THRL Pty Ltd

Plan for Wastewater and Sewage Management (PWaSM) for Amphitheatre and Woodcutters EcoCamps.

Main Range National Park, Queensland, Australia.

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

11th November 2025

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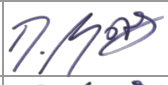
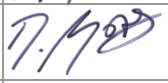
V1	Draft	Dan Morton			2nd May 2025
V2	Draft	Dan Morton	Karen Gillow		10th may 2025
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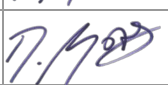
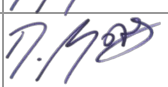
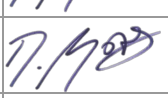
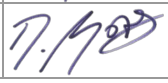
V4	Draft	Dan Morton	Josh Radford		10th June 2025
V5	Draft	Dan Morton	Josh Radford		11th June 2025
V6	Draft	Dan Morton	Josh Radford		12th June 2025
FINAL	Final	Dan Morton			11th November 2025

This Plan for Wastewater and Sewage Management (PWaSM) for Amphitheatre and Woodcutters EcoCamps has been reviewed by an independent expert Josh Radford, MSc, Associate Geologist, EMM Pty Ltd, in accordance with Variation of Conditions attached to Approval (Scenic Rim Trail – Thornton Trailhead to Spicers Canopy Nature Reserve, Queensland (EPBC 2016/7847) (the Variation)).

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Table of Contents

1 Introduction 4

2 Objectives 6

2.1 Legislation and Guidance for Recycled Water Use 6

2.2 Rationale 6

2.3 Environmental Values 7

2.4 Context of the Sites 7

2.4.1 Local Geology 7

2.4.2 Local Streamflow 8

2.4.3 Groundwater Bore Search 8

2.5 Conceptual Site Models 8

2.6 Climate 9

3 Summary of Activities at EcoCamps 10

3.1 Overview of WWTP at both EcoCamps 10

3.2 Overview of Irrigation areas at both EcoCamps 12

4 Irrigation Rationale 14

4.1 Soil Type 14

4.2 Area and Hydraulic Loading 15

5 WWTP Operations and Maintenance 17

5.1 Operations 17

5.1.1 Wastewater Treatment Plant 17

5.1.2 Irrigation 17

Service and Maintenance Program of WWTP 18

5.2 18

5.3 Irrigation Area Maintenance 21

5.3.1 Equipment 21

5.3.2 Vegetation 21

5.3.3 Drainage 21

5.3.4 Wet Weather Storage 21

6 Management Plan 22

6.1 Control Measures....22
6.2 Alarm points for operational failure of WWTPs....23
6.3 WWTP Sample Monitoring Program....23
6.4 Effluent Trigger Levels....24
6.5 Soil....25
6.6 Groundwater and Surface Waters....25
6.7 Irrigation Areas....25
7 Health Issues....27
8 Training Procedures....28
9 Reporting....29
9.1 Quality Assurance/Quality Control (QA/QC)....29
10 Corrective Action....30
11 Disclaimer and Limitations....31
11.1 Disclaimer....31
11.2 Limitations of this plan....31
12 References....33

Figures

Figure 1 Location Map....In Figures
Figure 2 Geology Map....In Figures
Figure 3 Surface Water Environmental Values....In Figures
Figure 4 Groundwater Environmental Values....In Figures
Figure 5 Bore Search....In Figures
Figure 6 Creeks and Watercourses....In Figures
Figure 7 EcoCamps Wastewater Micro CSM using MEDLI....In Figures
Figure 8 Amphitheatre Groundwater Conceptual Site Model....In Figures
Figure 9 Woodcutters Groundwater Conceptual Site Model....In Figures
Figure 10 EcoCamps Conceptual Site Model....In Figures
Figure 11 Surface Water Sampling....In Figures
Figure 12 Amphitheatre EcoCamp....In Figures
Figure 13 Woodcutters EcoCamp....In Figures
Figure 14 Amphitheatre Soil Sampling Locations....In Figures
Figure 15 Woodcutters Soil Sampling Locations....In Figures

Graphs

Graph 1: Bureau of Meteorology Mandala 2024 9

Schematics

Schematic 1 : Effluent irrigation and environmental interaction conceptual model, (Queensland, 2020). 7

Tables

Table 1: 2-stage AdvanTex AX-Max system 12

Table 2: Soil Classification, %Clay and CEC levels 14

Table 3: Soil Testing for Moisture Content 15

Table 4: Maintenance, Monitoring and Support Program 18

Table 5: Monitoring Schedule of the PWaSM 24

Table 6: Proposed Trigger Values Effluent Quality at both EcoCamps 25

Appendices

APPENDIX A : VARIATION OF CONDITIONS ATTACHED TO APPROVAL (SCENIC RIM TRAIL – THORNTON TRAILHEAD TO SPICERS CANOPY NATURE RESERVE, QUEENSLAND (EPBC 2016/7847)) 2

APPENDIX B : EFFLUENT QUALITY DATA AT AMPHITHEATRE AND WOODCUTTERS ECOCAMPS 3

APPENDIX C : STANDARD OPERATING PROCEDURES 4

APPENDIX D : Quality Assurance/Quality Control (QA/QC) 5

1 Introduction

Moreton Environmental and Health Pty Ltd (MEH) was engaged by THRL Pty Ltd ACN 137 592 593 (Scenic Rim Trail) to complete this Plan for Wastewater and Sewage Management (PWaSM) for Amphitheatre and Woodcutters EcoCamps.

In accordance with Variation of Conditions attached to Approval (Scenic Rim Trail – Thornton Trailhead to Spicers Canopy Nature Reserve, Queensland (EPBC 2016/7847) (the Variation)), as shown in **Appendix A.** The PWaSM outlines the methods (including survey methodology, effort, timing, frequency and responsibility) that will be implemented for the collection and analysis of data regarding influent and effluent quality, irrigation efforts, limits and alarm and trigger values within the wastewater treatment plant (WWTP) are discussed within the PWaSM. The soil and water quality data to establish the baseline and subsequently detect any change from baseline within 50 m and outside the boundaries of the **Woodcutters EcoCamp** and **Amphitheatre View Wilderness EcoCamp** attributable to onsite disposal of sewage or wastewater is detailed in the Sewage and Wastewater Monitoring Plan (SWMP) and outlined in **Error! Reference source not found.** of this PWaSM. The PWaSM specifies methods for collection and analysis of the following, unless otherwise stated:

a. the measures to be implemented for the duration of the approval to:
    i. ensure that all sewage and wastewater to be disposed of to land within the boundaries of the **Woodcutters Ecocamp** and **Amphitheatre View Wilderness Ecocamp** is treated to **advanced secondary** standard to produce **class A** quality effluent, in accordance with the *Queensland Plumbing and Wastewater Code* (2017) and *Guideline for low- exposure recycled water schemes, (Health, 2022); and Queensland Water Recycling Guidelines, (EPA, 2005)* (as replaced or amended from time to time);
    ii. ensure that treated sewage and wastewater is only disposed of to the sub-surface of land within the boundaries of the **Woodcutters Ecocamp** and **Amphitheatre View Wilderness Ecocamp** as shown in **Figures 10-13** in **Figures**;
    iii. minimise the volume of treated sewage and wastewater disposed of from the **Woodcutters Ecocamp** and **Amphitheatre View Wilderness Ecocamp**;
    iv. ensure that there are no adverse changes from baseline soil and water quality outside the boundaries of the **Woodcutters Ecocamp** and **Amphitheatre View Wilderness Ecocamp** as a result of disposal to land of treated sewage and wastewater;
    v. ensure that the disposal of treated sewage and wastewater does not introduce new pathogens or increase the extent of existing pathogens or invasive species of weeds, both within and outside the boundaries of the **Woodcutters Ecocamp** and **Amphitheatre View Wilderness Ecocamp**; and
    vi. ensure on-site staff are appropriately trained in the monitoring, maintenance and emergency response measures for the sewage and wastewater treatment system; and
b. the details of a sampling program for treated effluent to ensure it meets the standard specified in condition **15A.a.i.** before disposal to land;
c. corrective actions and subsequent further correction measures to be implemented if samples from the program required under condition 15A.b. of the Variation do not meet the specified

standard and/or contain contaminants that could adversely affect water quality with potential to harm the **Hastings River Mouse**, **Fleay's Frog** or the world heritage values of the Gondwana Rainforests of Australia World Heritage Plan (**GRAWHP)**,including the **Mountain Frog**; and

d. the protocols, corrective actions and subsequent further correction measures that will be implemented in the event that the onsite sewage and wastewater treatment monitoring and diagnostic system triggers an alarm, or in the event that the treatment system experiences a failure. Interim measures to manage sewage and wastewater to prevent contamination of soil or water or affect water quality with potential to harm the habitat of the **Hastings River Mouse, Fleay's Frog**, and **Mountain Frog** must be included.

Surface water assessment has and will be conducted at monitoring sites in the Main Range National Park as part of a 10-year monitoring program, outlined in the Scenic Rim Trail Management Plan (SRTMP), that will determine whether activities associated with the operation of the Spicers Scenic Rim Trail EcoCamps, including disposal of treated effluent, have had an adverse impact on water quality and therefore potential to impact Matters of National Environmental Significance (MNES) and/or world heritage values of the Gondwana Rainforests of Australia World Heritage area (GRAWHA), (Spicers, 2023).

2 Objectives

The objective of the PWaSM is to ensure that there are no adverse changes to soil and water quality outside the boundaries of the **Woodcutters EcoCamp** (Woodcutters) and.or **Amphitheatre View Wilderness EcoCamp** (Amphitheatre) (jointly referred to here as the EcoCamps) as a result of disposal to land of treated sewage and wastewater.

The PWaSM along with the SWMP outlines methodologies to monitor and operate the WWTPs at the EcoCamps, including disposal of treated effluent, to ensure no adverse impact on soil or water quality and therefore potential to impact Matters of National Environmental Significance (MNES) including the **Hastings River Mouse**, **Fleay's Frog** and the **Mountain Frog** and world heritage values of the Gondwana Rainforests of Australia World Heritage area (GRAWHA)**.**

2.1 Legislation and Guidance for Recycled Water Use

The following legislation and guidance are pertinent to recycled or treated effluent waters.

- *Environmental Protection Act 1994 Qld, (Queensland, 1994).*
- *Environmental Protection Regulation 1998 (Qld), (Queensland, 2019b);*
- *Environmental Protection (Water) Policy 2009, (Queensland, 2012);*
- *Environmental Protection (Water and Wetland Biodiversity) Policy 2019, (Queensland, 2019a);*
- *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy, (NHMRC and NRMMC, 2011);*
- *Sustainable Planning Act 2009 (Qld), (State of Queensland, 2009);*
- *Work Health and Safety Act 2011 (Qld),(Queensland, 2011);*
- *Public Health Regulation 2018, (Queensland, 2018b);*
- *Water Supply (Safety and Reliability Act) 2008, (Queensland, 2017b).*
- *Drainage and Plumbing Act 2018 (Qld), (Queensland, 2024);*
- *Eligibility criteria and standard conditions for sewage treatment works (ERA63), (Queensland, 2015);*
- *Model operating conditions ERA 63—Sewage Treatment, (Queensland, 2017a);*
- *Guideline for low- exposure recycled water schemes, (Health, 2022);*
- *Disposal of effluent using irrigation - Technical guideline, (Tennakoon and Ramsay, 2020);*
- *Water quality guidelines for recycled water schemes (Queensland, 2013);*
- *Monitoring and Sampling Manual, Environmental Protection (Water) Policy 2009, (Queensland, 2018a);*
- *Queensland Plumbing and Wastewater Code 2019, (Queensland, 2019c);*
- *AS 1546.3:2017 On-site domestic wastewater treatment units Secondary treatment systems, (Australia, 2017).*

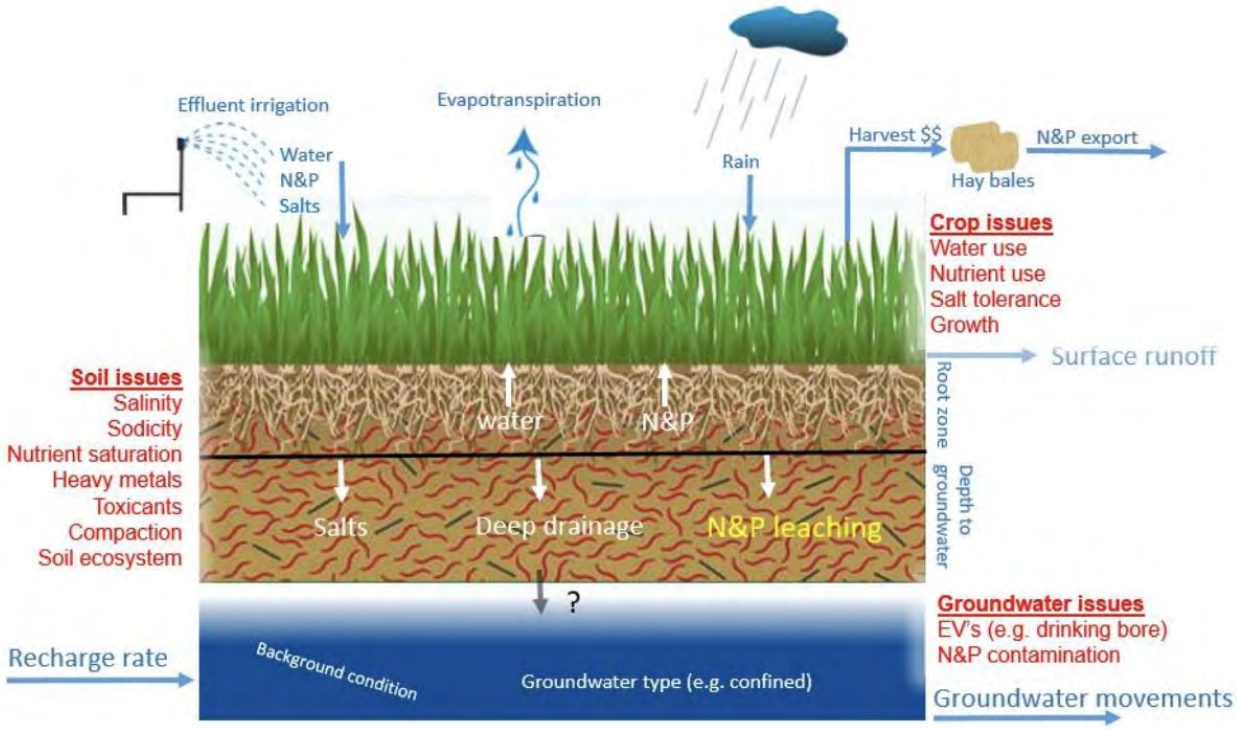
2.2 Rationale

The DEPH 2012 Technical Guideline for Disposal of Effluent via Irrigation states that land disposal requires proper planning and management to reduce the risk of impact to surface waters and groundwater, protect human health and maintain soil sustainability. Schematic 1 : Effluent irrigation and environmental interaction conceptual model, (Queensland, 2020)., shows the interactions involved in disposal of effluent to land.

The eligibility criteria and standard conditions for sewage treatment works (Environmental Relevant Activity (ERA) 63) states that treated effluent is permitted to be released to land provided that it is done in accordance with a written procedure that ensures:

- infiltration to groundwater and subsurface flows of contaminants to surface waters are prevented;
- surface pondage and run-off of effluent are prevented;
- degradation of soil structure is minimised;
- soil sodicity and the build-up of nutrients and heavy metals in the soil and subsoil are minimised;
- spray drift or overspray do not carry beyond effluent disposal areas;

- effluent disposal areas are maintained with an appropriate crop in a viable state for transpiration; and
- the crop on the disposal area is harvested and removed from the disposal area.



Schematic 1 : Effluent irrigation and environmental interaction conceptual model, (Queensland, 2020).

When weather conditions or soil conditions preclude the release of effluent to land, effluent must be directed to wet weather storage or be lawfully removed from the site.

A site-specific conceptual site model of the micro scale of interactions of the disposal of treated effluent on the land with the environment is shown in **Figure 7** in **Figures**.

2.3 Environmental Values

The details of the Environmental Values and the Water Quality Objectives (WQO) for the Condamine Basin, are discussed in detail in the SWMP, (MEH, 2024c), and include the Dalrymple and Glengallan Creeks, as shown in **Figure 3 and 4** in **Figures.**

2.4 Context of the Sites

The details of site context are discussed in detail in the SWMP, (MEH, 2024c) and briefly discussed in sections 2.4.1, 2.4.2, 2.4.2.

2.4.1 Local Geology

The predominant underlying geology of the Main Range National Park is basalt, agglomerate, shale, and dolomite of the Main Range Volcanics of Oligocene to Miocene age as shown in **Figure 2** in **Figures**.

2.4.2 Local Streamflow

The geometry of the underlying consolidated rocks is significant for groundwater flow. It appears there is geologic control over sub-surface flow and this flow is also predominantly to the west.

Amphitheatre EcoCamp is situated on a topographical divide and the EcoCamp is situated on the southern side of the ridge and all surface water overland and subsequent groundwater flow will flow to the Unnamed creek and the Dalrymple creek system.

Woodcutters EcoCamp is situated on a steep hillside and all surface water overland and groundwater flow will flow to the Dalrymple Creek.

2.4.3 Groundwater Bore Search

A groundwater bore search of the region around the sites including government bores within 10 km of the sites and private registered bores in the Goomburra, Upper Laidley Creek and Tarome areas. All but two (2) of the ten (10) bores regularly monitored by government staff represent alluvial aquifers, as shown in **Figure 5** in **Figures**.

2.5 Conceptual Site Models

MEH completed the following investigations and assessments, which have informed the development of the four conceptual models presented in **Figures 7, 8, 9** and **10** in **Figures**.

- Soil and Surface Water Investigations for Baseline Data Collection Plan at Amphitheatre and Woodcutters EcoCamps, Main Range National Park, Queensland, Australia. Scenic Rim Trail – Thornton Trailhead to Spicers Canopy Nature Reserve, Queensland (EPBC 2016/7847), dated 8 May 2019, (MEL, 2019b).
- MEDLI Modelling of Land Application of Treated Effluent at Amphitheatre and Woodcutters EcoCamps, Main Range National Park, Queensland, Australia, dated 18th April 2019, (MEL, 2019a).
- Reporting Hydraulic Assessment at Timber Getters EcoCamp. Main Range National Park, Queensland, Australia. Scenic Rim Trail – Thornton Trailhead to Spicers Canopy Nature Reserve, Queensland (EPBC 2016/7847), dated 20th November 2024,(MEH, 2024a) .

