THRL Pty Ltd trading as Scenic Rim Trail

Soil Investigations for Baseline of Annual Monitoring at Amphitheatre View and Timber Getters EcoCamps.

Main Range National Park, Queensland, Australia.

Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland (EPBC 2016/7847)

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Executive Summary

Moreton Environmental and Health Pty Ltd (MEH) has been engaged by THRL Pty Ltd ACN 137 592 593 (Scenic Rim Trail) to provide a baseline report on soil quality data for assessing potential impacts of treated wastewater effluent disposal areas, and potential impacts of the use of the lodges and their facilities at Scenic Rim Trail Timber Getters and Amphitheatre View Wilderness EcoCamps, Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland (EPBC 2016/7847).

This baseline report is required now that irrigation is beginning at the EcoCamps, agreement on variation to the approval has been achieved and the sewage and wastewater management plan (SWMP) produced outlining soil assessment at the EcoCamps . Baseline data and future testing within 50 metres of both the EcoCamps and the irrigation areas including detailed analysis to provide data on the ongoing suitability of the irrigation areas for irrigation is provided in this report.

Twenty-four hand-augered boreholes were advanced at Timber Getters and twenty-eight hand-augered boreholes were advanced at Amphitheatre on the 28th and 29th August 2025 and the 7th and 8th May 2026 to be representative of the soils within irrigations areas and within 50 meters of both the EcoCamps, as shown in **Figures 4-7** in **Figures**.

Six (6) boreholes were sampled at 100, 300 and 600 mm depth in both irrigation areas and the results of soil classification, physico-chemical and nutrient results are shown in **Tables 13 – 18** for Timber Getters and Amphitheatre irrigation areas respectively.

Soils demonstrated clay loams or silty clay loams or silty loams at both sites and generally had CEC of more than 10 and less than 35 meq/100g, demonstrating a moderate buffering capacity to changes in pH, available nutrients, calcium levels and soil structure.

The soils also demonstrated pH levels of 6.0 up to 6.5, non-saline, organic matter ranged from 2 to 18%, with a high degree of variability of organic matter within the horizons, as well as a high degree of buffering with respect to cation exchange, including nutrients. The soils had some to no dispersion characteristics, indicating stable soils with regards to erosion and a high degree of buffering capacity with regards to salts, which indicates suitable soils for irrigation.

Both soils in irrigation areas and areas within a 50-meter radius of both EcoCamp demonstrated metalloid concentrations within the site-specific EILs as shown in Table 15, All soil results shown in Table 18 below were below the SQG for metalloids concentrations within the soils within the irrigation area of the Amphitheatre EcoCamp., Table 20 and Table 21. The exception was the maximum value of zinc, which was above the SQG; however, the mean value is within criteria.

The irrigation areas had high levels of Organic Nitrogen, and low levels of Ammonia and Nitrates that indicate a natural ecosystem with a high level of nitrogen recycling.

These baseline studies of the irrigation areas demonstrate soils at the EcoCamps have naturally high degrees of nutrients and the EcoCamps are in a high nutrient environment, which may have implications for trigger levels of Treated Effluent.

The irrigation areas have a high ability to absorb nutrients from the irrigated treated effluent as shown in section 4.4.5 due to a high degree of buffering capacity with respect to cation and nutrient exchange.

The plant tissue analysis indicates the vegetation within the irrigation areas are within the correct range of elements for optimal growth and the nitrogen levels in the vegetation indicate room for increased Nitrogen in plant tissue.

Following the assessment of soils in the irrigation areas and within 50 m of the EcoCamps, MEH recommends the following:

- The baseline results of Physico-Chemical measurements, Cations and Anions concentrations, as well as Metalloids and Nutrient concentrations will be monitored in subsequent years and the soil quality of the irrigation area and within a 50-meter radius of both EcoCamp will be assessed for change;
- The irrigation areas will be assessed in subsequent years for change as well as their ability to absorb nutrients, buffer against erosion and salinity; and
- Given the high nutrient cycling environments described in the soils at the EcoCamps, the Sewage and Wastewater Monitoring Plan (SWMP) for Amphitheatre and Timber Getters EcoCamps, (MEH, 2025b) and Plan for Wastewater and Sewage Management (PWaSM) for Amphitheatre and Timber Getters EcoCamps, (MEH, 2025a) should be reviewed for any changes.

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1 Introduction

Moreton Environmental and Health Pty Ltd (MEH) was engaged by THRL Pty Ltd ACN 137 592 593 (Scenic Rim Trail) to complete a soil investigation assessment at the **Timber Getters Eco Camp** and **Amphitheatre View Wilderness Eco Camp** areas within the Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland (see **Figures 1 and 2** in **Figures**).

In accordance with Condition 8A in the Variation of Conditions attached to Approval (Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland (EPBC 2016/7847), dated 2019), this soil investigation assessment outlines the methods (including survey methodology, effort, timing, frequency) that will be implemented for the collection and analysis of data regarding soil quality to establish a baseline, and to subsequently detect any change from baseline within 50 meters of both the **Timber Getters Eco Camp** and **Amphitheatre View Wilderness Eco Camp** attributable to onsite disposal of sewage or wastewater, as well as habitation of the EcoCamps.

Condition 8A)a) states that "The sewage and wastewater management plan (SWMP) must specify methods for collection and analysis of **soil quality data** of soil profiles within the boundaries of **Timber Getters Ecocamp** and **Amphitheatre View Wilderness Ecocamp** and within all areas proposed for disposal of treated sewage and waste water and all areas within 50 meters of the **Timber Getters Ecocamp** and **Amphitheatre View Wilderness Ecocamp".** Following agreement of Variation of Conditions to Approval, MEH developed a Sewage and Wastewater Monitoring Plan (SWMP) for Amphitheatre and Woodcutters EcoCamps, (MEH, 2025b) and Plan for Wastewater and Sewage Management (PWaSM) for Amphitheatre and Woodcutters EcoCamps, (MEH, 2025a).

The SWMP states that data collection is designed to ensure monitoring will detect any on-site or downstream changes in soil quality from impacts of the Timber Getters and Amphitheatre EcoCamps (the EcoCamps), in accordance with the Scenic Rim Trail Management Plan, dated 31st March 2019, (O'Hara, 2019). To address requirements of condition 8A of the Variation, the SWMP designed the following monitoring regime, which MEH maintains is sufficient for the Environment Protection and Biodiversity Conservation (EPBC) Act 1999 assessment as outlined in the Scenic Rim Trail Management Plan (SRTMP), (O'Hara, 2019) and to monitor any potential impacts from the disposal of treated effluent and operation of the EcoCamps. The SWMP proposes:

1. Annual monitoring and assessment of changes of concentration of parameters in soil over time;
2. Annual monitoring of soils against site-specific Environmental Investigation Levels (EILs);
3. Annual monitoring of soils within irrigation disposal areas to be sustainable in the long term, up to 50 years as determined by MEDLI modelling;
4. Using the Before-After Control-Impact (BACI) study design;
5. Annual reporting of parameters in soil or water quality over time.

It should be noted that Moreton Environmental Pty Ltd (MEL) changed its name to Moreton Environmental and Health Pty Ltd (MEH) in 2020. MEL and MEH are the same company with the same Principal Scientist and Director, Dan Morton.

This soil assessment has been conducted in accordance with the limitations of the scope of work outlined within MEH fee proposal *PO25008* dated 12th March 2025. Written confirmation to conduct the work outlined in the fee proposal was received from Scenic Rim Trail by the return of a signed acceptance form dated **07 October 2027**.

1.1 Scope of works

MEH has devised the following sample design and methodology to monitor baseline conditions and any potential impact on soil and waters from the activities at the EcoCamps, including disposal of wastewater treatment and irrigation of treated effluent. The sample design and methodology has been derived at both EcoCamps by:

- Assessment of the potential drainage pathways, both groundwater and surface water, from the EcoCamps including the wastewater disposal areas, to the nearest surface water body (ephemeral or permanent);
- Defining the soils within 50m of the EcoCamps and within the irrigation disposal areas.

Soil, Groundwater and Surface water monitoring points will be selected and/or installed using the following guidance:

- *ANZECC and ARMCANZ (2000), National Water Quality Management Strategy, No. 7, Australian Guidelines for Water Quality Monitoring and Reporting, October 2000, Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management and Council of Australia and New Zealand (ARMCANZ, 2000).*
- *EPA Vic. (2000), Groundwater Sampling Guidelines, EPA Victorian Government,* (EPA, 2000).
- *AS 4482 1-2005 Guide to the investigation and sampling of sites with potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds, (Australia, 2005).*
- *NEPC, Schedule, B1 - Guideline on investigation levels for soil and groundwater, (NEPC, 2013d).*

Details of Location, Conceptual Site Model ,Geology, and Soil monitoring locations can be found in **Figures 1 – 7** in **Figures.**

1.2 Conceptual Site Model

The Conceptual Site Model or receptor pathway model (CSM) in **Figure 3** in **Figures** shows the receptor pathways considered in developing the sampling plan at the two EcoCamps in the **Timber Getters Ecocamp** and **Amphitheatre View Wilderness Ecocamp.**

1.3 Soil monitoring locations and analysis

The number of soil sampling locations has been calculated using the AS 4482.1-2005 Guide to the investigation and sampling of sites with potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds, (Australia, 2005).

Table 1: AS 4482 1-2005 Calculated Values

TIMBER GETTERS ECOCAMP		RISK PROFILE	
	Qualitative Level of Risk	Std	Low
Radius =	m	15	20
Grid size =	m	25.42	33.90
Area =	m^2	17500	17500
number of samples =		27.07	15.23
		27	15
	Diameter of hot spot detection	30	40
AMPHITHEATRE ECOCAMP		**RISK PROFILE**	
	Qualitative Level of Risk	Std	Low
Radius =	m	15	20
Grid size =	m	25.42	33.90
Area =	m^2	21875	21875

number of samples =		33.84	19.04
		34	19
	Diameter of hot spot detection	30	40

AS 4482.1 2005 recommends the number of sample locations in the standard (Std) risk profile as shown in Table 1 below. However, MEH has assessed the risk profile of contaminating the environment as low, due to the pristine surrounding environment and a small footprint of occupants (>25), and has, therefore, increased the "hot spot" diameter from 30 m to 40 m, which subsequently has reduced the number of sample locations required as shown in Table 1 above.

Nineteen hand-augered boreholes are proposed to provide adequate representative of the soils in the Amphitheatre EcoCamp area.

Fifteen hand-augered boreholes are proposed to provide adequate representative of the soils in the Timber Getters EcoCamp area.

Background samples were taken at each EcoCamp in order to facilitate site-specific EILs, the locations of which were up-gradient of the EcoCamps and in positions not influenced by the EcoCamps and their activities.

Hand-augered boreholes were advanced to take surface samples within 0.10 meters below ground level (mbgl). An additional three boreholes were advanced in the irrigation disposal areas to a maximum depth of 1.0 mbgl or until refusal due to hard conditions or bedrock.

The sampling was undertaken in accordance with MEH standard operating procedures, which are consistent with EPA approved guidelines and industry standards.

Soil samples were recovered from near or below the surface, being 0.15 mbgl for all boreholes, and an additional two samples of 0.5 and 0.9 mbgl for boreholes in the irrigation disposal areas. Soil was taken directly from within clods removed by an excavator, and soil representing that distinct depth or lithology was sampled using new nitrile gloves.

