP is the probability that a given event accumulated over a given duration will be exceeded in any one year.

[4] Cost of damage to infrastructure <$10M; <100 people affected; Social dislocation <100 people or <20 business months; <1km^2 impacted; impact duration <1 year; damage to the environment limited to items of low conservation value (degraded or cleared land, ephemeral streams, non-endangered flora and fauna), and remediation possible. Medium consequence: Cost of damage to infrastructure $10M-$100M; 100-1000 people affected; 100-1000 person or 20-2000 business months dislocated; <5km^2 impacted; impact duration <5 years; significant effects on rural land and local flora and fauna. Limited effects on items of local and state natural heritage, and limited effects on native flora and fauna within forestry, aquatic and conservation reserves, or recognised habitat corridors, wetlands or fish breeding areas.

Nolans. For a storm duration of 24 hours, the rainfall depth for a 0.0004 AEP event would be 367mm; for a 72 hour event, the rainfall depth would be 566mm. This design storm is considered an 'extreme' design storm event within the Australian Rainfall and Runoff design rainfall classification scheme[5] (Ball *et al.* 2019). Adoption of even more extreme design storms would only be adopted if the risk posed by Nolans can be shown to be greater than outlined above.

There is currently a trend among some regulators (requested but not yet found in any published guideline) to request that Probable Maximum Precipitation (PMP) events be included in landform designs. The PMP is generally equated to an event with an ARI of 10,000,000 years (AEP of 0.0000001). The likelihood of such an event occurring in 300 years is 0.003%. In other words, there is a 99.997% chance that the PMP would not occur in 300 years. Inclusion of such extremely rare events in landform designs is not warranted and stand at odds to standard engineering practice. Such extremely rare events are only adopted when the risk of failure is high to extreme, i.e., where failure has potential to cause loss of thousands of lives and property damage in the order of >$1B. In practice, failure of a waste dump at Nolans is unlikely to result in extreme discharges of water or sediment, or cause loss of life or very expensive property damage, unlike TSFs where collapse of a wall can cause large and dangerous flows of retained water and solids.

2.3.4 Erosion benchmarks for use in landform design

Critical to the erosion modelling process is the establishment of an erosion benchmark or threshold value below which landform designs are deemed acceptably stable, and above which erosion rates are considered unacceptably high. The NT EPA terms of reference states that Nolans' Mine Rehabilitation and Closure Plan should include description of measures to be take that will ensure soil stabilisation against erosion to a level similar to comparable landforms in surrounding undisturbed areas (NT EPA 2019).

From this it is concluded that the long-term erosion rates of Nolans' WRDs and RSF should be consistent with long-term rates of comparable undisturbed areas. A wide range of approaches have been used to define erosion threshold values (Howard and Loch 2019) that are similar to comparable landforms in surrounding undisturbed areas. The approaches include consideration of:

- rates of soil renewal;
- rates of natural erosion in adjoining areas; and
- potential for gully formation.

The soil renewal rate is the combined rate of soil depth increase caused by soil formation and fluvial and aeolian deposition. Renewal rates for mine waste that includes fractured waste rock on an arid zone mine site was estimated to be in the order of 4t/ha/y (Howard and Loch 2019).

[5] AR&R design rainfall classes – Very frequent: 12 to 1 exceedances per year (EY); Frequent: 1 EY to 0.1 AEP; Infrequent: 0.1 to 0.01 AEP; Rare: 0.01 to 0.0005 AEP; Extreme: <0.0005 AEP.

Natural rates of erosion for rangeland soils in the Northern Territory (average from 28 locations) was 3.8t/ha/y, and ranged from 2.4t/ha/y (lower 95%) to 5.2t/ha/y (upper 95%) (Elliott *et al.* 2002). In terms of potential for gully formation Klingebiel (1961) suggested that erosion rates >11t/ha/y led to gullying. Landloch have measured erosion on heavily gullied surfaces on three mining waste landforms in the Pilbara. Erosion rates associated with high rates of gully erosion were >40t/ha/y. Further, nine large-scale erosion plots have been operational at an iron ore mine site in the Pilbara region of Western Australia since July 2012. Three heavily rilled and gullied plots had a measured average erosion rate of 28t/ha/y. The remaining six plots are not heavily rilled or gullied and have a measured average erosion rate of 2t/ha/y. Erosion monitoring data were collected at the Murrin Murrin Cobalt-Nickel mine site (Goldfields, WA). Five measures of erosion on batter slope sections with limited rilling showed average annual erosion rates <8t/ha/y. Two measures of erosion on batter slope sections with rills and gullies had measured annual erosion rates of >20 t/ha/y (LPSDP 2016c).

Based on these results, an erosion benchmark at which erosion rates could be deemed similar to comparable landforms in surrounding undisturbed areas would be in the order of 4-8t/ha/y for the entire slope, and rates on the slope at any one point not exceeding 8-11t/ha/y. For the purposes of this report, long-term erosion benchmark values of <6t/ha/y (average annual erosion for the entire slope) and <12t/ha/y (peak average annual erosion for any point along the slope) were used to indicate designs with suitable long-term erosion potential.

2.3.5 Landform shape limitations

Depending on the erodibility of the materials on site, it is possible for erosion model predictions to indicate that quite steep, high, and/or long slopes would be stable. However, Landloch has observed regulators questioning very long and/or very steep landform batters on the basis of their constructability and the need for very exacting QA/QC (that historically has not been met by many mining proponents). Landform batter heights (single batters without a mid-batter berm) in excess of 40m high have been questioned previously by the WA regulators when uniform (single gradient) slopes were proposed. However, concave slopes have been accepted for heights of ~70m without the use of a mid-batter berm.

Very narrow mid-batter berms (5-10m wide once the rehabilitation shape has been created) have also been questioned because such narrow widths have been observed to consistently lead to rehabilitation failure. Rather, widths are expected to be set based on their ability to contain a rare rainfall event. For this report, a storm event with an AEP of 0.0004 (equivalent to an ARI of 2,500 years) and duration of 24 hours has been used.

Gradients steeper than 20 degrees are typically not readily accepted by the regulators because they are unsafe to traverse with machinery during rehabilitation works. Further, they cannot be easily ripped and spread with topsoil. A maximum gradient of 18 degrees was adopted for this report.

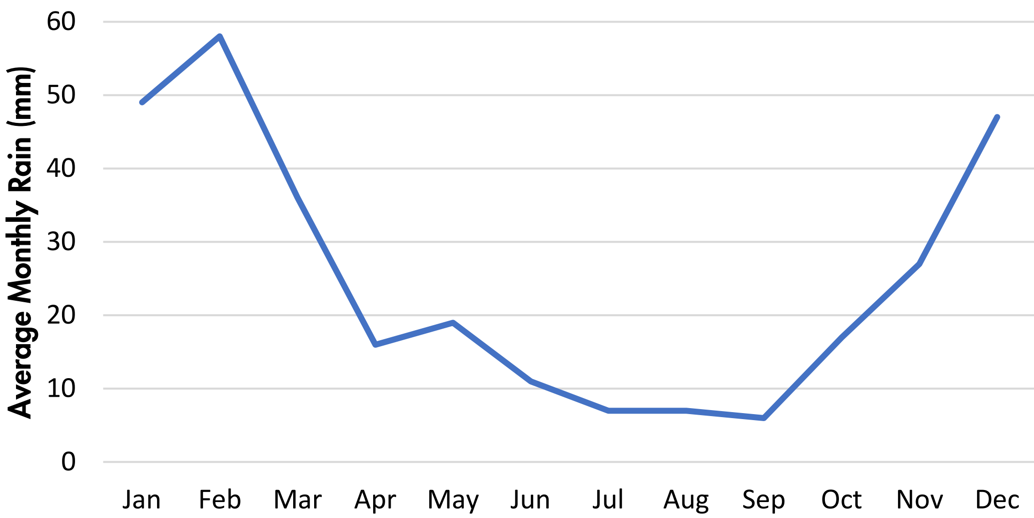
3 RAINFALL, EROSION, AND VEGETATION

Erosion potential of mine waste facilities is strongly influenced by the near-surface materials that are being stored, the shape of the landforms constructed, and the climate. With regards to climate, rainfall is most critical for landform design as rainfall totals and rainfall intensities influence runoff potential which in turn influences erosion potential.

3.1 Rainfall and erosion

3.1.1 Rainfall

Nolans has a hot, arid climate. The monthly distribution of rainfall is given in Figure 1. Average monthly rainfall is highest during the summer months of December, January and February and the shoulder months of March and November. Average monthly rainfall in these months range from 27 to 58mm. The remaining months have average rainfall values ranging from 7 to 19mm.



Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
49	58	36	16	19	11	7	7	6	17	27	47

Figure 1: Average monthly rainfall, Aileron (Bureau of Meteorology station 15543).

Figure 2 summarises the annual rainfall data for the site (Aileron data for 1949-2020), excluding years with incomplete data. The average yearly rainfall is 299mm (shown by the orange line). The maximum annual rainfall occurred in 1974 (1,011mm) and the minimum occurred in 1965 (62mm) (Figure 2). The median annual rainfall is 254mm, indicating that there are several annual rainfall totals that are much higher than the average. Figure 3 shows a histogram of annual rainfall events for the period 1949-2020, excluding years with incomplete data. Approximately 84% of years have rainfall totals between 120 and 520mm. There are three years that have very high annual rainfall totals (1975: 727mm, 2000: 777mm; 1974: 1,011mm).

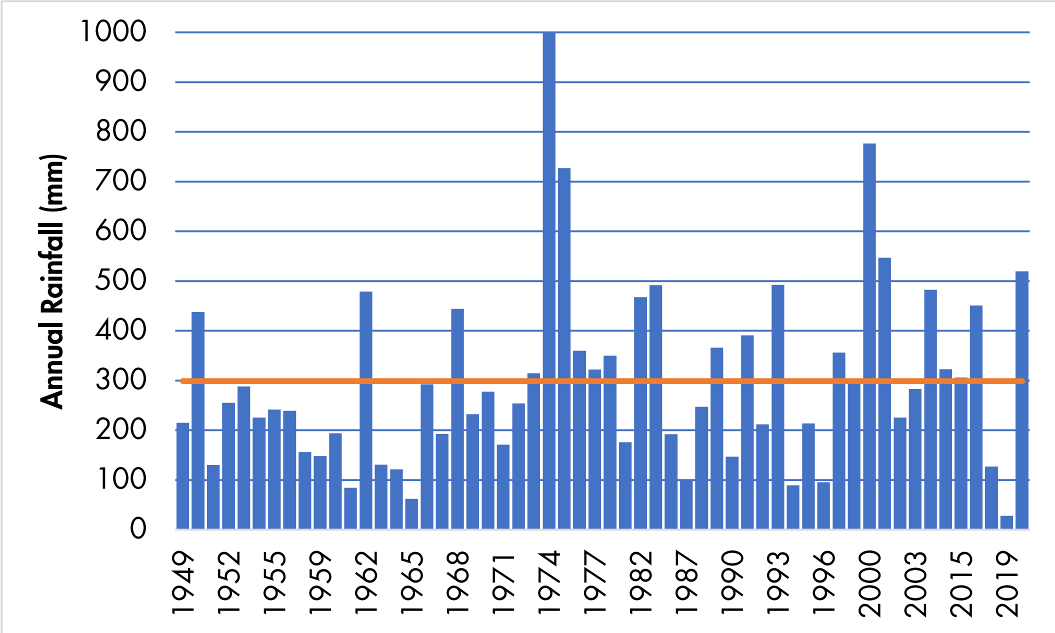


Figure 2: Annual rainfall totals for Aileron (Bureau of Meteorology station 15543)

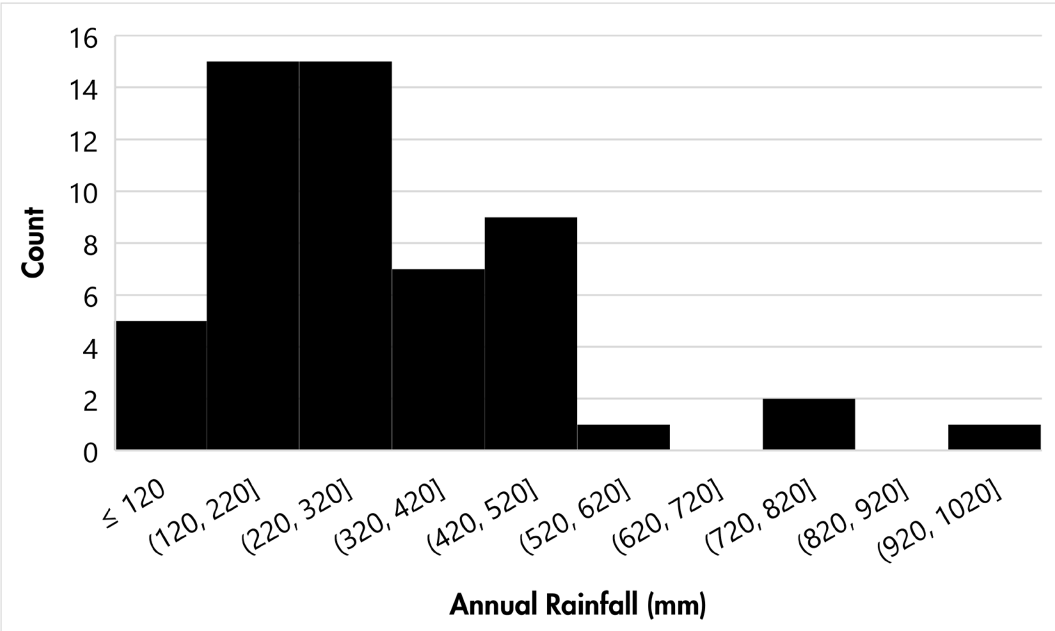


Figure 3: Annual rainfall histogram for 1949-2020, excluding years with incomplete data.

Rainfall is generally characterised by infrequent and intense rainfall events. The Bureau of Meteorology Intensity–Frequency–Duration (IFD) data (2016 system) for design storms indicate that a storm with an average exceedance probability of 1% and duration of 24 hours is 197mm (Table 2). Storms greater than 25mm are quite common.

Table 2: IFD data for Aileron (Source: Bureau of Meteorology 2016 Design Rainfalls)

Duration (hours)	Design Storm Depth (mm) for an Annual Exceedance Probability of:						
	63.2%	50%	20%	10%	5%	2%	1%
1	20.9	24.7	37.4	46.5	55.8	68.7	79.1
2	25.7	30.4	46.0	57.3	69.1	85.4	98.7
3	28.8	34.0	51.3	63.9	77.0	95.3	110
6	35.0	41.2	61.7	76.6	91.8	113	131
9	39.3	46.3	69.1	85.4	102	126	145
12	42.7	50.4	75.2	92.7	110	137	158
18	48.2	57.0	85.2	105	125	155	179
24	52.5	62.3	93.5	115	137	170	197

3.1.2 Rainfall erosivity

The erosive force of rain is expressed by rainfall erosivity. Gridded global rainfall erosivity data (Vrieling *et al* 2014) indicates an annual erosivity value for the Nolans area of 1,145MJ.mm/(ha.h.y) (Figure 4). This value is consistent with available erosivity mapping from Rosewell (1993) (1,000-1,500MJ.mm/(ha.h.y)).