MEH has completed three visual conceptual site models to demonstrate the following:

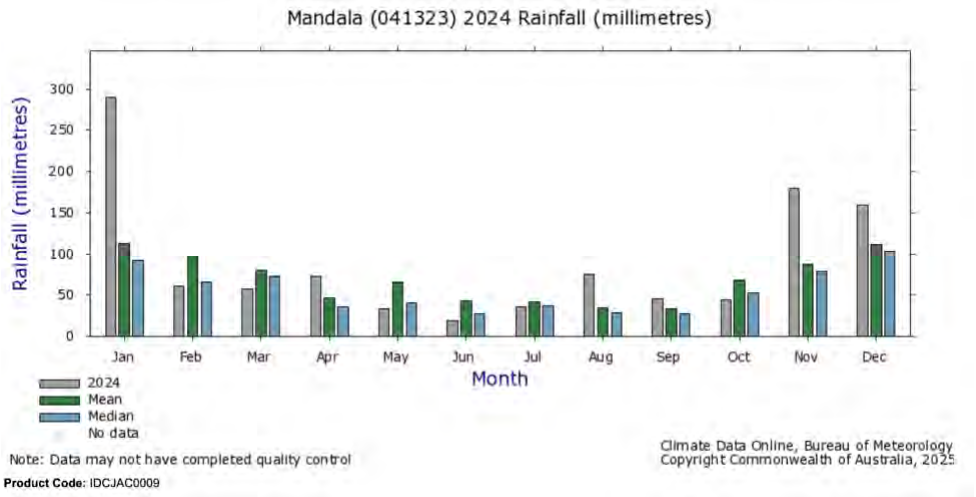
- Figure 7 demonstrates the relationships of soils, bedrock, rainfall, evapotranspiration and deep draining used in the MEDLI modelling as reported in MEDLI Modelling of Land Application of Treated Effluent at Amphitheatre and Woodcutters Ecocamps, Main Range National Park, Queensland, Australia, dated 18th April 2019, (MEL, 2019a).
- Figure 8 demonstrates the relationship between rainfall, surface water flow and groundwater originating under Amphitheatre EcoCamp and the location of potentially impacted monitoring locations SW01 (The closest permanent surface water to Amphitheatre EcoCamp) and SW05 (This location is considered far enough downstream of SW01 to have potential to be fed by groundwater from beneath Amphitheatre EcoCamp).
- Figure 9 demonstrates the relationship between rainfall, surface water flow and groundwater originating under Woodcutters EcoCamp and the location of potentially impacted locations SW03 (The closest permanent surface water to Woodcutters EcoCamp,) and SW06 (This

location is considered far enough downstream of SW03 to have potential to be fed by groundwater from beneath Woodcutters EcoCamp). Locations of monitoring points for Amphitheatre and Woodcutters EcoCamps are shown in Figure 11 in Figures.

- Figure 10 demonstrates a conceptual site model for contaminants from the following:
    - potential sources.
        - Building materials if upgrades or repairs are conducted at the EcoCamps;
        - The irrigation disposal areas;
        - The EcoCamps operations and residential status.
    - Release mechanisms, dust, soil, subsurface, overland flow, infiltration.
    - Pathways, soil, air, soil and surface water, soil and ground water.
    - Exposure routes, ingestion, dermal and physical hazard.
    - Receptors include Human (recreational, residential and workers).
        - Ecosystems both terrestrial and aquatic.

2.6 Climate

The climatic averages for the Main Range National Park (Mandala, BOM station 041323) region obtained from the Bureau of Meteorology (http://www.bom.gov.au) are shown below in Graph 1**.** The majority of irrigation will take place during the dryer months of the year but is not limited to these months. Irrigation may take place on any dry day of the year but close monitoring of expected weather conditions can help prevent runoff.



Graph 1: Bureau of Meteorology Mandala 2024

3 Summary of Activities at EcoCamps

Spicers operates supervised multi day walking tours, mostly within the Main Range National Park along southern Queensland's Scenic Rim. These are from Thornton to Spicers Peak Nature Refuge, a distance (by walking trail) of 53 km, made up of 32 km of new class 3, 4 and 5 track and utilising 24 km of existing track.

Accommodation during the supervised tours comprise the use of several existing Eco Lodges on private land (that required no new approvals) and the use of two EcoCamps – **Woodcutters EcoCamp** (Woodcutters) and **Amphitheatre View Wilderness EcoCamp** (Amphitheatre) (jointly referred to here as the EcoCamps)– at separate locations within the northern extent of the GRAWHA and a National Heritage listed area (approved, constructed and operating).

The EcoCamps have wastewater treatment plants (WWTP) installed and are subject to conditions of approval for the on-site disposal being able to demonstrate compliance with stated conditions, as follows:

In the DCCEEW variation of conditions attached (**Appendix A)**, **condition 8A** sets out the requirements for an approved SWMP. It includes survey method, effort, timing, frequency and responsibility for the collection and analysis of data regarding soil, water and riparian habitat quality to establish a baseline, and subsequently to provide a basis for measuring change to the receiving environment attributable to the on-site disposal of sewage or wastewater.

Condition 15A of the Variation requires an approved PWaSM that sets out implementation measures, a sampling program for treated effluent, corrective actions and subsequent further correction measures to be implemented if samples fall outside specified standards and/or contain contaminants.

The description of the WWTP is taken from Spicers Scenic Walks, Woodcutters EcoCamp Wastewater Treatment Plant Performance Report dated 27 November 2024, (Solutions, 2024)

3.1 Overview of WWTP at both EcoCamps

The WWTP servicing the Amphitheatre and Woodcutters EcoCamps are a 2-stage AdvanTex AX-Max system designed and manufactured byOrenco Systems Inc, and installed by ENVR Solutions Pty Ltd (formally ENVIA Holdings Pty Ltd) who are the QLD agent for Orenco in Australi. Orenco is a USA-based organisation, and has supplied and installed thousands of AdvanTex systems all over the world, particularly in places that are environmentally sensitive and require strict levels of treatment quality and efficiency.

The AdvanTex AX-Max unit is a multi-chambered unit, with pH and carbon augmentation input feeds, that produces Class A recycled water quality. The system is state-of-the-art and incorporates AdvanTex textile media, treatment chambers, submersible pumps, disinfection and control systems into a pre-installed unit. Core to the effectiveness of the AdvanTex system in providing high-quality and reliable treatment is the lightweight textile media filter installed inside the unit, which provides a large surface area, significant void space, and a high degree of water-holding capacity. This creates the perfect environment for billions of microorganisms to populate on the textile which consume the organic matter in the wastewater to provide consistent treatment 24 hours a day.

Because the textile filter material is suspended above the water inside the unit, expensive aerators and high energy-use blowers are not required. This makes the treatment process much more efficient

and less energy demanding by allowing microorganisms access to atmospheric oxygen rather than dissolved oxygen. Furthermore, treatment efficiency will occur during times of full occupancy or when little to no wastewater is being generated.

Image 1: Dual AX-Max Units installed at the Woodcutters EcoCamp

Most importantly, activated sludge is not produced from the treatment process and therefore, does not require daily draw-off and disposal management. The addition of a nitrate return-line back to the anoxic tank within the AdvanTex recirculation chamber facilitates the removal of nitrogen via biological denitrification. Removal of nitrogen is further enhanced by integrating an alkalinity and carbon dosing system and dosing ratios are automated according to the daily hydraulic loading on each system.

Table 1: 2-stage AdvanTex AX-Max system

PEAK DESIGN:	600 L/day
SYSTEM DESCRIPTION:	The Treatment Plant consists of: • 1 x AX-MAX037-14 (unit #1) with: ○ 14-ft (4.3-m) enclosure ○ 37.5-ft² (3.5 m²) of textile ○ septic chamber ○ pre-anoxic chamber ○ recirculation chamber • 1 x AX-Max025-14 (unit #2) with: ○ 14-ft (4.3-m) enclosure ○ 25-ft² (2.3 m²) of textile ○ post-anoxic chamber ○ recirculation chamber ○ discharge chamber ○ recirc pump ○ discharge pump ○ Orenco UV units. ○ discharge chamber ○ recirc pump ○ anoxic return pump ○ discharge pump. • 1 x Fiberglass Liquid Chem feed Units: • Alkalinity Dosing (sodium bicarbonate) • 1 x Fiberglass Liquid Chem feed Units: • Carbon Dosing (Micro-C) • 1 x Custom Control Panel with remote monitoring and alarm issuing • 1 x 5,000 L Recycled Water Storage Tank • 1 x 152 m2 subsurface dripline irrigation area.

3.2 Overview of Irrigation areas at both EcoCamps

After treatment via the AdvanTex treatment process, treated effluent flows into the final discharge chamber where it is disinfected via a UV disinfection system before being discharged to a downstream 5,000 L recycled water storage tank. From this storage tank, a purple pipe reticulation system delivers Class A recycled water to a designated 152 m^2 land application area where it is distributed via a sub-surface dripline irrigation network. The use of subsurface driplines ensures an even distribution of recycled water throughout the soil profile and prevents spray drift, surface pooling and over-saturation of the soil. The use of 'trickle' irrigation within the soil also maximises the potential for evapotranspiration in addition to soil percolation. Furthermore, beneficial residual nutrients remaining in the water are made available to plant root-mass within the rhizosphere of the soil profile. The irrigation area has been planted with native strappy leaf plants, ferns and small native shrubs which are all in good health. The irrigation at Amphitheatre and Woodcutters are the same in design.

Image 2: Installation of Subsurface Irrigation Driplines at the Woodcutters EcoCamp

Image 3: Current irrigation Area Showing Mature Growth of Vegetation

4 Irrigation Rationale

4.1 Soil Type

Following baseline soil investigations in 2018 in irrigation disposal areas at Amphitheatre and Woodcutters EcoCamp, two soil types have been identified as having potential differential hydraulic loading characteristics, as shown in **Table 2** (MEL, 2019b)**.**

Table 2: Soil Classification, %Clay and CEC levels

	Amphitheatre				Woodcutters			
Sample ID	Comp_A_0.1	Comp_A_0.3	Comp_A_0.5	Comp_A_0.8	Comp_W_0.1	Comp_W_0.3	Comp_W_0.5	Comp_W_1.0
CEC	23.36	25.3	25.3	33.5	25.1	19.7	19.7	17.9
%CLAY	48(50)	27(31)	29(33)	21(24)	24(28)	38(41)	36(41)	49(49)
%SAND	4(4)	3(3)	4(5)	2(2)	6(7)	6(6)	2(2)	5(5)
%SILT	44(46)	57(66)	54(62)	65(74)	56(65)	49(52)	49(56)	45(45)
%GRAVEL	4	13	13	12	14	7	13	1
Soil Type	Silty CLAY	Silty Clay LOAM	Silty Clay LOAM	Silt LOAM	Silty Clay LOAM	Silty CLAY	Silty CLAY	Silty CLAY

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

At Amphitheatre the root zone 0.1 – 0.5 was predominantly Silty Clay Loams with % Clay 30 – 50% and CEC 25 meq/100g. The underlying layer, which would be the layer restricting water flow, was Silt Loam, clay content >30% and CEC of 33.5 meq/100g.

The profile in BH22 and 23, (see **Figure 12** in **Figures** for location) showed a confining layer of CLAY between 0.35 and 0.5 mbgl, overlain with a suitable top soil of Silty CLAY from surface to 0.35 mbgl. The layer below the confining CLAY layer was a decomposed basalt. The %Clays increased with depth and with Silty Clay Loams at the surface moving into Silty Clays and decomposed basalt with depth. The root zone of 0.1 – 0.35 was predominantly Silty Clay Loams with % Clay ~30 % (estimated in the field) with a confining layer 0.35 – 0.6 with Clay content ~>50% (estimated in the field). The layer below of decomposed Basalt would have reduced clays and be more porous.

MEL composited BH22 and 23 for further analysis for MEDLI modelling, field capacity, wilting point and saturated water content, as well as porosity and bulk density, as shown in **Table 3.**

At Woodcutters the %Clays increased with depth and with Silty Clays Loams at the surface moving into Silty Clay with depth. The root zone 0.1 – 0.5 were predominantly Silty Clays with % Clay 30 – 40% and CEC 20-25 meq/100g. The underlying layer, which would be the layer restricting water flow, was Silt Clay content ~50% and CEC of 18 meq/100g. Overall, the particle size analysis reported that the dominant soil horizon in which the treated effluent would be impacting was a Silty Clay Loam or Silty Clay with a clay content of ~30-40%.

MEH composited a further two boreholes at Woodcutters, BH22 and 23, which showed similar soil properties to BH10 - 17 in the first round of sampling. A composite of lithologies at BH25 and 26 was

further analysis for MEDLI modelling, field capacity, wilting point and saturated water content, as well as porosity and bulk density, as shown in **Table 3**.

Table 3: Soil Testing for Moisture Content

			Amphitheatre			Woodcutters			
	Client's I.D.		COMP_A_0.1	COMP_A_0.3	COMP_A_0.5	COMP_W_0.1	COMP_W_0.3	COMP_W_0.5	COMP_W_0.8
	Laboratory No.		1	2	3	5	6	7	8
	Units	**LOR**							
Moisture *(air-dried)*	%	0.1	28	24	35	47	41	33	42
Porosity (calc)	%		52	37	51	68	64	61	59
Bulk Density(Core)	Mg/m^3	0.001	1.3	1.7	1.3	0.86	0.96	1	1.1
Field capacity @ 30 kPa	%	1	47	46	76	56	44	43	46
Permanent wilting point @ 1500 KPa	%	1	31	28	43	32	31	27	32
Available water capacity	%		16	18	33	24	13	16	14
Saturated Water Content	%	1	102	83	112	105	92	85	100

The 2 reports by STA Consulting Engineers, (STA Consulting Engineers, 2018a, STA Consulting Engineers, 2018b) at Woodcutters and Amphitheatre sites shows 2 boreholes advance to 600mm and 1500mm respectively. The hydraulic conductivity (ksat) values for Woodcutters and Amphitheatre sites were 1.0 m/day and 1.2 m/day respectively. The underlying soils at Woodcutters site would be considered semi-permeable and at Amphitheatre site permeable.

4.2 Area and Hydraulic Loading

In order to anticipate the effects of sustained irrigation upon the subject site the Department of Natural Resources MEDLI (Model for Effluent Disposal by Land Irrigation) software was used. The irrigation area has been calculated based on the amount of effluent to be disposed of and several effluent and soil properties. The MEDLI modelling recommended the use of improved pastures, Cutty Grass (*Carex appressa*), Creek Mat-rush (*Lomandra hystrix*), and Basket Grass (*Lomandra longifolia*) on the smaller area of $150m^2$ for wastewater disposal at Amphitheatre and Woodcutters.

The results of the modelling demonstrate that a larger area of $250m^2$, as opposed to $150m^2$, only marginally improving efficiency due to the strong nature of nutrient removal by the chosen pasture mixture above.

The irrigation area has been based upon the amount of effluent to be disposed and the permeability of the soils. The MEDLI modelling recommended at least $150m^2$ for each disposal area and Spicers choose an area for irrigation disposal at both EcoCamps of $150m^2$ as shown in **Figure 7 in Figures**.

In addition MEH conducted a hydraulic study at Woodcutters on the 5th September 2024 resulted in 6.188 kL of treated effluent water being applied to the irrigation in 6 hours 7 minutes, (MEH, 2024a). Since there is a total irrigation area of 150 m^2, and a depth of profile of 1.5 meters, the volume of profile is 225 m^3. It is assumed that the basaltic silty clay on site has an effective porosity in the order

of 10 to 15 percent on a volume/volume basis. Based on this estimate of effective porosity, the volume of wastewater pumped during a 6-hour hydraulic assessment falls well short of fully saturating the soil profile, and is calculated at 2.2 per cent of the volume on a volume/volume basis.

Assuming a sedge/reed root zone of 300 mm depth, the same calculation gives an estimated root zone volume of 45 m^3. The volume of wastewater injected during the hydraulic assessment represents 13 per cent of this volume on a volume/volume basis. Therefore, the volume of wastewater pumped during a 6-hour hydraulic assessment may be sufficient to fully saturate the soil profile. The effective porosity calculated from the NSW Soil Report gives a range of 12 – 20 per cent.

We can conclude that the root zone of the irrigation has the capacity to absorb the 10 kL capacity of the storage tank and the hydraulic assessment has demonstrated that applying 6 kL in 6 hours showed no signs of ponding or overland flow within the profile, (MEH, 2024a).

5 WWTP Operations and Maintenance

5.1 Operations

5.1.1 Wastewater Treatment Plant

Following the advanced secondary treatment process, treated water is pumped through a UV disinfection system to ensure all pathogens and coliforms are destroyed prior to being pumped into the Recycled Water Storage Tank.

Total nitrogen reduction in the multi-stage AX-Max WWTP can exceed 80 percent, depending on wastewater influent strength and other characteristics such as BOD, pH, alkalinity, temperature, and hydraulic retention time. Because nitrogen reduction is a complex, multi-staged process, it is important to understand the process, its related factors, and how to keep the process optimised.

In nitrogen reduction, ammonia is converted to nitrate in an aerobic environment via autotrophic bacteria and then reduced through heterotrophic bacterial action in an anoxicenvironment to nitrogen gas, which is released to the atmosphere.

Optimum nitrogen reduction typically requires the following:

- Adequate alkalinity of approximately 250 mg/L or higher
- pH of 6.5-8.5. Fixed-film microbial processes generally thrive between pH 6.5 and 8.5. Treatment problems typically result from rapid changes in pH rather than extreme long-term mean values, although long-term levels can result in less efficient process activity
- Primary tank DO level of 0 mg/L, filtrate DO level of 2.5-6 mg/L
- Adequate time for the nitrifying bacteria to develop
- Adequate temperature (below 4.4° C retards the process)
- Good organic removal (BOD)
- Dissolved oxygen levels < 0.5mg/L (preferably < 0.2mg/L)
- Carbon-to-nitrogen ratio greater than 4:1
- Adequate mixing to ensure chemical distribution throughout the vessel
- Sufficient residual alkalinity (100mg/L ±) in the secondary treatment stage to ensure optimum pH in the post-anoxic stage.

5.1.2 Irrigation

- Irrigation shall be limited to that which is sufficient to wet the soil to its undrained limit or avoid any ponding of water on the surface.
- Application of effluent to the irrigation area shall cease whenever there is rainfall (greater than 3mm) on the irrigation area. Irrigation is not to be repeated on any area for 1 day after the last application if rainfall of greater than 3mm has fallen. A rainfall guage will be fitted and cessation of irrigation will be automated.
- Irrigation is to cease when the undrained upper limit is reached, estimated to be 6kL/day. The irrigation pump will be limited to delivered a maximum of 6kL in any 24 hour period.
- Actions shall be taken if the condition of vegetation over the irrigation area is determined to be degraded. Actions may include replanting of the irrigation area with a species more suited to the nutrient levels and soil type.

- Regular inspection of the stormwater diversion infrastructure around the irrigation area shall be undertaken during summer and after heavy rainfall. Actions shall be taken to remediate any identified faults as soon as is practicable.

5.2 Service and Maintenance Program of WWTP

To ensure both WWTPs operate efficiently and continually perform to their design criteria, the following schedule of services has been implemented:

- Perform sampling of treated effluent and deliver to NATA accredited laboratory on a monthly basis.
- Service and maintain all equipment including UVs, pumps, floats, chemical dosing systems and spray nozzle manifolds, to Orenco's requirements.
- Maintain and clean all disinfection equipment to manufacturers requirements.
- Maintain irrigation network and areas.
- Provide general upkeep of WWTP area including ensuring that leaflitter and fallen tree debris does not build up on top off and in between the lid crevices of the AX-Max units.