Soil samples were then placed into sample jars using disposable nitrile gloves with a new pair of nitrile gloves being used for each sample taken. The glass jars were labelled with the trial pit number, depth of discrete sample collection, site reference and date before being placed in a chilled, darkened cooler (maximum temperature of 4°C) and sent to a NATA-accredited laboratory for analysis. The following parameters were measured in the disposal areas:

1.3.1 Soil Parameters

a) For soils within 50m of the EcoCamps:
- i. *Total Nitrogen, Total Kjeldahl Nitrogen, Nitrate, Nitrite, Ammonia and Total Phosphorus and reactive phosphorus (mg/kg);*
- *ii. Heavy metals ((As, Cd, Cr, Cu, Ni, Pb, Zn).*

b) *For soils within the irrigation disposal areas:*
- *i. Soil Classification by Particle Size Analysis (Sieve Hydrometer and SPD analysis;*
- *ii. Emerson Aggregate Testing;*
- *iii. Total Soluble Salts;*
- *iv. Major Cations;*
- *v. Major Anions;*
- *vi. Salinity Chloride - Soluble (1.5 soil water leach);*
- *vii. Exchange Acidity;*
- *viii. Sodium Absorption Ration (SAR) Calc;*
- *ix. Sulphur - Total as S;*
- *x. Phosphorus Sorption Capacity;*
- *xi. Bicarbonate Extractable P (Colwell);*
- *xii. Organic Matter in Soil (Walkley Black);*
- *xiii. pH, EC, moisture, Exchangeable Cations,*
- *xiv. TP, TN, TKN, NO2, NO3, Nox, NH3, TP;*
- *xv. Reactive Phosphorus*

1.4 Background Samples Sampling Methodology

The investigation undertaken in accordance with MEH standard operating procedures (SOP_PROC_001-Soil sampling, SOP_PROC_004-Quality Assurance and Quality Control) as shown in **Appendix A**, which are consistent with Qld Government-approved guidelines and industry standards, including the 2018 Monitoring and Sampling Manual, (Queensland, 2018a).

The soil surface was sampled by firstly clearing the soil of any organic material, e.g. grass and roots, with the sample then collected from fresh, exposed soil. Fresh soil was exposed prior to sampling to remove any smear affects from the sampling equipment. Soil peds or clods were removed from the auger or trowel and split so that samples could be taken from the middle of the peds or clods. The sampler did not sample from exposed surfaces, since these may not be representative of the soil. For more details on protocols for soil sampling protocol see SOP_PROC_001 in **Appendix A.**

Soil samples were placed into sample containers using disposable nitrile gloves, with a new pair of nitrile gloves being used for each sample taken. All sample containers were labelled with the surface water location, site reference and date before being placed in a chilled, darkened cooler (maximum temperature of 4°C).

2 Assessment Criteria

MEH recommends a Before-After Control-Impact (BACI) study design be used to monitor soil for impact of operations and wastewater disposal within 50m and downstream of EcoCamps.

MEH recommends that the median values of soil and water quality conditions at the monitoring points must not vary more than 10% when compared to baseline conditions (see https://www.waterquality.gov.au/anz-guidelines/monitoring/study-design/preparation#ecological).

2.1 Soil

The soil assessment criteria will address the overarching objectives of the SWMP by assessing the **soil quality data** of soil profiles within the boundaries of the EcoCamps and within all areas proposed for disposal of treated sewage and wastewater and all areas within 50 meters of both the EcoCamps.

The two areas of soil assessment, in the irrigation area and the surrounding area, have differing parameter listings, detailed in section 1.2.1 above, and differing assessment criteria.

All the soils including soils within the irrigation disposal areas and within 50 meteres of the EcoCamps shall be evaluated for contamination with heavy metals.

The irrigation disposal areas have an additional assessment goal of maintaining soil sustainability (Tennakoon and Ramsay, 2020); therefore, the assessment criteria will also consider the long term sustainability with regards to Nutrients and Physico-chemical Parameters, pH, EC and CEC, Salinity, Soil Sodicity, and Sodium Adsorption Ratio. In order to assess the sustainability of the surrounding vegetation to remove nutrients, vegetation analysis will be undertaken within the irrigation areas. The following sections outline details of the soil and vegetation analysis assessment criteria for the irrigation areas and within 50 meters of both EcoCamps.

Soils will be assessed against baseline criteria and if soils within the 50m of the EcoCamps have criteria which vary more than 10% from the baseline data OR are above the site-specific EILs as described below, then a trigger point will be deemed to have been breached and further action may be required as outlined in the SWMP, (MEH, 2025b).

2.1.1 Ecological Investigation Levels for Heavy Metals

The applicable soil assessment criteria for heavy metals that may be present in the soils within 50 meters of both the EcoCamps and have potential to impact on the environment are the environmental investigation levels (EILs) from the *National Environment Protection (Draft Assessment of Site Contamination) Amendment Measure (2013)*. The EILs are required to be determined with reference to the *National Environment Protection (Assessment of Site Contamination) Measure [NEPM] (2013) Schedule B(1) and B(5b)* (NEPC, 2013a, NEPC, 2013b, NEPC, 2013c).

Given historical and current land use around the EcoCamps, Lowest Observed Effect Concentration (LOEC) and 50% Effect Concentration (EC50) parameters have been adopted from the NEPM for the derivation of the EILs in the reference tables below. These will be used as soil assessment criteria for metal concentrations in the Ecocamps irrigation areas. The toxicity data of LOEC and EC30 has been used on the decision that breach of the SQG would have a moderate toxic effect on the environment, as shown in **Table 2,** overleaf.

Table 2: Risk Decision on ecological impact

Type of SQG	Toxicity data used to calculate the SQGs	Expected toxic effects if the SQG is not exceeded
SQG(NOEC & EC10)	**NOEC and EC10**	**slight toxic effects**

Type of SQG	Toxicity data used to calculate the SQGs	Expected toxic effects if the SQG is not exceeded
SQG(LOEC & EC30)	**LOEC and EC30**	**moderate toxic effects**
SQG(EC50)	**EC50**	**significant toxic effects**

The metals considered likely contaminants resulting from the land application of treated effluent and public use of a pristine environment are As, Cd, Cr, Cu, Ni, Pb, Zn, and Hg (Hart and Lake, 1987).

The derivation of EILs for the metals of interest and the Soil Quality Guideline (SQG) specific to the soil being investigated in the baseline and future assessments will be calculated by the addition of the Added Contaminant Level (ACL) to the ambient background concentration (ABC), thus:

$$(SQG_{(LOEC\ \&\ EC30)})\ (EC50) = ACL(EC50) + ABC$$

For the above to be valid, pH must be measured using the $CaCl_2$ method 4B1, (Rayment and Higginson, 1992) and Cation Exchange Capacity (CEC) measured using the silver-thiourea method (Chhabra, 1975).

The range of ACLs shown in the tables below have been calculated using the reported results from the background samples taken to determine the range of CEC, pH and % clay content of the soils observed on-site. The most applicable criteria for the irrigation areas are highlighted in red in these tables.

Using the reported results for the background samples collected and analysed in this investigation in the 0-0.5 mbgl depth profile (root zone), the range of expected ACLs are shown for the metals of interest As, Cr III, Cu, Ni and Zn.

The mean CEC level in background samples taken in irrigation areas of Timber Getters was determined at 19 meq/100g and mean CEC level in background samples taken in irrigation areas of Amphitheatre at 32 meq/100g. Therefore, for this investigation the CEC for soil-specific ACLs has been chosen as 20 meq/100g for Timber Getters and 30 meq/100g for Amphitheatre, (meq/100g and cmol/kg are numerically identical when measuring soil CEC).

Where a value of a contaminant is less than the limit of reporting (LOR) and needs to be used to calculate SQGs, half the value of the LOR will be used.

2.1.1.1 Arsenic

Table 3 below compares values of the generic SQG for soil with different land uses, based on either Lowest Observed Effect Concentration (LOEC) and 30% effect concentration (EC30) toxicity data ($SQG_{(LOEC\ \&\ EC30)}$), or 50% Effect Concentration (EC50) toxicity data ($SQG_{(EC50)}$), and the value(s) in red chosen for this investigation.

Table 3: Soil quality guidelines for fresh arsenic contamination

Land use	SQG(LOEC & EC30) (mg/kg total As)	SQG(EC50) (mg/kg total As)
Areas of ecological significance	**20**	**30**
Urban residential/public open space	**50**	**90**
Commercial/industrial	**80**	**140**

Note: The value in red has been chosen for this investigation.

SQG Arsenic is 20 mg/kg + 2.5 mg/kg = 22.5 mg/kg for Timber Getters and Amphitheatre.

2.1.1.2 Copper

In Table 4 below are shown the soil-specific ACLs (mg/kg) based on LOEC and EC30 data for freshwater copper (Cu) contamination that should theoretically provide the appropriate level of protection (that is 99, 80 or 60% of species) to soil processes, soil invertebrate species and plant species in soils with a pH ranging from 4.5 to 8 and a CEC ranging from 5 to 60 cmolc/kg for various land uses, (Schedule, 2013b). The lower of the CEC- or the pH-derived ACLs for a particular land use that apply to a soil is to be used.

Table 4: Soil-specific ACLs (mg/kg) for Copper

Urban residential/public open space land use						
Type of ACL	**CEC(cmolc/kg)**					
CEC-based ACLs	**5**	**10**	**20**	**30**	**40**	**60**
	50	**100**	**110**	**110**	**120**	**120**
	pH					
pH-based ACLs	**4.5**	**5.5**	**6**	**6.5**	**7.5**	**8**
	30	**70**	**100**	**140**	**290**	**420**

Note: The values in red have been chosen for this investigation.

SQG Copper is 110 mg/kg + 20 mg/kg = 130 mg/kg for Timber Getters and

SQG Copper is 110 mg/kg + 15 mg/kg = 125 mg/kg for Amphitheatre.

2.1.1.3 Chromium III

In Table 5 below, the soil-specific ACLs (mg/kg) based on LOEC and EC30 data for chromium III (Cr) contamination should theoretically provide the appropriate level of protection for soil invertebrate species.

There was toxicity data for a total of 21 species or soil microbial processes. There was data for 2 soil invertebrate species, 12 species of plants and 7 soil microbial processes. This data meets the minimum data requirements recommended in Schedule B5b to use the BurrliOZ SSD method (Campbell et al. 2000). The ACLs are based on clay content of the soil. Timber Getters Clay content was measured at 33% and Amphitheatre was measured at 25%; therefore, in this investigation, all soil samples had a greater than 10% clay content.

Table 5: Soil-specific ACLs (mg/kg) for Chromium III

Urban residential/public open space land use	
Type of ACL	**Clay Content (% clay)**

CEC-based ACLs	**1**	**2.5**	**5**	**>=10**
	190	**250**	**320**	**400**

Note: The values in red have been chosen for this investigation.

i. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
ii. The EIL is calculated from summing the ACL and the ABC.
iii. CEC measured using the silver-thiouera method (Chabra et al, 1972).

SQG Chromium III is 400 mg/kg + 39 mg/kg = 439 mg/kg for Timber Getters and

SQG Chromium III is 400 mg/kg + 44 mg/kg = 444 mg/kg for Amphitheatre.

2.1.1.4 Nickel

Table 6 below shows data for the soil-specific ACLs (mg/kg) at a range of cation exchange capacities (CEC) for fresh nickel (Ni) contamination based on LOEC and EC30 toxicity data, and based on EC50 toxicity.

Table 6: Soil-specific ACLs (mg/kg) for Nickel

	Cation exchange capacities (cmolc/kg)					
Land Use	**5**	**10**	**20**	**30**	**40**	**60**
Areas of ecological significance	**5**	**30**	**45**	**60**	**70**	**95**

Note: The values in red have been chosen for this investigation.

i. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
ii. The EIL is calculated from summing the ACL and the ABC.
iii. CEC measured using the silver thiouera method (Chabra et al, 1972)

SQG Nickel is 45 mg/kg + 52 mg/kg = 97 mg/kg for Timber Getters and

SQG Nickel is 60 mg/kg + 68 mg/kg = 128 mg/kg for Amphitheatre.