Approximately 75% of the Northern Territory has rainfall erosivity values that are higher than Nolans. Erosivity increases in a northerly direction towards the coast. Rainfall erosivity at Nolans is like that at Alice Springs and about 25% of that at Darwin. It can be expected that the Nolans area will have sufficient rainfall erosivity to render rehabilitated waste landform surfaces prone to erosion, particularly when slopes are steep or long, are constructed from fine-grained soils or wastes, or have low levels of surface contact cover. (The actual erosion rate will depend on rainfall erosivity as well as material erodibility and landform geometry.)

The distribution of average monthly erosivity (Figure 5), expressed as a proportion of annual rainfall or erosivity, shows that erosivity largely follows that of monthly rainfall except for February which contains a higher proportion of erosivity. This indicates that – on average – storms in February are more intense (i.e., have more erosivity) than storm during other months.

From a rehabilitation perspective, completing rehabilitation works prior to February appears advantageous as this would mean that the freshly disturbed surfaces could be armoured by the less intense rains that typically occur during November to January, and vegetation would have a chance to establish and provide some protection against the intense rains (noting that vegetation levels are not likely to be sufficiently high to completely control erosion in the long-term).

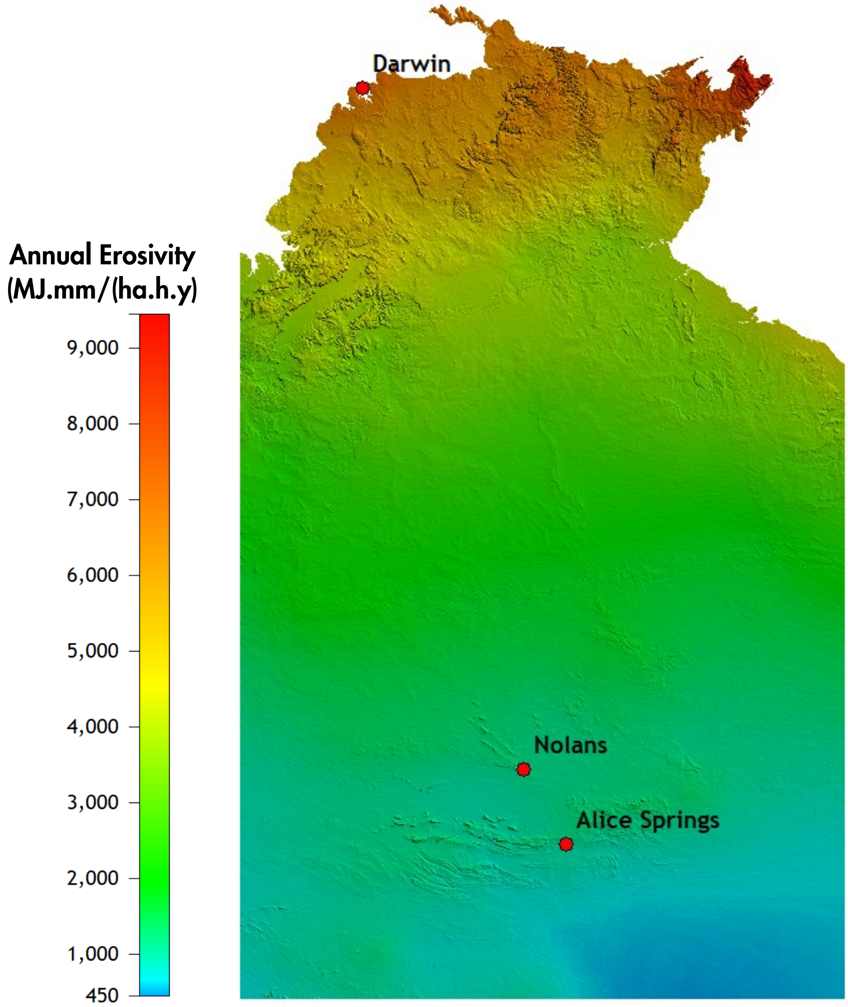


Figure 4: Annual erosivity mapping for the Northern Territory.

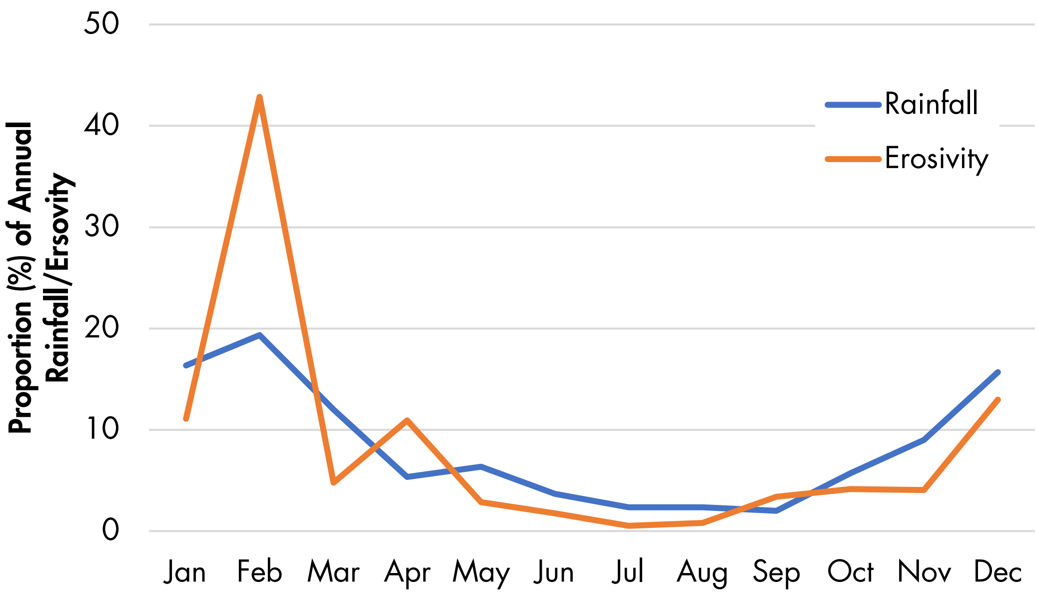


Figure 5: Distribution of monthly rainfall and erosivity expressed as a proportion of annual rainfall or erosivity.

3.2 Vegetation impacts on erosion

Annual rainfall of ~300mm will mean that vegetation levels (specifically surface contact cover rather than foliar cover) are likely to be low, and a high proportion of the land surface will be bare and exposed to the erosive forces of rain and to surface runoff. Erosion mitigation by vegetation at the closure time-scale is largely achieved through the presence of grasses or lying growing species that are in direct contact with the soil surface, especially in open woodlands where tree and shrub densities are low and where root densities are also low.

GHD (2016a) undertook a vegetation assessment for Nolans during which ground cover values were recorded. Ground cover included species up to 0.5m high and would include both grasses and low shrubs; these values would be an over-estimate of surface contact cover. The ground cover values reported ranged from 5-70%, with cover values on gravelly shrublands, alluvial plains, and rock outcrop areas being in the order of 10-30%. Relationships between projected foliar cover and basal cover (akin to surface contact cover) presented by van Vreeswyk *et al.* (2004) indicate that basal cover levels of <10% are associated with projected foliar cover levels of 10-30%.

The Revised Universal Soil Loss Equation's (RUSLE) (Renard *et al.* 1997) cover factor provides a useful benchmark for considering the effects of vegetation on erosion. Figure 6 is a typical curve relating erosion (soil loss ratio[6]) and cover percent for an arid zone soil with few trees and large shrubs.

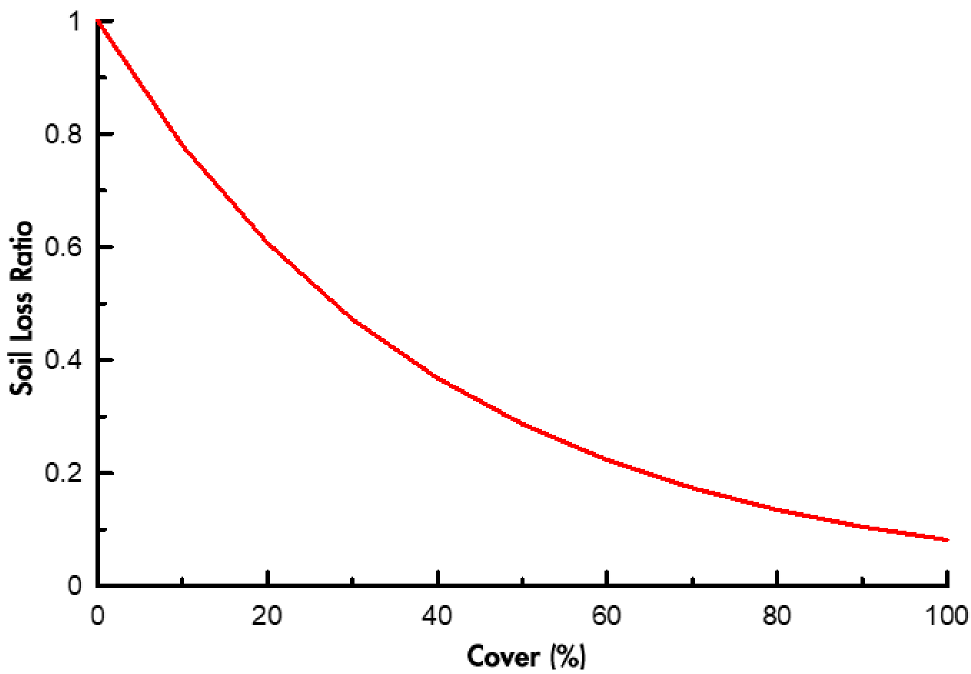


Figure 6: Soil loss ratio for a range of cover precent levels

[6] The soil loss ratio is the ratio of erosion from a surface of a given cover percent to erosion from a surface with no vegetative cover.

For a 10% surface contact cover level, erosion could be expected to be ~80% of the erosion that would occur from a bare surface. Therefore, although vegetation has some impact on soil erosion, it is unlikely to be able to manage erosion risk by itself in the long-term at Nolans. This means that the surface created during rehabilitation must be suitably stable against erosion without the assistance of vegetation. This approach will ensure stability is reached quickly, and that periodic events such as fire or drought, and other pressures such as grazing will not adversely impact erosion potential. Further, surfaces that are erosionally stable are also more likely to support the germination and growth of vegetation than are surfaces that are mobile and erosion prone.

4 MATERIAL PROPERTIES

The properties of soils and key mining wastes are discussed in this section. The information is used to estimate plant growth potential and erodibility parameters that are used in erosion predictions detailed in section 5.

4.1 Soils

Landloch recently undertook a soil assessment for Nolans (Landloch 2021). All the soils observed within the survey areas shared many common attributes. These included:

- Loam to light clay textures with clay contents ranging from 20-30%;
- Low rock fragment abundance in the surface soils (absent to few);
- Non-texture contrast soils;
- Weak surface structure, hardsetting to firm surface;
- Non-saline (typically <0.1dS/m);
- Non-sodic (<2% ESP in the surface soils) and infrequently spontaneously dispersive;
- Very low surface organic carbon (typically <0.5%);
- Rapid and uniform drainage; and
- Likely moderate permeability based on the presence of hardsetting surfaces (estimated to be 5-20mm/hr)

A map of the soils is given in Figure 7.

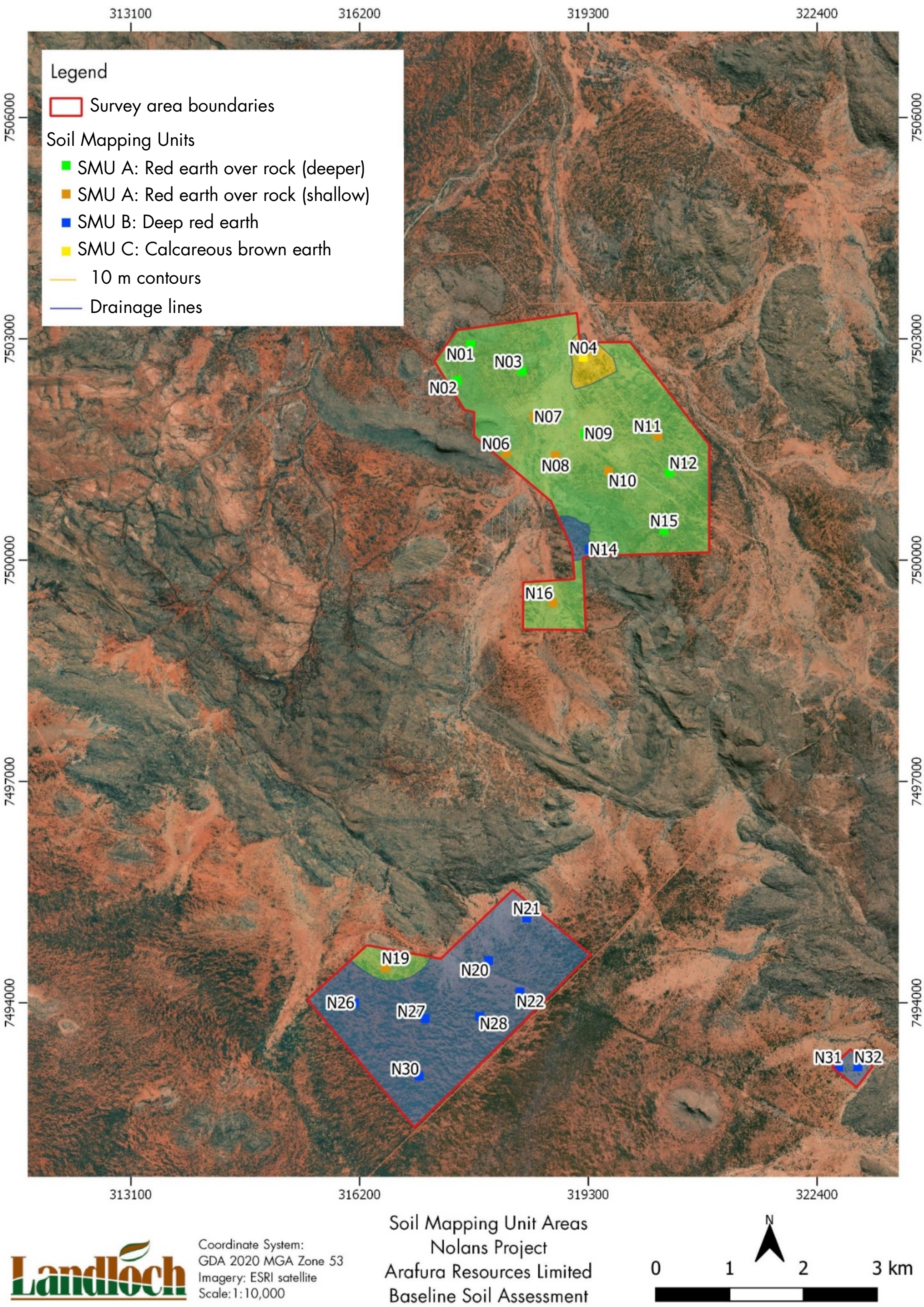


Figure 7: Nolan soils map

4.2 Mineral waste

Estimated abundances of the various waste types at Nolans were determined based on data supplied to Landloch by Nolans (2015 LOM pit data). 91 million loose cubic metres will need to be stored throughout the 25 year life of the mine. Three lithologies were identified (Table 3).