The WWTPs maintenance, inspection and service program will be carried out as follows.

- Weekly inspection duties to be performed as part of a proactive and preventative maintenance and monitoring plan.
- This will coincide with a monthly maintenance program which include effluent sampling.
- Other maintenance duties will be performed at various times over a quarterly period or as required and detailed in Table 4 below.
- All duties involved in the maintenance program have been itemised in Table 4 below. All servicing visits, call outs, equipment replacements and incident should be recorded in the maintenance register.

Table 4: Maintenance, Monitoring and Support Program

Area	Task	Frequency	By	Location
Remote Monitoring	Log into T-COM panel to remotely monitor and assess operating efficiency, alarms, and flow diagnostics	Daily	ENVR	Offsite
Remote Monitoring	Log into Control Panel via remote network link and download monthly operation log files captured and recorded via T-COM and manage into ENVIRA data system	Monthly	ENVR	Offsite
Remote Monitoring	Capture brief operating report of inflows, disposal, evapotranspiration, water quality results, faults/breakdowns and general maintenance events and submit to QBuild	Quarterly	ENVR	Offsite
Overall Site	General walk over of site to check for leaks, odours, issues etc.	Weekly	Spicers	Onsite
Overall Site	Sweep/blower accumulated leaves and green debris off top of AX-Max units	Weekly	Spicers	Onsite
Control Panel	Check if there is a fault alarm (red light) on the Control Panel door	Weekly	Spicers	Onsite

Area	Task	Frequency	By	Location
Control Panel	Inspect inside the Control Panel for damage, deterioration, or pest access. Rectify as required.	Monthly	ENVR	Onsite
Control Panel	Check all circuit breakers are in the on position	Monthly	ENVR	Onsite
Control Panel	Confirm and record pump voltages and amperages	Biannually	ENVR	Onsite
AX-MAX 1	Retrieve raw influent samples from primary treatment (septic) chamber	Monthly	ENVR	Onsite
AX-MAX 1	Perform visual inspection of tank's liquid levels	Monthly	ENVR	Onsite
AX-MAX 1	Check effluent filter and clean if required	Monthly	ENVR	Onsite
AX-MAX 1	Check and record scum and sludge accumulation in primary treatment (septic) chamber	Monthly	ENVR	Onsite
AX-MAX 1	Check all floats are operating and have clear movement in recirc/blend chamber	Monthly	ENVR	Onsite
AX-MAX 1	Check high-level and low-level alarms are functioning (recirc and discharge chamber)	Monthly	ENVR	Onsite
AX-MAX 1	Confirm automatic float operation of all pumps	Monthly	ENVR	Onsite
AX-MAX 1	Check and record colour and odour of biomat growth on textile	Monthly	ENVR	Onsite
AX-MAX 1	Check and verify adequate spray pattern of spinner nozzles	Monthly	ENVR	Onsite
AX-MAX 1	Flush internal plumbing manifolds	Monthly	ENVR	Onsite
AX-MAX 1	Clean spinner nozzles. Replace if necessary	Monthly	ENVR	Onsite
AX-MAX 1	Confirm air is circulating	Monthly	ENVR	Onsite
AX-MAX 1	Clean every pump's intake inlet	Biannually	ENVR	Onsite
AX-MAX 1	Wash down textile sheets using cleaning wand	Annually (if required)	ENVR	Onsite
AX-MAX 2	Check and confirm operation of ventilation fan	Weekly	Spicers	
AX-MAX 2	Retrieve treated effluent samples from discharge chamber	Monthly	ENVR	Onsite
AX-MAX 2	Perform visual inspection of tank's liquid levels	Monthly	ENVR	Onsite
AX-MAX 2	Check all floats are operating and have clear movement in recirc/blend chamber	Monthly	ENVR	Onsite
AX-MAX 2	Check high-level and low-level alarms are functioning (recirc and discharge chamber)	Monthly	ENVR	Onsite
AX-MAX 2	Confirm automatic float operation of all pumps	Monthly	ENVR	Onsite
AX-MAX 2	Check and record colour and odour of biomat growth on textile	Monthly	ENVR	Onsite
AX-MAX 2	Check and verify adequate spray pattern of spinner nozzles	Monthly	ENVR	Onsite

Area	Task	Frequency	By	Location
AX-MAX 2	Flush internal plumbing manifolds	Monthly	ENVR	Onsite
AX-MAX 2	Clean spinner nozzles. Replace if necessary	Monthly	ENVR	Onsite
AX-MAX 2	Confirm air is circulating	Monthly	ENVR	Onsite
AX-MAX 2	Clean every pump's intake inlet	Biannually	ENVR	Onsite
AX-MAX 2	Wash down textile sheets using cleaning wand	Annually (if required)	ENVR	Onsite
AX-MAX 2	Check UV lamps ae operating	Monthly	ENVR	Onsite
AX-MAX 2	Clean UV glass sleeves	Monthly	ENVR	Onsite
AX-MAX 2	Replace carbon in filter	Annually	ENVR	Onsite
AX-MAX 2	Wash down textile sheets using cleaning wand	Annually	ENVR	Onsite
AX-MAX 2	Replace UV lamps	Annually	ENVR	Onsite
RWS Tank	Visual inspection of tank's liquid level	Monthly	ENVR	Onsite
RWS Tank	Check all floats are operating and have clear movement	Monthly	ENVR	Onsite
RWS Tank	Check high-level and low-level alarms are functioning	Monthly	ENVR	Onsite
RWS Tank	Confirm float operation of all pumps	Monthly	ENVR	Onsite
RWS Tank	Clean pump's intake inlet	Monthly	ENVR	Onsite
Chemical Dosing	Check the volume of liquid in the carbon dose tank and replenish if necessary	Monthly	ENVR	Onsite
Chemical Dosing	Check the volume of liquid in the sodium bicarbonate dose tank and replenish if necessary	Monthly	ENVR	Onsite
Chemical Dosing	Review dosing ratios of peristaltic pumps and recalibrate if necessary	Monthly	ENVR	Onsite
Irrigation Area	Inspect irrigation network and disposal areas for leaks and pooling	Weekly	Spicers	Weekly
Irrigation Area	Flush irrigation network	Annually	ENVR	Onsite
Permit/Approval Management	Provide ongoing consulting, correspondence and reporting to DES and QBuild on the client's behalf	ENVR	Ongoing	Offsite
Permit/Approval Management	Facilitation of a 24 hour/7-day, remote alarm response management service	ENVR	Ongoing	Onsite/Offsite
Permit/Approval Management	Provision of reports and monitoring results while maintaining appropriate records of works as required by the EA Permit	ENVR	Ongoing	Offsite

5.3 Irrigation Area Maintenance

Irrigation areas should be regularly monitored to prevent environmental harm and limit possible health risks. These principles are essential for the controlled and sustainable disposal of treated effluent.

5.3.1 Equipment

All irrigation equipment including sub-surface drip lines, valves, pumps and control boxes should be regularly inspected and maintained to ensure irrigation is closely controlled. Filters should be regularly inspected and cleaned to maintain pressure and prevent clogging of valves. Valves that have failed to close can cause excessive irrigation and possible environmental harm.

5.3.2 Vegetation

MEDLI modeling predicts no major stress will be placed upon the vegetation through the proposed irrigation regime, (MEL, 2019a). If vegetation becomes unmanageable, a portion should be removed and disposed of as waste to the municipal landfill.

As revealed in the modeling, a healthy crop cover is essential for the effective treatment of nutrients exposed to soils as a result of effluent disposal. Irrigation areas should consist only of the recommended grasses, Cutty Grass (*Carex appressa*), Creek Mat-rush (*Lomandra hystrix*), and Basket Grass (*Lomandra longifolia*).

Any pest species such as crofton weed, lantana, devil's fig or tobacco bush should be appropriately eradicated following methods outlined in the section 2.9 – Pest Management in the SRTMP, (Spicers, 2023).

5.3.3 Drainage

Irrigation should not take place during periods of rainfall thereby preventing ponding or pooling beyond and within the disposal area boundary. It is recommended irrigation does not occur if the previous day has had greater than 3mm of rainfall.

5.3.4 Wet Weather Storage

The treated effluent storage tank has a capacity of 10kL and the estimated daily load is less than 500L per day with a peak design capacity of 600L/day. Therefore, the treated effluent tank has a minimum capacity for 20 days. In 2024, a maximum of 5 days of continuous rainfall occurred during the year.

6 Management Plan

Rational, appropriate management practices are essential to avoid detrimental impacts on the surrounding environment, including groundwater quality and the surrounding aquatic environs.

The following broad outcomes are set for the PWaSM:

- No effluent runoff from the irrigation area at any time during the operation of the irrigation area.
- No stormwater runoff to mix with irrigating waters or to enter a land application area.
- No contamination of the receiving environment as a result of stormwater runoff from the site.
- No sedimentation of receiving waters as a result of the operation of the irrigation scheme.
- No degradation of surface and groundwaters as a result of the operation of the irrigation scheme.
- No impact on public health as a result of the irrigation scheme.
- No impact on the existing water quality of downstream receiving waters as a result of the operation of the irrigation scheme.

6.1 Control Measures

The following control measures shall be implemented prior to the operation of the effluent treatment facility in accordance with **15A) a) i) ii) and iii)** of the Variation as shown in **Appendix A**.

- Minmise water usage within the facilities in the EcoCamps, including pressure reduction devices on tap outlets and minimum flush toilets.
- Alarms within the WWTPs to ensure:
  - No overflows;
  - No pump failures;
  - Adequate UV sanitation of treated effluent.
- Stormwater on site is all captured and re-used on site.
- Any overland flow from upgrdient of the irrigation areas are to be diverted around trhe irrigations areas to ensure no additional overland flow of water in irrigation areas.
- The effluent irrigation infrastructure shall be subsurface irrigation so as to eliminate the possibility of spray drift from the area.
- The effluent irrigation pipelines shall be placed underground to reduce the risk of damage from impact with machinery such as a whipper snipper.

The following alarm points are designed to alert the operators of the WWTP of system failures in the WWTPs in accordance with **15A) d)** of the Variation as shown in **Appendix A**.

6.2 Alarm points for operational failure of WWTPs

The following trigger points are identical at both EcoCamps and both WWTPs have two (2) treatment process trains separated between an AX-MAX #1 and AX-MAX #2 unit:

AX-MAX #1	AX-MAX #2

• Recirc/blend chamber
  • High-level
  • Low-level
  • Recirc pump 1 failure
  • Recirc pump 2 failure
  • Filtrate return pump failure
• Discharge chamber
  • High-level
  • Low-level
  • Discharge pump 1 failure
  ○ Ventilation fan failure alarm
• Control Panel
  ○ Mains power failure alarm
	• Recirc/blend chamber
	• High-level
	• Low-level
	• Recirc pump 1 failure
	• Discharge chamber
	• High-level
	• Low-level
	• Discharge pump 1 failure
	• Discharge pump 2 failure
	• UV lamp 1 failure
	• UV Lamp 2 failure
	• Ventilaion fan failure
	• Alkainity dosing system
	• Low-level alarm
	• Carbon dosing system
	• Low-level
	• Control Panel
	• Lost mains power
	• Pump left in off position (all pumps)

If any of the above alarms are triggered, ENVR as the service operator of the plants, , is contacted by email issued via the telemetry within the control panel. ENVR will then take appropriate action to rectify any faults in accordance with corrective action procedures as outlined in **Section 10**.

In order to ensure compliance with **15A) a) i), iv, v), b)** of the Variation as shown in **Appendix A**, the following sampling program of treated effluent release to land, soil within the 50m of the EcoCamps and within all areas proposed for disposal of treated sewage, As well as, surface water and groundwater underlying the Eco Camps and all drainage channels and downstream water bodies outside of the boundaries of the EcoCamps with potential hydraulic connectivity with sewage and wastewater disposal areas.

6.3 WWTP Sample Monitoring Program

In accordance with condition **15A** (**Appendix A)**, treated effluent wastewater, surface water, groundwater and soils potentially impacted by effluent disposal should be monitored using the following criteria and frequency detailed in **Error! Reference source not found.** as a minimum, in accordance with **15A) a) iv) v) b)** of the Variation as shown in **Appendix A**. It should be noted that monitoring releases to land is only required when the EcoCamps are occupied and it is understood that the Eco Camps are not occupied between November and March. In addition, it should be noted that soil, surface and groundwater monitoring in **Error! Reference source not found.** is covered in more detail in the SWMP. The quantity of water being irrigated is monitored by a flow meter and should be monitored on a weekly basis.

Table 5: Monitoring Schedule of the PWaSM

Schedule		Analyses	Frequency
Releases to Land		*Biochemical Oxygen Demand (BOD)*	**Monthly (when Irrigating)**
		Total Suspended Solids (SS)	
		Total Nitrogen (TN Total Kjeldahl (TKN)) Oxidised Nitrogen (NOx)	
		Ammonia Nitrogen (NH3) Total Phosphorus (TP)	
		Alkalinity	
		pH, Electrical Conductivity (EC) and Turbidity	
		E. coli	
		Oil and Grease (O&G)	
Soil Monitoring	**Group**	**Analyses**	
	Physio-chemical properties	*pH, electrical conductivity*, moisture content, *cation exchange capacity, salinity, sodicity*	**Annually**
	Anions	Sulphur, chloride, calcium, magnesium	
	Cations	Sodium, potassium, sodium absorption capacity,	
	Metals	Arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc	
	Nutrients of N	*Total nitrogen,* total Kjeldahl nitrogen, nitrite + nitrate	
	Nutrients of P	*Total phosphorus*, reactive phosphorus, *phosphate sorption capacity*	
	Organic matter	Organic matter	
Groundwater and Surface Waters	Microbial	*E. coli (cfu / 100ml)*;	**Biannually**
	Nutrients of N	*Ammonia (mg/L as N),* Total Kjeldahl Nitrogen, *Nitrate*, Nitrite (mg/L as N),	
	Nutrients of P	*Total Phosphorus*, Ortho Phosphate (mg/L);	
	Anions	Major Anions Chloride, Sulphate, Bicarbonate, Fluoride;	
	Cations	Major Cations Sodium, Potassium, Calcium, Magnesium;	
	Metals	Total and dissolved metal concentrations (As, Cd, Cr, Cu, Ni, Pb, Zn);	
	Physio-chemical properties	pH, electrical conductivity, temperature, dissolved oxygen, total disslved solids, Oxidation-Reduction Potential, and Turbidity	

6.4 Effluent Trigger Levels

The Eligibility Criteria and Standard Conditions for Sewage Treatment Works (ERA63), (Queensland, 2015), and Queensland Water Recycling Guidelines, (EPA, 2005), suggests Total Nitrogen median levels over 12 months of 30 mg/L and a maximum value of 60 mg/L in any one sample, as well as Total Phosphorus median levels over 12 months of 10 mg/L and a maximum value of 20 mg/L in any one sample.

Quality of effluent is directly proportional to the quality of influent. Spicers EcoCamps and the associated Sewage Treatment Plants (STPs) were designed to minimise water usage and, therefore, influent production, in accordance with clause **15A.a) iii)** of the Variation. Therefore, if the throughput of water is minimised in the system, the influent nutrients levels will increase, which is

directly related to the ability of the system to reduce the nutrient levels in the effluent. The level of nutrients in the influent is related to the level of nutirents in the effluent. The Total Nitrogen levels in both Woodcutters and Amphitheatre EcoCamps over the last five years have resulted in a median level of 53 mg/L and a maximum level of 84 mg/L; the Phosphorus levels in both EcoCamps over the last five years have resulted in a median level of 25 mg/L and a maximum level of 33 mg/L. These levels are above guidelines shown above, however, as previously stated the disposal areas have the capacity to absorb 6 kL a day of irrigated treated effluent without any contribution to deep drainage and the surrounding ecosystem at both EcoCamps have a good buffering capacity as well as a high background level of nutrients. Therefore, we propose to use a trigger value slightly higher than the 110% of the median and maximum values of effluent quality from both EcoCamps and to use E.coli levels associated with class A water, in accordance with **15A) a) i)** of the Variation as shown in **Appendix A** and Queensland Plumbing Code, (Queensland, 2019c), and AS1546.3:2017, (Australia, 2017). Results from Review of Effluent quality data at Amphitheatre and Woodcutters EcoCamps, (MEH, 2024b), can be seen in **Appendix B**.

Table 6: Proposed Trigger Values for Effluent Quality at both EcoCamps

moreton environmental and health	TN	pH	TP	EC	E.coli
	mg/L	Scale	mg/L	µS/cm	cfu /100ml
Median	60		25		10
Max	95	8.5	35	1600	1000
Min		5.0			

Note: TN, TP are derived from 110% of the median and maximum values of effluent quality and pH, EC and E.coli levels are derived from Eligibility ERA63 criteria.

6.5 Soil

The system design has been optimised to ensure a sustainable nutrient balance. A soil monitoring program for a suite of parameters has been proposed as a part of this PWaSM within **Error! Reference source not found. Error! Reference source not found.** to ensure no degradation in soil properties. Details of methods (including survey methodology, effort, timing, frequency and responsibility) that will be implemented for the collection and analysis of data regarding soil quality are given in the SWMP in accordance with **15A) a) iv)** of the Variation as shown in **Appendix A**. Erosion control methods should be put in place and properly maintained including the perimetyermof the irrigation disposal areas.

6.6 Groundwater and Surface Waters

A surface water and groundwater monitoring program for a suite of parameters has been proposed as a part of this PWaSM within **Error! Reference source not found. Error! Reference source not found.**. Details of methods (including survey methodology, effort, timing, frequency and responsibility) that will be implemented for the collection and analysis of data regarding water quality are given in the SWMP in accordance with **15A) a) iv)** of the Variation as shown in **Appendix A**.

6.7 Irrigation Areas

Operators shall be responsible for monitoring the irrigation area while in operation or automated systems installed to monitor the irrigation areas. If any circumstance arises where it is thought that runoff or release of treated effluent to the receiving environment may occur, then irrigation shall cease. Operators shall:

- Rainfall will be monitored and time of irrigation automated to only occur 1 day after rainfall is greater than 3mm a day.
- monitor the condition of the effluent irrigation infrastructure over the site to ensure that any identified concerns relating to infrastructure degradation are rectified as quickly as is practicable.
- regularly inspect the condition of the irrigation area, noting any signs of erosion or degradation of the condition of the vegetation.

The water quality of the receiving environment, including groundwater and receiving waters, shall be monitored in accordance with the SWMP and SRTMP.

7 Health Issues

As the effluent will be treated to a Class A, no health impacts are anticipated from irrigation, however in order to remain conservative, the following restrictions will be enforced in communal areas:

- The effluent irrigation is to take place only at times where no residents and visitors are likely to be present (10am – 2pm);
- Appropriate signage will be erected notifying residents and visitors that the area is being used for effluent irrigation purposes for public health and safety; and
- Operators of the plant will have appropriate PPE during maintenance or sampling times.

8 Training Procedures

All personnel employed onsite will receive training from Spicers or Envir Solutions or MEH, depending on which is appropriate as per Section 8 of this plan.