2.1.1.5 Mercury

Mercury is an extremely toxic substance with a lowest-observed-effect concentration [LOEC]) of only 0.25 mg/kg ((Liu et al., 2010).

The Soil Quality Guideline (SQG) specific to the soil being investigated will be calculated by the addition of the Added Contaminant Level (ACL) to the ambient background concentration (ABC), thus:

$(SQG_{(LOEC\ \&\ EC30)}) = ACL(LOEC) + ABC$

SQG Mercury is 0.25 mg/kg + 0.5 mg/kg = 0.75 mg/kg for Timber Getters and Amphitheatre.

2.1.1.6 Lead

Table 7 below shows, the soil-specific ACLs (mg/kg) at a range of cation exchange capacities for fresh nickel (Ni) contamination based on LOEC and EC30 toxicity data, and based on EC50 toxicity.Table 7: Generic added contaminant limit for lead in soils irrespective of their physico-chemical properties

Chemical	Pb added contaminant level (ACL), mg added contaminant/kg) for various land uses
	Areas of ecological significance
Lead (Pb)	470

Notes:

1. Aged values are applicable to lead contamination present in soil for at least 2 years. For Fresh contamination refer to Schedule B5c.
2. The EIL is calculated from summing the ACL and the ABC.

SQG Lead is 470 mg/kg + 4.7 mg/kg = 475 mg/kg for Timber Getters and

SQG Lead is 470 mg/kg + 2.5 mg/kg = 478 mg/kg for Amphitheatre

2.1.1.7 Zinc

In Table 8 below is shown soil-specific ACLs based on lowest observed effect concentration (LOEC) and 30% effect concentration toxicity (EC#)) data ($ACL_{(LOEC\ \&\ EC30)}$, mg/kg) for fresh zinc (Zn) which should theoretically provide the appropriate level of protection (for 80% of species) to soil processes, invertebrate species and vegetation species in soils with a pH ranging from 4.0 to 7.5, and CEC values ranging from 5 to 60 cmolc/kg. These are the recommended ACL values in freshly contaminated soils with each land use.

Table 8: Soil-specific ACLs (mg/kg) for Zinc

Protection of 99% species for areas of ecological significance						
pH	CEC (cmolc/kg)					
	5	10	20	30	40	60
4	4	5	5	5	5	5
4.5	6	8	8	8	8	8
5	8	10	10	10	10	10
5.5	10	15	15	15	15	15
6	5	25	25	25	25	25
6.5	15	25	35	35	35	35
7	15	25	45	55	55	55

Protection of 99% species for areas of ecological significance						
pH			CEC (cmolc/kg)			
7.5	90	25	45	60	75	80

The above derivation of EILs for the metals of interest and the Soil Quality Guideline (SQG) specific to the soil being investigated in this assessments have been calculated by the addition of the Added Contaminant Level (ACL) to the ambient background concentration (ABC), thus:

SQG(LOEC & EC30) = ACL(LOEC & EC30) + ABC

$SQG_{(Timber\ Getters)}$= 25 + 90 = 115 mg/kg & $SQG_{(Amphitheatre)}$= 25 + 66 = 91 mg/kg

2.2 Irrigation Disposal Area

The following assessment criteria will be used to assess the long term sustainability of the **irrigation disposal areas.**

2.2.1 Nutrients and Physico-chemical Parameters

The decision on the applicable soil assessment criteria to select Nutrients and Physico-chemical parameters for this investigation was made with reference to the MEDLI modelling completed for the site.

The physico-chemical properties, anions and cations, nutrients and level of organic matter in the soil have the ability to promote or retard growth of the vegetation used to further polish treated wastewaters. The plant medium selected by the operator of Scenic Rim Trail is pastures and the assessment criteria for this monitoring program uses the selected pasture as the target receptor for foliage assessment.

2.2.2 pH, EC and CEC

Soil pH affects the availability of nutrients in the soil, with various nutrient availability having different affected pH range. In general, most nutrients are available to plants in the range of pH 5 – 9, (Hazelton P & Murphy B, 2013).

Cation Exchange Capacity (CEC) is the capacity of the soil to hold and exchange cations, and provides buffering capacity to changes in pH, available nutrients, calcium levels and soil structure, (Hazelton P & Murphy B, 2013).

Metson, (1961) suggests the following ratings of CEC cmol(+)/kg, (Metson, 1961).

Table 9: Ratings of CEC

Ratings	CEC cmol(+)/kg
Very Low	<6
Low	6-12
Moderate	12-25
High	25-40
Very High	>40

2.2.3 Salinity

Soil salinity refers to the accumulation of water-soluble salts in soils, which are predominantly sodium, but also potassium, calcium and magnesium have an effect on salinity, usually in the forms of chlorides, sulphates or carbonates (Hazelton P and Murphy B, 2013).

MEH converted EC 1:5 (µS/m) to electrical conductivity of saturated conductivity ECe (dS/m) by using the method of Slavich and Petterson (1993), i.e. multiplying the EC 1:5 by a factor of 8.6 and dividing by 100 (Slavich, 1993).

Hazelton P & Murphy B, (2013) suggest that using values adapted from (Richards, 1954), the following Saline ratings can be given:

Table 10: Salinity ratings for soil based on ECe

Rating	ECe dS/m	Effects on Plants	WQO for the site
Non-saline	<2	salinity effects mostly negligible	
Slightly Saline	2-4	yields of sensitive crops affected	
Moderately Saline	4-8	yields of many crops are affected	Average root zone salinity ECSE 4.5 – 7.7 dS/cm
Highly Saline	8-16	only tolerant crops yield satisfactorily	
Extremely Saline	>16	only very tolerant crops yield satisfactorily	

2.2.4 Soil Sodicity

Sodicity of soils occurs when exchangeable sodium on the cation-exchange complex leads to clay dispersion in soil, when soil becomes wet, (Hazelton P & Murphy B, 2013).

The exchangeable sodium percentage (ESP) is the proportion of exchangeable sodium to all other exchangeable cations by way of CEC.

2.2.5 Sodium Adsorption Ratio

Sodium Adsorption Ratio (SAR) is a dimensionless empirical measure of the sodium imbalance of a soil solution and is a measure of the sodium in the infiltrating water, which may lead to deflocculation or dispersal of the soil, (Hazelton P & Murphy B, 2013).

Hart (ANZECC 1992) suggests that very sensitive plants such as citrus and avocado can only tolerate levels of 2 – 8 SAR in irrigation water, (Hart, 1974), (ANZECC and ARMCANZ, 2000). The WQO suggest irrigation water ranging from 16 – 46 level of SAR.

2.3 Plant Tissue Analysis

There are no criteria for plant tissue analysis defined in the EA. The certificate of analysis from the laboratory provides an optimal range for parameters based upon the region, soil type, crop, crop stage and sample type provided. The optimal range for tested parameters, provided by the laboratory for pasture crop, are shown in Table 11 below.

Table 11: Optimal Ranges for Plant Tissue Analysis

Parameter of Interest	Units	Optimal Range	Parameter of Interest	Units	Optimal Range
Total Nitrogen	%	3-4.5	**Boron**	ppm	30-80
Nitrate N	ppm		**Copper**	ppm	6-15
Phosphate	%	0.2-0.35	**Iron**	ppm	50-200
Potassium	%	2-2.5	**Manganese**	ppm	50-250
Calcium	%	0.25-0.55	**Zinc**	ppm	15-20
Magnesium	%	0.2-0.6	**Sodium**	%	0.1-1

Sulfate	%	0.25-0.4	**Chloride**	%	0.05-1.4

3 Laboratory Analysis

3.1 Basis of Selection of Laboratory Samples

Forty-five (45) soil samples were selected for analysis on the basis of the historical use of the irrigation field, stratigraphic position, site distribution and field observations.

3.2 Analysis Undertaken

All samples were submitted to an analytical laboratory accredited by the National Association of Testing Authorities (NATA) for the tests performed. The analytical methods used are accredited in-house methods referenced from National Environmental Protection Council (NEPC), American Society for Testing and Materials (ASTM), and modified United State Environmental Protection Agency (USEPA) / American Public Health Association (APHA) documents.

Laboratory analysis for organic compounds and inorganic analysis was undertaken by Australian Laboratory Services Pty Ltd (ALS). ALS is NATA accredited for the analysis methods undertaken and summarised in Table 12 below.

Table 12: Analytical Methods

Group	Analyte	ALS Reference
Physico-chemical properties	pH, electrical conductivity, moisture content	SOIL – EA002 pH (1:5), SOIL – EA010 (solids): Electrical Conductivity (1:5), SOIL – EA055-103 Moisture Content
Anions	Sulphur, chloride	SOIL – ED042T Sulfur – Total as S (high temperature furnace method, SOIL – ED045G (solids) Chloride Soluble by Discrete Analyser
Cations	Calcium, magnesium, sodium potassium, SAR, salts	SOIL – ED093S Soluble Major Cations (Ca, Mg, Na, K), SOIL – EA006 Sodium Adsorption Ratio (SAR), SOIL – EA014 Total Soluble Salts
Exchangeable Cations	Exchangeable calcium, magnesium sodium potassium	SOIL – ED006 Rayment & Lyons 2011 Exchangeable Cations on Alkaline Soils (Ca, Mg, Na, K), SOIL – ED007 Exchangeable Cations (Ca, Mg, Na, K)
Nutrients of N	Ammonia, total nitrogen total Kjeldahl nitrogen, nitrite + nitrate	SOIL – EK055 Ammonia as N, SOIL – EK057G Nitrite by Discrete Analyser, SOIL – EK058G Nitrate by Discrete Analyser, SOIL – EK061G Total Kjeldahl Nitrogen by Discrete Analyser, SOIL - EK062G Total Nitrogen as N (TKN + NOx)
Nutrients of P	Total phosphorus, reactive phosphorus, phosphate sorption capacity, bicarbonate extractable phosphorus	SOIL - EK067G Total Phosphorus as P by Discrete Analyser, SOIL - EK071G Reactive Phosphorus as P By Discrete Analyser, SOIL - EK072 Phosphate Sorption Index & Phosphate Sorption Capacity, SOIL – EK080 Bicarbonate Extractable Phosphorus (Colwell)
Emerson Aggregate Test	Colour, texture, Emerson class number	SOIL – EA058 Emerson Aggregate Test
Exchange Acidity	Exchange acidity, exchangeable aluminium	SOIL – ED005 Exchange Acidity

3.3 Quality Assurance/Quality Control (QA/QC)

For any given project, all investigation data is potentially subject to sampling and data reduction errors. Data Quality Objectives (DQOs) are, therefore, established to control the sources of errors and quantify the errors whenever possible. Quality Control (QC) procedures are designed to both increase sample data quality and help interpret discrepancies in results.

All work was conducted in accordance with industry-accepted standards and quality assured procedures. Field quality control includes rigorous sample collection, decontamination procedures, and sample documentation.

Unfortunately, during this particular round of soil sampling, QC procedures were not implemented as no representative QC samples were collected for subsequent laboratory analyses. However, four field duplicates were collected in Timber Getters and Amphitheatre. Following these analyses, laboratory and sampling data quality objectives were analysed and reported in terms of data precision, accuracy, and completeness.

Standard field procedures require that for soil sampling, samples are collected from discrete locations and not composited. A rinsate blank was not collected in order to verify the sampling procedure, as the media was sampled directly into sample jars using new nitrile gloves for each sample.

Laboratory Quality Assurance (QA) and Quality Control (QC) procedures included matrix spikes, laboratory duplicates and method blanks were conducted by the Laboratory. Further detail of MEL's QA/QC procedures is presented in **Appendix A**.