Table 3: Abundance of lithologies.

Lithology	Abundance (%) of Waste			Total (%)
	Fresh	Transitional/Mixed	Oxidised	
Gneiss	38.4	27.7	5.7	71.7
Pegmatite	7.2	7.9	1.2	16.4
Schist	6.8	4.4	0.8	11.9
Total (%)	*52.3*	*40.0*	*7.7*	*100*

Gneiss is the dominant waste lithology (71.7% of total waste). Pegmatite and Schist wastes occur in similar volumes (16.4% and 11.9% respectively). The majority of waste is fresh (52.3%), with an appreciable proportion of transitional waste (40.0%), and a small proportion of oxidised waste (7.7%). Given these abundances, the waste landforms at Nolans are likely to be dominated by fresh and transitional waste.

Testing for acid, metalliferous, and saline drainage has concluded that the risk of acid, metalliferous, or saline drainage is low, and the mineralised waste material can generally be managed as non-acid-forming waste (GHD 2016b).

4.3 Waste testing – plant growth and durability

Rock durability is of concern in wastes that are completely or partially oxidised. Nolans will produce an appreciable proportion of oxide and transitional wastes (47.7% of the total waste). Therefore, the risk posed by the breakdown of the rock was assessed. Plant growth parameters were also assessed as there is the possibility that waste may be used near the surface of rehabilitated WRDs and the RSF in order to mitigate the risk of erosion. These wastes will contain both coarse-grained rock (for which durability is important) and a fine component (for which plant growth potential is important).

4.3.1 Sampling

Twelve drill core samples of representative waste rock were supplied by Nolans for testing of durability and plant growth. Details of these samples are given in Table 4. Four samples each of gneiss, pegmatite, and schist were supplied. Two of the samples were oxidised, six were transitional, and four were fresh. Table 5 shows the number of samples of each lithology/oxidation state combination. Photos of each of the waste samples is given in Appendix A.

Table 4: Details of drill core samples supplied

Sample ID	Hole ID	Depth (m)		Lithology	Oxidation State
		From	To		
24301	NBDH833	1.00	9.70	Gneiss	Oxidised
24302	NBDH833	40.00	47.75	Gneiss	Transitional
24303	NBDH836	15.00	22.50	Gneiss	Transitional
24304	NBDH836	175.80	185.70	Gneiss	Fresh
24305	NBDH877	2.30	11.50	Pegmatite	Transitional*
24306	NBDH833	58.00	65.40	Pegmatite	Transitional
24307	NBDH837	49.10	64.16	Pegmatite	Transitional
24308	NBDH837	73.00	87.00	Pegmatite	Fresh
24309	NBDH840	73.00	85.40	Schist	Oxidised
24310	NBDH877	72.56	79.60	Schist	Transitional
24311	NBDH840	100.00	106.50	Schist	Fresh
24312	NBDH1077	84.80	93.00	Schist	Fresh

* Mostly oxidised

Table 5: Number of drill core sample supplied.

Lithology	Number of Samples			Total
	Fresh	Transitional/Mixed	Oxidised	
Gneiss	1	2	1	4
Pegmatite	1	3		4
Schist	2	1	1	4
Total	*4*	*6*	*2*	*12*

4.3.2 Testing regime

The following tests were conducted on the coarse fraction of each waste sample:

- Rock density;
- Water absorption;
- Hardness (impact test); and
- Slake durability.

The fines fraction (<2mm) of each waste sample was tested for:

- $pH_{1:5}$ (water);
- $EC_{1:5}$;
- Exchangeable cations (Ca, Mg, Na, K);
- Total N and P;
- Plant available P and K (Colwell); and
- Plant available S (KCl).

4.3.3 Classification scheme – rock durability

Classification of the long-term durability of the waste samples were made using the classification scheme for the quality and durability of quarried armourstone from The Rock Manual (CIRIA, UR, CETMEF 2007), except for slake durability and hardness. The Rock Manual scheme includes a range of criteria that can be used to guide recommendations on material durability. It classifies materials as either excellent, good, marginal, or poor for use as armourstone. For this project, lithology, weathering grade, rock density, and water absorption were selected from the Rock Manual classification. Slake durability results were classified using the scheme provided by Gamble (1971) and recommended by the International Society for Rock Mechanics (ISRM 1978). This classification has six classes of durability based on the second durability cycle results. These were grouped to conform to the four class system of the Rock Manual as shown in Table 6. The hardness test used the classification from the ISRM which classifies rocks into 13 groups. These were further grouped to conform to the four class system as shown in Table 7.

Table 8 provides the criteria used to classify the durability of different waste samples. The overall suitability of the material was defined by the average of the classification scores (rounded to the nearest integer), calculated by adding all the scores and dividing by the number of criteria used. Each lithology and oxidation state were considered separately.

Table 6: Classification scheme for durability results

Slake Durability Classification	Slake Durability Index (2nd Cycle)	Assigned Classification
Very high	100-98	Excellent
High	98-95	Good
Medium high	95-85	
Medium	85-60	Marginal
Low	60-30	Poor
Very low	30-0	

Table 7: Classification rock hardness results

ISRM Hardness Class	Hardness Term	Test Description	Assigned Classification
R6	Extremely strong	Can only be chipped with geological hammer	Excellent
R5	Very strong	Fractured after many blows of geological hammer	
R4	Strong	Fractured after more than one blow of geological hammer	Good
R3	Medium strong	Can't be peeled with pocketknife. Can be fractured with single firm blow of geological hammer	
R2	Weak	Can be peeled by pocketknife with difficulty. Shallow indentations made by firm blow with geological hammer	Marginal
R1	Very weak	Cumbles under firm blow with geological hammer. Can be peeled by pocketknife	Poor
R0	Extremely weak	Indented by thumbnail	
S1-S6	Soils	Can be penetrated/indented with a hand/finger	

Table 8: Classification scheme for testing of rock durability

Criteria	Excellent (Score = 1)	Good (Score = 2)	Marginal (Score = 3)	Poor (Score = 4)
Lithology	• Unfoliated igneous and metamorphic rocks • Quartzites & high silica cement sandstone • Compact crystalline sandstone	• Crystalline dolomite • Crystalline limestone • Moderately well cemented sandstone	• Argillaceous (very fine-grained, clayey) limestone • Poorly cemeted sandstone • Dolomite reef rock with void cavities	• Shaly limestone • Reef breccia • Shale • Slate • Schist • Chalk • Gypsiferous carbonates
Weathering grade	Fresh, unweathered	Faintly weathered (staining on major surfaces)	Slightly weathered (staining persists through a majority of the rock mass)	Moderately weathered (less than half the rock mass is decomposed)
Rock density (g/cm^3)	>2.7	2.5-2.7	2.3-2.5	<2.3
Water absorption (%)	<0.5	0.5-2.0	2.0-6.0	>6.0
Hardness	R5, R6	R3, R4	R2	R1, R0, S1, S2, S3, S4, S5, S6
Slake durability	>98	98-85	85-60	<60

4.3.4 Classification scheme – plant growth potential

Classification of the plant growth potential of the fine fraction considered $pH_{1:5}$ (water), $EC_{1:5}$, and exchangeable cations, specifically Exchangeable Sodium Percent (ESP), Effective Cation Exchange Capacity (ECEC), Total N, Organic C, Total P, plant available P and K (Colwell), and plant available S (KCl).

Soil pH for the Nolans area is slightly acidic to alkaline (6.5-7.5) (Landloch 2021). $pH_{1:5}$ (water) values less than 5.5 and greater than 8.5 are likely to impact plant growth. Soil $EC_{1:5}$ values >2dSm are likely to impact of the growth of vegetation of all but salt tolerant species; values <0.5dS/m are likely to be suitable for all rangeland species (Tanji and Kielen 2002). ESP values >6% along with ECEC values >3meq/100g are indicate a potentially dispersive fine fraction (Hazelton and Murphy 2106; McKenzie et al. 2004). Table 9 summarises the fertility of Nolans soils (Landloch 2021).

Table 10 provides the criteria used to classify the plant growth potential of the different waste samples.

Table 9: Summary of fertility of the Nolans soils (average ± std dev.).

Total N mg/kg	OC %	Total P mg/kg	Colwell P mg/kg	Colwell K mg/kg	S (KCl) mg/kg
305 ± 154	0.3 ± 0.2	294 ± 258	20 ± 9	252 ± 89	8.5 ± 0.4

Table 10: Classification scheme for testing of Nolans samples – fine fraction

Criteria	Properties of suitable fines
$pH_{1:5}$ (water)	5.5-8.5
$EC_{1:5}$ (dS/m)	<2dS/m, preferably >0.5dS/m
Dispersion potential	ESP <6% if ECEC >3meq/100g. Materials with ECEC <3meq/100g are less likely to be prone to dispersion regardless of ESP
Total N (mg/kg)	>200mg/kg
Total P (mg/kg)	>50mg/kg
Available P (mg/kg)	>10mg/kg
Avaialble K (mg/kg)	>150mg/kg
Avaialble S (mg/kg)	>10mg/kg

4.3.5 Results - durability

The classification of the rock fraction is summarised in Table 11. A full listing of the results is given in Appendix B. All materials have been assessed as being good or excellent for use as an armourstone, except for the oxidised schist which is classed as marginal, and the pegmatite oxide which was not given a classification because no sample was provided. It is present in very small proportions and will not alter the landform advice given in the report in any case.

Table 11: Summary of the classification of the rock fraction.

Criteria	Gneiss - Fresh	Gneiss - Transitional	Gneiss - Oxide	Pegmatite - Fresh	Pegmatite - Transitional	Schist - Fresh	Schist - Transitional	Schist - Oxide
Lithology	1	1	1	1	1	3	3	3
Weathering grade	1	2	3	1	3	1	2	3
Rock density	2	2	2	2	2	1	1	1
Water absorption	1	1	1	2	2	1	1	3
Hardness	1	1	1	1	1	1	1	3
Slake durability	1	1	1	1	1	1	1	3
Class	Excellent	Excellent	Good	Excellent	Good	Excellent	Good	Marginal

* Codes shown are described in Table 8.

4.3.6 Results – plant growth potential

A summary of the plant growth potential of the rock fines is given in Table 12. A full listing of the results is given in Appendix B. Cells shaded in orange indicate values that fall outside of the classification scheme for suitable materials.

All wastes are strongly alkaline (9.0-9.8). This is in contrast to the acidic to slightly alkaline pH of the surface soils. This difference in pH may lead to differences in nutrient availability for vegetation, which in turn may impact vegetation growth. The waste rock is also very low in nutrients (Total N and plant available P and S). For these reasons, soils should be present at the surface of rehabilitated landforms and the waste rock should be seen primarily as a possible useful rock armouring material. Direct seeding into waste rock fines should only be planned after trial work to show the higher pH (and likely lower plant available water) will not adversely impact growth has been completed.

Table 12: Summary of characterisation data for the rock fines.

Criteria	Gneiss - Fresh	Gneiss - Transitional	Gneiss - Oxide	Pegmatite - Fresh	Pegmatite - Transitional	Schist - Fresh	Schist - Transitional	Schist - Oxide
$pH_{1:5}$ (water)	9.8	9.4	9.2	9.5	9.5	9.0	9.5	9.5
$EC_{1:5}$ (dS/m)	0.07	0.06	0.08	0.10	0.10	0.04	0.06	0.03
ESP (%)	3.2	5.8	1.1	1.9	2.4	5.7	5.0	14.8
Total N (mg/kg)	<20	<20	20	<20	<20	<20	<20	<20
Total P (mg/kg)	170	97	108	1140	655	94	215	200
Available P (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5
Avaialble K (mg/kg)	967	1163	166	535	486	2715	2170	1290
Avaialble S (mg/kg)	<10	<10	<10	<10	<10	15	<10	<10

4.4 Summary

The soils by themselves are likely to be very erodible. Mixing rock into the soils could be considered as a way of increasing the soil's erosion resistance while maintaining water holding capacity to support vegetation. Mixing rock into the soils would also mitigate to some degree the impacts of the alkaline pH and low fertility of the waste rock fines.

The fresh and transitional wastes appear to be durable and suitable for use near the surface of rehabilitated landforms. By themselves (i.e., not addition of soil), it is likely to be able to be used as quite steep and long gradients. However, establishment of vegetation may be limited.

The oxide waste rock is less durable than the fresh and transitional rock. It would be prudent to consider the oxidised wastes as less suitable. For this reason, it is suggested that oxidised wastes should not be placed near the surface (within the surface 1m) of rehabilitated landforms.

Using this information, different types of surfaces were assessed for erosion potential using the WEPP erosion model. A summary of the WEPP (Water Erosion Prediction Project) erosion model along with generation of the climate sequence and model input conditions are provided in Appendix C. The following surface types were considered in the sections below:

- Soil only;
- Fresh/transitional rock only; and
- Fresh/transitional rock mixed with soil.

For the fresh/transitional rock mixed with soil, an approximate mixing ratio of 1 part soil to 2 parts waste rock is assumed to yield the minimum soil void ratio. This is based on Landloch's previous testing of similar material mixtures and data from Bodman and Constantin (1965) and Coughlan *et al.* (1978) that show mixing of a fine-grained and coarse-grained material (e.g., soil into waste rock) will have a minimum soil void ratio when there is ~30-40% of fines and ~60-70% coarse by volume.

This would assume an upper limit on rock diameter in the surface of ~0.5m. This mixture can be achieved either by pre-mixing and then spreading to the reshaped batter, or by placement of soil over a reshaped fresh rock batter, followed by ripping of the soil into the waste rock.

Erodibility parameters for these 3 different surfaces were estimated by comparing their baseline properties to those of materials with similar baseline properties that Landloch have previously assessed for erodibility using laboratory or field based techniques. These techniques include the application of simulated rain and simulated overland flows. The erodibility parameters are material-specific and were used to predict long-term erosion. Other site-specific conditions (i.e., climate and landform batter shape) are considered within the erosion model itself.

5 EROSION PREDICTIONS

A range of two dimensional (2D) batter slope geometries were considered for long-term erosion, with the results discussed in the section below. Uniform (single gradient) batters with a height of 15m were considered. Concave profiles (multiple gradient) with a maximum height of 60m and a maximum gradient of the upper section of 18° were also considered. All erosion predictions given below assume that water is controlled on the dump top and that no runoff is allowed to discharge from the top to the downslope batters. Erosion thresholds used to define suitable designs are given in Section 2.3.4[7].

[7] Acceptable erosion rates are mean average annual erosion rates <=6t/ha/y and peak average annual erosion rates <=12/t/ha/y.