Personnel will use the following standard operating procedures (SOPs) when conducting monitoring at the Ecocamps:

- FTP 001 - Water Quality Field Readings.
- SOP_PROC_001-Soil sampling.
- SOP_PROC_002-Surface Water sampling.
- SOP_PROC_004-Quality Assurance and Quality Control.

These SOP are shown in **Appendix C**, and are consistent with Qld Government-approved guidelines and industry standards, including the 2018 Monitoring and Sampling Manual, (Queensland, 2018a).

9 Reporting

Results of all monitoring activities undertaken shall be forwarded to DEECCW annually or as required in the SRTMP.

This will include the following annual reports:

1. Surface Water Investigations for Annual Monitoring of Surface and Groundwaters at Amphitheatre and Woodcutters EcoCamps.
2. Soil Investigations for Annual Monitoring at Amphitheatre and Woodcutters EcoCamps.
3. Operatonal Performance and Effluent Monitoring at Amphitheatre and Woodcutters EcoCamps Waste Water Ttreatment Plants.

9.1 Quality Assurance/Quality Control (QA/QC)

For any given project, all investigation data is potentially subject to sampling and data reduction errors. Therefore, data quality objectives (DQO) are 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.

Methodology of the quality assurance (QA) and quality control (QC) are further discussed in this section of the report with further details presented in **Appendix D.** Results are discussed in Section **Error! Reference source not found.**.

QC samples will be collected and/or analysed in accordance with National Environmental Protection Measure (NEPM) guidelines, (NEPC, 2013a). One field duplicate and one field triplicate sample will be collected per 10 primary samples and one trip blank per sampling event. Further details of MEH quality control and quality assurance procedures are shown in Quality Assurance and Control (**Appendix D).**

10 Corrective Action

Management shall investigate and document events of non-compliance with the above targets in section 6, including alarm ponts for operations and effluent quality triggers.

If the effluent quality is above the maximum or below the minimum values in any one sampling event or the effluent quality is above the median value on an annual basis, as shown in Table 6.

Then the trigger has been breached and management must investigate further if multiple lines of evidence such as breaches of WQO, statistical tests, time series and trend analysis in verifying if a decrease in a population, or change in soil, water or habitat quality referred to in condition **8A, 14.c. or 15A** of the Variation as shown in **Appendix A**, has occurred or is likely to occur due to impacts from the disposal of effluent, the approval holder must report this to the Department within **5 business days** of being detected.

Non compliance of soil and water quality are detailed in the SWMP, if multiple lines of evidence such as breaches of WQO, statistical tests, time series and trend analysis in verifying any impacts on soils and water quality and the causation of change leads to conclusions of a decrease in a population of the MNES, or change in soil, water or habitat quality referred to in condition **8A, 14.c. or 15A** of the Variation as shown in **Appendix A**, has occurred or is likely to occur, the approval holder must report this to the Department within **5 business days** of being detected. Management procedures shall be modified where necessary to achieve compliance with conditions of the Variation as shown in **Appendix A**,.

Non-conformance with this PWaSM shall be documented included in the Non-conformance Register.

Management shall implement the corrective action as required within the agreed time frame noted on the corrective action record (CAR).

A record of the corrective action required will be implemented by the operations manager of the WWTP and will include the use of the PDCA cycle which has four stages:

1. Plan — determine goals for the required action and the required actions changes to achieve the goal.
2. Do — implement the changes.
3. Check — evaluate the results in terms of performance.
4. Act — standardise and stabilise the change or begin the cycle again, depending on the results. The actions and/or changes to the operational processes must be sustainable and achieve the goal in the long term.

11 Disclaimer and Limitations

11.1 Disclaimer

This Plan for Wastewater and Sewage Management (the "PWaSM") has been prepared by Moreton Environmental and Health Pty Ltd ABN 61 634 786 196 (MEH) for the exclusive use THRL Pty Ltd ACN 137 592 593 (Spicers) for its own use for the purpose of a managing operations of land application of treated effluent at the WWTP at Whitsunday Shores (the “site”).

The PWaSM 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 Plan.
- In conjunction with the license conditions or conditions set out in other plans including the site based management plan.
- The cost and other constraints imposed on the Plan.
- Other relevant issues which are not within the scope of the Plan.

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

No warranty or representation is made to Spicers or third parties (express or implied) in respect of the Plan, particularly with regard to any commercial investment decision made on the basis of the Plan. Use of the PWaSM by Spicers or third parties or operators of the WWTP shall be at their own risk and extracts from the PWaSM may only be published with permission of MEH. This disclaimer must accompany every copy of the PWaSM, which is an integral document and must be read in its entirety and reference made the license conditions or conditions setout in other plans including the site based management plan.

11.2 Limitations of this plan

The outcome of this PWaSM is limited to information supplied at the time the PWaSM was written. It is intended that this PWaSM provides a description of the operating parameters of the irrigation scheme and potential impacts on the environment and recommendations on how to address and manage the impacts at the site.

This PWaSM has been prepared for Spicers or operators of the plant for their own use and is based on information provided by Spicers and operators of the plant. MEH takes no responsibility and disclaims all liability whatsoever for any loss or damage that Spicers or future owners or operators of the plant may suffer as a result of using or relying on any such information or recommendations contained in this PWaSM, except where it is expressly indicated in this PWaSM that it has verified the information to its satisfaction. This PWaSM does not provide a complete operation procedure, and it is limited to the scope defined herein.

Should further information become available regarding the conditions at the site, MEH reserves the right to review the PWaSM in the context of the additional information.

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

The PWaSM 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.

This plan has been prepared by MEH in response to and subject to the following limitations:

1. The specific instructions received from Spicers;
2. It may not be relied upon by any third party not named in this report for any purpose except with the prior written consent of MEH (which consent may or may not be given at the discretion of MEH);
3. This plan comprises the documentation sections, tables, figures and appendices as referred to in the index to this plan 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 plan only relates to the site referred to in the scope of works being located at Amphitheatre and Woodcutters EcoCamps as part of the Spicers Scenic Rim Trail, Thornton Trailhead to Spicers Canopy Nature Reserve, within the Main Range National Park, Queensland, Australia (“the site”);
5. The plan relates to the site 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; and
7. Our General Limitations set out at the back of the body of this report.

12 References

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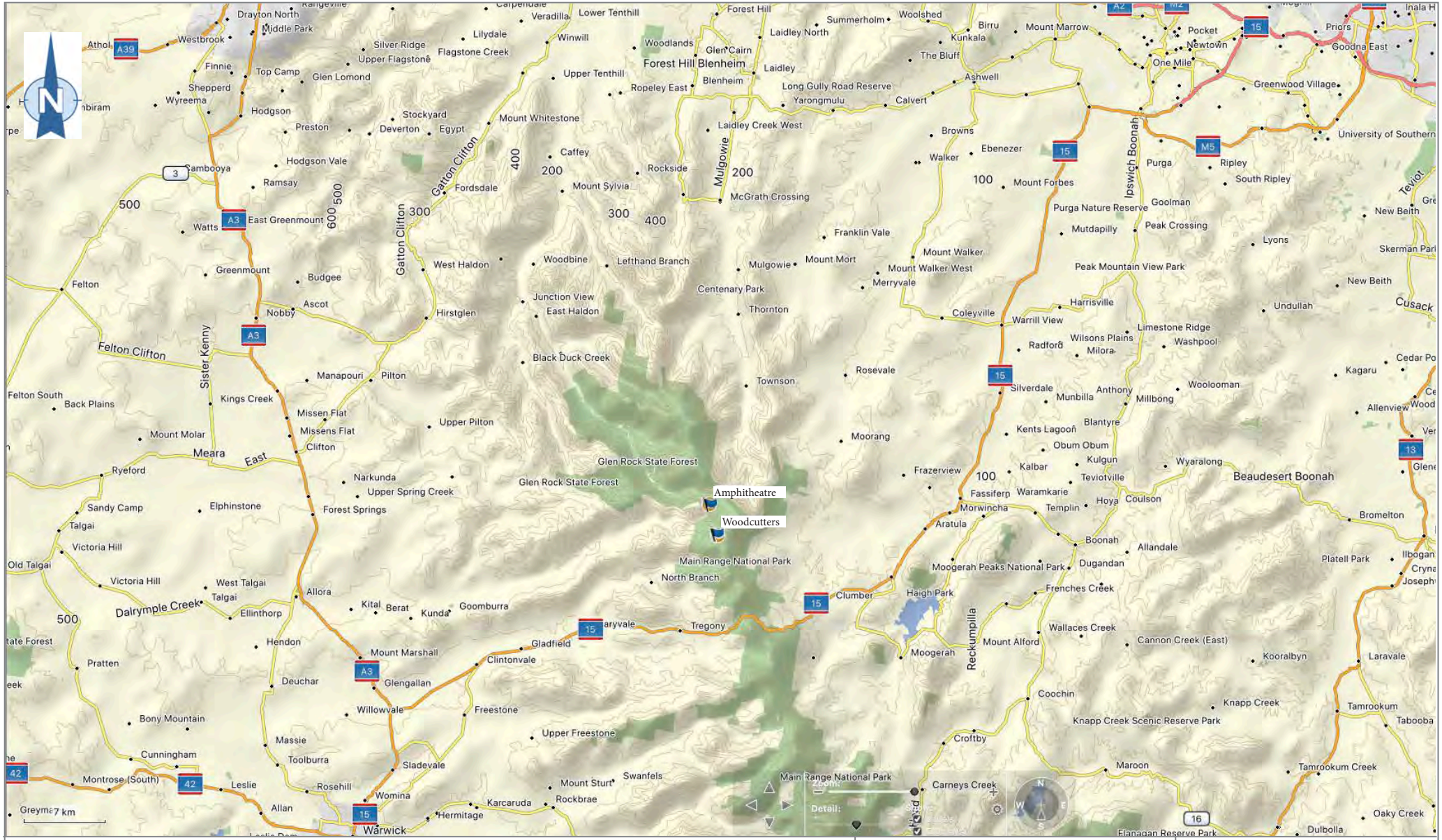
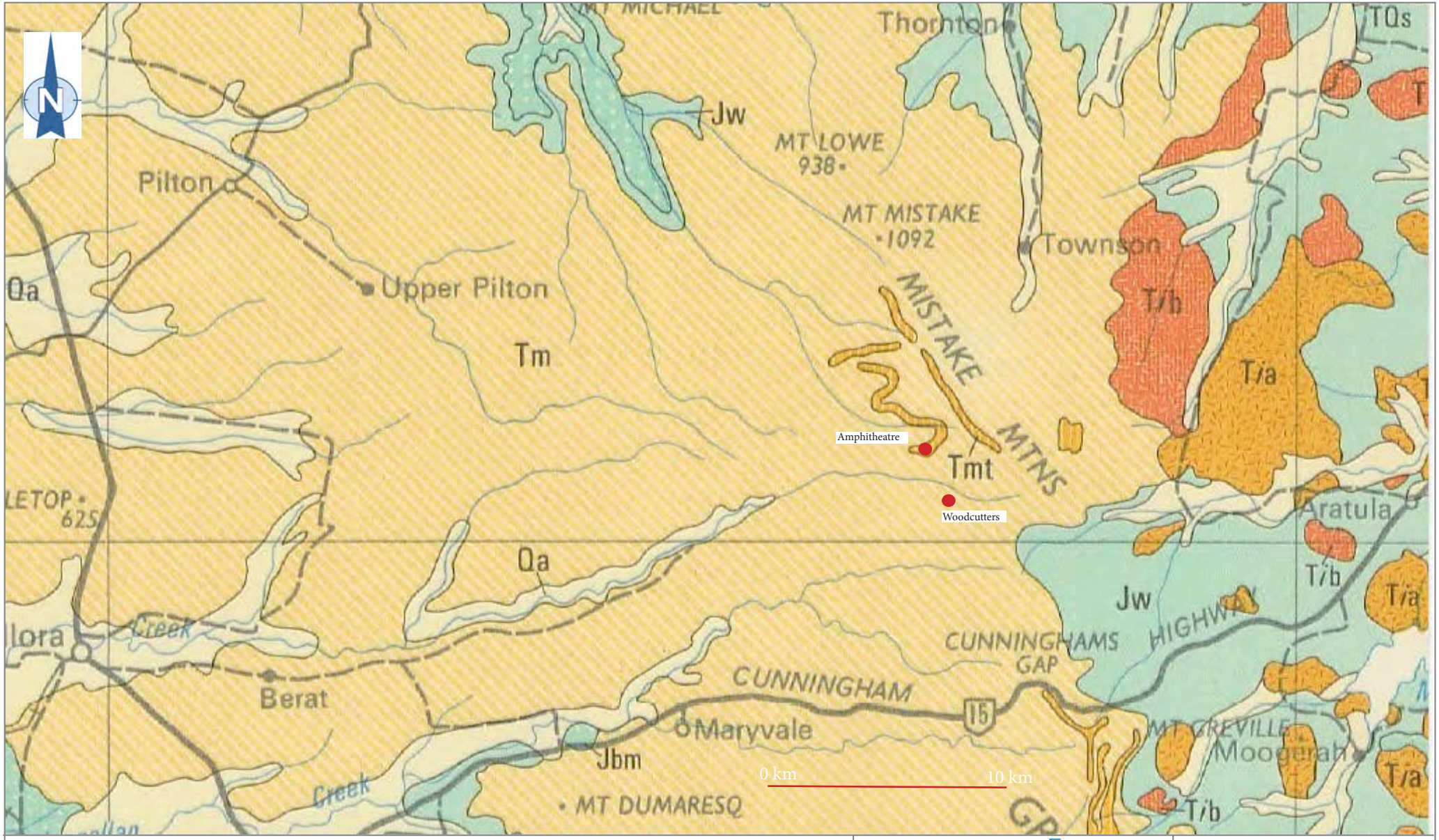
FIGURES



Legend

moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Title:	Location Map
		Location:	Main Range National Park, Queensland
Drawn by:	Dan Morton	Source:	Google Earth
Project Manager:	Dan Morton	Scale:	Scale Bar Job No: 25005
		Date:	March 2025 FIGURE : 01



Legend

Main Range Volcanics — *Basalt, agglomerate, shale, dolomite*

Flood Plains, river terraces

Main Range Volcanics - ***Basalt, agglomerate, shale, dolomite***

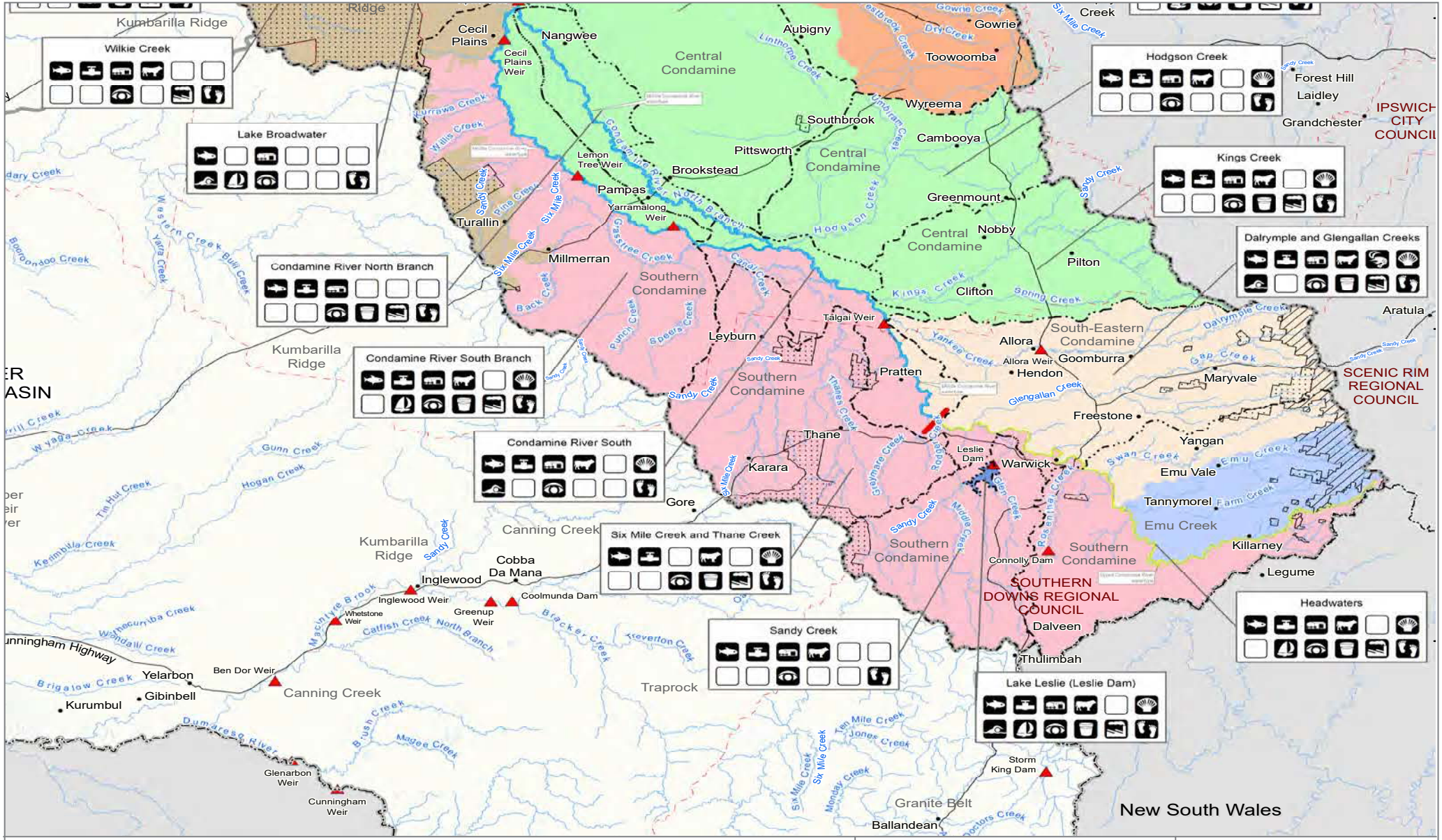
Compiled by W.G. Whitaker and P.M. Green, Regional Mapping Section, from data available at June, 1978.

