ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2: APPENDICES AND ATTACHMENTS

INTEGRATED WASTE MANAGEMENT FACILITY

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TWM PNG Ltd t/a Total Waste Management

Integrated Waste Management Facility

Environmental Impact Statement

Volume 2 – Appendices and Attachments

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(Landfill Concept Design Report)

TWM PNG LIMITED

Landfill Concept Design Report

Prepared for:

TWM PNG Limited

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with TWM PNG Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

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1 Preliminaries

1.1 Introduction

TWM PNG Limited (TWM) has engaged SLR Consulting (SLR) to design an industrial landfill at the TWM Solid Waste Facility (TWM SWF) based in Roku, Papua New Guinea. For the purposes of this concept design, the proposed cell (Cell 1) is intended to be used for the landfilling of either:

- Non-hazardous waste materials; or
- Hazardous waste materials.

The conceptual landfill design presents several design elements to be further discussed and agreed upon between SLR and TWM for inclusion within the detailed design report. The concept design details input data, assumptions made, regulatory requirements considered and preliminary design drawings.

1.2 Concept Design Scope

The scope of work to be covered as part of the concept landfill design includes consideration of:

1 Void space maximisation within the nominated footprint;

2 Geometry and stability of the landfill;

3 Local groundwater depths;

4 Materials suitability;

5 Leachate barrier requirements;

6 Leachate collection and extraction infrastructure;

7 Leachate treatment requirements;

8 Surface water management;

9 Groundwater management;

10 Consideration of gas control requirements; and

11 Final capping and rehabilitation profile.

The concept design for the Cell 1 landfill is aimed at providing sufficient detail to calculate waste void capacity based on a number of scenarios, high level requirements of the leachate containment (engineered cell lining system) as well as leachate collection and extraction infrastructure, landfill gas and surface water management and estimates of construction cut and fill volumes.

This concept design report is to be read in conjunction with the TWM Cell 1 Concept Design Drawings (SLR 2019).

1.3 Waste Acceptance Scenarios

For the purposes of the concept design, the following waste acceptance types are proposed as detailed below.

- Hazardous wastes identified in *Title 40 Code of Federal Regulations Part* 261 – *Identification and Listing of Hazardous Waste.* Exclusions or restrictions pertaining Hazardous wastes are included within Title 40 Code of Federal Regulations *Parts 264, 265, 266, 267, 268 and 273.*

In accordance with the US EPA (1993), waste is a regulated hazardous waste if it:

(1) is listed in Subpart D of Title 40 Code of Federal Regulations (CFR) Part 261 (termed a "listed" waste);

(2) exhibits a characteristic of a hazardous waste as defined in Subpart C of 40 CFR Part 261; or

(3) is a mixture of a listed hazardous waste and a non-hazardous solid waste.

Characteristics of hazardous wastes as defined in Subpart C of 40 CFR Part 261 include ignitability, corrosivity, reactivity, and toxicity.

The toxicity characteristic leaching procedure (TCLP) is the test method used to determine the mobility of organic and inorganic compounds present in liquid, solid, and multiphase wastes.

Note: Exclusions or restrictions pertaining hazardous wastes disposal are included within 40 CFR Parts 264, 265, 266, 267, 268 and 273. Ignitable or reactive waste must not be placed in a landfill, unless the waste and landfill meet all applicable requirements of Part 268, and the resulting waste, mixture, or dissolution of material no longer meets the definition of ignitable or reactive waste under Part 261.21 or 261.23. The placement of bulk or non-containerized liquid hazardous waste or hazardous waste containing free liquids (whether or not sorbents have been added) in any landfill is prohibited.