3.4 Data Usability

Information generated from environmental investigations requires some statement in regard to the usability of the data and, therefore, Quality Assurance (QA) and Quality Control (QC) are an integral part of the analysis and interpretation of environmental data.

QA involves all of the actions, procedures, checks and decisions undertaken to ensure the representativeness and integrity of samples and accuracy and reliability of analytical results (NEPC 2013). QC is the component of QA which monitors and measures the effectiveness of other procedures by the comparison of these measures to previously decided objectives.

If data is assessed in terms of data usability, in accordance with the relevant guidance as described above, and meets all requirements, then the data may be considered as of suitable quality to support the project conclusions. Where data does not comply with all requirements, it will be assessed on a case by case basis and may be considered as estimates with low reliability.

3.4.1 Grouping of Data and Statistical Interpretation

For statistical interpretation, all data must be grouped appropriately, (e.g. different types of fill, natural etc.) grouped separately, with at least seven data points for each group.

Further to meeting the above requirements, for the site to be considered uncontaminated or having no significant impact on the environment resulting in material environmental harm the following must be also be met,:

- the 95% Upper Confidence Limits (UCL) of the arithmetic average concentration must be below the acceptable limit;
- the standard deviation of the results must be less that 50% of the criterion; and
- no single value may exceed 250% of the criteria.

If the 95% of the UCL of the arithmetic average concentration exceeds the acceptable limit, the site or a sampling area cannot be considered uncontaminated or successfully remediated (Schedule, 2013a).

Note: If the data is grouped and statistically interpreted to the above requirements, then it will be considered as reliable and suitable to support the project conclusions. If data fails one of the above requirements, then it will be assessed on a case by case basis where the land use, media and contaminant will be taken into consideration in determining it's suitability (DEC, 2006).

3.5 Tolerable Limits on Decision Errors

The National Environmental Protection Measure (NEPM) states that "At the very least, the maximum and the 95% UCL of the arithmetic mean contaminant concentration should be compared to the relevant Tier 1 screening criteria" (Schedule, 2013a).

Following the above six steps of the DQO process, step 7 is to optimise the design of the proposed sampling and analysis program. Accordingly, the proposed sampling and analysis program is incorporated into Section 4 and 5 and forms the Sampling Analysis Quality Plan (SAQP).

The inputs into the decision process are complete and the limited SAQP for the site is presented below.

3.5.1 Sample Analysis

Soil samples were selected for laboratory analysis based on lithology and field observations (visible soil horizons). The parameters outlined in **Table 12 above** were selected to characterise the soil samples collected during the site visit.

4 Results

4.1 QA/QC

Laboratory certificates of analysis are shown in **Appendix C** and a table presenting a summary of these analytical results is shown in **Table 17** in **Tables** at the end of this report.

The quality assurance report included with the official laboratory results presented in **Appendix C** show that both the ALS laboratory method blank and sample were free from analyte concentrations above the nominated laboratory reporting level. Laboratory duplicate sample RPDs for ALS were below the nominated acceptance criteria as were the percentage recoveries. Thus, the internal laboratory QA/QC results included in **Appendix C** meet the laboratory's quality control requirements.

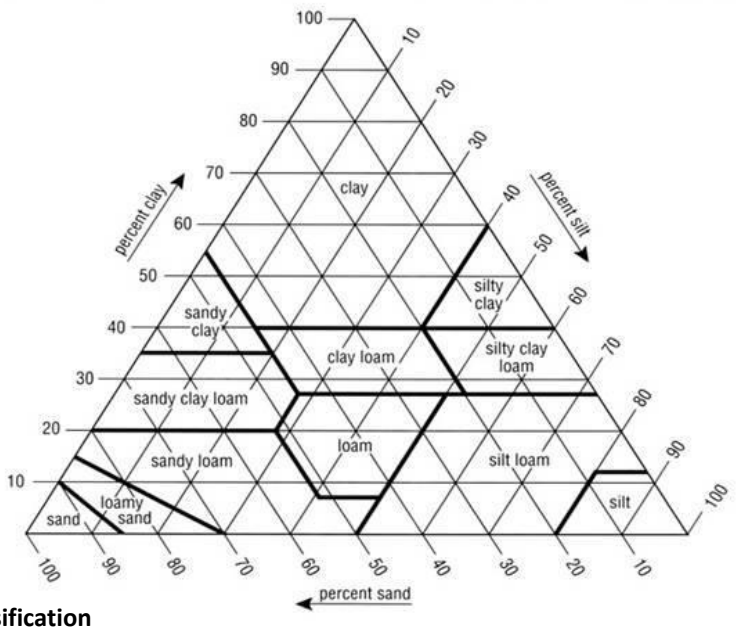
The field duplicates of primary samples demonstrated precision in the sampling techniques, with only 1 sample (2%) being >50% relative percentage difference (RPD) and 31 samples (48%) being <50% RPD and 32 samples (50%) were not applicable due to one of the samples being below the limit of reporting (LOR).

Therefore, the quality assurance and quality control assessment has determined that the accuracy and precision of the duplicate laboratory results are acceptable.

4.2 Soil Classification

Particle size analysis undertaken for the baseline investigation to determine the water and nutrient holding capabilities and resultant drainage of the soils within the irrigation disposal areas are shown in Table 13 and Table 16 respectively.

The samples have been classified using the Australian Standard AS 1726 – *Geotechnical site investigations* using particle size distribution of Clay (<2 µm), Silt (2-60 µm) Sand (0.06-2.00 mm) Gravel (>2 mm) and Cobbles (>6 cm). This has been translated into soil types using the soil classification Flow Chart 1. below.



Flow Chart 1 : Soil Classification

4.3 Soil Quality Results: Timber Getters EcoCamp Irrigation Area

Fifteen(15) hand-augered boreholes were advanced on the 29th August 2025 to be representative of the soils within 50 meters of the Timber Getters EcoCamp area, as shown in **Figure 7** in **Figures**.

Three (3) background, two (2) additional and three (3) irrigation area hand-augered boreholes were advanced on the 7th May 2026. The three (3) background boreholes had one surface soil sample taken from each borehole, to use in calculating EILs (see section 2.1.1), as well as two more primary samples and four duplicates for use in quality control (see section 4.1).

The three (3) irrigation area hand-augered boreholes were sampled at 100, 300 and 600 mm depth and the results of soil classification, physico-chemical and nutrient results are shown in **Table 13** below and discussed thereafter.

Table 13: Soil Classification and Results in Irrigation area at Timber Getters 2025

	Sample ID	TG_I-1-100	TG_I-1-300	TG_I-1-600	TG_I-2-100	TG_I-2-300	TG_I-2-600	TG_I-3-100	TG_I-3-300	TG_I-3-600
	Soil Texture		Dusky Red (2.5YR 3/2), Light Medium Clay	Very Dark Gray (7.5YR 3/1), Light Medium Clay		Very Dark Brown (7.5YR 2.5/3), Medium Heavy Clay	Dark Brown (7.5YR 3/2), Light Medium Clay		Very Dark Brown (7.5YR 2.5/2), Light Medium Clay	Very Dark Brown (7.5YR 2.5/2), Medium Clay
	Soil Classification		CLAY	Gravelly LOAM		CLAY	SILY CLAY LOAM		CLAY LOAM	CLAY LOAM
	Clay (<2 µm)	----	45	22	----	44	32	----	35	30
	Silt (2-60 µm)	----	37	28	----	40	45	----	41	45
	Sand (0.06-2.00 mm)	----	10	5	----	12	11	----	11	11
	Gravel (>2mm)	----	8	45	----	4	12	----	13	14
	Cobbles (>6cm)	----	<1	<1	----	<1	<1	----	<1	<1
	Emerson Class Number		5	7		5	7		7	7
	Horizon	A	B	C	A	B	C	A	B	C
	Soil stratum (m)	0-0.10	0.15-0.30	0.30-0.60	0-0.10	0.15-0.30	0.30-0.60	0-0.10	0.15-0.30	0.30-0.60
	Depth Stratum (m)	0.10	0.15	0.30	0.10	0.15	0.30	0.10	0.15	0.30
August 2025	pH	6.5	6.4	6.3	----	6.3	6.1	6.2	6.0	6.1
	EC 1:5 uS/cm	19	23	17	----	13	12	14	10	11
	Orgainc matter %	12.2	8.1	11.2	4.2	3.2	8.7	7.6	17.6	10.0
	CEC	22.4	18.6	18.1	19.1	17.6	17.9	17.6	19.5	18.6
	ESP	1.8	1.7	1.8	0.7	0.8	1.3	0.5	0.4	0.7
	Total Nitrogen	4210	1490	900	1850	1230	2630	1170	4230	2680
	Total Phosphorus	1940	1790	1700	2390	1900	3320	1450	3260	3410

The samples highlighted in light yellow are considered to be in the root zone of grasses in Timber Getters irrigation area

4.3.1 Soil Classification: Timber Getters EcoCamp Irrigation Area

The clay loams or silty clay loams of the soil horizons generally have a CEC of more than 17 and less than 23 meq/100g, demonstrating a moderate buffering capacity to changes in pH, available nutrients, calcium levels and soil structure.

Lithology of the soil profiles encountered can be seen in the trial pit logs in **Appendix B**.

4.3.2 Physico-Chemical Properties: Timber Getters EcoCamp Irrigation Area

The analysis of physico-chemical properties pH and EC including organic matter content for the soil samples from Timber Getters, submitted to ALS are summarised below. The high standard deviations observed are a result of grouping soil horizons for analysis, due to the small sample size.

- Soil pH results in this round of baseline indicate that the site soils are neutral in nature with reported pH values ranging from pH 6.0 up to pH 6.5.
- The reported EC of the soils in this round of baseline ranged from 10 µS/cm to 23 µS/cm, converting to ECe (dS/m) by using the method of Slavich and Petterson, (Slavich, 1993), 1 - 2 (dS/cm). These results demonstrate the ECe (dS/m) soils within the area are considered to be non-saline.
- The total soluble salt ranged from 33 mg/kg to 77 mg/kg with an average of 51 in baseline soil survey for the irrigation area at Timber Getters.
- Organic matter of the soils in this round of baseline ranged from 3.2 to 17.6%, with low and high values at various depths across the three, indicating a high degree of variability of organic matter.
- The CEC of the soils in this round of baseline ranged from 17.6 meq/100g to 22.4 meq/100g, which indicates a high degree of buffering capacity with respect to cation exchange.
- Emerson aggregate testing for soils resulted in an Emerson class number of 5 or 7 for all sample locations in the irrigation area of Timber Getters. An Emerson class number of 5 indicates some dispersion and 7 indicates no dispersion of soils.
- The physico-chemical properties in Timber Getters irrigation area indicate stable soils with regards to erosion and a high degree of buffering capacity with regards to salts, which indicates suitable soils for irrigation.

4.3.3 Cations and Anions Properties: Timber Getters EcoCamp Irrigation Area

Table 14: Exchange Acidity / Cations in irrigation area at Timber Getters in this baseline study

Parameter	Units	Min Value within Irrigation Area	Max Value within Irrigation Area	Mean Value within Irrigation Area
Exchange Acidity	meq/100g	0.10	0.70	0.23
Exchangeable Aluminium	meq/100g	0.40	0.40	0.40
Exchangeable Calcium	meq/100g	13.00	24.40	18.88
Exchangeable Magnesium	meq/100g	8.10	17.40	11.54
Exchangeable Potassium	meq/100g	0.60	1.40	0.97
Exchangeable Sodium	meq/100g	0.20	0.50	0.28
Cation Exchange Capacity	meq/100g	22.20	38.00	31.82
Exchangeable Sodium Percent	%	0.30	1.40	0.86
Calcium/Magnesium Ratio		1.00	2.20	1.68

Parameter	Units	Min Value within Irrigation Area	Max Value within Irrigation Area	Mean Value within Irrigation Area
Magnesium/Potassium Ratio		7.80	31.00	13.58

Reported soil concentrations of the exchangeable cations (Al, Ca, Mg, K & Na) for all soil samples within the irrigation area at Timber Getters in this baseline study submitted are shown in Table 14 above. We have not differentiated the values within the soil horizons as there was no discernible trend in depth.