Geology from 1:250 000 series maps published by the Geological Survey of Queensland (GSQ), Geological Survey of New South Wales (GSNSW) and the Bureau of Mineral Resources, Geology and Geophysics; 1:100 000 series maps published or in preparation by GSQ and GSNSW, and other sources.

moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Source:	
Drawn by:	Dan Morton	Scale:	Scale Bar Job No: 25005
Project Manager:	Dan Morton	Date:	March 2025 FIGURE : 02

Title:	Geology
Location:	Main Range National Park, Queensland



Legend

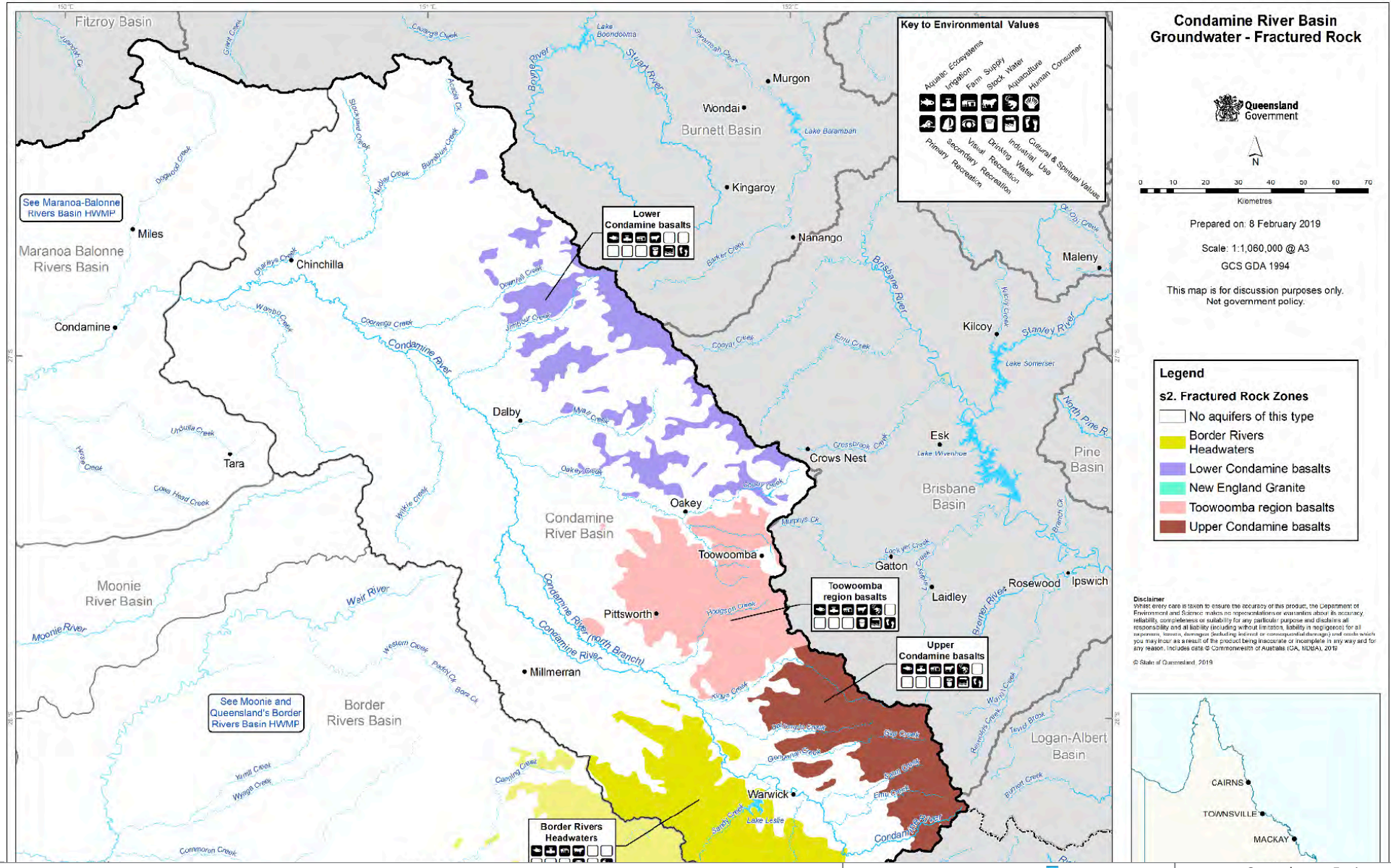
WQ4223 - Condamine River Basin Part of basin 422 under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019.

moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Source:	
Drawn by:	Dan Morton	Scale:	Scale Bar — Job No: 25005
Project Manager:	Dan Morton	Date:	March 2025 — FIGURE : 03

Title: Surface Water Environmental Values

Location: Main Range National Park, Queensland



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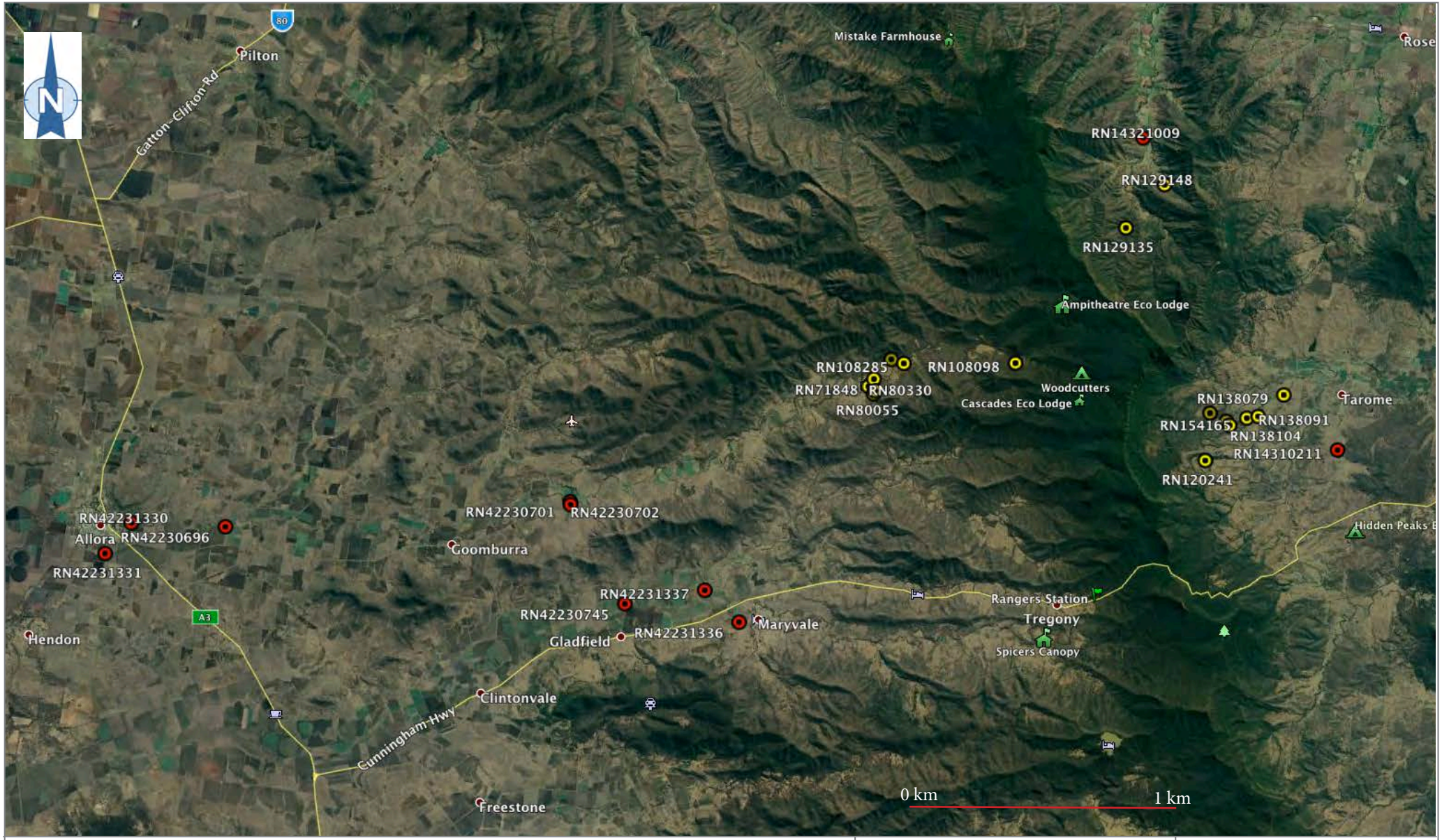
moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Title:	Groundwater Environmental Values
Drawn by:	Dan Morton	Location:	Main Range National Park, Queensland
Project Manager:	Dan Morton	Source:	
		Scale:	Scale Bar
		Job No:	25005
		Date:	March 2025
		FIGURE :	04



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moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Source:	
Drawn by:	Dan Morton	Scale:	Scale Bar Job No: 25005
Project Manager:	Dan Morton	Date:	March 2025 FIGURE : 05

Title: Bore Search

Location: Main Range National Park, Queensland

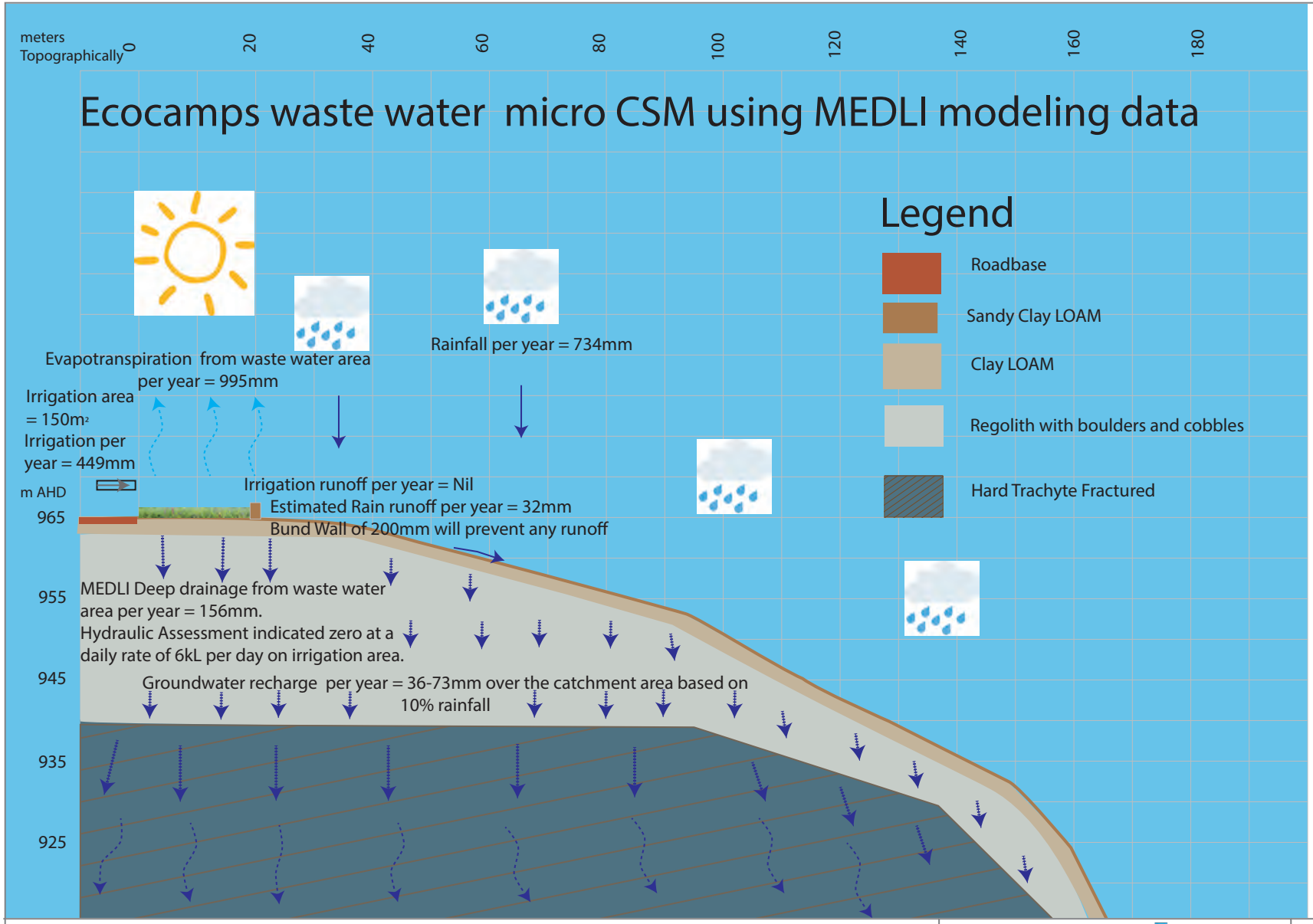
Legend

moreton environmental and health

Client: Spicers Retreats Hotels & Lodges Pty Ltd	Source:
Drawn by: Dan Morton	Scale: Scale Bar Job No: 25005
Project Manager: Dan Morton	Date: March 2025 FIGURE : 06

Title: Creeks and Watercourses

Location: Main Range National Park, Queensland



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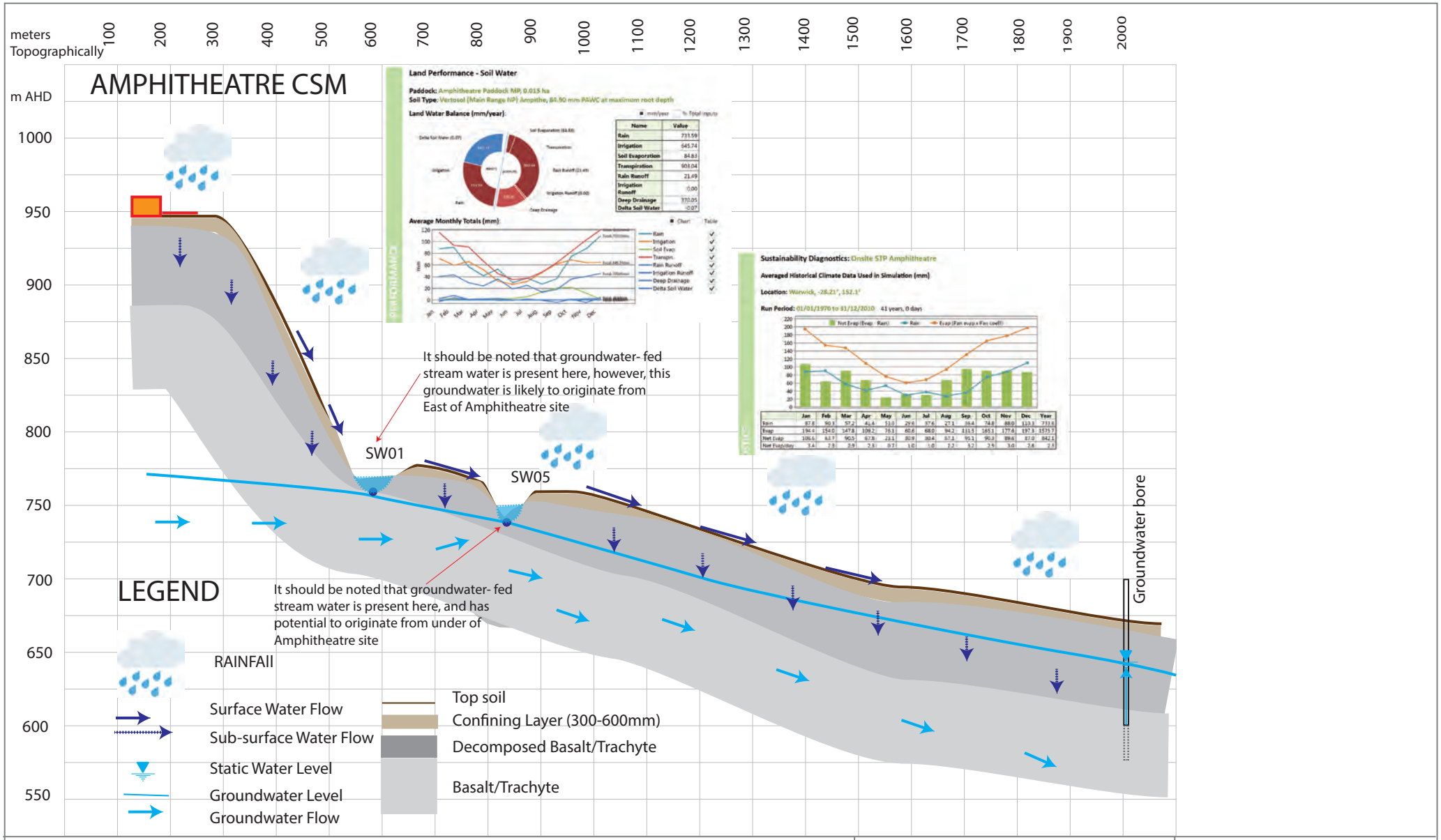
moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Source:	
Drawn by:	Dan Morton	Scale:	Scale Bar Job No: 25005
Project Manager:	Dan Morton	Date:	March 2025 FIGURE : 07

Title: EcoCamps Waste Water Micro CSM using MEDLI Data

Location: Main Range National Park, Queensland



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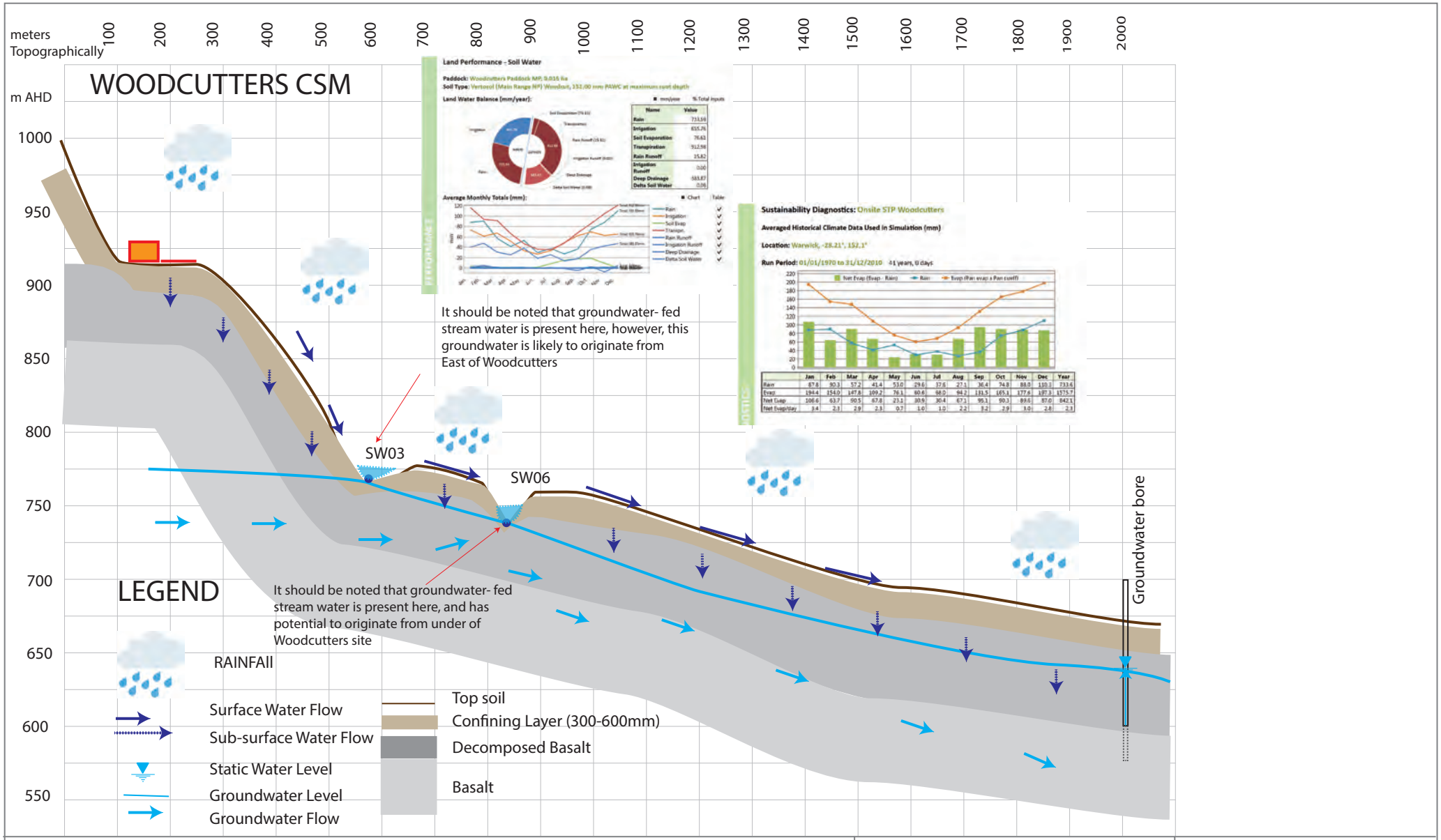
moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Source:	
Drawn by:	Dan Morton	Scale:	Scale Bar Job No: 25005
Project Manager:	Dan Morton	Date:	March 2025 FIGURE : 08