2 Reliance Documentation

SLR has reviewed and relied upon the following background documentation for the preparation of this Concept Design:

- Baseline Environmental and Geotechnical Study (ACEM Geotechniques, 2018)
- Environmental Permit EP-L2(485) (The Independent State of Papua New Guinea, January 2016)
- Road base and sub-base pavement material (Soil Engineers, 2018)
- TWM stormwater drainage mapping
- Detailed Survey 'Work force site – Roku Road Central Province A1/LS – 004' (Lavatore Surveys, 2016)
- Roku Landfill Site Proposed Landfill Cross Sections (Heading & Associates, 2018)
- Reference Guide for Treatment of Waste Streams – Roku IWMF (TWM)
- Groundwater Survey at Total Waste Management Site, Roku, Central Province, Papua New Guinea Report 2018/07 (Geoscience for Mining, Energy and Humanity Geological Survey Division, 2018)
- Environmental Management Plan, Integrated Waste Management Facility (TWM, 2018)
- ADG Waste Summary (TWM, 2019)

3 Review of Existing Documentation

SLR has undertaken a review of available information including previous design assessments, volumetric surveys, environmental management and monitoring reports. A review of the regulatory framework and requirements is included within Section 4. Existing documentation relevant to the landfill design is described within Table 1.

Table 1 Existing Site Information

Information Source	Information Presented and Relevance to Landfill Design
Baseline Environmental and Geotechnical Study (ACEM Geotechniques, 2018)	The report presents the results of an investigation carried out by ACEM Geotechniques at the site of the proposed W&RM facility at Roku. The aims of the investigation were to provide details on the: • Preliminary geotechnical information for the proposed site works • Baseline soil conditions at the site including any contamination at the former timber yard • Baseline groundwater level and water quality • Baseline Noise levels and Air Quality The geotechnical fieldwork consisted of • 2 boreholes to 8m BGL with standpipe piezometers, permeability testing and groundwater sampling for chemical analysis • 6 test pits to obtain both geotechnical and environmental data ACEM note that the CWR bedrock will be suitable for side wall construction of the landfill and is also likely to produce road pavement material including, ordinary and select fill, basecourse and subbase. ACEM additionally note the rocky and well-graded nature of material won from the quarry will allow fill batters ranging from 1:1 to 1V:1.5H. ACEM initially recommended 1V:1.5H batters for the landfill.
Road base and sub-base pavement material (Soil Engineers, 2018)	Soil Engineers provided recommendations based on the two test results obtained from loose soil from 'Test Pits 1 & 2'. Soil Engineers noted the test results indicated that the proposed material does not meet the specifications, however is potentially suitable for use as road and/or sub base by undertaking the following measures: I. Freshly crushed material is recommended and will be needed for a retest to verify strength II. Blend with granular material from another quarry/source to increase compaction density and strength and will reduce fines.
Roku Landfill Site Proposed Landfill Cross Sections (Heading & Associates, 2018)	Heading & Associates provided a high-level conceptual landfill volumetric model to determine an estimate of the available airspace. The landfill model is noted to extend beyond the current site boundary. Early analysis estimates have determined the initial landfill cell to be an estimated 15,340m^2 in area and 212,000m^3 in volume in order to provide at least 5 years of solid waste disposal capacity.
Reference Guide for Treatment of Waste Streams – Roku IWMF (Total Waste Management)	The TWM reference guide contains a list of accepted waste streams, waste classification, treatment method, waste origin and disposal method.

Information Source	Information Presented and Relevance to Landfill Design
Groundwater Survey at Total Waste Management Site, Roku, Central Province, Papua New Guinea Report 2018/07, (Geoscience for Mining, Energy and Humanity Geological Survey Division, 2018)	An investigation was undertaken by MRA to assess the general groundwater conditions and to identify potential water bearing layers (aquifer) within the site. The groundwater investigation was carried out by the use of Vertical Electrical Sounding (VES) profiling method. The investigation identified two aquifers, a shallow perched aquifer and a deep aquifer. The deep aquifer occurs in coarse sand and gravel between 7-9m in lower lying areas and 16-28 m in higher elevated areas. The investigation recommends further investigation of the aquifer using borehole drilling to confirm the depth and thickness of the deep aquifer in conjunction with a pumping test.
Environmental Management Plan, Integrated Waste Management Facility (Total Waste Management, 2018)	The Environmental Management Plan was prepared by TWM for the operations of the Integrated Waste Management Facility. The EMP is applicable to the operations of all plant and infrastructure on the Site, including landfilling activities. The EMP specifies the proposed waste water treatment plant will process approximately 3,200m^3 of receive domestic wastewaters, leachate from the landfill and composting, and any contaminated stormwaters collected at the site. The EMP provides an overview of the expected waste tonnage, landfill construction, operations, cell closure, leachate management, groundwater monitoring and landfill gas management.
ADG Waste Summary (TWM, 2019)	The ADG Waste Summary provides a high level estimate of wastes to be accepted at the proposed landfill facility. A summary of the wastes to be accepted, is proposed to comprise as follows: Oil and Gas wastes (18%), Grease trap waste (33%), WWTP sludge (16%), drilling muds (16%) and other hazardous wastes* (17%). **Waste Acceptance scenario 2 only*