All WEPP models assumed a minimum cover thickness of 0.5m over any underlying sub-layer. Surfaces that include only soil should assume a soil thickness of 0.5m over any underlying layer. Predictions of the soil/rock mixture also used a 0.5m thick layer, comprised of the equivalent of 0.2m of soil mixed into 0.3-0.4m of waste (some of the soil will fill the voids present in the waste and result in a slightly thinning of the resultant layer).

Thicknesses of 0.5m are achievable in practice with typical rehabilitation machinery (with the maximum rock size being ~0.5m). Placement of thin layers (e.g., 0.1m of topsoil) requires considerable skill and often smaller dozers than are present on site to achieve uniformly over the rehabilitated surface.

5.1 Erosion of the soil only

5.1.1 15m high batters

Erosion predictions for the soil are given in Table 13. The cells shaded green represent batter geometries that produce acceptable erosion rates. Cells shaded orange represent batter geometries that produce unacceptable erosion rates. All erosion predictions given below assume that water is controlled on the dump top and water is not allowed to discharge from the top onto the steeper outer batters. The surface is assumed to be bare of vegetation.

Table 13: Long-term erosion predictions for soils only without vegetation.

Batter Height (m)	Uniform Batter Gradient (°)	Uniform Batter Gradient (%)	Batter Footprint (m)	WEPP-Predicted Average Annual Erosion (t/ha/y)	
				Mean	Peak
15	12	21.2	71	27	32
	14	24.9	60	32	38
	16	28.7	52	37	43
	18	32.5	46	42	47

All predictions indicate that erosion of soils is transport limited, with erosion rates controlled by the capacity of the runoff that is generated at Nolans to transport the eroded sediment. Transport limit is reached at very short slope lengths, meaning that concave slope profiles may be of limited value for these materials in terms of reducing erosion.

All geometries are predicted to result in unacceptably high long-term erosion potential. Decreasing slope gradient is not sufficient to reduce erosion to acceptable levels for gradients between 12 and 18 degrees and a batter height of 15m. These erosion rates are sufficiently high to render these slopes prone to rill and/or gully erosion.

5.2 Erosion of the waste rock only

5.2.1 15m high batters

Erosion predictions for fresh/transitional waste rock on a uniform slope gradient are given in Table 14. The cells shaded green represent batter geometries that produce acceptable erosion rates. Cells shaded orange represent batter geometries that produce unacceptable erosion rates. All erosion predictions given below assume that water is controlled on the dump top. The surface is assumed to be bare of vegetation.

Table 14: Long-term erosion predictions for waste rock only without vegetation.

Batter Height (m)	Uniform Batter Gradient (°)	Uniform Batter Gradient (%)	Batter Footprint (m)	WEPP-Predicted Average Annual Erosion (t/ha/y)	
				Mean	Peak
15	12	21.2	71	<0.1	<0.1
	14	24.9	60	<0.1	<0.1
	16	28.7	52	<0.1	<0.1
	18	32.5	46	<0.1	<0.1

The fresh/transitional rock without addition of any other wastes or soils is predicted to be very stable for a height of 15m and gradients ranging from 12 to 18 degrees. WEPP predicts that no rilling will initiate.

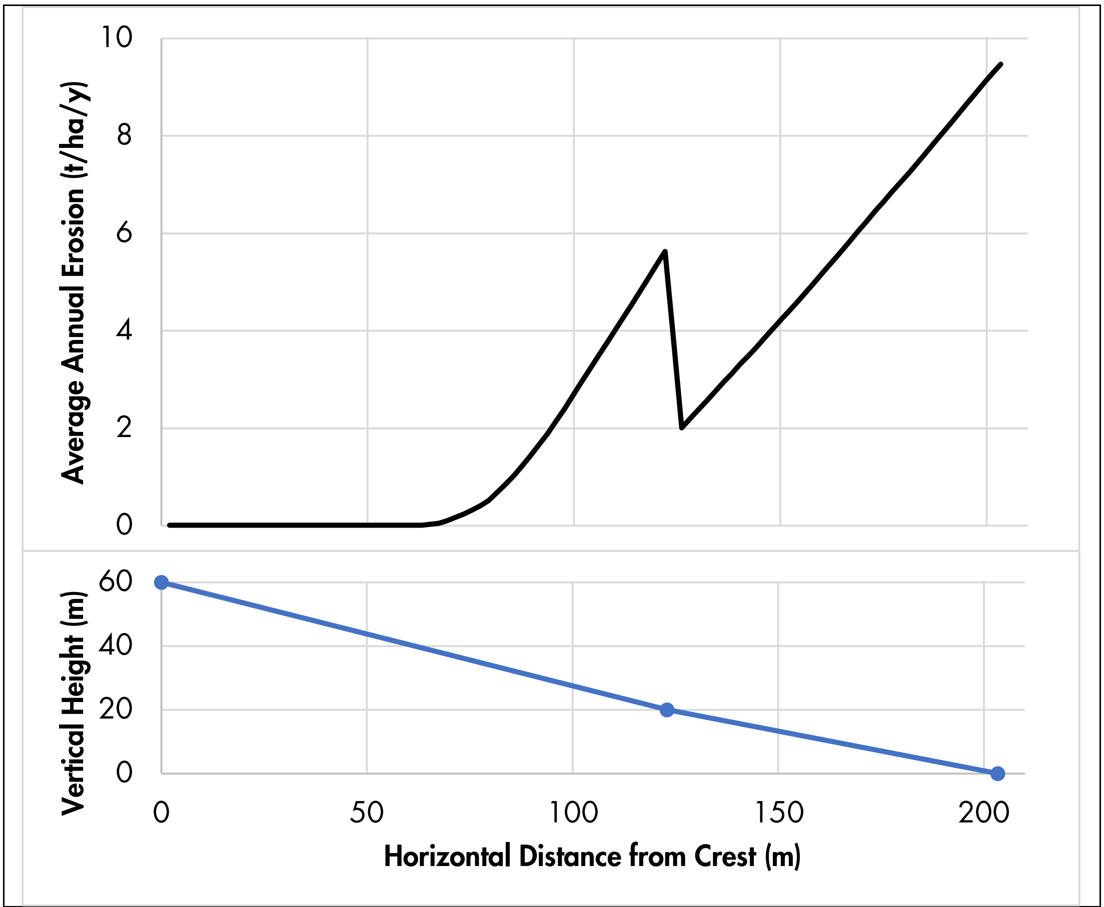
Although these slopes are highly stable, all geometries considered would not likely support significant levels of vegetation. Use of these surfaces would be incompatible with closure designs for which vegetation establishment is a requirement for the post-mining land use and for which there would be vegetation related closure criteria.

5.2.2 60m high batters

Slopes with a total height of 60m were also modelled. A uniform 18 degree slope that is 60m high is predicted to erode at unacceptable rates. The mean average annual erosion rate was 4.5t/ha/y, and the peak average annual erosion rates was 15t/ha/y. Such long slopes are also unlikely to be considered low risk by regulars given the higher degree of QA/QC required to successfully achieve these long slopes.

In order to achieve a height of 60m with waste rock only, a concave profile could be adopted. A suitable profile is given in Figure 8. The profile contains an upper section (40m vertical height) with a gradient of 18 degrees and a lower section (20m vertical height) with a gradient of 14 degrees.

Similar to the uniform batter discussed above, this concave profile would not likely support significant levels of vegetation and would be incompatible with a post-mining land use that requires vegetation.



Horizontal Distance from Crest (m)	Batter Gradient (°)	Batter Gradient (%)	WEPP-Predicted Average Annual Erosion (t/ha/y)	
			Mean	Peak
0-123	18	32.5	2.9	9.5
123-203	14	24.9		

Figure 8: Concave option for a 60m high profile constructed from fresh/transitional waste rock only.

5.3 Erosion of the soil/rock mix

5.3.1 15m high batters

Erosion predictions for a soil/rock mix are given in Table 15. The cells shaded green represent batter geometries that produce acceptable erosion rates. Cells shaded orange represent batter geometries that produce unacceptable erosion rates. All erosion predictions given below assume that water is controlled on the dump top. The surface is assumed to be bare of vegetation.

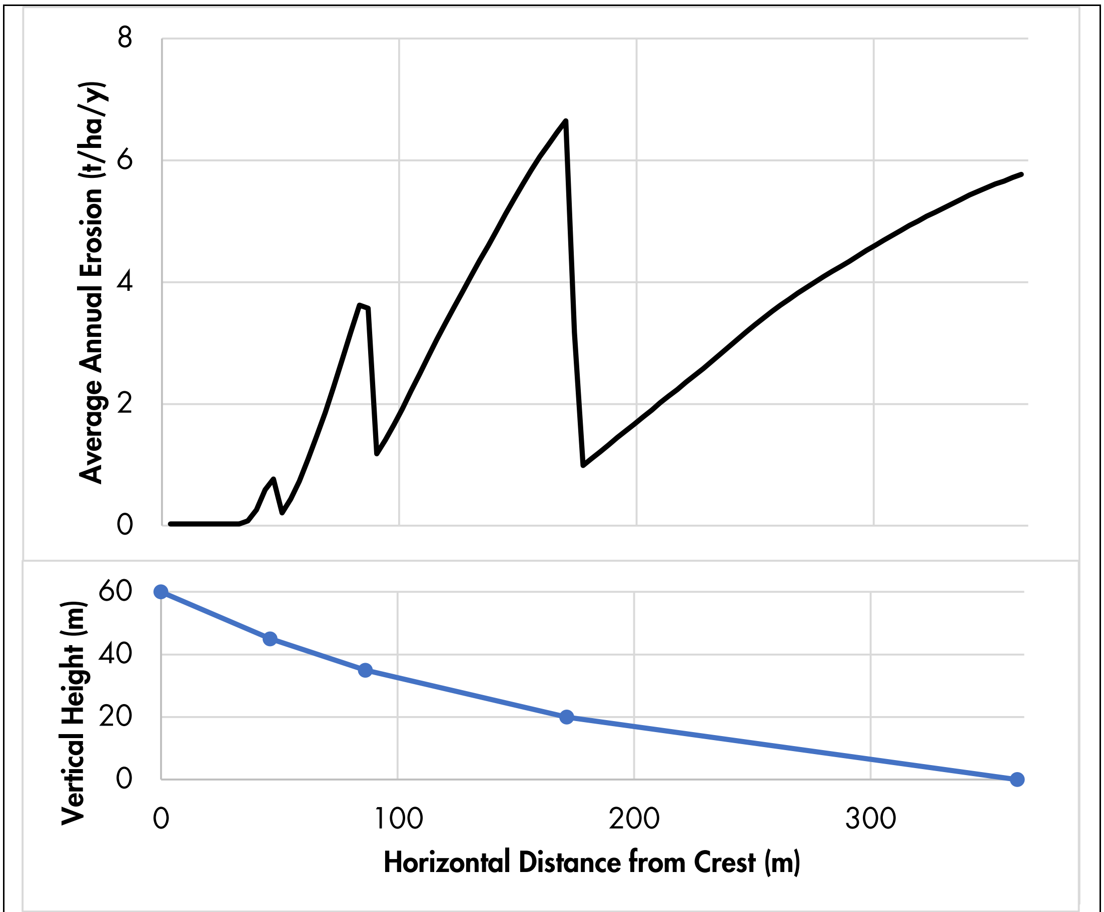
The 1:2 soil/rock mixture is predicted to be acceptably stable for a height of 15m when uniform gradient slopes are used, ranging from 12 to 18 degrees. Batters that are steeper, higher, or longer than those modelled may be unacceptably stable. WEPP predicts that minimal rilling will initiate on these profiles. The incorporation of soil into the surface fresh/transitional waste rock will improve the ability for vegetation to establish.

Table 15: Long-term erosion predictions for a soil/rock mixture without vegetation.

Batter Height (m)	Uniform Batter Gradient (°)	Uniform Batter Gradient (%)	Batter Footprint (m)	WEPP-Predicted Average Annual Erosion (t/ha/y)	
				Mean	Peak
15	12	21.2	71	2.1	7.0
	14	24.9	60	2.4	7.7
	16	28.7	52	2.5	8.2
	18	32.5	46	2.8	8.6

5.3.2 60m high batters

In order to achieve 60m high with the soil/rock mixture, a concave profile could be adopted, though the footprint is significant. A suitable profile is given in Figure 9.

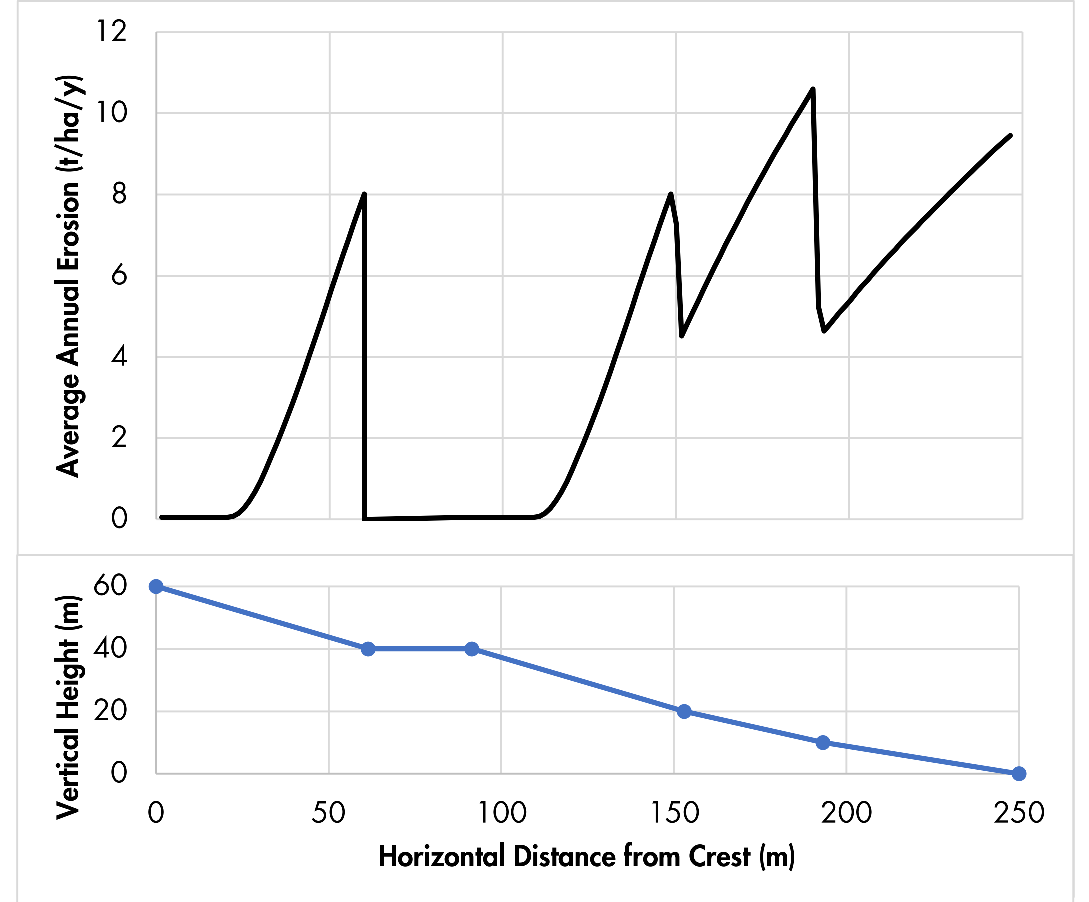


Horizontal Distance from Crest (m)	Batter Gradient (°)	Batter Gradient (%)	WEPP-Predicted Average Annual Erosion (t/ha/y)	
			Mean	Peak
0-46	18	32.5	3.1	6.7
46-86	14	24.9		
86-172	10	17.6		
172-362	6	10.5		

Figure 9: Concave option for a 60m high profile constructed from fresh/transitional waste rock.