Title:	Amphitheatre Groundwater Conceptual Site Model
Location:	Main Range National Park, Queensland

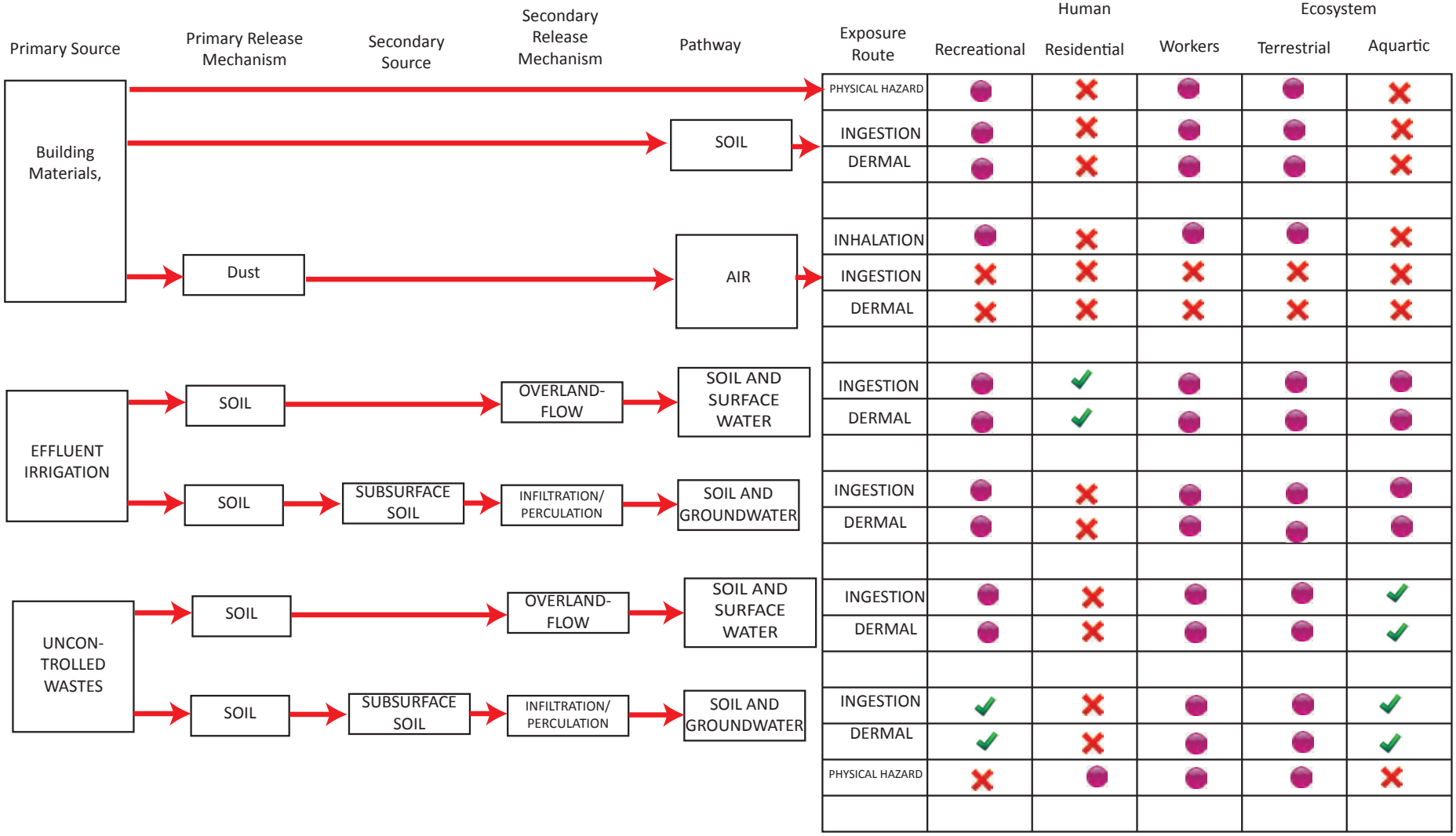


Legend

moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Title:	Timber Getters Groundwater Conceptual Site Model
Drawn by:	Dan Morton	Location:	Main Range National Park, Queensland
Project Manager:	Dan Morton	Source:	
		Scale:	Scale Bar Job No: 25005
		Date:	March 2025 FIGURE : 09

CONCEPTUAL SITE MODEL Spicers Eco Camps



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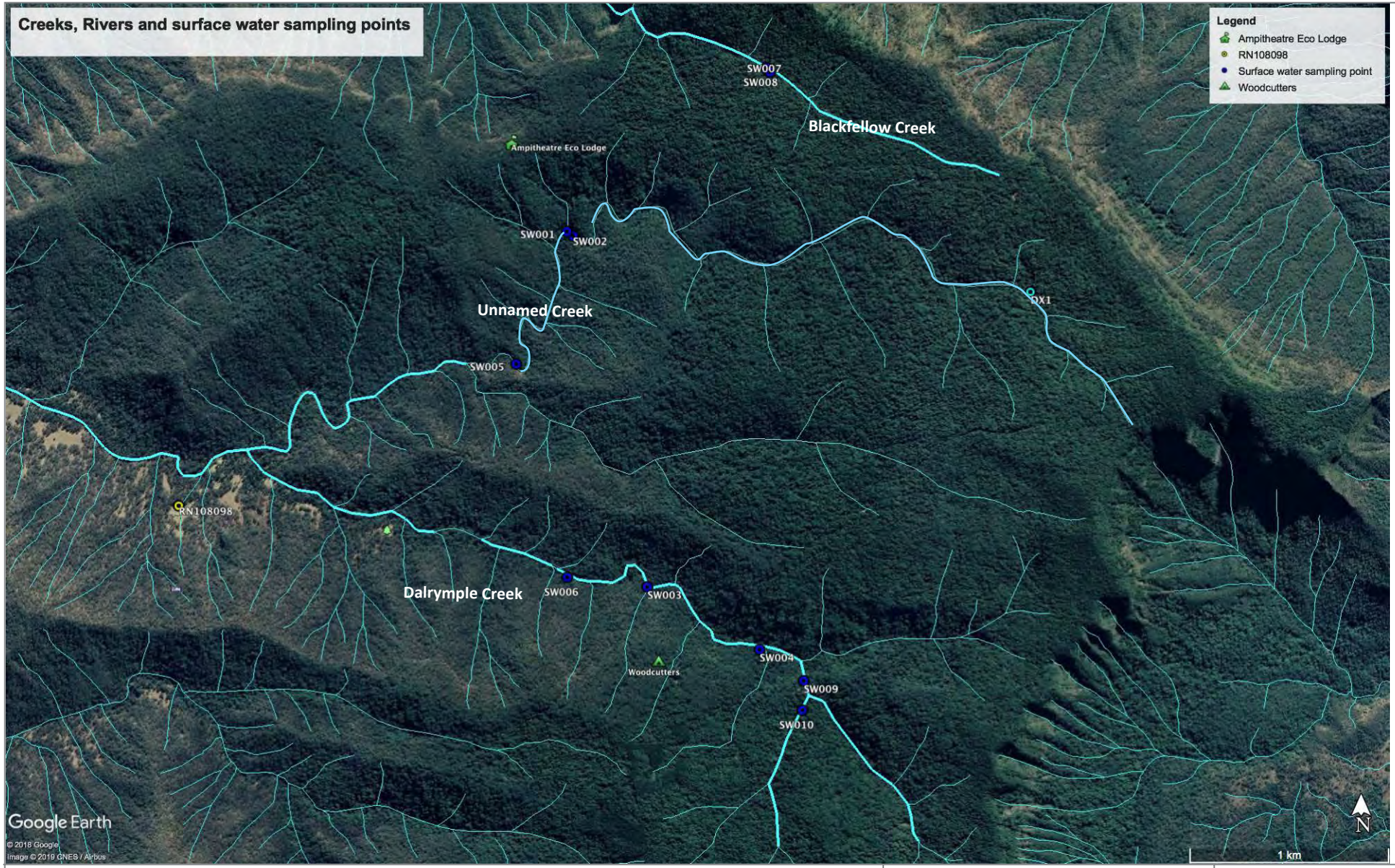
moreton environmental and health

Client: Spicers Retreats Hotels & Lodges Pty Ltd	Source:
Drawn by: Dan Morton	Scale: Scale Bar Job No: 25005
Project Manager: Dan Morton	Date: March 2025 FIGURE : 10

Title: Eco Camps Conceptual Site Model

Location: Main Range National Park, Queensland



Legend

SW01

Surface Water Monitoring Point

Resource Groundwater Bore

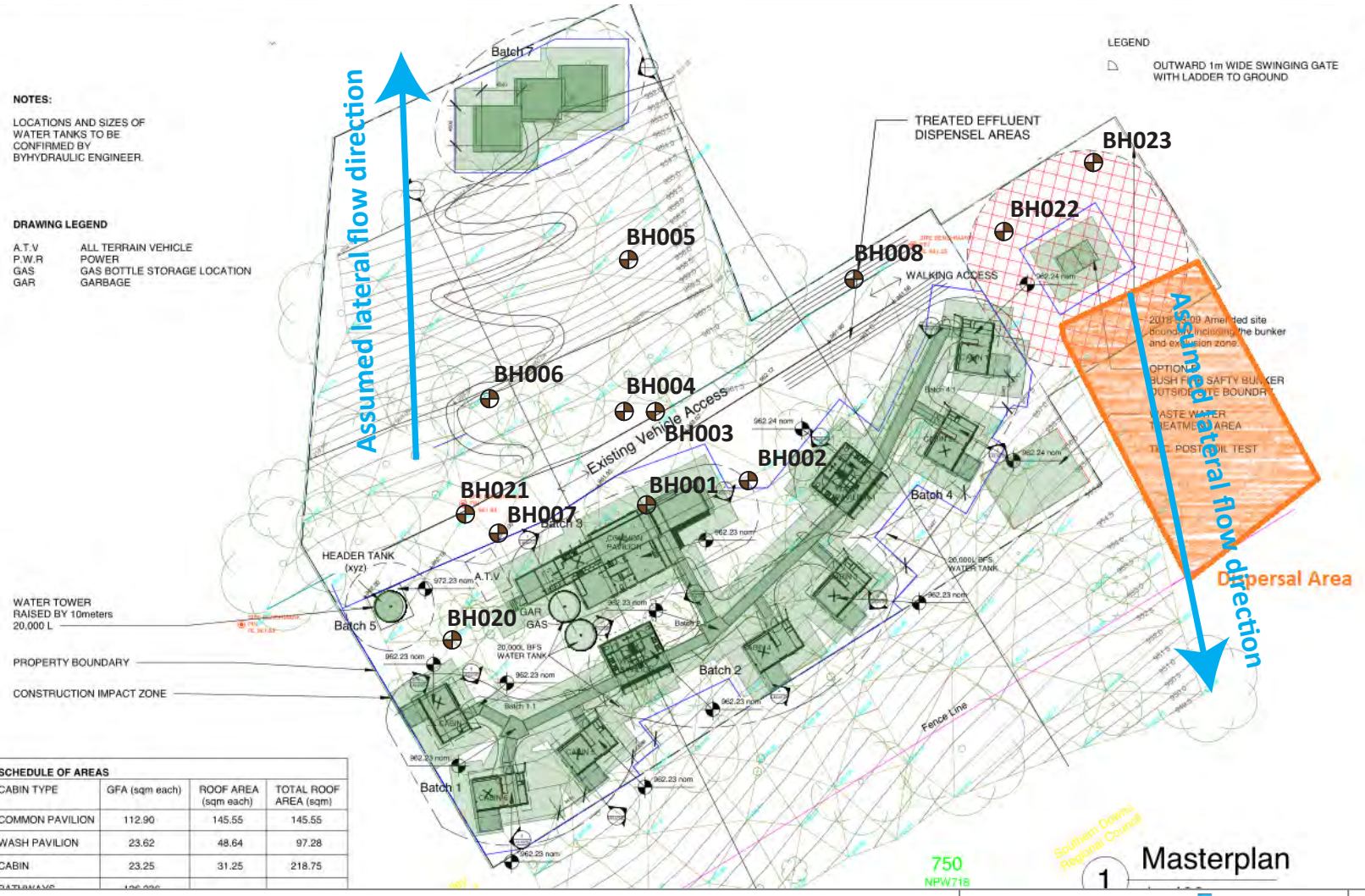
moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Source:	
Drawn by:	Dan Morton	Scale:	Scale Bar Job No: 25005
Project Manager:	Dan Morton	Date:	March 2025 FIGURE : 11

Title: Recommended Surface Water Sampling

Location: Main Range National Park, Queensland

AMPHITHEATRE ECOCAMP



Legend

- Peizometer
- Borehole
- Irrigation Area

moreton environmental and health

Client:	Spicers Retreats Hotels & Lodges Pty Ltd	Title:	Amphitheatre EcoCamp
Drawn by:	Dan Morton	Location:	Main Range National Park, Queensland
Project Manager:	Dan Morton	Source:	
		Scale:	Scale Bar
		Job No:	25005
		Date:	March 2025
		FIGURE :	12

WOODCUTTERS ECOCAMP

DRAWING LEGEND

A.T.V ALL TERRAIN VEHICLE
P.W.R POWER
GAS GAS BOTTLE STORAGE LOCATION

NOTES

SPECULATIVE GROUND LEVELS NOT YET SURVEYED
DATA TO BE PROVIDED PRIOR TO FINAL SITING OF CABINS
-L.R.
2017.5.30

LOCATIONS AND SIZES OF WATER TANKS TO BE CONFIRMED BY HYDRAULIC ENGINEER

SCHEDULE OF AREAS

CABIN TYPE	GFA (sqm each)	ROOF AREA (sqm each)	TOTAL ROOF AREA (sqm)
COMMON PAVILION	113.90	145.55	146.55
WASH PAVILION	23.62	48.68	97.36
CABIN	23.25	31.12	217.84
PATHWAYS	127.559		

Legend

Peizometer
Borehole
Irrigation Area

moreton environmental and health

Client: Spicers Retreats Hotels & Lodges Pty Ltd	Source:
Drawn by: Dan Morton	Scale: Scale Bar Job No: 25005
Project Manager: Dan Morton	Date: March 2025 FIGURE : 13

Title: Woodcutters EcoCamp
Location: Main Range National Park, Queensland

Legend

- Peizometer
- Borehole
- Irrigation Area

moreton environmental and health

Client: Spicers Retreats Hotels & Lodges Pty Ltd	Source:
Drawn by: Dan Morton	Scale: Scale Bar Job No: 25005
Project Manager: Dan Morton	Date: March 2025 FIGURE : 14

Title: Proposed Soil Monitoring Locations at Amphitheatre EcoCamp

Location: Main Range National Park, Queensland

Legend

- Peizometer
- Borehole
- Irrigation Area

moreton environmental and health

Client: Spicers Retreats Hotels & Lodges Pty Ltd	Source:
Drawn by: Dan Morton	Scale: Scale Bar Job No: 25005
Project Manager: Dan Morton	Date: March 2025 FIGURE : 15

Title: Proposed Soil Monitorong Locations at Woodcutters

Location: Main Range National Park, Queensland

APPENDIX A : VARIATION OF CONDITIONS ATTACHED TO APPROVAL (SCENIC RIM TRAIL – THORNTON TRAILHEAD TO SPICERS CANOPY NATURE RESERVE, QUEENSLAND (EPBC 2016/7847))