4 Regulatory Framework and Standards

It is agreed between TWM and SLR, that the landfill design shall be designed to meet 'best practice' requirements. The following regulatory framework and standards are proposed to be complied with for the implementation of 'best practice' environmental standards at the facility:

- Environmental Permit EP-L2 (485) (The Independent State of Papua New Guinea, January 2016)
- Environmental Code of Practice for Sanitary Landfill Sites, Papua New Guinea 2001
- Solid Waste Disposal Facility Criteria – Technical Manual (US EPA, 1998)
- Code of Federal Regulations, Title 40 – Protection of Environment. Volume: 26 Part 264 – Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (2014)

4.1 Regulatory Authorities

The Conservation and Environment Protection Authority (CEPA), formally the Department of Environment and Conservation (DEC), is the Papua New Guinea governmental authority responsible for administering the environmental effects of a project in accordance with the *Environment Act 2000* and its' subsequent regulations.

The landfill facility will be designed to meet the following criteria:

4.2 Environmental Permit EP-L2(485)

The Site Environmental Permit (The Independent State of Papua New Guinea, January 2016) issued by CEPA under *Section 65* of the *Environment Act 2000* was issued:

- To carry out works associated with the construction and operation of an Integrated Waste Management Facility; and
- To discharge wastes into the environment from industrial activities associated with:
    - Construction and operation of a wastewater treatment plant
    - Quarrying involving the extraction of greater than 100,000 tonnes per year
    - Construction and operation of a private landfill for disposal of municipal wastes
    - Incineration, reprocessing, treatment or disposal of industrial or biomedical waste of a capacity greater than 10 tonnes per year
    - Recycling waste material including but not limited to glass, oil, metal, paper and putrescible materials with a capacity greater than 100 tonnes per year.

4.3 Environmental Code of Practice for Sanitary Landfill Sites, Papua New Guinea 2001

The Code has the aim of protecting the existing natural environment from negative impacts of uncontrolled waste management; assist with the planning and design of new landfills; and promote approaches to waste reduction. It was previously administered by the former DEC and is now administered by CEPA. The code aims to assist in managing existing landfills and provides guidance on planning and constructing new landfill cells. The code applies to all public and private land.

The code classifies landfill sites according to use requirements, size and populations served. The landfill classifications are as follows:

- Class 1 sites – municipal facilities utilising compactors/graders, receiving greater than 1,000 tonnes per day and serving towns with populations of or greater than 20,000 people having the capacity to receive and treat special wastes;
- Class 2 sites – municipal facilities that are manually operated and treat less than 1,000 tonnes per day and serve towns of between 4,000 to 20,000 people which do not have the capacity to receive and treat special wastes;
- Class 3 sites – facilities which are managed privately and are manually operated like Class 2 sites.

The code provides minimum standards that must be met for design and operation, which are enforced through conditions applied through the environmental permitting process. The Code of Practice aims at environmental improvements and is not prescriptive in the design requirements, rather it relies on the skills of experienced designers. To this end there is no difference between hazardous and non-hazardous landfill design expectations.

4.4 Environment (Registration of Contaminants and Hazardous Contaminants) Regulation 2011

The regulations classify contaminants and hazardous contaminants. Contaminants include all pesticides, except those listed in Schedule 2 of the Regulation. Schedule 2 lists the hazardous contaminants and include:

- Biodegradable plastic shopping bags;
- All controlled substances listed in Annexes A to E of the Montreal Protocol.
- All substances listed in Annex A, Annex B and Annex C of the Stockholm Convention;
- All hazardous wastes listed in the Annexes to the Basel Convention and Waigani Convention;
- Synthetic greenhouse gases a) hydrofluorocarbons (HFCs) and b) Perfluorocarbons (PFCs).