The profile contains 4 sections, an uppermost section (15m vertical height) with a gradient of 18 degrees, a second section (10m vertical height) of 14 degrees, a third section (15m vertical height) of 10 degrees, and a lower section (20m vertical height) with a gradient of 6 degrees.

This concave is quite complex and has a significant footprint. Another option may be to produce a 'stacked' concave profile, consisting of two batters separated by a berm wide enough to adequately store sediment and runoff from an extreme event, assuming a design life of 300 years and a design AEP of 0.0004 (see Section 2.3 for discussion). A stacked concave profile option is shown in Figure 10.



Horizontal Distance from Crest (m)	Batter Gradient (°)	Batter Gradient (%)	WEPP-Predicted Average Annual Erosion (t/ha/y)	
			Mean	Peak
0-62	18	32.5	5.4	11
62-92	Berm			
92-153	18	32.5		
153-193	14	24.9		
193-251	10	17.6		

Figure 10: Concave option for a 60m high profile constructed from fresh/transitional waste rock and including a 30m wide berm.

The smaller lift could be positioned either at the top of the landform batter as shown in Figure 10 or at the base of the landform. However, positioning it at the top carries less risk as the wide berm only needs to manage runoff and sediment generated from a smaller upper lift. If the berm is placed lower, it would need to manage runoff and sediment from a much longer slope length.

5.4 A note of vegetation and erosion control

All of the WEPP erosion predictions assume no impact of vegetation on erosion control. If vegetation were to establish, erosional stability would improve from those values indicated. The potential benefit (assuming 1-10% surface contact cover is achieved) would be in the order 5-20% reduction in erosion rates.

6 ENGINEERED RUNOFF CONTROL STRUCTURES

6.1 Cross-batter berms

The erosion predictions indicate that a wide cross-batter berm may be advantageous in the case where a 60m high soil/rock mix batter is considered. In this case, the berm would need to hold runoff generated from a design storm with an AEP of 0.0004 (1 in 2,500 year event) and duration of 24 hours, and still remain functional after 300 years.

The required capacity within the berm would need to be ~30m^3/m width of slope[8]. Assuming a 5 degree backslope, this would be equivalent to a berm width of 30m (the width once the landform is reshaped, not the width left during construction). Berm width is defined as the horizontal distance from the surface of the upper lift to the crest of the lower lift (Figure 11).

6.2 Crest bunds

Crest bunds are often placed on the very edge of the flat waste landform top. They are placed in order to mitigate the risk posed by uncontrolled discharge from the landform top to the steep-gradient outer batter slopes. They are essential when designing a water retaining landform. When used, crest bunds should be constructed from stable materials that are not prone to structural decline. They should be constructed such that their outer face has the same gradient as the outer slope of the landform. Their inner face should be sloped at an angle of 10% so that water (if it ponds) does not pond near the outer face of the landform. The top of the bund should be at least 2m wide. The height is set so that an extreme rainfall event can be store, while allowing for some lateral movement of water and some freeboard. A minimum height of 1m is recommended for Nolans.

[8] The required capacity of the berm was determined by calculating the volume of sediment deposited over 300 years into the berm (assumed to be 6t/ha/y) and the amount of runoff from a design storm with a return period of 2,500 years and a duration of 24 hours. A design storm with an AEP of 0.0004 and duration of 24 hours would have a rainfall total of ~367mm. To ensure conservatism, it was assumed that 80% of this rainfall was converted to runoff. Sediment density was assumed to be 1t/m^3.

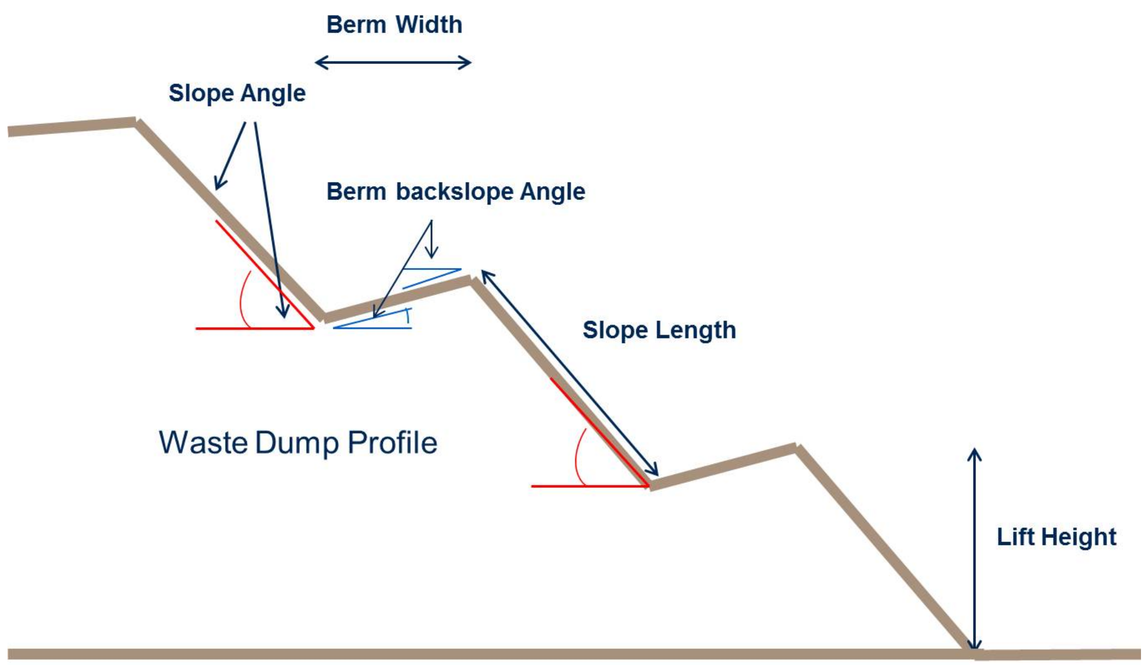


Figure 11: Definition of rehabilitation berm width and backslope gradient.

6.3 Toe drains/bunds

In the instance where the risk of off-site impact of sediment movement is low, and where landforms are design to erode at acceptable rates, there is no need for a toe drain or bund to contain eroded sediment. This is because the erosion rates are similar to those that occur naturally in the surrounding environment.

7 GENERAL LANDFORM GUIDANCE

7.1 Flood protection

Rock armouring of landform batters that are located within the 100-year flood line is recommended. This armouring should be sized according to a surface water flow study that calculates the potential flow velocities that will be experienced. These calculations cannot be performed at present as the shape and locations of the landform are not yet set.

The fresh waste rock will likely be a very suitable source of rock armour for flood protection works, assuming the correct rock sizes can be sourced either from the run of mine waste, or from crushing to reduce the size or utilising special blasting patterns to produce the large size required. The required rock size will depend on the final placement of the waste landforms relative to the flood flows. Rock sizing is typically determined based on a surface water flood study and consideration of flow velocities around the base of the waste landforms that are caused by the diverted flows. Alternately, flood bunds are also used in some cases to divert water away from the waste landforms rather than allowing the water to interact with the landform batter.

7.2 Ramps

Ramps are a consistent source of failure in rehabilitated landforms. Where possible, ramps should be removed as part of the rehabilitation of the landform. Where they are left, their erosion potential must be assessed using a 3-D landform evolution model.

7.3 Landform shapes

Where batters are not a simple shape in plan view, there is potential for water-concentrating areas (indents) to be created (Figure 12). Indents may be large or quite small, but are of concern irrespective of magnitude. Such features should be avoided if at all possible.

From Landloch's experience with many waste dumps across Australia, one consistent observation is that erosion (rills, gullies) occurs most frequently on corners of waste dumps. Dozers are less successful at cross-ripping on-contour when the dozer works around corners, irrespective of the skill of the operator. Not surprisingly, the problem is accentuated when the corner is sharp. Ideally, all corners should have a radius of curvature of at least 100m.

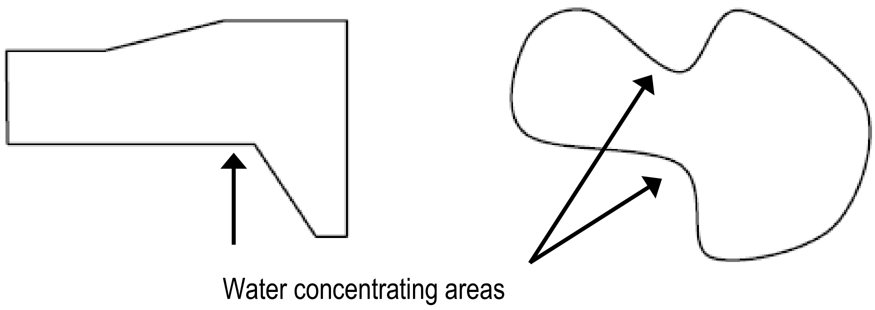


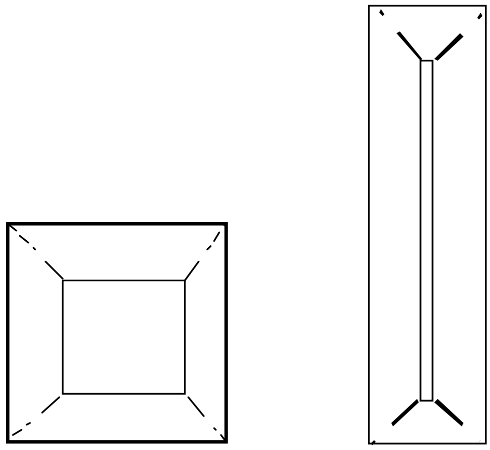
Figure 12: Conceptual plan view of a waste landform showing flow-concentrating features.

Landform shape also influences the potential cost of rehabilitation. Rehabilitation of batter surfaces is considerably more expensive than rehabilitating flat waste landform tops (it is estimated that batters are four times more expensive that dump tops to rehabilitate). Therefore, wherever possible, the surface area of the landform top should be maximised, and the perimeter of the batters minimised. This can be done by changing the landform shape. Landforms that are squarer in plan view tend to have smaller perimeters and larger dump tops than do longer, more rectangular waste landforms (for dumps that store the same volume of waste).

Modifying shape can also alter the storage volume available. As an example (Chandler *et al.* 2002), Figure 13 shows two waste landforms of similar footprint, heights, and slope gradients. However, Dump A differs to Dump B in that:

- It stores 35% more waste;
- Its perimeter is 20% less; and
- Its waste dump top is 3.5 times larger.

Therefore, the costs of rehabilitation would be less per unit volume of waste rock stored for Dump A than Dump B. Assuming a cost of $10,000/ha and $40,000/ha for rehabilitating the dump top and batters respectively, Dump A would cost 17% less to rehabilitate than Dump B.



Dump A Dump B

Figure 13: Two waste landforms with similar footprint, but different storage volumes and batter perimeter.

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APPENDIX A – WASTE ROCK SAMPLE PHOTOS

24301	NBDH833	1.00	9.70	Gneiss	Oxidised

24302	NBDH833	40.00	47.75	Gneiss	Transitional

24303	NBDH836	15.00	22.50	Gneiss	Transitional

24304	NBDH836	175.80	185.70	Gneiss	Fresh

24305	NBDH877	2.30	11.50	Pegmatite	Transitional

24306	NBDH833	58.00	65.40	Pegmatite	Transitional

24307	NBDH837	49.10	64.16	Pegmatite	Transitional

24308	NBDH837	73.00	87.00	Pegmatite	Fresh

24309	NBDH840	73.00	85.40	Schist	Oxidised

24310	NBDH877	72.56	79.60	Schist	Transitional

24311	NBDH840	100.00	106.50	Schist	Fresh

24312	NBDH1077	84.80	93.00	Schist	Fresh

APPENDIX B – LAB TESTING

CHAIN OF CUSTODY

ALS Laboratory: *please tick →*

☐ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 2 Byth Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
☐MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 1/29 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
☐NEWCASTLE 5 Rose Gum Road Warabrook NSW 2304 Ph: 02 4968 9433 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 02 4423 2063 E: nowra@alsglobal.com
☐PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townesville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: Lndloch Pty Ltd
OFFICE: Perth
PROJECT: 2466.20a **PROJECT NO.:**
ORDER NUMBER: **PURCHASE ORDER NO.:**
PROJECT MANAGER: Evan Howard howarde@landloch.com.au **CONTACT PH:** 0407 375 650
SAMPLER: Anna Reed reed@landloch.com.au **SAMPLER MOBILE:** 0410 825 026
COC Emailed to ALS? (YES) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): **reed@landloch.com.au**
Email Invoice to (will default to PM if no other addresses are listed): **admin@landloch.com.au**

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: EP / 187 / 21
COUNTRY OF ORIGIN: Australia

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 20.6 °C
Other comment:

RELINQUISHED BY: Anna Reed	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME: 09/03/2021	DATE/TIME: 9/3/21 1140	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

EP2102426

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	GEO30B Dry and Pulverise	EN84 Dry and Crush	EN34 1:5 Leach	ED008 Exchangable Cations with pre treatment - All Parameters	IN-4S pH plus EC (1:5)	NT-11S Toatal N + Total P	IN-6S Colwell P and K	ED047 Potassium Chloride Extractable Sulfur (KCL-40)	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	24301	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
2	24302	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
3	24303	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
4	24304	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
5	24305	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
6	24306	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
7	24307	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
8	24308	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
9	24309	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
10	24310	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
11	24311	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
12	24312	9/03/2021 0:00	S		2	X	X	X	X	X	X	X	X	Please ref quote EP/187/21
				TOTAL	24									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EP2102426**	Page	: 1 of 5
Client	: **LANDLOCH**	Laboratory	: Environmental Division Perth
Contact	: EVAN HOWARD	Contact	: Customer Services EP
Address	: PO BOX 5175 SOUTH LAKE WESTERN AUSTRALIA 6164	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: 08 9494 2835	Telephone	: +61-8-9406 1301
Project	: 2466.20a	Date Samples Received	: 09-Mar-2021 11:40
Order number	: ----	Date Analysis Commenced	: 10-Mar-2021
C-O-C number	: ----	Issue Date	: 18-Mar-2021 14:55
Sampler	: ANNA REED		
Site	: ----		
Quote number	: EP/187/21		
No. of samples received	: 12		
No. of samples analysed	: 12		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, 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.