APPENDIX B : EFFLUENT QUALITY DATA AT AMPHITHEATRE AND WOODCUTTERS ECOCAMPS

moreton environmental and health

Woodcutters EcoCamp

Sample Date	BOD_5	TSS	TKN	NH3	NO_x	TN	pH	Alk	TP	EC	O&G	C.P	E.coli	Turbidity
	mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*Scale*	*mg/L*	*mg/L*	*µS/cm*	*mg/L*	*Spores /100ml*	*cfu /100ml*	*NTU*
Contaminants Release to Land 1						*30 / 60*	*5.0-8.5*		*10 / 20*	*1600*			*1000/100ml*	
Envir Solutions 2		*10*	*<2*		*20-30*		*6.5-8.5*	*100-150*						
22-May-20	22	5	1.3	1.12	0.9	2.2	8.17	348	0.18	760	5		24	1
28-May-20	16	5	0.6	0.22	2.03	2.6	8.5	371	0.24	791	5	2	10	0.6
11-Jun-20	8	5	1.5	0.84	7.03	8.5	8.35	330	0.51	803	5	1	240	0.4
30-Jul-20	19	5	9.4	1.82	40.1	49.5	8.03	154	6.57	1010	5	70	4000	1.2
6-Aug-20	12	5		7.5	42.4	49.9	7.86	157	6.8	1010	5	2	36	0.7
13-Aug-20	3	5	5.5	0.15	38.4	43.9	8.14	188	8.89	1010	5		70	0.8
3-Sep-20	34	5	6	0.21	37.7	43.7	7.16	211	7.61	1040	8	1	10	0.8
17-Sep-20	12	8	3.4	0.23	36.1	39.5	7.35	228	8.93	1100	5		2	1.9
Average	**16**	**5**	4	**2**	**26**	**30**	**8**	248	**5**	**941**	**5**	**15**	**549**	**1**
Median	**14**	**5**	3	**1**	37	**42**	**8**	220	**7**	**1010**	**5**	**2**	**30**	**1**
Max	34	8	9.4	7.5	42.4	49.9	8.5	371	8.93	1100	8	70	4000	1.9
Min	**3**	**5**	**0.6**	**0.15**	**0.9**	**2.2**	**7.16**	**154**	**0.18**	**760**	**5**	**1**	**2**	**0.4**
15-Jan-21	2	5	5.6	0.03	22.6	28.9	8.24	268	18.1	1140	5		1	0.8
29-Apr-21	5	5	4.1	0.05	24.4	28.5	7.55	92	18.8	818	5		1	1.7
31-May-21		5	4.2	0.19	23.5	27.7	6.89	4	21.2	611	5		1	3
6-Jul-21	11	5	13.3	5.06	26.3	39.6	5.29	2	17.8	629	5		1	5.7
2-Sep-21	8	7	19.8	12.2	39.7	65.4	5	1	29.5	960	5		6	4.7
8-Oct-21	11	5	17.2	13.1	44.2	61.4	3.91	1	28.5	955	5		2	2.7
9-Dec-21	5	5	22.2	14.3	51.2	77.6	5.6	1	33.3	1130	5		2	2.2
Mean	**7**	**5**	12	**6**	33	**47**	**6**	**53**	**24**	**892**	**5**		**2**	**3**
Median	**7**	**5**	13	**5**	**26**	**40**	**6**	**2**	**21**	**955**	**5**		**1**	**3**
Max	11	7	22.2	14.3	51.2	77.6	8.24	268	33.3	1140	5		6	5.7
Min	**2**	**5**	**4.1**	**0.03**	**22.6**	**27.7**	**3.91**	**1**	**17.8**	**611**	**5**		**1**	**0.8**
22-Feb-22	3	6	9	0.04	43.2	69.4	6.97	61	32.8	1140			1	2.9
16-Jun-22	17	6	11.8	2.79	42.8	54.3	5.9	6	26.3	843	5		120	5.1
11-Aug-22	2	6	22	8.53	56.8	78.8	3.85	1	29	834	6		2	8.1
28-Sep-22	11	5	20	10.7	42.5	62.5	3.86	1	28	930	5		1	5.7
24-Nov-22	3	5	13.7	8.83	48.5	63.3	5.54	3	27.7	859	5		10	6.7
13-Dec-22	10	7	14.2	4.75	50.7	66.4	4.36	1	27.7	874			2	5.5
Mean	**8**	**6**	15	**6**	47	**66**	**5**	**12**	**29**	**913**	**5**		**23**	**6**
Median	**7**	**6**	14	**7**	48	**65**	**5**	**2**	**28**	**867**	**5**		**2**	**6**
Max	17	7	22	10.7	56.8	78.8	6.97	61	32.8	1140	6		120	8.1
Min	**2**	**5**	**9**	**0.04**	**42.5**	**54.3**	**3.85**	**1**	**26.3**	**834**	**5**		**1**	**2.9**
3-Feb-23	3	5	10.9	0.04	67.6	83.8	7.22	70	28.6	1050	5		100	6.6
28-Sep-23	28	14	17	3.64	57.9	73.9	4.5	2	25.5	902	5		2	24.7
Mean	**16**	**6**	15	**5**	50	**68**	**5**	**18**	**28**	**932**	**5**		**32**	**7**
Median	**16**	**6**	14	**5**	48	**66**	**5**	**3**	**28**	**888**	**5**		**2**	**6**
Max	28	14	22	10.7	67.6	83.8	7.22	70	32.8	1140	6		120	24.7
Min	**3**	**5**	**9**	**0.04**	**42.5**	**54.3**	**3.85**	**1**	**25.5**	**834**	**5**		**1**	**2.9**
27-Feb-24	4	5	5.8	0.06	40	45.8	5	2	27.6	929	5			2.9
24-May-24	2	5	7.5	0.03	39.5	47	7.8	479	21.6	1150	5		10	3.4
Mean	**3**	**5**	7	**0**	40	**46**	**6**	**241**	**25**	**1040**	**5**		**10**	**3**
Median	**3**	**5**	7	**0**	40	**46**	**6**	**241**	**25**	**1040**	**5**		**10**	**3**
Max	4	5	7.5	0.06	40	47	7.8	479	27.6	1150	5		10	3.4
Min	**2**	**5**	**5.8**	**0.03**	**39.5**	**45.8**	**5**	**2**	**21.6**	**929**	**5**		**10**	**2.9**
OVERALL														
Mean	**10**	**6**	11	**4**	39	**51**	**6**	**114**	**22**	**943**	**5**	**15**	**123**	**4**
Median	**7**	**5**	13	**5**	40	**46**	**6**	**3**	**25**	**941**	**5**	**2**	**2**	**3**
Max	28	14	22	14	68	84	8	479	33	1150	6	70	549	25
Min	**2**	**5**	**4**	**0**	**23**	**28**	**4**	**1**	**5**	**611**	**5**	**1**	**1**	**1**

Note:

1 Eligibility criteria and standard conditions for sewage treatment works (ERA63) - Version 2, exceedances are in red.

2 Criteria supplied by Envir Solutions for use as input into MEDLI modelling for output effluent for Advan Tex Waste Water Treatment System, excedances are in mauve.

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Amphitheatre EcoCamp

Sample Date	BOD_5	TSS	TKN	NH3	NO_x	TN	pH	Alk	TP	EC	O&G	C.P	E.coli	Turbidity
	mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*Scale*	*mg/L*	*mg/L*	*µS/cm*	*mg/L*	*Spores /100ml*	*cfu /100ml*	*NTU*
Contaminants Release to Land 1						*30 / 60*	*5.0-8.5*		*10 / 20*	*1600*			*1000/100ml*	
Envir Solutions 2		*10*	*<2*		*20-30*		*6.5-8.5*	*100-150*						
22-May-20	3	5	0.5	0.31	0.18	0.7	3.73	312	0.14	673	5		1	0.9
28-May-20	11	5	0.6	0.47	0.3	0.9	7.03	341	0.15	703	5	2	1	0.6
11-Jun-20	21	5		0.07	2.33	0.5	8.51	322	0.21	709	5	0	1	0.5
30-Jul-20	5	5	5.4	0.12	22.7	28.1	8.36	218	3.42	848	5	2	1	0.6
6-Aug-20	12	6	4.4	0.19	26.4	30.8	8.02	207	4.62	884	5	6	2	0.7
13-Aug-20	15	9	13.6	0.51	30.1	43.7	7.48	103	14.6	914	5		2	4.5
3-Sep-20	11	5	6.7	0.41	40.2	46.9	7.51	105	9.49	955	5	1	1	1
17-Sep-20	13	17	7	0.34	36.7	43.7	7.31	86	12.2	956	13		6	3.4
Average	**11**	**7**	5	**0**	**20**	**24**	**7**	212	**6**	**830**	**6**	**2**	**2**	**2**
Median	**12**	**5**	5	**0**	**25**	**29**	**7**	213	**4**	**866**	**5**	**2**	**1**	**1**
Max	21	17	13.6	0.51	40.2	46.9	8.51	341	14.6	956	13	6	6	4.5
Min	**3**	**5**	**0.5**	**0.07**	**0.18**	**0.5**	**3.73**	**86**	**0.14**	**673**	**5**	**0**	**1**	**0.5**
15-Jan-21	2	5	8.7	3.09	25.4	37.3	5.76	4	13.6	589	5		1	1.6
29-Apr-21	10	5	2.6	0.1	11.4	16.4	6.88	26	5.95	347	5		1	2.2
31-May-21	1	5	9.5	4.92	22.5	32	4.78	1	12.6	443	5		1	3.2
6-Jul-21	6	5	14.2	6.83	22.5	36.7	5.62	5	13.6	584	5		1	2.7
2-Sep-21	2	5	11	3.11	39.5	54.2	3.87	1	27.5	895	5		1	3.2
8-Oct-21	10	5	13.6	8.48	33	46.4	3.73	1	27.7	899	7		2	2.2
9-Dec-21	13	6	8.5	0.26	29.7	42.5	7.6	199	30.2	1350	6		8	3.4
Mean	**6**	**5**	10	**4**	**26**	**38**	**5**	**34**	**19**	**730**	**5**		**2**	**3**
Median	**6**	**5**	10	**3**	**25**	**37**	**6**	**4**	14	**589**	**5**		**1**	**3**
Max	13	6	14.2	8.48	39.5	54.2	7.6	199	30.2	1350	7		8	3.4
Min	**1**	**5**	**2.6**	**0.1**	**11.4**	**16.4**	**3.73**	**1**	**5.95**	**347**	**5**		**1**	**1.6**
22-Feb-22	10	5	9.4	0.04	43.2	52.6	8.49	314	31.1	1380			1	2.2
9-Jun-22	14	12	7.3	0.18	40.2	47.5	7.35	80	27	888	5		81	3.9
11-Aug-22	3	13	19.4	6.19	59.7	79.1	3.81	1	30.5	858	6		2	8
28-Sep-22	6	5	14.2	9.08	39	56.6	5.21	5	30	966	5		7	2.8
24-Nov-22	6	5	16.7	8.29	52.4	69.1	3.9	1	28.6	863	6		100	3.8
14-Dec-22	2	8	12.4	6.8	50.1	62.5	4.63	1	29.4	866	5		2	5
Mean	**7**	**8**	13	**5**	47	**61**	**6**	**67**	**29**	**970**	**5**		**32**	**4**
Median	**6**	**7**	13	**6**	47	**60**	**5**	**3**	**30**	**877**	**5**		**5**	**4**
Max	14	13	19.4	9.08	59.7	79.1	8.49	314	31.1	1380	6		100	8
Min	**2**	**5**	**7.3**	**0.04**	**39**	**47.5**	**3.81**	**1**	**27**	**858**	**5**		**1**	**2.2**
2-Feb-23	2	5	15	7.97	55.7	71.1	3.68	1	28.1	921	5		1	1.7
23-Sep-23	31	8	11.3	0.07	75.2	77.5	7.91	170	21.7	1290	5		2	3.3
Mean	**17**	**8**	13	**5**	51	**64**	**6**	**80**	**29**	**1010**	**5**		**28**	**4**
Median	**17**	**7**	13	**6**	49	**62**	**5**	**4**	**29**	**905**	**5**		**3**	**4**
Max	31	13	19.4	9.08	75.2	79.1	8.49	314	31.1	1380	6		100	8
Min	**2**	**5**	**7.3**	**0.04**	**39**	**47.5**	**3.68**	**1**	**21.7**	**858**	**5**		**1**	**1.7**
27-Feb-24	2	5	7.9	0.01	56	63.9	7.4	56	26.1	1020	5			0.7
23-May-24	2	5	10.9	3.85	44.6	67.4	4.17	1	23.9	993	5		2	1.8
Mean	**2**	**5**	9	**2**	50	**66**	**6**	**29**	**25**	**1007**	**5**		**2**	**1**
Median	**2**	**5**	9	**2**	50	**66**	**6**	**29**	**25**	**1007**	**5**		**2**	**1**
Max	2	5	10.9	3.85	56	67.4	7.4	56	26.1	1020	5		2	1.8
Min	**2**	**5**	**7.9**	**0.01**	**44.6**	**63.9**	**4.17**	**1**	**23.9**	**993**	**5**		**2**	**0.7**
OVERALL														
Mean	**9**	**7**	10	**3**	39	**51**	**6**	**84**	**21**	**909**	**5**	**2**	**13**	**3**
Median	**6**	**7**	10	**3**	47	**60**	**6**	**4**	**25**	**877**	**5**	**2**	**2**	**3**
Max	31	13	19	9	75	79	8	314	31	1380	7	6	100	8
Min	**1**	**5**	**3**	**0**	**11**	**16**	**4**	**1**	**6**	**347**	**5**	**0**	**1**	**1**

Note:

1 Eligibility criteria and standard conditions for sewage treatment works (ERA63) - Version 2, exceedances are in red.

2 Criteria supplied by Envir Solutions for use as input into MEDLI modelling for output effluent for Advan Tex Waste Water Treatment System, excedances are in mauve.

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Amphitheatre and Woodcutters EcoCamps Combined Statistics

	BOD_5	TSS	TKN	NH3	NO_x	TN	pH	Alk	TP	EC	O&G	C.P	E.coli	Turbidity
	mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*Scale*	*mg/L*	*mg/L*	*µS/cm*	*mg/L*	*Spores /100ml*	*cfu /100ml*	*NTU*
						30 / 60	*5.0-8.5*		*10 / 20*	*1600*			*1000/100ml*	
Mean	**9**	**6**	**10**	**4**	**39**	**51**	**6**	**99**	**22**	**926**	**5**	**9**	**68**	**3**
Median	**6**	**6**	**11**	**4**	**43**	**53**	**6**	**3**	**25**	**909**	**5**	**2**	**2**	**3**
Max	31	14	22	14	75	84	8	479	33	1380	7	70	549	25
Min	**1**	**5**	**3**	**0**	**11**	**16**	**4**	**1**	**5**	**347**	**5**	**0**	**1**	**1**

APPENDIX C : STANDARD OPERATING PROCEDURES

Field Test Procedure – Water Quality readings in the Field FTP001

1 Purpose and Scope

pH is a representation of the concentration of the hydronium ion (H+) in solution and is used to indicate the alkalinity or acidity of a substance as ranked on a logarithmic scale from 1.0 to 14.0. Acidity increases as the pH gets lower. 5.4 pH | Monitoring & Assessment | US EPA

Oxygen is measured in its dissolved form as dissolved oxygen (DO) in mg/L or parts per million. Wastewater contains organic materials that are decomposed by microorganisms, which use oxygen in the process. 5.2 Dissolved Oxygen and Biochemical Oxygen Demand | Monitoring & Assessment | US EPA

2 General

pH and dissolved oxygen are measured throughout the treatment process and are particularly significant during the biological nutrient removal process. Careful monitoring of both pH and dissolved oxygen are important for the health of the microorganisms responsible for the biological treatment of wastewater.

3 Equipment

Table 1 – Equipment Used

Description
Sampling gloves
Sample collection container
Field meter (pH, Temp, EC, DO, Turbidity).

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4 Procedure

1. Take a sample of the water into a laboratory clean container. The use of a container being used for sampling at the laboratory is adequate, ensure no additives or preservatives are included in the bottle.
2. Rinse the bottle three times with sample water (surface or ground) and set aside.
3. Turn on the meter.
4. Rinse probes with distilled water and drip dry.
5. Submerse both probes entirely into the test solution and gently stir.
6. Wait for the readings on the meter display to stabilise.
7. Record the results in the appropriate weekly or monthly site data sheet.
8. Probes should be cleaned using distilled water and returned to their protective storage cases. The pH probe should be stored in the pH sensor storage solution.
9. Transfer the collected data to the appropriate site data spreadsheet file.

GENERAL SOIL SAMPLING – SOP-001

1 Purpose and scope

This is a standard procedure for the collection of soil or sediment samples for environmental assessment. This procedure must be followed to ensure that soil samples are collected in an appropriate and consistent manner, that the soil sampling is appropriate for the media and analytes, and to allow the documentation of standard operating procedures used for soil sample collection and handling.

This procedure has been written for environmental soil sampling of *in situ* and *ex situ* soils and fills for general physical and chemical tests and non-volatile, semi-volatile, and volatile analyses.

2 Definitions

CoC - chain of custody form

OH&S - occupational health and safety

PID - photo-ionisation detector

VOCs - volatile organic compounds

SVOCs – semi volatile organic compounds

3 References

Guidance considered in preparing this standard operating procedure included:

- Australian Standard AS 4482.1 (2005) Guide to sampling and investigation of potentially contaminated soil, Part 1: Non-Volatile and semi-volatile compounds
- Environment Protection Authority (September 1995) Contaminated Sites: Sampling Design Guidelines. NSW EPA, Chatswood, NSW
- National Environment Protection Council (NEPC) (2013) National Environmental Protection (Assessment of Site Contamination) Measure, Schedule B(2) Guideline on Data Collection, Sample Design and Reporting. National Environment Protection Council Service Corporation, Adelaide, SA
- Standards Australia (2005) Guide to the sampling and investigation of potentially contaminated soil,

Part 1: Non-volatile and semi-volatile compounds (AS 4482.1¬2005)

- Standards Australia (1999) Guide to the sampling and investigation of potentially contaminated soil, Part 2: Volatile substances (AS 4482.2-1999).

4 General

Related environmental procedures include:

- SOP_PROC_002-Surface Water Sampling
- SOP_PROC_003-Groundwater Sampling
- SOP_PROC_004-Air Quality Sampling
- SOP_PROC_005-Personal protective equipment
- SOP_PROC_006-Establishment of contaminant control zones
- SOP_PROC_007-Quality Assurance and Quality Control
- SOP_PROC_008-Decontamination of personnel
- SOP_PROC_009-Decontamination of plant and equipment
- SOP_PROC_010-Decontamination of sampling equipment
- SOP_PROC_011-Vehicle and heavy machinery operations.
- SOP_PROC_012-Manaul handling
- SOP_PROC_013-First Aid
- SOP_PROC_014- Measurement of volatiles – PIDs.

Sampling locations and depths should be clearly stated in a sampling analysis quality plan (SAQP) prior to commencement of fieldwork.

A health and safety plan (HSP) should be produced prior to the commencement of any field work.

Soil samples should be representative of the target depth, media and environmental condition from which they are collected. Soil samples should not be influenced by the method of extraction or sampling from the soil.

Soil samples should not be retained if they have come into direct contact with machinery or sampling equipment that has not been decontaminated.

In general samples should be collected at the surface, and at depth; such as at regular intervals for consistent with the lithology or contaminant transport encountered during the assessment. This may include soil profiles or horizons or areas of contamination or media.

The assessor must record all information on how the samples were taken in the geological log including refusal or exceedance of equipment reach. The geological log should clearly document the reason sampling was discontinued and a description of material if it continues to greater depths.

Surface samples should be 0 – 0.10 m or 0 – 0.15 m and samples from depth should not exceed a depth range of 0.3 m to avoid compositing effects. Some land uses may require shallower surface samples, e.g. banana lands 0.075 m, and this should be established as part of the SAQP.

As a general rule, never composite samples unless stated in the SAQP.

5 Procedure

5.1 Sample collection

All personnel who will come into contact with the soil must always use clean disposable gloves for each sample. Prevention of contamination exposure to personnel and cross-contamination of samples is paramount in soil sampling.

All sampling equipment is to be decontaminated before use and between samples

5.2 Sample Collection

Once collected, samples are to be transferred immediately to the appropriate sample container, ensuring that the container is filled to the top so that no head-space remains.

5.3 Hand tools

Hand tools, including spatulas, trowels, shovels, spades, etc, can be used to collect samples from the land surface, walls and floors of test pits or excavations, stockpiles, etc.

The surface to be sampled is first to be cleared of any organic material, e.g. grass and roots, and the sample collected from fresh, exposed soil. Fresh soil should be exposed prior to sampling to remove any smear affects from the sampling equipment. Soil peds or clods should be removed from the auger or trowel and split so that samples can be taken from the middle of the peds or clods. The sampler should not sample from exposed surfaces, which may not be representative of contamination, especially where release of volatiles may have occurred from the exposed soil.

Test pits or excavations are not to be entered unless appropriate assessment of stability has been conducted and documented. Test pits over 1 m depth are not to be entered.

5.4 Test Pits

The sampler should direct the excavator operator as to where the sample is to be collected and ensure the location is accurate. The sampler must be aware of the 'swing zone' of the machine and follow *SOP_PROC_008-Vehicle and heavy machinery operations.*

Sampling from excavator buckets is permissible, providing the procedures in *Section 5.1 – 5.3* are adhered to by the sampler, where appropriate, and the following sampling quality controls are observed by the sampler:

- The sample must be collected from within soil clods or material which has not contacted the excavator bucket
- The bucket must be screened with a PID prior to sampling where volatiles are a contaminant of concern.