4.3.4 Metalloid Properties: Timber Getters EcoCamp Irrigation Area

Table 15: Metalloid soil concentrations in irrigation area at Timber Getters in this baseline study

Parameter	Units	SQG Timber Getters	Min Value within Irrigation Area	Max Value within Irrigation Area	Mean Value within Irrigation Area
Arsenic	mg/kg	22.5	All results were below LOR of 5 mg/kg		
Cadmium	mg/kg	20[2]	All results were below LOR of 1 mg/kg		
Chromium	mg/kg	439[1]	39	57	49.7
Copper	mg/kg	130	18	68	32.0
Lead	mg/kg	475	All results were below LOR of 5 mg/kg		
Nickel	mg/kg	97	39	70	55.1
Zinc	mg/kg	115[(3)]	62	118	85.9
Mercury	mg/kg	0.75	All results were below LOR of 0.1 mg/kg		

Notes:

(1) – The SQG is the for Chromium III and the soil result is Chromuim (III + VI). Therefore, the SQG is more conservative.

(2) – As there are no EILs fpor Cadmium, we are using HILs 'A' under NEPM Schedule B1, (NEPC, 2013d).

(3) – Calculated using pH and CEC levels in Timber Getters irrigation areas.

All soil results shown in Table 15 above were below the SQG for metalloids concentrations within the soils within the irrigation area of the Timber Getters EcoCamp, with an exception of maximum value of zinc; however, the mean value is within criteria.

Subsquent years will assess if there is any change in the status of metalloid soil concentrationms within the soils of the irrigation areas.

4.3.5 Nutrient Properties: Timber Getters EcoCamp Irrigation Area

- The root zone (A horizon) within the irrigation area at Timber Getters in this baseline study shows:
  - Total Nitrogen levels ranging from 1,170 to 4,210 mg/kg, with the majority of the nitrogen in the organic form TKN (Organic N), none detected as Ammonia and low levels in Nox; and
  - Total Phosphorus levels ranging from 1,450 to 2,390 mg/kg.
- The B horizon within the irrigation area at Timber Getters in this baseline study shows:
  - Total Nitrogen levels ranging from 1,490 to 4,230 mg/kg, slightly lower than the A horizon, with the majority of the nitrogen in the organic form TKN (Organic N), none detected as Ammonia and low levels in Nox; and
  - Total Phosphorus levels ranging from 1,790 to 3,260 mg/kg.
- The C horizons within the irrigation area at Timber Getters in this baseline study shows:
  - Total Nitrogen levels ranging from 900 to 2,680 mg/kg, being slightly lower than the B horizon with the majority of the nitrogen in the organic form TKN (Organic N), none detected as Ammonia and low levels in Nox; and

- Total Phosphorus levels ranging from 1,700 to 3,410 mg/kg.

- The Total Phosphorus were similar in the three horizons in the irrigation area at Timber Getters in this baseline study.

4.4 Soil Quality Results Amphitheatre EcoCamp Irrigation Area

Nineteen (19) hand-augered boreholes were advanced on the 28th August 2025 to be representative of the soils within 50 meters of the Amphitheatre EcoCamp area, as shown in **Figure 6** in **Figures**.

Three (3) background, two (2) additional and three (3) irrigation area hand-augered boreholes were advanced on the 8th May 2026. The three (3) background boreholes had one surface soil sample taken from each borehole, to use in calculating EILs (see section 2.1.1), as well as two more primary samples and four duplicates for use in quality control (see section 4.1).

The three (3) irrigation area hand-augered boreholes were sampled at 100, 300 and 600mm depth and the results of soil classification, physico-chemical and nutrient resultsd are shown in Table 16below and discussed thereafter.

Table 16: Soil Classification and Results in Irrigation area at Amphitheatre 2025

	Sample ID	AMP_I-1-100	AMP_I-1-300	AMP_I-1-600	AMP_I-2-100	AMP_I-2-300	AMP_I-2-600	AMP_I-3-100	AMP_I-3-300	AMP_I-3-600
	Soil Texture	Black (5YR 2.5/1), Medium Clay	Dusky Red (2.5YR 3/2), Light Clay	Dark Brown (7.5YR 3/2), Medium Clay	----, ----	Very Dark Grayish Brown (10YR 3/2), Light Medium Clay	Dark Reddish Brown (5YR 3/2), Light Clay	----, ----	Very Dark Gray (7.5YR 3/1), Light Medium Clay	Reddish Black (2.5YR 2.5/1), Light Clay
	Soil Classification		LOAM	SILTLOAM		LOAM	SILT LOAM		SILT LOAM	SILT LOAM
	Clay (<2 µm)	----	22	19	----	18	16	----	18	19
	Silt (2-60 µm)	----	54	54	----	57	53	----	66	64
	Sand (0.06-2.00 mm)	----	16	14	----	14	11	----	9	11
	Gravel (>2mm)	----	8	13	----	11	20	----	7	6
	Cobbles (>6cm)	----	<1	<1	----	<1	<1	----	<1	<1
	Emerson Class Number		5	7		5	7		7	7
	Horizon	A	B	C	A	B	C	A	B	C
	Soil stratum (m)	0-0.10	0.15-0.30	0.30-0.60	0-0.10	0.15-0.30	0.30-0.60	0-0.10	0.15-0.30	0.30-0.60
	Depth Stratum (m)	0.10	0.15	0.30	0.10	0.15	0.30	0.10	0.15	0.30
August 2025	pH	----	6.0	6.4	6.0	5.8	5.7	6.2	5.9	6.0
	EC 1:5 uS/cm	----	15	10	13	19	16	35	33	22
	Organic Matter %	17.8	7.7	2.4	2.7	13.1	8.2	2.9	11.8	10.1
	CEC	30.7	35.0	38.0	37.1	31.0	28.6	36.4	27.4	22.2
	ESP	0.3	0.6	1.4	0.6	0.7	1.2	0.8	1.0	1.1
	Total Nitrogen	5590	3120	1200	5440	4300	1760	6810	5000	3710
	Total Phosphorus	1850	1670	1400	1520	2250	2060	1960	1820	1920

The samples highlighted in light yellow are considered to be in the root zone of grasses in Amphitheatre irrigation area

4.4.1 Soil Classification: Amphitheatre EcoCamp Irrigation Area

The loams or loamy silts of the soil horizons generally have a CEC of more than 20 and less than 40 meq/100g, demonstrating a high buffering capacity to changes in pH, available nutrients, calcium levels and soil structure.

Lithology of the soil profiles encountered can be seen in the trial pit logs in **Appendix B**.

4.4.2 Physico-Chemical Properties Amphitheater EcoCamp Irrigation Area

The analysis of physico-chemical properties pH and EC including organic matter content for the soil samples from Amphitheatre, submitted to ALS are summarised below. The high standard deviations observed are a result of grouping soil horizons for analysis, due to the small sample size.

- Soil pH results in this round of baseline testing indicate that the site soils are neutral in nature with reported pH values ranging from pH 6.0 up to pH 6.4.
- The reported EC of the soils in this round of baseline ranged from 10 µS/cm to 35 µS/cm, converting to ECe (dS/m) by using the method of Slavich and Petterson (1993), 1 - 3 (dS/cm). These results demonstrate the ECe (dS/m) soils within the area are considered to be non saline.
- The total soluble salt ranged from 33 mg/kg to 152 mg/kg with an average of 78 in baseline soil survey for the irrigation area at Amphitheatre.
- Organic matter of the soils in this round of baseline ranged from 2.7 to 17.8%, with low and high values at various depths across the three, indicating a high degree of variability of organic matter.
- The CEC of the soils in this round of baseline ranged from 22.8 meq/100g to 38 meq/100g, which is indicates a high degree of buffering capacity with respect to cation exchange.
- Emerson aggregate testing for soils resulted in an Emerson class number of 5 or 7 for all sample locations in the irrigation area of Amphitheatre. An Emerson class number of 5 indicates some dispersion and 7 indicates no dispersion of soils.
- The physico-chemical properties in Amphitheatre irrigation area indicate stable soils with regards to erosion and a high degree of buffering capacity with regards to salts, which indicates suitable soils for irrigation.

4.4.3 Cations and Anions Properties Amphitheatre EcoCamp Irrigation Area

Reported soil concentrations of the exchangeable cations (Al, Ca, Mg, K & Na) for all soil samples within the irrigation area at Amphitheatre in this baseline study submitted are shown in Table 17 below. We have not differentiated the values within the soil borizons as there was no discernible trend in depth.

Table 17: Exchange Acidity / Cations in irrigation area at Amphitheatre in this baseline study

Parameter	Units	Min Value within Irrigation Area	Max Value within Irrigation Area	Mean Value within Irrigation Area
Exchange Acidity	meq/100g	0.10	0.70	0.23
Exchangeable Aluminium	meq/100g	0.40	0.40	0.40
Exchangeable Calcium	meq/100g	13.00	24.40	18.88
Exchangeable Magnesium	meq/100g	8.10	17.40	11.54
Exchangeable Potassium	meq/100g	0.60	1.40	0.97
Exchangeable Sodium	meq/100g	0.20	0.50	0.28
Cation Exchange Capacity	meq/100g	22.20	38.00	31.82
Exchangeable Sodium Percent	%	0.30	1.40	0.86

Parameter	Units	Min Value within Irrigation Area	Max Value within Irrigation Area	Mean Value within Irrigation Area
Calcium/Magnesium Ratio		1.00	2.20	1.68
Magnesium/Potassium Ratio		7.80	31.00	13.58

4.4.4 Metalloid Properties Amphitheatre EcoCamp Irrigation Area

All soil results shown in Table 18 below were below the SQG for metalloids concentrations within the soils within the irrigation area of the Amphitheatre EcoCamp.

Subsequent years will assess if there is any change in the status of metalloid soil concentrationms within the soils of the irrigation areas.

Table 18: Metalloid soil concentrations in irrigation area at Amphitheatre in this baseline study

Parameter	Units	SQG Amphitheatre	Min Value within Irrigation Area	Max Value within Irrigation Area	Mean Value within Irrigation Area
Arsenic	mg/kg	22.5	All results were below LOR of 5 mg/kg		
Cadmium	mg/kg	20[2]	All results were below LOR of 1 mg/kg		
Chromium	mg/kg	444[1]	44	69	55.6
Copper	mg/kg	125	11	16	13.1
Lead	mg/kg	478	All results were below LOR of 5 mg/kg		
Nickel	mg/kg	128	49	71	61.0
Zinc	mg/kg	91[(3)]	51	82	62.3
Mercury	mg/kg	0.75	All results were below LOR of 0.1 mg/kg		

Notes:

(1) – The SQG is the for Chromium III and the soil result is Chromuim (III + VI). Therefore, the SQG is more conservative.

(2) – As there are no EILs fpor Cadmium, we are using HILs 'A' under NEPM Schedule B1, (NEPC, 2013d).

(3) – Calculated using pH and CEC levels in Amphitheatre irrigation areas.