- ED021, ED047, EK080 conducted by ALS Brisbane, NATA Site No. 818.
- Sample/s xxx has been crushed by ALS prior to preparation and analysis. This procedure is not part of the ALS NATA accreditation.
- 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	24301	24302	24303	24304	24305
			Sampling date / time	09-Mar-2021 00:00	09-Mar-2021 00:00	09-Mar-2021 00:00	09-Mar-2021 00:00	09-Mar-2021 00:00
Compound	CAS Number	LOR	Unit	EP2102426-001	EP2102426-002	EP2102426-003	EP2102426-004	EP2102426-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**9.2**	**9.5**	**9.3**	**9.8**	**9.2**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**80**	**51**	**73**	**67**	**148**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	<1.0
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**13.0**	**0.9**	**3.2**	**3.8**	**19.7**
Exchangeable Magnesium	----	0.1	meq/100g	**1.4**	**0.6**	**0.7**	**0.1**	**2.0**
Exchangeable Potassium	----	0.1	meq/100g	**0.3**	**0.2**	**0.2**	**0.2**	**0.9**
Exchangeable Sodium	----	0.1	meq/100g	**0.2**	**0.2**	**0.1**	**0.1**	**0.3**
Cation Exchange Capacity	----	0.1	meq/100g	**14.8**	**1.9**	**4.3**	**4.2**	**22.8**
Exchangeable Sodium Percent	----	0.1	%	**1.1**	**8.4**	**3.2**	**3.2**	**1.3**
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	**166**	**1440**	**885**	**967**	**463**
ED047: Potassium Chloride Extractable Sulfur (KCl-40)								
ø KCl-40 Extractable Sulfur	----	10	mg/kg	<10	<10	<10	<10	<10
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.1**	<0.1	<0.1	**0.1**	**0.2**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**20**	<20	<20	<20	<20
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**20**	<20	<20	<20	<20
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**108**	**98**	**96**	**170**	**542**
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	24306	24307	24308	24309	24310
			Sampling date / time	09-Mar-2021 00:00	09-Mar-2021 00:00	09-Mar-2021 00:00	09-Mar-2021 00:00	09-Mar-2021 00:00
Compound	CAS Number	LOR	Unit	EP2102426-006	EP2102426-007	EP2102426-008	EP2102426-009	EP2102426-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**9.8**	**9.5**	**9.5**	**9.5**	**9.5**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**99**	**48**	**96**	**25**	**64**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	<1.0
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**4.9**	**5.1**	**8.0**	**0.3**	**2.0**
Exchangeable Magnesium	----	0.1	meq/100g	**0.3**	**4.8**	**3.6**	**0.5**	**1.4**
Exchangeable Potassium	----	0.1	meq/100g	**0.8**	**0.5**	**0.4**	**0.2**	**0.4**
Exchangeable Sodium	----	0.1	meq/100g	**0.2**	**0.4**	**0.2**	**0.2**	**0.2**
Cation Exchange Capacity	----	0.1	meq/100g	**6.2**	**10.8**	**12.4**	**1.1**	**4.0**
Exchangeable Sodium Percent	----	0.1	%	**2.7**	**3.3**	**1.9**	**14.8**	**5.0**
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	**427**	**569**	**535**	**1290**	**2170**
ED047: Potassium Chloride Extractable Sulfur (KCl-40)								
ø KCl-40 Extractable Sulfur	----	10	mg/kg	<10	<10	<10	<10	<10
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.1**	**0.2**	**0.2**	<0.1	**0.1**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	<20	<20	<20	<20
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	<20	<20	<20	<20	<20
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**284**	**1140**	**1140**	**200**	**215**
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	24311	24312	----	----	----
			Sampling date / time	09-Mar-2021 00:00	09-Mar-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EP2102426-011	EP2102426-012	--------	--------	--------
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**9.1**	**8.8**	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**54**	**30**	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**2.0**	**0.5**	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**1.0**	**0.6**	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	**0.3**	**0.2**	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	**0.3**	<0.1	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**3.5**	**1.3**	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**7.7**	**3.7**	----	----	----
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	**3160**	**2270**	----	----	----
ED047: Potassium Chloride Extractable Sulfur (KCl-40)								
ø KCl-40 Extractable Sulfur	----	10	mg/kg	<10	**21**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	<0.1	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	<20	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	<20	<20	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**88**	**99**	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) ED021: Bicarbonate Extractable Potassium (Colwell)

(SOIL) EK080: Bicarbonate Extractable Phosphorus (Colwell)

(SOIL) ED047: Potassium Chloride Extractable Sulfur (KCl-40)

QUALITY CONTROL REPORT

Work Order	: **EP2102426**	Page	: 1 of 5
Client	: **LANDLOCH**	Laboratory	: Environmental Division Perth
Contact	: EVAN HOWARD	Contact	: Customer Services EP
Address	: PO BOX 5175 SOUTH LAKE WESTERN AUSTRALIA 6164	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: 08 9494 2835	Telephone	: +61-8-9406 1301
Project	: 2466.20a	Date Samples Received	: 09-Mar-2021
Order number	: ----	Date Analysis Commenced	: 10-Mar-2021
C-O-C number	: ----	Issue Date	: 18-Mar-2021
Sampler	: ANNA REED		
Site	: ----		
Quote number	: EP/187/21		
No. of samples received	: 12		
No. of samples analysed	: 12		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, 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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA002: pH 1:5 (Soils) (QC Lot: 3560140)									
EP2102426-010	24310	EA002: pH Value	----	0.1	pH Unit	9.5	8.9	5.86	0% - 20%
EP2102426-001	24301	EA002: pH Value	----	0.1	pH Unit	9.2	9.2	0.00	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 3560139)									
EP2102426-010	24310	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	64	65	0.00	0% - 20%
EP2102426-001	24301	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	80	79	0.00	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 3560126)									
EP2102426-001	24301	EA055: Moisture Content	----	0.1	%	<1.0	<1.0	0.00	No Limit
EP2102426-010	24310	EA055: Moisture Content	----	0.1	%	<1.0	<1.0	0.00	No Limit
ED007: Exchangeable Cations (QC Lot: 3564780)									
EP2102426-001	24301	ED007: Exchangeable Sodium Percent	----	0.1	%	1.1	1.1	0.00	0% - 50%
		ED007: Exchangeable Calcium	----	0.1	meq/100g	13.0	12.6	2.64	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	1.4	1.4	0.00	0% - 50%
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.3	0.3	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.00	No Limit
		ED007: Cation Exchange Capacity	----	0.1	meq/100g	14.8	14.4	2.63	0% - 20%
EP2102426-010	24310	ED007: Exchangeable Sodium Percent	----	0.1	%	5.0	4.9	2.61	0% - 20%
		ED007: Exchangeable Calcium	----	0.1	meq/100g	2.0	2.0	0.00	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	1.4	1.3	0.00	0% - 50%
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.00	No Limit
		ED007: Cation Exchange Capacity	----	0.1	meq/100g	4.0	3.9	2.88	0% - 20%
ED021: Bicarbonate Extractable Potassium (Colwell) (QC Lot: 3556820)									
EP2102426-001	24301	ED021: Bicarbonate Extractable K (Colwell)	----	100	mg/kg	166	149	10.8	No Limit
EP2102426-009	24309	ED021: Bicarbonate Extractable K (Colwell)	----	100	mg/kg	1290	1270	1.25	0% - 50%

Sub-Matrix: **SOIL**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
				Laboratory Duplicate (DUP) Report					
ED047: Potassium Chloride Extractable Sulfur (KCl-40) (QC Lot: 3556821)									
EP2102426-001	24301	ED047: KCl-40 Extractable Sulfur	----	10	mg/kg	<10	<10	0.00	No Limit
EP2102426-011	24311	ED047: KCl-40 Extractable Sulfur	----	10	mg/kg	<10	<10	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 3560141)									
EP2102426-011	24311	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EP2102426-001	24301	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.1	0.1	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 3561560)									
EP2102395-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	23300	21900	6.22	0% - 20%
EP2102426-002	24302	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	<20	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 3561561)									
EP2102426-012	24312	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	<20	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 3561559)									
EP2102395-001	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	2330	2120	9.20	0% - 20%
EP2102426-002	24302	EK067G: Total Phosphorus as P	----	2	mg/kg	98	89	10.0	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 3561562)									
EP2102426-012	24312	EK067G: Total Phosphorus as P	----	2	mg/kg	99	111	11.2	0% - 20%
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 3556824)									
EP2102426-001	24301	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	0.00	No Limit
EP2102426-011	24311	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	0.00	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA002: pH 1:5 (Soils) (QCLot: 3560140)								
EA002: pH Value	----	----	pH Unit	----	4 pH Unit	101	70.0	130
				----	7 pH Unit	99.8	70.0	130
EA010: Conductivity (1:5) (QCLot: 3560139)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	93.6	106
ED007: Exchangeable Cations (QCLot: 3564780)								
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	21.6 meq/100g	91.8	82.9	117
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.76 meq/100g	99.5	78.4	119
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	1 meq/100g	110	87.9	129
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.9 meq/100g	108	92.9	132
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	25.3 meq/100g	93.4	84.7	117
ED007: Exchangeable Sodium Percent	----	0.1	%	<0.1	----	----	----	----
ED021: Bicarbonate Extractable Potassium (Colwell) (QCLot: 3556820)								
ED021: Bicarbonate Extractable K (Colwell)	----	100	mg/kg	<100	403 mg/kg	70.5	70.0	130
ED047: Potassium Chloride Extractable Sulfur (KCl-40) (QCLot: 3556821)								
ED047: KCl-40 Extractable Sulfur	----	10	mg/kg	<10	53 mg/kg	75.8	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3560141)								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	99.6	89.8	109
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 3561560)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	1000 mg/kg	81.4	78.0	112
				<20	100 mg/kg	82.4	70.0	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 3561561)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	1000 mg/kg	82.0	78.0	112
				<20	100 mg/kg	84.7	70.0	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 3561559)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2	440 mg/kg	89.0	78.0	108
				<2	44 mg/kg	101	70.0	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 3561562)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2	440 mg/kg	86.5	78.0	108
				<2	44 mg/kg	96.1	70.0	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 3556824)								
EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	100 mg/kg	94.0	75.0	112
				<5	44.9 mg/kg	101	75.0	112
				<5	155 mg/kg	99.8	80.0	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3560141)							
EP2102426-002	24302	EK059G: Nitrite + Nitrate as N (Sol.)	----	2.5 mg/kg	103	70.0	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 3561560)							
EP2102395-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	# Not Determined	70.0	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 3561559)							
EP2102395-002	Anonymous	EK067G: Total Phosphorus as P	----	100 mg/kg	97.0	70.0	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 3556824)							
EP2102426-002	24302	EK080: Bicarbonate Ext. P (Colwell)	----	40 mg/kg	95.2	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP2102426**	Page	: 1 of 8
Client	: **LANDLOCH**	Laboratory	: Environmental Division Perth
Contact	: EVAN HOWARD	Telephone	: +61-8-9406 1301
Project	: 2466.20a	Date Samples Received	: 09-Mar-2021
Site	: ----	Issue Date	: 18-Mar-2021
Sampler	: ANNA REED	No. of samples received	: 12
Order number	: ----	No. of samples analysed	: 12

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser	EP2102395--002	Anonymous	**Total Kjeldahl Nitrogen as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Matrix Spikes (MS)					
TKN as N By Discrete Analyser	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
Total Phosporus By Discrete Analyser	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)			*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA002: pH 1:5 (Soils)								
Soil Glass Jar - Unpreserved (EA002)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	16-Mar-2021	✓	**16-Mar-2021**	16-Mar-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
EA010: Conductivity (1:5)								
Soil Glass Jar - Unpreserved (EA010)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	16-Mar-2021	✓	**16-Mar-2021**	13-Apr-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA055: Moisture Content (Dried @ 105-110°C)								
Soil Glass Jar - Unpreserved (EA055)								
24301,	24302,	**09-Mar-2021**	**----**	----	----	**12-Mar-2021**	23-Mar-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
ED007: Exchangeable Cations								
Soil Glass Jar - Unpreserved (ED007)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	06-Apr-2021	✓	**16-Mar-2021**	06-Apr-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
ED021: Bicarbonate Extractable Potassium (Colwell)								
Soil Glass Jar - Unpreserved (ED021)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	05-Sep-2021	✓	**17-Mar-2021**	05-Sep-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
ED047: Potassium Chloride Extractable Sulfur (KCl-40)								
Soil Glass Jar - Unpreserved (ED047)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	06-Apr-2021	✓	**16-Mar-2021**	06-Apr-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Soil Glass Jar - Unpreserved (EK059G)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	06-Apr-2021	✓	**16-Mar-2021**	18-Mar-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Soil Glass Jar - Unpreserved (EK061G)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	06-Apr-2021	✓	**17-Mar-2021**	13-Apr-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
EK067G: Total Phosphorus as P by Discrete Analyser								
Soil Glass Jar - Unpreserved (EK067G)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	06-Apr-2021	✓	**17-Mar-2021**	13-Apr-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Soil Glass Jar - Unpreserved (EK080)								
24301,	24302,	**09-Mar-2021**	**16-Mar-2021**	05-Sep-2021	✓	**17-Mar-2021**	05-Sep-2021	✓
24303,	24304,							
24305,	24306,							
24307,	24308,							
24309,	24310,							
24311,	24312							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Bicarbonate Extractable K (Colwell)	ED021	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Potassium Chloride Extractable Sulfur (KCl-40)	ED047	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosporus By Discrete Analyser	EK067G	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Bicarbonate Extractable K (Colwell)	ED021	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	12	**25.00**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Potassium Chloride Extractable Sulfur (KCl-40)	ED047	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	4	21	**19.05**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosporus By Discrete Analyser	EK067G	4	21	**19.05**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Bicarbonate Extractable K (Colwell)	ED021	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Potassium Chloride Extractable Sulfur (KCl-40)	ED047	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosporus By Discrete Analyser	EK067G	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **SOIL**

Evaluation: ✘ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
TKN as N By Discrete Analyser	EK061G	1	21	**4.76**	**5.00**	✘	NEPM 2013 B3 & ALS QC Standard
Total Phosporus By Discrete Analyser	EK067G	1	21	**4.76**	**5.00**	✘	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM Schedule B(3).
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM Schedule B(3).
Bicarbonate Extractable K (Colwell)	ED021	SOIL	In house: Referenced to Rayment & Lyons Method 18A1 Potassium is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by ICP.
Potassium Chloride Extractable Sulfur (KCl-40)	* ED047	SOIL	In house: Referenced to Rayment and Lyons, method 10D1. ALS is not NATA accredited for this testing procedure.
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 9171. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrrogen, each determined seperately as N.
Total Phosporus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Lyons Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FIA.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Lyons method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Bicarbonate Extractable K (Colwell)	ED021PR	SOIL	In house: Referenced to Rayment & Lyons Method 18A1 Potassium is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by ICP.
KCl-40 Extractable Sulfur Preparation	ED047-PR	SOIL	KCl-40 Extractable Sulfur Preparation
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Lyons Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.

Preparation Methods	Method	Matrix	Method Descriptions
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Dry and Crush	* EN84	SOIL	In house
Dry and Pulverise (up to 100g)	GEO30B	SOIL	Samples are oven dried and pulverised to nominal 90% passing 75 µm.