5.5 Soil cores

For push tubes, split spoons, etc, samples should be transferred directly to the sampling container and procedures in *Section 5.1 – 5.3* adhered to by the sampler, where appropriate.

5.6 Augers

Samples should be collected from the auger with a trowel by cutting away the outside and collecting soil from the centre of the auger bit. Samples should then be transferred directly to the sampling container. Procedures in *Section 5.1 – 5.3* must be adhered to by the sampler, where appropriate.

5.7 Field screening for VOCs

If volatiles are a contaminant of concern and field screening using a photo-ionisation detector (PID) is required, a sample should also be transferred to a ziplock plastic bag. Refer to SOP_PROC_011- Measurement of volatiles – PIDs for field screening procedure.

5.8 Composite sampling

Composite sampling is used to reduce analytical costs and involves the bulking and thorough mixing of soil samples (collected as above) to form one composite sample for laboratory analysis. Generally, compositing is not encouraged and should only be undertaken if specifically stated in the SAQP. Samples should be sent to the laboratory for compositing with appropriate instructions recorded on the CoC. Composite sampling must not be undertaken where volatile substances are present, including BTEX compounds and $C_6 – C_9$ TPHs, or soils have high clay content.

Composite samples must be collected from the same soil/fill horizon and no more than four sub-samples should be included in a composite sample. The sub-samples should be equal in size, from immediately adjacent sampling points, evenly spaced, and composited laterally.

6 Sampling containers

Sample containers from a NATA laboratory, usually 125 mL to 250 mL clear glass jars, are to be used by the sampler. This will ensure the jars are decontaminated, clean and dry, and of the appropriate size and material. Ensure the appropriate preservative is present if required, and all jars have a gastight, non-absorptive seal, which allow no headspace. The laboratory should be contacted if numerous and/or specialty analytes are required, to confirm the required sample container type and size.

6.1 Sample Labelling

Samples should be labelled clearly on the outside wall of the container with the project number, sampler's initials, sample location, depth of sample and the date. The sample location and depth should also be provided on the container lid. All labelling should be with water proof pens/markers.

The sample location number should be followed by either the sample depth or a letter, e.g. BH1 0.0 - 0.15 or TP3 A.

6.2 Sample handling, storage and dispatch

The soil jars, once filled with sample with no head space, are to be wiped clean and wrapped in bubble wrap/padding, and immediately placed in a cooler such as an Esky. Coolers should be kept out of direct sunlight, hot vehicles, etc, as far as practical, and appropriate cooling media added (ice or ice bricks) to ensure samples are kept below 4˚C. For longer term storage, samples should be kept below 4˚C in a fridge/freezer.

A chain of custody (CoC) form is to be filled out and the CoC is to be sent with the sample/s to the laboratories. The CoC/s is to be placed in a ziplock plastic bag or plastic folder to prevent damage. All samples sent to the laboratories are to be included on the CoC/s, and if no analyses required, marked as 'Hold'.

If additional air space exists in the cooler, this should be filled with scrunched up newspaper, bubble wrap or similar to minimise movement of the samples. Coolers are to be secured with heavy tape and security seals, and clearly show the laboratory and sender contact information.

All samples, including QC samples, are to be transported to the primary and secondary laboratories. If dispatch is by courier, coolers are not to be dispatched on Fridays (or days before public holidays) unless delivery the next day has been organised.

If samples cannot be dispatched on the day of sampling with refreshed ice-blocks or ice for transport, then the samples are to be refrigerated until dispatch. The laboratory should be contacted if any delays to dispatch occur to confirm holding times available prior to extraction/analysis.

6.3 Sample location logging

A geological log is to be completed for each sample location by a qualified environmental scientist. Logs are to be completed for all sample locations, including surface samples and *ex situ* samples.

The log is to include:

- Job details, date, location, methods, climatic conditions
- Soil classification (material type and texture), colour, consistency or density, odour, staining, presence of artefacts, moisture content, sample number, and depth
- Depth of water inflow and/or groundwater level, if encountered, and comments regarding water if required; depth of excavation/drilling, excavation/drilling refusal and any field measurements taken or other relevant field observations.

7 QA documentation

A CoC is to be completed for all samples sent to the laboratories and/or to be analysed by the laboratories. Samples not to be analysed should be described as "Hold".

The CoC is to detail laboratory reference numbers (including quotes),site identification, the samplers initials, nature of the sample, collection time and date, analyses to be performed, sample preservation method, any relevant comments, e.g. level contamination expected, level of quality control required and dispatch information and signature.

7.1 Samples

QC sampling should be documented in the SAQP, which should include trip spikes and trip blanks as prepared by the laboratory and should be organised through the laboratory prior to conducting the field work. Trip spikes and trip blanks should be held for as little time as possible prior to the field work, and should be kept below 4°C in a fridge/freezer. After sample collection, trip spikes and trip blanks are to be handled as a primary sample, and should also be included on the CoC.

For detailed explanation MEH's QA/QC controls and procedures, refer SOP_PROC_007-Quality Assurance and Quality Control.

GENERAL SURFACE WATER SAMPLING – SOP-002

1 Purpose and scope

This is a standard procedure for the collection of surface water samples for environmental assessment. This procedure must be followed to ensure that surface water samples are collected in an appropriate and consistent manner, that the surface water sampling is appropriate for site, and to allow the documentation of standard operating procedures used for surface water sample collection and handling.

This procedure has been written for environmental surface water sampling of *fresh or marine waters* for general physical and chemical tests and non-volatile, semi-volatile, and volatile analyses.

2 Definitions

CoC - chain of custody form

OH&S - occupational health and safety

PID - photo-ionisation detector

VOCs - volatile organic compounds

SVOCs – semi volatile organic compounds

3 References

Guidance considered in preparing this standard operating procedure included:

- Australian Standard AS 4482.1 (2005) Guide to sampling and investigation of potentially contaminated soil, Part 1: Non-Volatile and semi-volatile compounds, (Australia, 2005).
- Environment Protection Authority (September 1995) Contaminated Sites: Sampling Design Guidelines. NSW EPA, Chatswood, NSW, (EPA, 1995).
- National Environment Protection Council (NEPC) (2013) National Environmental Protection (Assessment of Site Contamination) Measure, Schedule, B2 - Guideline on site characterization, National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 16 May 2013, (NEPC, 2013).
- Standards Australia (1999) Guide to the sampling and investigation of potentially contaminated soil, Part 2: Volatile substances, (Standards Australia, 1999).
- ANZECC & ARMCANZ, (2000), Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The guidelines, (ANZECC & ARMCANZ, 2000).
- ANZECC & ARMCANZ, (2000), Australian and New Zealand guidelines for fresh and marine water quality. Volume 2, Aquatic ecosystems, (ANZECC and ARMCANZ, 2000a).
- ANZECC & ARMCANZ, (2000), Australian and New Zealand guidelines for fresh and marine water quality. Volume 3, Primary industries, (ANZECC and ARMCANZ, 2000b).

4 General

Related environmental procedures include:

- SOP_PROC_002-Surface Water Sampling
- SOP_PROC_003-Groundwater Sampling
- SOP_PROC_004-Air Quality Sampling
- SOP_PROC_005-Personal protective equipment
- SOP_PROC_006-Establishment of contaminant control zones
- SOP_PROC_007-Quality Assurance and Quality Control
- SOP_PROC_008-Decontamination of personnel
- SOP_PROC_009-Decontamination of plant and equipment
- SOP_PROC_010-Decontamination of sampling equipment
- SOP_PROC_011-Vehicle and heavy machinery operations.
- SOP_PROC_012-Manaul handling
- SOP_PROC_013-First Aid
- SOP_PROC_014- Measurement of volatiles – PIDs.

Sampling locations should be clearly stated in a sampling analysis quality plan (SAQP) prior to commencement of fieldwork.

A health and safety plan (HSP) should be produced prior to the commencement of any field work.

Surface water samples should be collected:

- at the site of the reported pollution
- at the point of any contributing or suspected sources
- in an area upstream from the suspected source/s (control site)
- at points downstream of the suspected source (to measure extent). Samples should be collected as far downstream from the source as suspected of being polluted.

Reference or control sites must be sampled (if water is present) in order to understand the background conditions at the time of sampling, and in order to fully understand the potential impact from the pollution event under investigation. If assessing sediment, reference or control sites must be sampled. See Sampling design and preparation—Control and Reference sites.

As a general rule, never composite samples unless stated in the SAQP.

5 Procedure

5.1 Sample collection

All personnel who will come into contact with the surface water must always use clean disposable gloves for each sample. Prevention of contamination exposure to personnel and cross-contamination of samples is paramount in soil sampling.

All sampling equipment is to be disposable (one sample use) or decontaminated before use and between samples.

5.2 Sample Collection

Most samples taken will be grab samples—taken by filling sample containers over a 'short' period (seconds or minutes).

Place water quality meter (probe) in the flow of the stream, up stream of where you are sampling and allow to equilibrium over time, whilst you are sampling.

Surface water samples should be taken directly from the water body. Sample jars/containers should be labelled prior to sampling with permanent mark and allowed to dry and field sample bottles ticked for field filtered on container, if required. The sampler must use clean nitrile sampling gloves for each sample site (not each sample bottle).

The sampler should collect the samples in the following order:

1. Take any microbiological samples first to minimise cross contamination and minimise the time the lid is off the container.

2. Use the **1 x 250ml** green plastic with no preservative usually for Alkalinity, EC, pH, Cl, SO4, F, Hardness, Nitrite, Nitrate, Reactive P, Silica, plus TDS (Calc. only), Acidity:

    a. Rinse in water body three times; and

    b. Fill and use to fill other containers, usually with preservatives.

3. Sample dissolved metals Field Filtered sample next, use the Red, **1 x 60mL** plastic (HNO_3 acid)), ticked for field filtered and follow method below:

    a. Use the disposable syringe for filtered samples, usually for dissolved metals (Red, **1 x 60mL** plastic (HNO_3 acid));

    b. Extract a full syringe from green plastic container;

    c. Place filter on end of syringe ensuring it is placed with flow direction into the Red, **1 x 60mL**

plastic;

d. Press syringe filtering the water into the Red, **1 x 60mL** plastic (HNO_3 acid); and

e. Repeat b – d until Red, **1 x 60mL** plastic (HNO_3 acid) is full, **DO NOT OVER FILL** or you will lose some preservative.

4. Refill green plastic container and continue to fill other sample containers noting if containing preservative such as purple **1 x 60mL** plastic (H_2SO_4 acid).

5. When all other containers have been filled to the appropriate level, fill the 250ml green plastic with no preservative to full.

6. If collecting water samples for volatiles such as petroleum products using **1 x 100mL** glass bottle or **1 x 40mL** glass vials (Sulfuric Acid), then follow procedure below:

   a. Fill glass bottle or vial from 250ml green plastic until **nearly** full;

   b. Complete filling of the glass bottle or vial to full ensuring meniscus proud of bottle using the lid of the container and replace lid over proud meniscus thus preventing any air space in container.

   c. Check there are no air space in the container by inverting once, if air space is present, repeat b above.

7. Ensure you take duplicates and triplicates of surface water samples at the appropriate frequency, which is usually every ten samples. So every ten sample locations take a duplicate and triplicate at one location, labelled DUP01 and DUP02.

8. Finally record GPS location, Sample ID and field parameters on MEH Observations sheets provided.

6 Sampling containers

Sample containers from a NATA laboratory, usually **1 x 250ml** green plastic, Red, **1 x 60mL** plastic (HNO_3 acid)), purple **1 x 60mL** plastic (H_2SO_4 acid) or **1 x 100mL** glass bottle or **1 x 40mL** glass vials (Sulfuric Acid) for volatiles.

Always check with laboratory when ordering jars to ensure you have the right containers.

6.1 Sample Labelling

Samples should be labelled clearly on the outside wall of the container with the project number, sampler's initials, sample ID (eg SW01, etc) and the date. All labelling should be with waterproof pens/markers.

Sometimes labels are printed by the lab in advance, in which case only the date is required to be hand written on the bottles on site.

Use large, zipped lock bags (labelled) to group samples for each sample location i.e. SW01, etc. Keep sample containers in bags prior during and in eskis to minimise wrong ID.

6.2 Sample handling, storage and dispatch

The surface water samples, once filled with sample with no head space (if appropriate), are to be wiped clean and wrapped in bubble wrap/padding, and immediately placed in a cooler such as an Esky. If trekking to inaccessible sites it is OK to transport in ruck sack and when back at vehicle wiped clean and wrapped in bubble wrap/padding, and i placed in a cooler such as an Esky. Esky coolers should be kept out of direct sunlight, hot vehicles, etc, as far as practical, and appropriate cooling media added (party ice or ice bricks) to ensure samples are kept below 4˚C. For longer term storage, samples should be kept below 4˚C in a fridge/freezer.

A chain of custody (CoC) form is to be filled out and the CoC is to be sent with the sample/s to the laboratories. The CoC/s is to be placed in a ziploc plastic bag or plastic folder to prevent damage. All samples sent to the laboratories are to be included on the CoC/s, and if no analyses required, marked as 'Hold'.

If additional air space exists in the cooler, this should be filled with scrunched up newspaper, bubble wrap or similar to minimise movement of the samples. Coolers are to be secured with heavy tape and security seals, and clearly show the laboratory and sender contact information.

All samples, including QC samples, are to be transported to the primary and secondary laboratories. If dispatch is by courier, coolers are not to be dispatched on Fridays (or days before public holidays) unless delivery the next day has been organised.

The laboratory should be contacted if any delays to dispatch occur to confirm holding times available prior to extraction/analysis. Always check holding times when planning sampling events.

7 QA documentation

A CoC is to be completed for all samples sent to the laboratories and/or to be analysed by the laboratories. Samples not to be analysed should be described as "Hold".

The CoC is to detail laboratory reference numbers (including quotes),site identification, the samplers initials, nature of the sample, collection time and date, analyses to be performed, sample preservation method, any relevant comments, e.g. level contamination expected, level of quality control required and dispatch information and signature.

7.1 Samples

QC sampling should be documented in the SAQP, which should include trip spikes and trip blanks as prepared by the laboratory and should be organised through the laboratory prior to conducting the field work. Trip spikes and trip blanks should be held for as little time as possible prior to the field work, and should be kept below 4°C in a fridge/freezer. After sample collection, trip spikes and trip blanks are to be handled as a primary sample, and should also be included on the CoC.

For detailed explanation of MEH's QA/QC controls and procedures, refer SOP_PROC_007-Quality Assurance and Quality Control.

8 References

ANZECC & ARMCANZ 2000a. Australian and New Zealand guidelines for fresh and marine water quality. Volume 2, Aquatic ecosystems / *In:* AUSTRALIAN AND NEW ZEALAND ENVIRONMENT AND CONSERVATION COUNCIL, A. A. R. M. C. O. A. A. N. Z. (ed.).

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AUSTRALIA, S. 2005. AS 4482 1-2005 Guide to the investigation and sampling of sites with potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds.

EPA, N. 1995. Sampling Design Guidelines.

NEPC 2013. Schedule, B2 - Guideline on site characterisation. *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 16 May 2013*.

STANDARDS AUSTRALIA 1999. AS 4482 2-1999 Guide to the sampling and investigation of potentially contaminated soil - Volatile substances.

APPENDIX D : Quality Assurance/Quality Control (QA/QC)

QUALITY ASSURANCE AND QUALITY CONTROL – SOP-004

1. Purpose and scope

This is a standard procedure for the use of quality assurance and quality control procedures during project samples for environmental assessment. This procedure must be followed to ensure that all samples are collected in an appropriate and consistent manner, that the sampling is appropriate for the media and analytes, and to allow the documentation of standard operating procedures used for sample plans, design, collection and interpretation of results.

This procedure has been written for environmental assessment of all media, soils, water and air general physical and chemical tests and non-volatile, semi-volatile, and volatile analyses.

2. Definitions

CoC - chain of custody form

OH&S - occupational health and safety

PID - photo-ionisation detector

VOCs - volatile organic compounds

PARCC parameters - precision, accuracy, representativity, comparability and completeness

QA – quality assurance

QC – quality control

Precision - measure of the reproducibility

Accuracy - measure of the agreement between an experimental determination and the true value of the parameter being measured

Representativity - degree to which the samples reflect the site specific conditions

3. Reference List

- Australian New Zealand Environment and Conservation Council (1996) *Guidelines for the laboratory analysis of contaminated soils*. ANZECC, Canberra, ACT.
- Australian Standard AS 4482.1 (2005) *Guide to the sampling and investigation of potentially contaminated soil, Part 1: Non-volatile and Semi-volatile compounds*. Standards Australia, Homebush, NSW.

- National Environment Protection Council (NEPC) (1999) *National Environmental Protection (Assessment of Site Contamination) Measure, Schedule B(2) Guideline on Data Collection, Sample Design and Reporting*. National Environment Protection Council Service Corporation. Adelaide, SA.
- National Environment Protection Council (NEPC) (1999) *National Environmental Protection (Assessment of Site Contamination) Measure, Schedule B(3) Guideline on Laboratory Analysis of Potentially Contaminated Soil*. National Environment Protection Council Service Corporation. Adelaide, SA.
- NSW Environment Protection Authority (1994) *Contaminated Sites: Guidelines for Assessing Service Station Sites*. NSW EPA, Chatswood, NSW.
- NSW Environment Protection Authority (1997) *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*. NSW EPA, Chatswood, NSW.
- United States Environmental Protection Agency, Contract Laboratory Program (1994) *National Functional Guidelines for Inorganic Data Review*. USEPA, Washington, DC.
- United States Environment Protection Agency, Contract Laboratory Program (1999) *National Functional Guidelines for Organic Data Review*. USEPA, Washington, DC.

4. General

Related environmental procedures include:

- SOP_PROC_002-Surface Water Sampling
- SOP_PROC_003-Gropundwater Sampling
- SOP_PROC_004-Air Quality Sampling
- SOP_PROC_005-Personal protective equipment
- SOP_PROC_006-Establishment of contaminant control zones
- SOP_PROC_007-Quality Assurance and Quality Control
- SOP_PROC_008-Decontamination of personnel
- SOP_PROC_009-Decontamination of plant and equipment
- SOP_PROC_010-Decontamination of sampling equipment
- SOP_PROC_011-Vehicle and heavy machinery operations.
- SOP_PROC_012-Manaul handling
- SOP_PROC_013-First Aid
- SOP_PROC_014- Measurement of volatiles – PIDs.

5. Introduction to Date Usability

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.

Moreton Environmental would like to acknowledge the NSW Auditor Mark Salmon, Principal Scientist in Easterly Point Environmental and colleague, mentor and friend of Dan Morton, originally produced the development of these QAQC 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 2013). 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.*

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.

6. 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,

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

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.

6.1. Precision

6.1.1. 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) x 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.

6.1.2. 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). 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 landuse criteria.

6.1.3. 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.

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

6.1.4. 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.

6.2. 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

6.2.1. 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.

6.2.2. 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.

6.2.3. 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.

6.3. 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:

6.3.1. 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 investigators discretion.

6.3.2. 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 investigators discretion.

6.3.3. 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.

6.3.4. 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.

6.4. 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.

6.4.1. 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.

6.4.2. 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.