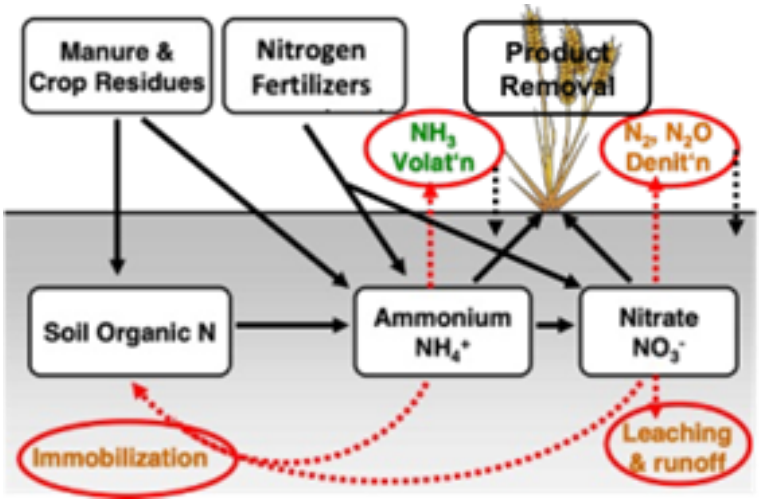
4.4.5 Nutrient Properties Amphitheatre EcoCamp Irrigation Area

- The root zone (A horizon) within the irrigation area at Amphitheatre in this baseline study shows:
  - Total Nitrogen levels ranging from 5440 to 6810 mg/kg, with the majority of the nitrogen in the organic form TKN (Organic N),none in Ammonia and low levels in Nox; and
  - Total Phosphorus levels ranging from 1520 to 1960 mg/kg.
- The B horizon within the irrigation area at Amphitheatre in this baseline study shows:
  - Total Nitrogen levels ranging from 3120 to 5000 mg/kg, slightly lower than the A horizon, with the majority of the nitrogen in the organic form TKN (Organic N),none in Ammonia and low levels in NOx.
  - Total Phosphorus levels ranging from 1670 to 2250 mg/kg.
- The C horizons within the irrigation area at Amphitheatre in this baseline study shows:
  - Total Nitrogen levels ranging from 1200 to 4300 mg/kg, slightly lower than the B horizon with the majority of the nitrogen in the organic form TKN (Organic N) and none in Ammonia or low levels in NOx.
  - Total Phosphorus levels ranging from 1400 to 2060 mg/kg.
- The Total Phosphorus were similar in the three horizons in the irrigation area at Amphitheatre in this baseline study.

4.5 Summary of Nutrient Cycling in Irrigation Areas of both EcoCamps

The high levels of Organic Nitrogen and low levels of Ammonia and Nitrates indicate a natural ecosystem with high level of nitrogen recycling. Almost all the available nitrogen has been taken up by vegetation and there is a high degree of compost (organic N) waiting to be assimilated into Ammonia and then Nitrates for uptake by vegetation.

The level of Organic-N is higher in Amphitheatre than Timber Getters, albeit, both sites demonstrate high levels of Organic-N in their soils. This is a vibrant rainforest with a high degree of nutrient cycling occurring naturally in the soils and plants of the edcosystem.



Schematic 2 : Nitrogen cycling inputs and losses, (Norton, 2025).

This baseline study of the irrigation areas and the previous baseline study in 2019, (MEL, 2019), demonstrate the soils at both the EcoCamps have naturally high degrees of nutrients and the EcoCamps are in a high nutrient environment. This may have implications for trigger levels of Treated Effluent as shown in Table 6 of the Plan for Wastewater and Sewage Management (PWaSM) (MEH, 2025a), for Amphitheatre and Woodcutters EcoCamps.

However, the irrigation areas have a high ability to absorb nutrients from the irrigated treated effluent as shown in sections above4.4.5 due to a high degree of buffering capacity with respect to cation and nutrient exchange.

4.5.1 Plant Tissue Analysis

Results of plant dry tissue analysis are given in **Table 19** below. There are no criteria for plant tissue analysis defined in the PWaSM, other than an optimal range for parameters based upon the region, soil type, crop, crop stage and sample type provided. The optimal range for tested parameters, provided by the laboratory for pasture crop, are shown in **Table 11**.

Table 19: Plant Analysis for Amphitheater and Timber Getters

		Lab Number	1JLP25042	1JLP25043	Optimal Range
		Date Received	30/09/2025	30/09/2025	
		Sample Name 1	30/09/25	30/09/25	
		Sample Name 2	Ampitheathre	Timber Getters	
		Sample Name 3	Moreton Environmental	Moreton Environmental	
Boron	mg/kg		26.01	21.68	30-80
Calcium	%		1.33	0.60	0.25-0.55
Chloride	%		0.46	0.19	0.05-1.4
Copper	mg/kg		10.73	8.11	6-15
Iron	mg/kg		128.35	44.53	50-200
Magnesium	%		0.41	0.31	0.2-0.6
Manganese	mg/kg		279.41	312.18	50-250
Nitrate Nitrogen	mg/kg		< 40.00	< 40.00	
Phosphorus	%		0.26	0.33	0.2-0.35
Potassium	%		1.11	0.73	2-2.5
Sodium	%		0.06	0.19	0.1-1
Sulfur	%		0.18	0.14	0.25-0.4
Total Nitrogen	%		2.58	1.81	3-4.5
Zinc	mg/kg		31.72	15.12	

The plant tissue analysis indicates the plants within the irrigation areas are within the correct range of elements for optimal growth, and the nitrogen levels in the plants indicate room for increased Nitrogen in plant tissue.

4.6 Soil Quality Results for EcoCamp Areas

In accordance with Sewage and Wastewater Monitoring Plan (SWMP) for Amphitheatre and Timber Getters EcoCamps, (MEH, 2025b).

MEH assessed the **soil quality data** of soil profiles within the boundaries of **Timber Getters Eco Camp** and **Amphitheatre View Wilderness EcoCamp** and within all areas proposed for disposal of treated sewage and wastewater and all areas within 50 metres of both the **Timber Getters EcoCamp** and **Amphitheatre View Wilderness EcoCamp**.

MEH achieved the above by the advanced nineteen (19) hand-augered boreholes to be representative of the soils in the Amphitheatre EcoCamp area and fifteen (15) hand-augered boreholes to be representative of the soils in the Timber Getters EcoCamp area.

A background samples were taken at each EcoCamp in order to facilitate site specific EILs.

Hand-augered boreholes were advanced to take surface samples within 0.10 meters below ground level (mbgl).

4.6.1 Soil Quality Results for Metalloid Soil Concentrations within 50m of Timber Getters EcoCamp Area

All soil results were below the SQG for metalloids concentrations within the soils within a 50-meter radius of the Timber Getters EcoCamp. The following results in Table 20 are for the EILs for metals.

Table 20: Soil Metalloid Concentrations in Baseline 2025 Study at Timber Getters

Parameter	Units	SQG Timber Getters	Minimum Value within EcoCamp Area	Maximum Value within EcoCamp Area	Mean Value within EcoCamp Area
Arsenic	mg/kg	22.5	All results were below LOR of 5 mg/kg		
Cadmium	mg/kg	20[2]	All results were below LOR of 1 mg/kg		
Chromium	mg/kg	439[1]	19	65	42.4
Copper	mg/kg	130	15	31	21.5
Lead	mg/kg	475	7	14	10.5
Nickel	mg/kg	97	26	73	46.6
Zinc	mg/kg	25[(3)]	56	12	83.2
Mercury	mg/kg	0.75	All results were below LOR of 0.1 mg/kg		

Notes:

(1) – The SQG is the for Chromium III and the soil result is Chromuim (III + VI). Therefore, the SQG is more conservative.

(2) – As there are no EILs fpor Cadmium, we are using HILs 'A' under NEPM Schedule B1, (NEPC, 2013d).

(3) – Calculated using pH and CEC levels in Timber Getters irrigation areas.

4.6.2 Soil Quality Results for Nutrient Soil Concentrations within 50m of Timber Getters EcoCamp Area

- The surface soil samples within the 50 m-radius Ecocamp area at Timber Getters in this baseline study shows Total Nitrogen levels ranging from 8010 to 1140 mg/kg, with the majority of the nitrogen in the organic form TKN (Organic N), a mean value of Ammonia of 65 mg/kg, and a mean value of NOx of 16 mg/kg.
- The surface soil samples within the 50 m-radius Ecocamp area at Timber Getters in this baseline study shows Total Phosphorus levels ranging from 3700 to 271 mg/kg.

4.6.3 Soil Quality Results for Metalloid Soil Concentrations within 50m of Amphitheater EcoCamp Area

All soil results were below the SQG for metalloids concentrations within the soils within a 50-m radius of the Amphitheatre EcoCamp. The following results are for the EILs for metals.

Table 21: Soil Metalloid Concentrations in Baseline 2025 Study at Amphitheatre

Parameter	Units	SQG Amphitheatre	Minimum Value within EcoCamp Area	Maximum Value within EcoCamp Area	Mean Value within EcoCamp Area
Arsenic	mg/kg	22.5	All results were below LOR of 5 mg/kg		
Cadmium	mg/kg	20[2]	All results were below LOR 1 mg/kg		
Chromium	mg/kg	444[1]	22	74	47.6
Copper	mg/kg	135	10	20	14.6
Lead	mg/kg	478	5	5	5
Nickel	mg/kg	128	34	77	56.5
Zinc	mg/kg	25[(3)]	42	86	60.0
Mercury	mg/kg	0.75	All results were below LOR 0.1 mg/kg		

Notes:

(1) – The SQG is the for Chromium III and the sopil result is Chromuim (III + VI). Therefore, the SQG is more conservative.

(2) – As there are no EILs fpor Cadmium, we are using HILs 'A' under NEPM Schedule B1, (NEPC, 2013d).

(3) – Calculated using pH and CEC levels in Timber Getters irrigation areas.

4.6.4 Soil Quality Results for Nutrient Soil Concentrations within 50m of Amphitheatre EcoCamp Area

The surface soil samples within the Amphitheatre EcoCamp 50m area in this baseline study show Total Nitrogen levels ranging from 8010 to 1140 mg/kg, with the majority of the nitrogen in the organic form TKN (Organic N), a mean value of Ammonia of 65 mg/kg, a mean value of NOx of 16 mg/kg and Total Phosphorus levels ranging from 3700 to 271 mg/kg

5 Conclusions

Moreton Environmental and Health Pty Ltd (MEH) was engaged by THRL Pty Ltd ACN 137 592 593 (Scenic Rim Trail) to complete soil investigations at **Timber Getters Eco Camp** and **Amphitheatre View Wilderness Eco Camp**.

Fifteen(15) and nineteen (19) hand-augered boreholes were advanced on the 29th August 2025 to be representative of the soils within 50 meters of the Timber Getters and Amphitheatre EcoCamp areas, respectively, as shown in **Figures 4-7** in **Figures**.

Three (3) background, two (2) additional and three (3) irrigation area hand-augered boreholes were advanced on the 7th May 2026 in both EcoCamps. The three (3) background boreholes had one surface soil sample taken from each borehole, to use in calculating EILs (see section 2.1.1), as well as two more primary samples and four duplicates for use in quality control (see section 4.1) at both EcoCamps.

Six (6) hand-augered boreholes were sampled at 100, 300 and 600 mm depth in both irrigation areas and the results of soil classification, physico-chemical and nutrient results are shown in Table 13 234-and Table 16 for Timber Getters and Amphitheatre irrigation areas respectively.

Predominantly, Timber Getters and Amphitheatre irrigation areas demonstrated clay loams or silty clay loams or silty loams and generally had CEC of more than 10 and less than 35 meq/100g, demonstrating a moderate buffering capacity to changes in pH, available nutrients, calcium levels and soil structure.

The soils also demonstrated pH levels of 6.0 up to 6.5, non-saline, organic matter ranged from 2 to 18%, with a high degree of variability of organic matter within the horizons, as well as a high degree of buffering with respect to cation exchange, including nutrients. The soils had some to no dispersion characteristics, indicating stable soils with regards to erosion and a high degree of buffering capacity with regards to salts, which indicates suitable soils for irrigation.