4.5 Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 258 – Criteria for Municipal Solid Waste Landfills

The purpose of this part is to establish minimum national criteria under the Resource Conservation and Recovery Act (RCRA or the Act), as amended, for all municipal solid waste landfill (MSWLF) units and under the Clean Water Act, as amended, for municipal solid waste landfills that are used to dispose of sewage sludge. The Part details minimum national criteria ensure the protection of human health and the environment.

4.6 Solid Waste Disposal Facility Criteria – Technical Manual (US EPA, 1998)

THE USEPA published the *Solid Waste Disposal Facility Criteria – Technical Manual* (40 CFR Part 258) (herein referred to as the "*Technical Manual*") in 1993 and updated it in 1998 to provide owners/operators of landfills with guidance for complying with the federal landfill regulations. The Technical Manual includes references to each relevant legislative requirement and associated applicability and technical considerations. The manual is not a regulatory document, and does not provide mandatory technical guidance, but does provide assistance for complying with technical aspects of the US EPA landfill Criteria.

Part 258 was established to provide minimum national criteria for all solid waste landfills that are not regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA), and that:

- Receive municipal solid waste; or
- Co-dispose sewage sludge with municipal solid waste; or
- Accept non-hazardous municipal waste combustion ash.

Each subpart is divided as follows:

- Subpart A addresses the general applicability of the Part 258 Criteria;
- Subpart B covers location restrictions;
- Subpart C explains the operating requirements;
- Subpart D discusses design standards;
- Subpart E covers ground-water monitoring and corrective action; and
- Subpart F chapter addresses closure and post-closure care.

4.7 Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 261 – Identification and Listing of Hazardous Waste

This Part identifies those solid wastes which are subject to regulation as hazardous wastes under Parts 262 through 265, 268, and parts 270, 271, and 124 and which are subject to the notification requirements of Section 3010 of RCRA. Part 261 is divided into the following sub-parts as follows:

- Subpart A defines the terms ‘‘solid waste’’ and ‘‘hazardous waste’’, identifies those wastes which are excluded from regulation under Parts 262 through 266, 268 and 270 and establishes special management requirements for hazardous waste produced by conditionally exempt small quantity generators and hazardous waste which is recycled.
- Subpart B sets forth the criteria used by EPA to identify characteristics of hazardous waste and to list particular hazardous wastes.
- Subpart C identifies characteristics of hazardous waste.
- Subpart D lists particular hazardous wastes.

4.8 Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 264 – Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities and Part 265 – Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities. (2014)

Regulations governing hazardous waste landfills are codified in Part 264/265, Subparts K through N. In addition to these unit-specific requirements, landfills managing hazardous waste are subject to the general facility standards found in Subparts A through E in Part 264/265.

The regulation specifies that the liner system must have a liner that is designed, constructed, and installed to prevent any migration of wastes out of the landfill to the adjacent subsurface soil or ground water or surface water at anytime during the active life (including the closure period) of the landfill. The liner must be constructed of materials that prevent wastes from passing into the liner during the active life of the facility.

4.9 Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 268 – Land Disposal Restrictions

This Part identifies hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may continue to be land disposed. Part 268 is divided into the following sub-parts as follows:

- Subpart A—General
- Subpart B—Schedule for Land Disposal Prohibition and Establishment of Treatment Standards
- Subpart C—Prohibitions on Land Disposal
- Subpart D—Treatment Standards
- Subpart E—Prohibitions on Storage

4.10 Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 267 – Standards for Owners and Operators of Hazardous Waste Facilities Operating Under a Standardised Permit

The purpose of this part is to establish minimum national standards which define the acceptable management of hazardous waste under a 40 CFR part 270, subpart J standardized permit.

5 Project Understanding

The TWM facility is located on Napa Napa Road, Porebada, Central Province, Port Moresby and approximately 22 km west of Port Moresby. The site is zoned 'isolation industries' and is 12.5 hectares in size.