CHAIN OF CUSTODY – Client

EAST WEST – 02 6762 1733

East West
82 Plain St
Tamworth NSW 2340

T 02 6762 1733
F 02 6765 9109
E admin@eastwestonline.com.au
W www.eastwestonline.com.au

Client: LANDLOCH	Client Project Name / Number / Site etc (ie report title): Arafura Nolans survey 2466:20a
Contact Person: Glenn Bailey	PO No: 2466:20a
Project Mgr: Glenn Bailey	East West Quote Number: QUO-150401SC (3)
Sampler: Glenn Bailey	Date results required:
Address: 19 Peace Street, 4350 Harlaxton	Or choose: Standard *Note: Inform lab in advance if urgent turnaround is required – surcharges apply.*
Phone: Mobile: 0432 698 449	Lab comments:
Email: bailey@landloch.com.au	

Sample Information					Tests Required									Comments
East West Sample ID	Client Sample ID or information	Depth	Date Sampled	Type of Sample	Landloch suite 1 or 1W 8	Landloch suite 2 or 2W 22	pH & EC 7							Provide as much information about the sample as you can
1	N01-1		16-19/02/2021	Soil	X									
2	N01-2		16-19/02/2021	Soil		X								
3	N01-3		16-19/02/2021	Soil		X								
4	N01-4		16-19/02/2021	Soil		X								
5	N01-5		16-19/02/2021	Soil			X							
6	N04-1		16-19/02/2021	Soil	X									
7	N04-2		16-19/02/2021	Soil		X								
8	N04-3		16-19/02/2021	Soil		X								
9	N04-4		16-19/02/2021	Soil		X								
10	N06-1		16-19/02/2021	Soil	X									
11	N06-2		16-19/02/2021	Soil		X								
12	N06-3		16-19/02/2021	Soil		X								
13	N06-4		16-19/02/2021	Soil		X								
14	N06-5		16-19/02/2021	Soil			X							
15	N09-1		16-19/02/2021	Soil	X									
16	N09-2		16-19/02/2021	Soil		X								
17	N09-3		16-19/02/2021	Soil		X								

210453

					suite 1	suite 2	pH&EC
18	N09-4		16-19/2/21	SOIL			X
19	N12-1				X		
20	N12-2					X	
21	N12-3						X
22	N12-4					X	
23	N12-5					X	
24	N14-1				X		
25	N14-2					X	
26	N14-3					X	
27	N14-4					X	
28	N14-5						X
29	N20-1				X		
30	N20-2					X	
31	N20-3					X	
32	N20-4						X
33	N32-1				X		
34	N32-2					X	
35	N32-3					X	
36	N32-4						X
37	N32-5					X	
	~~N32-5~~						

Relinquished by (Company): Landloch	Received by (Company): EW	*Lab use only:*
Print Name: Glenn Bailey	Print Name: Jason	Samples received: Cool or Ambient
Date and Time: 12pm 20.2.2021	Date and Time: 25 FEB 2021	Temperature Received at:
Signature: G. Bailey	Signature:	~~Transported~~ by: Hand delivered / Courier

210453

210453

82 Plain Street Tamworth NSW 2340
e admin@eastwestonline.com.au
t 02 6762 1733
f 02 6765 9109
abn 82 125 442 382

eastwestonline.com.au

eastwest geo ag enviro

ANALYSIS REPORT SOIL

PROJECT NO:	**EW210453**	**Date of Issue:**	**10/03/2021**
Customer:	LANDLOCH PTY. LTD. (QLD)	Report No:	1
Address:	PO BOX 57 HARLAXTON QLD 4350	Date Received:	25/02/2021
		Matrix:	Soil
Attention:	Glenn Bailey	Location:	Arafura Nolans Survey 2
Phone:	0432 698 449	Sampler ID:	Client
Fax:	07 4613 1826	Date of Sampling:	16/02/2021
Email:	bailey@landloch.com.au	Sample Condition:	Acceptable

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

Signed: Stephanie Cameron
Laboratory Operations Manager

ASPAC PROFICIENT LAB
Visit www.aspac-australasia.com to view our certification details.

East West is certified by the Australian-Asian Soil & Plant Analysis Council to perform various soil and plant tissue analysis. The tests reported herein have been performed in accordance with our terms of accreditation.

This report must not be reproduced except in full and EWEA takes no responsibility of the end use of the results within this report.

This analysis relates to the sample submitted and it is the client's responsibility to make certain the sample is representative of the matrix to be tested.

Samples will be discarded one month after the date of this report. Please advise if you wish to have your sample/s returned.

ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N01-1	N01-2	N01-3	N01-4
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-1**	**210453-2**	**210453-3**	**210453-4**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.55	7.68	6.93	7.22
Chloride Soluble	DA	DAP-06	mg/kg	2	8.08	11.4	5.45	8.35
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.02	0.11	0.02	0.04
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	167	NA	NA	NA
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	148	NA	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	0.15	NA	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	20.1	NA	NA	NA
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	361	NA	NA	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	8.16	NA	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	0.45	NA	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	<0.20	NA	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	7.51	NA	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	13.0	NA	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	0.33	NA	NA	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	365	224	176	268
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	449	857	565	871
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	88.1	113	110	173
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	<10.0	<10.0	<10.0	16.3
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	<1.00	<1.00	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.94	0.57	0.45	0.69
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	2.25	4.29	2.83	4.36
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	0.73	0.94	0.92	1.44
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.04	0.04	0.04	0.07
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	0.01	0.01	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	3.97	5.86	4.25	6.57
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	3.06	4.55	3.08	3.02

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ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

					N01-1	N01-2	N01-3	N01-4
				CLIENT SAMPLE ID	N01-1	N01-2	N01-3	N01-4
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-1**	**210453-2**	**210453-3**	**210453-4**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	1.27	0.61	0.49	0.48
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	23.6	9.81	10.6	10.5
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	56.6	73.2	66.5	66.3
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	18.5	16.1	21.6	22.0
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	1.10	0.74	1.02	1.08
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.28	0.19	0.26	0.17
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	155	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	571	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	70.0	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	<10.0	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	0.40	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	2.86	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	0.58	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	0.04	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	3.89	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	4.89	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	0.68	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	10.2	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	73.4	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	15.0	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	1.12	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	0.29	0.29	0.29

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ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N01-5	N04-1	N04-2	N04-3
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-5**	**210453-6**	**210453-7**	**210453-8**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.08	8.61	8.86	8.77
Chloride Soluble	DA	DAP-06	mg/kg	2	NA	11.6	15.6	19.3
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.10	0.10	0.09	0.11
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	640	NA	NA
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	561	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	0.72	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	18.4	NA	NA
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	388	NA	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	9.25	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	0.42	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	0.52	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	14.6	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	24.7	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	0.40	NA	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	486	193	857
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	5101	4783	4898
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	241	190	285
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	<10.0	<10.0	28.7
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	NA	<1.00	<1.00	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	1.25	0.49	2.20
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	25.5	23.9	24.5
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	2.01	1.58	2.38
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	0.04	0.04	0.12
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	NA	0.01	0.01	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	28.8	26.0	29.2
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	12.7	15.1	10.3

ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N01-5	N04-1	N04-2	N04-3
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-5**	**210453-6**	**210453-7**	**210453-8**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	0.62	0.31	0.93
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	4.32	1.90	7.53
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	88.5	91.8	83.9
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	6.97	6.08	8.13
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	0.15	0.17	0.43
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	NA	0.04	0.04	0.04
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	319	99.0	181
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	2066	1068	1070
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	198	151	178
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	<10.0	<10.0	<10.0
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	0.82	0.25	0.46
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	10.3	5.34	5.35
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	1.65	1.26	1.48
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	0.04	0.04	0.04
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	12.9	6.91	7.35
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	6.26	4.24	3.61
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	0.50	0.20	0.31
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	6.36	3.68	6.31
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	80.4	77.3	72.8
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	12.8	18.2	20.2
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	0.34	0.63	0.59
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	0.09	0.16	0.15

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ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N04-4	N06-1	N06-2	N06-3
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-9**	**210453-10**	**210453-11**	**210453-12**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.57	7.18	7.92	8.84
Chloride Soluble	DA	DAP-06	mg/kg	2	35.4	13.5	13.1	7.00
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.15	0.03	0.03	0.06
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	219	NA	NA
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	150	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	0.18	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	8.66	NA	NA
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	215	NA	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	8.30	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	0.37	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	0.65	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	41.6	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	75.9	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	0.43	NA	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	138	183	239	494
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	5179	635	1023	4454
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	850	199	309	789
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	58.5	<10.0	13.6	131
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	<1.00	<1.00	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.35	0.47	0.61	1.27
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	25.9	3.18	5.12	22.3
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	7.08	1.66	2.58	6.58
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.25	0.04	0.06	0.57
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	0.01	0.01	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	33.6	5.36	8.37	30.7
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	3.66	1.91	1.99	3.39

ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N04-4	N06-1	N06-2	N06-3
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-9**	**210453-10**	**210453-11**	**210453-12**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.05	0.28	0.24	0.19
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	1.05	8.76	7.32	4.13
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	77.1	59.3	61.1	72.6
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	21.1	31.0	30.8	21.4
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	0.76	0.81	0.71	1.86
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.03	0.21	0.13	0.04
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	114	NA	226	464
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	2146	NA	921	1401
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	490	NA	258	652
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	<10.0	NA	<10.0	51.3
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.29	NA	0.58	1.19
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	10.7	NA	4.61	7.01
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	4.08	NA	2.15	5.43
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	0.04	NA	0.04	0.22
ECEC	Calculation	PMS-15C1	cmol/kg	na	15.2	NA	7.39	13.9
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	2.63	NA	2.14	1.29
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.07	NA	0.27	0.22
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	1.93	NA	7.84	8.58
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	70.8	NA	62.3	50.5
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	26.9	NA	29.1	39.2
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	0.29	NA	0.59	1.61
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.07	0.07	0.15	0.08

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ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N06-4	N06-5	N09-1	N09-2
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-13**	**210453-14**	**210453-15**	**210453-16**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	10.0	9.70	7.28	7.20
Chloride Soluble	DA	DAP-06	mg/kg	2	24.8	NA	6.85	5.95
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.12	0.40	0.04	0.02
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	254	NA
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	829	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	0.20	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	39.5	NA
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	NA	312	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	8.59	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.69	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.38	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	8.84	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	13.5	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	0.42	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	452	NA	278	213
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	3861	NA	918	1136
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	948	NA	189	151
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	1066	NA	<10.0	11.1
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	NA	<1.00	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	1.16	NA	0.71	0.55
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	19.3	NA	4.59	5.68
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	7.90	NA	1.58	1.26
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	4.63	NA	0.04	0.05
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	NA	0.01	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	33.0	NA	6.93	7.54
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	2.44	NA	2.91	4.51

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N06-4	N06-5	N09-1	N09-2
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-13**	**210453-14**	**210453-15**	**210453-16**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.15	NA	0.45	0.43
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	3.51	NA	10.3	7.24
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	58.5	NA	66.2	75.3
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	23.9	NA	22.7	16.7
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	14.0	NA	0.63	0.64
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.03	NA	0.16	0.15
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	285	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	659	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	621	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	562	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.73	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	3.30	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	5.18	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	2.44	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	11.7	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.64	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.14	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	6.27	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	28.3	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	44.4	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	21.0	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.10	NA	0.10	0.10

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N09-3	N09-4	N12-1	N12-2
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-17**	**210453-18**	**210453-19**	**210453-20**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	7.48	7.64	5.81	6.90
Chloride Soluble	DA	DAP-06	mg/kg	2	6.80	NA	17.2	6.50
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.04	0.02	0.01	0.02
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	386	NA
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	174	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	0.28	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	20.5	NA
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	NA	191	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	8.77	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.56	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.40	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	13.6	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	22.0	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	0.34	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	179	NA	184	284
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	1440	NA	1428	1017
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	189	NA	190	118
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	10.1	NA	<10.0	<10.0
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	NA	<1.00	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.46	NA	0.47	0.73
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	7.20	NA	7.14	5.09
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	1.58	NA	1.58	0.98
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.04	NA	0.04	0.04
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	NA	0.01	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	9.29	NA	9.25	6.85
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	4.57	NA	4.51	5.17

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	**N09-3**	**N09-4**	**N12-1**	**N12-2**
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-17**	**210453-18**	**210453-19**	**210453-20**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.29	NA	0.30	0.74
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	4.94	NA	5.10	10.6
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	77.5	NA	77.2	74.2
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	17.0	NA	17.1	14.4
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	0.47	NA	0.47	0.63
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.12	NA	0.12	0.16
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	163	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1201	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	132	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	<10.0	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.42	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	6.01	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	1.10	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	0.04	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	7.58	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	5.46	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.38	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	5.52	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	79.2	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	14.5	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	0.57	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.15	NA	0.15	0.15

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N12-3	N12-4	N12-5	N14-1
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-21**	**210453-22**	**210453-23**	**210453-24**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.83	6.66	7.58	5.74
Chloride Soluble	DA	DAP-06	mg/kg	2	NA	9.65	12.6	6.25
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.03	0.03	0.07	0.01
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	199
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	155
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	0.31
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	15.2
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	NA	NA	156
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	8.18
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.39
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.20
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	9.57
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	16.2
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.36
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	239	137	152
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	1028	1011	333
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	237	232	55.1
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	12.7	19.8	<10.0
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	NA	<1.00	<1.00	1.91
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	0.61	0.35	0.39
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	5.14	5.06	1.67
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	1.98	1.93	0.46
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	0.06	0.09	0.04
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	NA	0.01	0.01	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	7.79	7.44	2.58
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	2.60	2.61	3.63

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	**N12-3**	**N12-4**	**N12-5**	**N14-1**
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-21**	**210453-22**	**210453-23**	**210453-24**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	0.31	0.18	0.85
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	7.86	4.72	15.1
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	65.9	68.0	64.6
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	25.3	26.0	17.8
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	0.71	1.16	1.69
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	NA	0.14	0.15	0.82
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	124	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	904	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	199	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	<10.0	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	0.32	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	4.52	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	1.66	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	0.04	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	6.55	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	2.73	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	0.19	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	4.85	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	69.0	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	25.3	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	0.66	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	0.15	0.17	0.32

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

					N14-2	N14-3	N14-4	N20-1
				CLIENT SAMPLE ID				
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-25**	**210453-26**	**210453-27**	**210453-29**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.36	6.29	6.43	6.22
Chloride Soluble	DA	DAP-06	mg/kg	2	4.86	6.70	5.70	7.80
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.01	0.01	0.01	0.01
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	343
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	183
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	0.44
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	20.8
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	NA	NA	214
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	8.30
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.48
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.42
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	10.1
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	9.26
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.39
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	412	216	138	239
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	388	457	461	514
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	47.7	58.2	99.8	58.7
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	<10.0	<10.0	<10.0	<10.0
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	<1.00	<1.00	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	1.06	0.55	0.35	0.61
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	1.94	2.29	2.31	2.57
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	0.40	0.49	0.83	0.49
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.04	0.04	0.04	0.04
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	0.01	0.01	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	3.45	3.38	3.55	3.73
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	4.88	4.71	2.77	5.25