Both soils in irrigation areas and areas within a-50 m radius of both EcoCamps demonstrated Metalloid concentrations within the site specific EILs calculated (SQG) for the areas as shown in Table 15, All soil results shown in Table 18 below were below the SQG for metalloids concentrations within the soils within the irrigation area of the Amphitheatre EcoCamp., Table 20 and Table 21. The exception was the maximum value of zinc, which was above the SQG, however the mean value is within criteria. The SQG are calculated for comparison mainly against mean values rather than a one off maximum value.

The irrigation areas had high levels of Organic Nitrogen, and low levels of Ammonia and Nitrates that indicate a natural ecosystem with high level of nitrogen recycling. Almost all the available nitrogen has been taken up by plants and there is a high degree of compost (Organic-N) waiting to be assimilated into Ammonia and then Nitrates for uptake by plants.

The levels of Organic-N are higher in Amphitheatre than Timber Getters, albeit, both sites demonstrate high levels of Organic-N in their soils. This is a vibrant rainforest with a high degree of nutrient cycling occurring naturally in the soils and plants of the ecosystem.

This baseline study of the irrigation areas and the previous baseline study in 2019, (MEL, 2019), demonstrate the soils at the EcoCamps have naturally high degrees of nutrients and the EcoCamps are in a high nutrient environment. This may have implications for trigger levels of Treated Effluent as shown in Table 6 of the Plan for Wastewater and Sewage Management (PWaSM), (MEH, 2025a) for Amphitheatre and Woodcutters EcoCamps.

However, the irrigation areas have a high ability to absorb nutrients from the irrigated treated effluent as shown in section 4.4.5 due to a high degree of buffering capacity with respect to cation and nutrient exchange.

The plant tissue analysis indicates the vegetation within the irrigation areas are within the correct range of elements for optimal growth and the nitrogen levels in the vegetation indicate room for increased Nitrogen in plant tissue.

6 Recommendations

Following the assessment of soils in the irrigation areas and within 50 meters of the EcoCamps, MEH recommends the following:

- The baseline results of Physico-Chemical, Cations and Anions, as well as Metalloids and Nutrient will be monitored in subsequent years and the soil quality of the irrigation area and within a 50-metre radius of both EcoCamp will be assessed for change;
- The irrigation areas will be assessed in subsequent years for change as well as their ability to absorb nutrients, buffer against erosion and salinity; and
- Given the high nutrient cycling environments described in the soils at the EcoCamps, the Sewage and Wastewater Monitoring Plan (SWMP) for Amphitheatre and Timber Getters EcoCamps, (MEH, 2025b) and Plan for Wastewater and Sewage Management (PWaSM) for Amphitheatre and Timber Getters EcoCamps, (MEH, 2025a) should be reviewed for any changes.

7 Disclaimer

This report (the "Report") has been prepared for the exclusive use THRL Pty Ltd ACN 137 592 593 (THRL),for the purpose of the assessment of soils within the at the **Timber Getters Eco Camp** and **Amphitheatre View Wilderness Eco Camp** areas within the Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland, in accordance with Condition 8A in the Variation of Conditions attached to Approval (Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland (EPBC 2016/7847), dated 2019)

The Report must be read in light of:

- The limited readership and purposes for which it was intended.
- Its reliance upon information provided by the client and others which MEH has not verified and over which MEH has no control.
- The limitations and assumptions referred to throughout the Report.
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- Other relevant issues which are not within the scope of the Report.

Subject to the limitations referred to above, MEH has exercised all due care in the preparation of the Report and believes that the information, conclusions, interpretations and recommendations of the Report are both reasonable and reliable.

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7.1 Limitations of this report

The outcome of this Report is limited to information supplied for the activities associated with the scope of works only. It is intended that this assessment provide a description of the potential soil contamination and recommendations on how to address and manage any contamination issues at the site.

Soil and rock formations are often variable, resulting in heterogeneous distribution of parameters of interest across a site. Parameter concentrations may be estimated at chosen sample locations, however, conditions between sample sites can only be inferred on a basis of geological and hydrological conditions and the nature and the extent of identified concentration of the parameter. Boundaries between zones of variable contamination are often indistinct and, therefore, interpretation is based on available information and the application of professional judgement. The accuracy with which sub-surface conditions are characterised depends on the frequency and methods of sampling and the uniformity of sub-surface conditions and is, therefore, limited by the scope of the works undertaken.

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Should further information become available regarding the conditions at the site, including previously unknown likely sources of contamination, MEH reserves the right to review the Report in the context of the additional information.

The findings, observations and conclusions expressed in this report are not, and should not be considered as an opinion concerning the commercial feasibility of the property or asset.

The Report may contain various remarks about and observations on legal documents and arrangements such as contracts, supply arrangements, leases, licences, permits and authorities. A consulting scientist can make remarks and observations about the technical aspects and implications of those documents and general remarks and observations of a non-legal nature about the context of those documents. However, as a consulting scientist MEH is not qualified, cannot express and should not be taken as in any way expressing any opinion or conclusion about the legal status, validity, enforceability, effect, completeness or effectiveness of those arrangements or documents.

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1. The specific instructions received from THRL;
2. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of **Morton Environmental and Health Pty Ltd** (which consent may or may not be given at the discretion of **Moreton Environmental and Health Pty Ltd**);
3. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
4. The report only relates to the site referred to in the scope of works being located at the Amphitheatre View and Timber Getters EcoCamps on the Scenic Rim Trail – Thornton Trailhead to Scenic Rim Trail Canopy Nature Reserve, Queensland (EPBC 2016/7847) (“the site”)
5. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
6. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
7. Fill, soil, groundwater and rock to the depth tested on the site may be fit for the use specified in this report. Unless it is expressly stated in this report, the fill, soil and/or rock may not be suitable for classification as clean fill if deposited off site; and
8. Our General Limitations set out at the back of the body of this report.

8 Glossary and Terms

Acidify addition of acid to lower pH**.**

Apedal describes a soil in which none of the soil material occurs in the form of peds or soil aggregates in the moist state.

Background natural level of a property/parameter**.**

Baseline initial value of a measure.

Borehole an uncased well drill hole.

Conductivity (EC) conductivity of water is an expression of its ability to conduct an electric current. This property is related to the ionic content of the sample, which is in turn a function of the total dissolved (ionisable) solids (TDS) concentration. An estimate of TDS in fresh water can be obtained by multiplying EC by 0.65.

Confidence Limits (statistics) an interval so constructed as to have a prescribed probability of containing the true value of an unknown parameter.

Contaminant generally, any chemical species introduced into the soil or water. More particularly relates to those species that render soil or water unfit for beneficial use.

Discrete sample samples collected from different locations and depths that will not be composited but analysed individually.

Ecological investigation levels (EILs) depend on specific soil physico-chemical properties and land use scenarios and generally apply to the top 2m of soil.

Ecological screening levels (ESLs) for petroleum hydrocarbon materials broadly apply to coarse and fine grained soils and various land uses. They are applicable to the top 3m of soil.

Electrolytic conductivity (EC) (see Conductivity**)**

Gleyed soils waterlogged soils. Develop where drainage is poor, or the water table is high. A reducing environment exists in the saturated layers, which become mottled greyish-blue or brown because of the content of ferrous iron and organic matter.

Groundwater water held in the pores of an aquifer.

Head space air space at the top of a soil or water sample.

Health investigation levels (HILs) are generic and apply across Australia to all soil types generally to a depth of 3 m below surface.

Health screening levels (HSLs) for petroleum hydrocarbons depend on physicochemical properties of soil as it affects hydrocarbon vapour movement in soil and the characteristics of building structures. They apply to different soil types, land uses and depths below surface to >4 m and have a range of limitations.

Heavy Metals all metallic elements whose atomic mass exceeds that of calcium (20) and includes lead (Pb), copper (Cu), Zinc (Zn), cadmium (Cd), and tin (Sn).

Heterogeneous condition of having different characteristics in proximate locations. Non-uniform. (Opposite of **homogeneous**).

Horizon individual soil layer, based on texture and colour, which differs from those above and below.

Investigation levels and screening levels are the concentrations of a contaminant above which further appropriate investigation and evaluation will be required. Ecological investigation levels (EILs) may also be referred to as soil quality guidelines in relevant references (see NEPM Schedules B5b and B5c).

Limit of Reporting (LOR) is the lowest concentration a laboratory technique or procedure can report with the appropriate confidence of accuracy.

Massive refers to the condition of the soil layer in which the layer appears to be as a coherent or solid mass which is largely devoid of peds.

MEDLI (Model for Effluent Disposal using Land Irrigation). Modelling software developed by the Queensland government for designing and analysing effluent disposal systems.

Metals are elements, compounds, or alloys that are good conductors of both electricity and heat. Common metals analysed are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn).

Mottled a pattern where soils have masses, blobs or blotches of sub-dominant, varying colours indicating regular water saturation/unsaturation.

National Association of Testing Authorities (NATA), NATA accreditation provides a means of determining, formally recognising and promoting the competence of facilities to perform specific types of testing, inspection, calibration, and other related activities

National Environmental Protection Measure (NEPM), NEPMs are broad framework-setting statutory instruments defined in the NEPC Act. They outline agreed national objectives for protecting or managing particular aspects of the environment.

Occupational health and safety (OH&S) is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment.

Organics chemical compounds comprising atoms of carbon, hydrogen and others (commonly oxygen, nitrogen, Phosphorus, sulfur). Opposite is inorganic, referring to chemical species not containing carbon.

Parameters population value of a particular characteristic, which is descriptive of the distribution of a random variable.

Ped an individual natural soil aggregate. In an undisturbed state peds will group together to form larger aggregates.

Pedal describes a soil in which some or all of the soil material occurs in the form of peds in the moist state.

Permeability property of porous medium relating to its ability to transmit or conduct liquid (usually water) under the influence of a driving force. Also referred to as hydraulic conductivity.

pH logarithmic index for the concentration of hydrogen ions in an aqueous solution, which is used as a measure of acidity.

Podzolic a term applied to acid soils with strong texture contrast between loamy topsoils and clayey subsoils.

Precision is a measure of the reproducibility of results under a given set of conditions and is assessed on the basis of agreement between a set of duplicate results obtained from duplicate analyses.

Profile the solum. This includes the soil A and B horizons and is basically the depth of soil to weathered rock.

QA/QC Quality Assurance / Quality Control involves all of the actions, procedures, checks and decisions undertaken to ensure the representativeness and integrity of samples, and accuracy and reliability of analytical results. Quality control is the component of QA, which monitors and measures the effectiveness of other procedures by the comparison of these measures to previously decided objectives.

Relative Percentage Difference (RPD) expresses the precision of results by comparing the difference between the two samples to the average of the two samples.

Representative Sample assumed not to be significantly different than the population of samples available. In many investigations samples are often collected to represent the worst case situation.

Stratigraphy vertical sequence of geological units.

Subsoil subsurface material comprising the B and C horizons of soils with distinct profiles. They often have brighter colours and higher clay content than topsoils.

Texture is the size of particles in the soil. Texture is divided into six groups, depending on the amount of coarse sand, fine sand, silt and clay in the soil.

Topsoil part of the soil profile, typically the A1 horizon, containing material, which is usually darker, more fertile and better, structured than the underlying layers.

Upper Confidence Limit (UCL) is the upper confidence Interval of a two-sided estimated interval of a parameter. This interval is expected to include the true value of the parameter with a specified confidence percentage, e.g., 95% of such intervals are expected to include the true values of the estimated parameters.

Water table interface between the saturated zone and unsaturated zones. The surface in an aquifer at which pore water pressure is equal to atmospheric pressure.