The Facility is operated by TWM as an Integrated Waste Management facility (IWMF) and includes the following site infrastructure: staff quarters, guard house, laundry, accommodation, workshop, and office. Currently, TWM hold a number of Australian hazardous waste import permits and through the development of the landfill, seek to expand PNG's capacity to treat, recycle and dispose of hazardous materials in-country.

It is proposed the IWMF will include the following plant and infrastructure at the facility:

- Weighbridge and receival hall
    - Enclosed point of receival for all incoming wastes. Wastes are then inspected, weighed and allocated for treatment, storage, disposal as appropriate
- Sorting and segregation
    - C&I, C&D wastes are inspected for recycling and/or beneficial re-use.
- Recycling, composting and beneficial re-use
- Incineration plant
    - Hazardous wastes are identified, processed through incineration with residual ash proposed to be disposed at the landfill
- Waste oil recycling
    - Waste Oil Processing Unit to condition waste oils for beneficial re-use.
- Fixation
    - Contaminated wastes to be identified, fixated and bound before disposal to landfill or beneficial re-use.
- Waste water treatment plant
    - Generated waste waters processed before either re-use or further processing
- Landfill facility
    - To receive all residual waste streams post treatment or directly.
- Storage area (Hazardous waste)
    - Separate storage for consolidation of hazardous wastes or treatable streams for export.

The site is bound by:

- Napa Napa Road to the north with Avenell Engineering Systems beyond.
- Roku village to the south.
- Disused quarry to the east.
- Industrial activities to the west.

5.1 Site Topography

The Site is generally undulating, extending to a hill located in the south-eastern corner of the site. On the western and eastern boundaries, the site has been extensively cleared and levelled in a series of benches following a natural incline to the crest of the hill sloping down from the South to the North. The land around the site falls to the west from an elevation of RL103 to a valley of RL22.

5.2 Site Geology

5.2.1 Regional Geology

The 1;250,000 Geological Sheet, defines the rock within the Site is classified as Tep (Paga Beds). Tep is described as Partly calcareous, siliceous argillite and shale, calcilutite, chert, minor calcarenite and dolomite.

5.2.2 Site Geology

Geotechnical logs for the test pits, show that the ground profile varies from bare bedrock to shallow soil depths over completely weathered rock (CWR). ACEM notes the two boreholes comprise of bands of completely fractured and fragment rock interspersed with bands of harder rock. The rock is a siltstone of the Port Moresby Beds and varies from Qa=0.5MPa to Qa=5MPa, with much of the rock being in the range 1-2 MPa. Further geotechnical information for the site is provided within the Baseline Environmental and Geotechnical Study report (ACEM Geotechniques, 2019).

5.3 Landfill Design Regulatory Overview

A regulatory overview of the primary Cell 1 landfill design requirements included within Section 4 is included within Table 2.

Table 2: Landfill Design Requirements - Regulatory Overview

Design Element	Standard	Design Requirements
Landfill Waste Acceptance Rate	Environmental Permit EP-L2(485) Condition 91(a)	The Permit Holder shall construct an engineered landfill with a capacity of approximately 70 tonnes of commercial and industrial non-restricted waste materials per day.
Liner Design	Environmental Permit EP-L2(485) Condition 91(b)	The landfill will be constructed with a high-density polyethylene (HDPE) geo-membrane barrier combined with clay liners and a leachate collection system.
Liner Design	Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 264/265	Standard configuration of a composite lining system (top to bottom) is as follows: (A) A top liner designed and constructed of materials (e.g., a geomembrane) to prevent the migration of hazardous constituents into such liner during the active life and post-closure care period; and (B) A composite bottom liner, consisting of at least two components. The upper component must be designed and constructed of materials (e.g., a geomembrane) to prevent the migration of hazardous constituents into this component during the active life and post-closure care period. The lower component must be designed and constructed of materials to minimize the migration of hazardous constituents if a breach in the upper component were to occur. The lower component must be constructed of at least 3 feet (91 cm) of compacted soil material with a hydraulic conductivity of no more than 1×10^{-9} m/s.
Leachate Collection	Environmental Permit EP-L2(485) Condition 97:	The leachate system shall be designed with a minimum 2% slope to drain liquids to the leachate collection sump, from where it is pumped via leachate riser pipes to a central collection well before being pumped to the on-site WWTP.
Leachate Collection	Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 264	A leachate collection and removal system immediately above the liner that is designed, constructed, maintained, and operated to collect and remove leachate from the landfill. The Regional Administrator will specify design and operating conditions in the permit to ensure that the leachate depth over the liner does not exceed 30 cm (one foot).