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

					N14-2	N14-3	N14-4	N20-1
				CLIENT SAMPLE ID				
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-25**	**210453-26**	**210453-27**	**210453-29**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	2.66	1.14	0.43	1.25
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	30.6	16.4	9.98	16.4
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	56.3	67.6	65.0	69.0
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	11.5	14.4	23.5	13.1
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	1.26	1.29	1.23	1.17
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.32	0.33	0.31	0.30
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.17	0.17	0.17	0.17

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N20-2	N20-3	N20-4	N32-1
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-30**	**210453-31**	**210453-32**	**210453-33**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.67	6.81	7.42	6.30
Chloride Soluble	DA	DAP-06	mg/kg	2	4.54	7.50	NA	6.80
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.01	0.02	0.02	0.01
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	234
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	149
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	0.25
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	15.4
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	NA	NA	176
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	8.29
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.53
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.39
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	7.91
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	7.89
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.29
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	367	206	NA	198
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	609	509	NA	435
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	96.0	141	NA	78.7
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	<10.0	<10.0	NA	<10.0
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	<1.00	NA	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.94	0.53	NA	0.51
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	3.05	2.55	NA	2.18
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	0.80	1.18	NA	0.66
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.04	0.04	NA	0.04
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	0.01	NA	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	4.84	4.30	NA	3.39
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	3.81	2.17	NA	3.32

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N20-2	N20-3	N20-4	N32-1
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-30**	**210453-31**	**210453-32**	**210453-33**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	1.18	0.45	NA	0.77
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	19.4	12.3	NA	15.0
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	62.9	59.1	NA	64.1
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	16.5	27.3	NA	19.3
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	0.90	1.01	NA	1.28
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.23	0.26	NA	0.33
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.17	0.17	NA	0.17

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N32-2	N32-3	N32-4	N32-5
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-34**	**210453-35**	**210453-36**	**210453-37**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.80	6.75	7.22	7.20
Chloride Soluble	DA	DAP-06	mg/kg	2	12.7	6.40	NA	5.50
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.03	0.01	0.01	0.02
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	NA
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	NA	NA
Potassium (Available)	Bicarb/ICP	R&L 18A1	mg/kg	10	NA	NA	NA	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	177	181	NA	331
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	456	603	NA	950
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	88.9	112	NA	230
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	<10.0	<10.0	NA	10.8
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	<1.00	<1.00	NA	<1.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.45	0.46	NA	0.85
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	2.28	3.02	NA	4.75
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	0.74	0.93	NA	1.92
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.04	0.04	NA	0.05
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.01	0.01	NA	0.01
ECEC	Calculation	PMS-15A1	cmol/kg	na	3.53	4.47	NA	7.57
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	3.08	3.23	NA	2.48

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PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

				CLIENT SAMPLE ID	N32-2	N32-3	N32-4	N32-5
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-34**	**210453-35**	**210453-36**	**210453-37**
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.61	0.50	NA	0.44
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	12.9	10.4	NA	11.2
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	64.6	67.5	NA	62.7
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	21.0	20.9	NA	25.3
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	1.23	0.97	NA	0.62
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.31	0.25	NA	0.15
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.17	0.17	NA	0.17

ANALYSIS REPORT

PROJECT NO: EW210453 **Location: Arafura Nolans Survey 2466:20a**

					N32-2	N32-3	N32-4	N32-5
				CLIENT SAMPLE ID				
				DEPTH				
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**210453-34**	**210453-35**	**210453-36**	**210453-37**

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Soils are air dried at 40^{0}C and ground <2mm.

NB: LOR is the Lowest Obtainable Reading.

DOCUMENT END

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Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030028-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030028
Client ID	24301
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.7
Slake Durability (2nd cycle) (%)	99.6
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

Authorised Signatory

G. Creely

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030029-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030029
Client ID	24302
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.8
Slake Durability (2nd cycle) (%)	99.6
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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Authorised Signatory

G. Creely

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Laboratory No. 9926

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030030-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030030
Client ID	24303
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.7
Slake Durability (2nd cycle) (%)	99.6
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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G. Creely

Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030031-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030031
Client ID	24304
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.8
Slake Durability (2nd cycle) (%)	99.8
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030032-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030032
Client ID	24305
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.0
Slake Durability (2nd cycle) (%)	98.7
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	Fragments

NOTES/REMARKS:

Sample/s supplied by the client

Authorised Signatory

G. Creely

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030033-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030033
Client ID	24306
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.6
Slake Durability (2nd cycle) (%)	99.6
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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G. Creely

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Laboratory No. 9926

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030034-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030034
Client ID	24307
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.5
Slake Durability (2nd cycle) (%)	98.9
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	Fragments

NOTES/REMARKS:

Sample/s supplied by the client

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Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030035-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030035
Client ID	24308
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.7
Slake Durability (2nd cycle) (%)	99.6
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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G. Creely

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030036-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030036
Client ID	24309
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	91.7
Slake Durability (2nd cycle) (%)	82.8
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Slight Deterioration
Appearance of fragments passing through the drum	Fragments & Fines

NOTES/REMARKS:

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Laboratory No. 9926

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030037-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030037
Client ID	24310
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.7
Slake Durability (2nd cycle) (%)	99.5
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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Laboratory No. 9926

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030038-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030038
Client ID	24311
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.5
Slake Durability (2nd cycle) (%)	99.1
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

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Authorised Signatory

G. Creely

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

Trilab
Soil Rock Calibration

Brisbane
346A Bilsen Road,
Geebung
QLD 4034
Ph: +61 7 3265 5656

Perth
2 Kimmer Place,
Queens Park
WA 6107
Ph: +61 8 9258 8323

SLAKE DURABILITY INDEX TEST REPORT

Test Method: AS 4133.3.4

Client	Landloch Pty Ltd	**Report No.**	P21030039-SD
		Workorder No.	0020385
Address	PO Box 5175 South Lake 6164	**Test Date**	24/03/2021
		Report Date	30/03/2021
Project	2466.20a - Arafura Nolans		

Sample No.	21030039
Client ID	24312
Depth (m)	Not Supplied
Slake Durability (1st cycle) (%)	99.4
Slake Durability (2nd cycle) (%)	99.0
Slake Durability (3rd cycle) (%)	-
Slake Durability (4th cycle) (%)	-
Water Used	Tap Water
Temperature (^{o}C)	20.2
Appearance of fragments retained in the drum	Original Form
Appearance of fragments passing through the drum	None

NOTES/REMARKS:

Sample/s supplied by the client

Authorised Signatory

G. Creely

APPENDIX C – WEPP EROSION MODEL

The WEPP model

The WEPP model was developed by the United States Department of Agriculture to predict runoff, erosion, and deposition for hillslopes. WEPP is a simulation model with a daily input time step, although shorter time steps are used by internal calculations on days when rainfall occurs. Plant and soil characteristics important to erosion processes are updated every day. When rainfall occurs, those plant and soil characteristics are considered in determining the likelihood of runoff. If runoff is predicted to occur, the model computes sediment detachment, transport, and deposition at points along the slope profile.

The erosion component of the WEPP model uses a steady-state sediment continuity equation as the basis for the erosion computations. Soil detachment in interrill areas is calculated as a function of the effective rainfall intensity and runoff rate. Soil detachment in rills is predicted to occur if the flow hydraulic shear stress is greater than the soil's critical shear stress, and when the sediment load of the flow is below its transport capacity. Deposition in rills is computed when the sediment load is greater than the capacity of the flow to transport it.

Climate file

All WEPP model simulations completed used a 100-year stochastic climate sequence for the site developed from daily and sub-daily observed data from locations near to Alice Springs. For each day of simulation, WEPP requires ten daily weather variables:

- Precipitation (mm),
- Precipitation duration (hr),
- Peak storm intensity,
- Time to storm peak,
- Average minimum temperature,
- Average maximum temperature,
- Dew point temperature,
- Solar radiation,
- Wind speed, and
- Wind direction.

Of these, the four rainfall-related variables (underlined in list above) are of particular importance because previous studies have shown that predicted runoff and erosion are most sensitive to these rainfall variables (Nearing *et al.* 1990; Chaves and Nearing 1991).

For most sites around the world, complete historical weather data on these variables are not available. To use WEPP for runoff and erosion prediction, synthetic weather sequences that statistically preserve the mean and variations in the historical observations are required.

CLIGEN is a stochastic weather generator that can be used to provide WEPP climate input files. CLIGEN has been extensively assessed for a wide range of climates, and it was found that CLIGEN was most suitable to provide the required climate input for WEPP to predict runoff and erosion (Yu 2003). The following parameter values were computed and used to develop the synthetic climate sequence for Nolans:

- Mean daily rainfall on wet days for each month,
- Standard deviation and skewness coefficient of daily rainfall for each month,
- Probability of a wet day following a dry day for each month,
- Probability of a wet day following a wet day for each month,
- Mean daily max. temperature for each month,
- Standard deviation of daily max. temperature for each month,
- Mean daily min. temperature for each month,
- Standard deviation of daily min. temperature for each month,
- Mean maximum 30-min rainfall intensity for each month, and
- Probability distribution of the dimensionless time to peak storm intensity.

These parameter values were assembled to create a CLIGEN parameter file for the site. Wind data (used to calculate soil evaporation) were not synthesised by CLIGEN because Priestley-Taylor's method for estimating the potential evaporation will automatically be used by WEPP. A 128-year climate sequence was generated using CLIGEN version 5.1 (Yu 2002).

The average annual rainfall totals for both the observed data and the CLIGEN climate sequence are the same (276mm/y). The average monthly rainfall of the CLIGEN climate sequence is compared with the data drill data in Figure B-1. The absolute error between the CLIGEN sequence and the observed monthly averages is less than 0.01mm/month, equivalent to less than 1mm difference over the entire year.

Daily rainfall totals were compared using their AEP (Figure B-2). The data shows that the daily rainfall totals in the CLIGEN sequence closely match the observed data.

Based on this analysis it is concluded that the CLIGEN climate sequence:

- accurately reproduces average annual rainfall totals;
- accurately reproduces mean monthly rainfall totals;
- accurately reproduces daily rainfall totals and their average recurrence intervals; and
- can be used within the WEPP model to predict long-term erosion for Nolans.

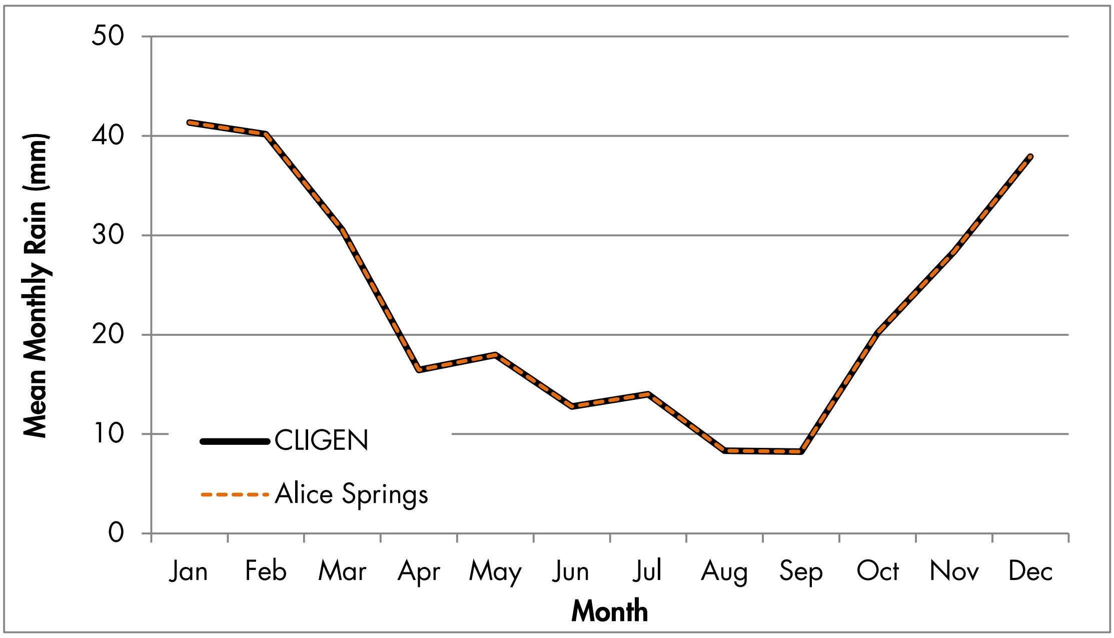

Figure B-1: Comparison of CLIGEN mean monthly rainfall with patched Alice Springs data (1920-202).

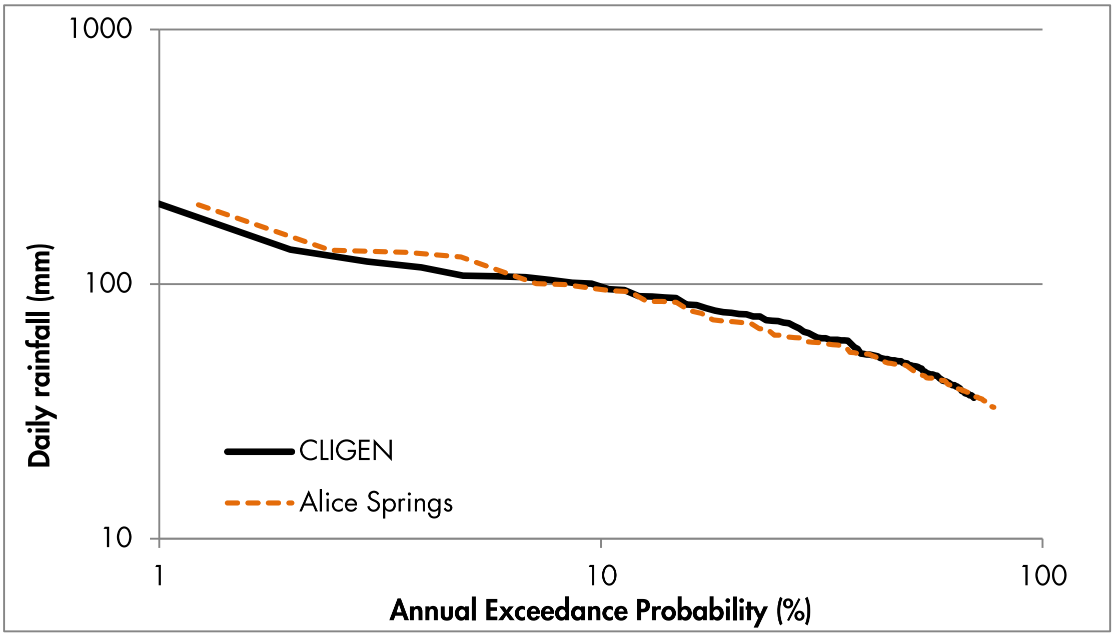

Figure B-2: Comparison of daily rainfall totals in the CLIGEN sequence with the daily rainfall totals from the patched Alice Springs data (1920-202).