9 References

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FIGURES

TABLES

Table 22: Summary of Results

Table 23: Quality Control on Field Duplicates

Appendix A QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC)

1. Data Usability

1.1 Introduction

Information generated from environmental investigations requires some statement in regard to the usability of the data[1] and, therefore, quality assurance (QA) and quality control (QC) are an integral part of the analysis and interpretation of environmental data. QA/QC used in contaminated sites investigations is briefly reviewed in this section.

MEH would like to acknowledge the NSW Auditor Mark Salmon, Principal Scientist in Cavvanba Consulting and colleague, mentor and friend of Dan Morton, originally developed these QA/QC procedures.

Quality assurance involves all of the actions, procedures, checks and decisions undertaken to ensure the representativity and integrity of samples, and accuracy and reliability of analytical results (NEPC 1999). Quality control is the component of QA, which monitors and measures the effectiveness of other procedures by the comparison of these measures to previously decided objectives.

There are various components of QA/QC, which address the operation of the laboratories and the routine procedures conducted to achieve a minimum level of quality. Examples of QA components include sample control, data transfer, instrument calibration, staff training, etc. Examples of QC components include the measurement of samples to access the quality of reagents and standards, cleanliness of apparatus, accuracy and precision of methods and instruments, etc. Generally, the National Association of Testing Authorities (NATA) addresses the management of laboratory QA issues through accreditation, or similar and monitoring of these issues is not addressed on a project-by-project basis.

On a project specific basis, those involved in collecting, assessing or reviewing the relevant data should ensure the minimum level of QA is conducted. Appropriate numbers and types of QC samples should be collected and analysed, both field QC samples and laboratory QC samples. While minimum levels of QA/QC are specified in some guidelines, e.g. NSW EPA 1994, AS 4482.1-1997, NEPC 1999, the minimum level required may vary between projects, based on site and project specific aspects. This means that the minimum specified requirements may not be sufficient for a particular project. As described in the NEPM (NEPC 1999):

> *As a general rule, the level of required QC is that which adequately measures the effects of all possible influences upon sample integrity, accuracy and precision, and is capable of predicting their variation with a high degree of confidence.*

[1] To avoid confusion with the data quality objectives (DQOs) process, the term data usability is used rather than data quality.

A common example of where site requirements dictate additional QA and associated QC samples is when site history indicates the use of petrol or volatile solvents, field procedures may need to be more stringently adhered to and additional QC samples may be required, including trip blanks and trip spikes.

2. PARCC parameters

Following receipt of laboratory analytical results, data validation is conducted to determine if the specified acceptance criteria have been met. This is conducted to ensure that all data, and subsequent decisions based on that data, are technically sound. Data quality is typically discussed in terms of precision, accuracy, representativity, comparability and completeness. These are referred to as the PARCC parameters[2]. Field QA/QC and laboratory QC is described below within the PARCC framework.

2.1 Precision

Duplicates

Precision is a measure of the reproducibility of results under a given set of conditions and is assessed on the basis of agreement between a set of duplicate results obtained from duplicate analyses. The precision of a duplicate determination is measured by comparing the difference between the two samples to the average of the two samples, expressed as a relative percentage difference (RPD).

The determination is:

$$RPD = (P-D)/(P+D/2) \times 100$$

P = primary sample

D = duplicate sample

Three types of duplicates are commonly used:

A. field duplicates are used to measure the precision of the sampling and analytical process;

B. inter-laboratory duplicates are used to check on the analytical performance of the primary laboratory; and

C. laboratory duplicates are used to measure the precision of the analytical process.

Field Duplicates

Field duplicates (or blind replicates) are collected from the same location and submitted to the laboratory for analyses, as a primary sample. The sample nomenclature is such that the laboratory is not aware which sample is a duplicate. The RPD is calculated to determine the degree of repeatability (precision) of results obtained from the duplicate analysis. Where results are below the practical quantification limit (PQLs) or limits of reporting (LORs), i.e. non detects, RPDs cannot be calculated. Where one result is detected, the results are considered to conform when the detected result is less than five times the PQL/LOR.

The PQL/LOR is the lowest concentration of an analyte that can be determined with acceptable precision (repeatability) and accuracy under the test conditions. The PQL/LOR is usually calculated as five times the lower limit of detection (or method detection limit).

[2] The PARCC parameters are sometimes referred to as data quality indicators (DQIs).

However, adjustments in PQLs/LORs may be required due to interference from high contaminant concentrations.

As environmental samples can exhibit a high degree of heterogeneity, field duplicates often exceed the acceptance criterion, particularly if the samples are co-collected, for example, because of the potential for losing volatiles during sample splitting. The NSW EPA require that before results which fail the acceptance criterion are described as due to low concentrations or sample heterogeneity, the sample should be re-analysed. This may not be necessary when the analytical results are significantly less than the land use criteria.

Inter-laboratory duplicates

Inter-laboratory duplicates (or split samples) are field duplicates which are sent to a second laboratory and analysed for the same analytes and, as far as possible, by the same methods. These provide a check on the analytical performance of the primary laboratory.

Laboratory Duplicates

Laboratory duplicates (or check samples) are field samples which are split by the laboratory and thereafter treated as separate samples. The RPD is calculated to determine the degree of repeatability (precision) of results obtained from the duplicate analysis.

USEPA (1994) specifies that for inorganics, if the results for laboratory duplicates fall outside of the recommended control limits for a particular analyte, all results for that analyte, in all associated samples of the same matrix, should be qualified as an estimated quantity. For organics, USEPA (1999) does not specify recommended actions for laboratory duplicates.

2.2 Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Inasmuch as the true sample concentrations are not known, the determination of accuracy is achieved through the analysis of known reference materials or assessed by the analysis of matrix spikes. Spiking of reference material into the actual sample matrix is the preferred technique because it provides a measure of the matrix effects on the analytical recovery.

Accuracy is measured in terms of percentage recovery as defined by:

$$\%R = ((SSR - SR) / SA) \times 100$$

%R = percentage recovery spike

SSR = spiked sample result

SR = sample result

SA = spike added

Matrix spikes/matrix spike duplicates

These are samples prepared in the laboratory by dividing a sample into two aliquots and then spiking each with identical concentrations of specific analytes. The matrix spike (MS) and matrix spike duplicate (MSD) are then analysed separately and the results compared to determine the accuracy and precision of the analytes.

Surrogate spikes

Surrogate spikes provide an indication of analytical accuracy. They are used only for analyses, which use gas chromatography and are compounds which are similar to the organic analytes of interest in chemical composition, extraction and chromatography, but which are

not normally found in field samples. Surrogates are generally spiked into all sample aliquots prior to preparation and analysis.

If the surrogate spike recovery does not meet the prescribed DQO, the samples should be re-analysed.

Laboratory control samples

Laboratory control samples (quality control check samples) are laboratory prepared samples of an appropriate clean matrix (i.e. sand or distilled water) which are spiked with known concentrations of specific analytes. The laboratory control sample (LCS) is then analysed and the results are used to assess sample preparation and analytical accuracy, free of matrix effects. Certified reference material (CRM) is another form of LCS and involves the analysis of a known standard as part of the laboratory batch, e.g. British Columbia sediment samples for analysis of metals.

2.3 Representativity

Representativity refers to the degree to which the samples reflect the site-specific conditions. It is primarily dependent on the design and implementation of the sampling program, with representativity of the data being partially ensured by the avoidance of cross-contamination, adherence to sample handling and analytical methods, use of field duplicates, ensuring that samples do not exceed holding times prior to analysis, use of chain-of-custody forms and other appropriate documentation.

There are a number of QC samples which can be collected to assist in the qualification of representativity, including:

Rinsate blanks

Used to determine if sampling equipment has been adequately decontaminated to ensure that cross-contamination between samples has not occurred. The frequency for rinsate blanks is one per piece of equipment per day (AS 4482.1-1997), however it should be noted that cross-contamination will bias samples upwards, and the frequency should, therefore, be at the investigator's discretion.

Trip blanks

Used only when volatile organics are sampled to determine if transport in motor vehicles or similar has resulted in contamination of the samples. For trip blanks, a sufficient number should be analysed to allow the Representativity of the sampling to be determined. However, it should be noted that cross-contamination would bias samples upward, and the frequency should, therefore, be at the investigator's discretion.

Trip spikes

Used only when volatile organics are sampled to attempt to quantify loss of volatiles during the analytical process. For trip spikes, a sufficient number of samples should be analysed to allow qualification of the likely loss of volatiles during the field sampling.

Laboratory blanks

Laboratory blanks (or method blanks, or analysis blanks) are used to verify that contaminants are not introduced into the samples during sample preparation and analysis. The NEPM (NEPC 1999) specifies that laboratory blanks should be conducted at a frequency of "at least one per process batch". The DQO for laboratory blanks is non-detect at the PQL/LOR.

2.4 Comparability

Comparability is a qualitative parameter designed to express the confidence with which one data set may be compared with another, including established criteria. Using consistent methods and ensuring that PQLs/LORs are below the relevant criteria maintain comparability.

QC sample completeness

Quality control sample completeness is defined as the number of QC samples which should have been analysed, compared to the actual number analysed. If the appropriate number of QC samples are not analysed with each matrix or sample batch, then the data reviewer should use professional judgement to determine if the associated sample data should be qualified.

QC sample frequency and criteria

Based on EPA made or approved guidelines, the following QC samples are required for all contaminated site investigations, unless otherwise specified as part of the data quality objectives (DQOs) process review. All data to be used for validation should conform as a minimum to the requirements specified, regardless of minimum sample size.

Table 1 : Quality Control Samples

Quality control sample	Frequency	Results [1]
Precision		
Field duplicates.	≥ 5%	≤ 30 - 50% [2]
Inter-laboratory duplicates.	≥ 5%	≤ 30 - 50% [2]
Laboratory duplicates.	≥ 10%	Lab specified [3]
Accuracy		
Surrogate spikes.	Organics by GC	70 – 130% [4]
Matrix spikes (MSs).	≥ 1/media type	70 - 130% [5]
Laboratory control samples (LCSs).	≥ 1/lab batch	70 - 130% [6]
Certified reference material (CRM).	LCS for metals	Lab specified [7]
Representativity		
Rinsate samples.	≥ 1/field batch	< LOR
Trip blanks.	≥ 1/field batch (volatiles)	< LOR
Trip spikes.	≥ 1/field batch (volatiles)	70 - 130%, ≤ 30 - 50% [8]

Laboratory blanks.	≥ 1/lab batch	< LOR

Notes:

1. Where results are laboratory specified, the laboratory analytical reports should be consulted for specific information.
2. Relative percentage differences (RPDs) for field duplicates from AS 4482.1 (1997).
3. RPDs for laboratory duplicates specified by the laboratory. Based on the magnitude of the results compared to the level of reporting (LOR), e.g. ALS: result < 10 x LOR = no limit, 10 – 20 x LOR = 0-50%, > 20 x LOR = 0-20%. LabMark: < 5 x LOR = 0-100%, 5 – 10 x LOR = 0-75%, > 10 x LOR = 0-50% or 0-30% for metals.
4. Surrogate recoveries specified by laboratory based on global acceptance criteria or dynamic recovery limits based on statistical evaluation of actual laboratory data.
5. MS recoveries specified by laboratory based on global acceptance criteria.
6. LCS recoveries specified by laboratory based on global acceptance criteria or dynamic recovery limits based on statistical evaluation of actual laboratory data.
7. CRM recoveries specified by laboratory based on global acceptance criteria.
8. Trip spike results are specified as either recoveries or RPDs.

Appendix B Trial Pit Logs

Appendix C Laboratory Certificates of Analyses

Appendix D Site Specific Health and Safety Plan