Design Element	Standard	Design Requirements
Leak Detection System	Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 264	• The leachate collection and removal system between the liners, and immediately above the bottom composite liner in the case of multiple leachate collection and removal systems, is also a leak detection system. This leak detection system must be capable of detecting, collecting, and removing leaks of hazardous constituents at the earliest practicable time through all areas of the top liner likely to be exposed to waste or leachate during the active life and post-closure care period. The requirements for a leak detection system in this paragraph are satisfied by installation of a system that is, at a minimum: (i) Constructed with a bottom slope of one percent or more; (ii) Constructed of granular drainage materials with a hydraulic conductivity of 1×10^{-4} m/s or more and a thickness of 30 cm or more; or constructed of synthetic or geonet drainage materials with a transmissivity of 3×10^{-5} m^2/sec or more; (iii) Constructed of materials that are chemically resistant to the waste managed in the landfill and the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and equipment used at the landfill; (iv) Designed and operated to minimize clogging during the active life and post-closure care period; and (v) Constructed with sumps and liquid removal methods (e.g., pumps) of sufficient size to collect and remove liquids from the sump and prevent liquids from backing up into the drainage layer. Each unit must have its own sump(s). The design of each sump and removal system must provide a method for measuring and recording the volume of liquids present in the sump and of liquids removed. The owner or operator shall collect and remove pumpable liquids in the leak detection system sumps to minimize the head on the bottom liner. • The owner or operator of a leak detection system that is not located completely above the seasonal high water table must demonstrate that the operation of the leak detection system will not be adversely affected by the presence of ground water
Landfill Staging	Environmental Permit EP-L2(485) Condition 92:	The landfill shall be designed for separate cells to be constructed consecutively as required. The Permit Holder hall ensure that all cells will be separated by internal bund to manage stormwater and leachate, and each cell shall be installed with a leachate sump.

Design Element	Standard	Design Requirements
Final Cover	Environmental Permit EP-L2(485) Condition 96:	The permit holder shall, as soon as practicable, install the final covering of the completed landfill cell. The final covering shall consist of three layers: • Lower layer: gas distribution layer comprising porous material and a network of high-density polyethylene pipes connecting the landfill gas trenches to the landfill gas extraction wells to vent the landfill gases • Middle layer: A layer of compacted soil and geo-synthetic material; • Upper (final surface) layer: The surface or cap layer shall be topsoil, planted with shallow rooted vegetation, such as natural grasses, that are drought and heat tolerant with low nutrient needs.
Final Cover	Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 264/265	At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to: (1) Provide long-term minimization of migration of liquids through the closed landfill; (2) Function with minimum maintenance; (3) Promote drainage and minimize erosion or abrasion of the cover; (4) Accommodate settling and subsidence so that the cover's integrity is maintained; and (5) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.
Stormwater Management	Environmental Permit EP-L2(485) Condition 16:	The Permit holder shall develop and install a stormwater management system of adequate capacity to contain and control surface runoff during peak precipitation periods and extreme weather events that may occur during the Term of this permit (25 years). This system shall be based on a minimum 1 in 20 year storm event, but the permit holder shall review this storm event period and re-design the stormwater system accordingly in the event that an extreme weather event or prolonged period of high precipitation exceeds the capacity of the system to fully contain and control surface runoff within the premises.
Groundwater Monitoring	Environmental Permit EP-L2(485) Condition 98:	• The permit holder shall install groundwater monitoring wells at selected locations around the landfill site prior to commencement of operations. The groundwater monitoring wells shall be located in accordance with the Environmental Code of Practice for Sanitary Landfill Sites, DEC, 2001, where reasonably practicable and shall include as a minimum, the following locations:

Design Element	Standard	Design Requirements
		• 100m upstream of the landfill • At the mid-stream edge of the landfill • 100m downstream along the main drain • Downstream of the landfill at the boundary of the premises

6 Conceptual Landfill Design

SLR's concept design considerations for Cell 1 include:

- Development of the geometry of the landfill footprint and cap to maximise void space whilst considering siting and environmental constraints as well as safe construction and operation;
- Leachate barrier requirements;
- Leachate collection and extraction infrastructure requirements;
- Groundwater elevations;
- Final capping and landfill rehabilitation profile;
- Leachate storage and treatment requirements;
- Landfill stability assessment;
- Landfill Gas (LFG) generation and landfill gas management system layout; and
- Surface water management;

The following sections discuss the individual design components.

6.1 Conceptual Design Parameters

Design parameters and assumptions for the concept landfill have been agreed with TWM within the design basis memorandum (620.12961, SLR 2019) and are summarised below.

6.1.1 Cell Geometry

CEPA requires landfills to be developed as a series of independent cells. It is therefore proposed that the landfill will be constructed in two independent stages. The landfill footprint is proposed to be constructed in two stages (Stage 1 Eastern and Stage 2 Western Stage). The proposed Eastern Stage, to be acquired by TWM, is located within a quarry void. Landfill access is proposed to be via the existing site access point. The road easement adjacent to the landfill is proposed to be utilised for the construction of a landfill access road.

The floor of each landfill cell will be contoured to provide a fall of at least 2% towards the leachate drainage collection pipes. The leachate collection pipework for each cell will be sloped at not less than 2 per cent towards a leachate sump within each cell. The minimum gradient of the cell floor shall be confirmed via a performance-based design calculation of the estimated leachate level within the leachate drainage layer (maximum of 300mm) during the detailed design phase.

Leachate will be extracted from each sump and initially discharged into an on-site leachate dam. Leachate extraction infrastructure would need to be installed into each cell and designed to enable the leachate elevation compliance requirements (currently no higher than 300 mm above the base of the drainage layer) to be met.

To maximise landfill capacity, internal side-walls are proposed to be constructed at a slope of 1 Vertical to 3 Horizontal (1V:3H). The stability of the batter slopes and liner will be confirmed within the detailed design.

The floor of the landfill is to maintain a minimum two-metre buffer between the known groundwater level and the base of the landfill. The proposed landfill footprint is depicted in Drawing No. 620.12961-C03 in **Appendix A.**

6.1.2 Landfill Staging and Filling

The conceptual landfill construction staging and filling will commence in the following sequence:

1. Stage 1: Eastern Footprint Area (Dis-used Quarry)
2. Stage 2: Western Footprint Area (Within current TWM site boundary)

The landfill sequence is designed to reduce the area of uncapped waste where possible and to allow progressive rehabilitation. Landfill staging and filling parameters assumed in this assessment are detailed in Table 3.

Table 3: Landfill staging and filling parameters

Aspect	Parameter
Estimated annual waste stream	12,000 tonnes per annum
Daily cover allowance (%)	10%
Compaction of Waste	Assumption of 1.0 t/m^3

Preliminary volumetric modelling of the proposed landfill was carried out to determine the expected void, which is estimated to provide 142,850 cubic metres of void space, as detailed in Table 4.

Table 4: Cell 1 Void Capacity and Estimated Life

Stage	Waste Capacity (m^3)	Earthworks Cut (m^3)	Earthworks Fill (m^3)	Base Liner Surface Area (m2)	Capping Surface Area (m2)	Estimated Life
1	46,950	55,475	37,100	10,100	6,800	4 years
2	95,900	93,700	45,550	9,750	12,700	8 years
Total	142,850	149,175	82,650	19,850	19,500	12 years

6.1.3 Conceptual Final Landform

A conceptual design of the final landform is recommended to comprise the following elements, as defined within Drawing No. 620.12961-C10 in **Appendix A**:

- To facilitate runoff and reduce the risk of erosion, side-slopes and the crown of the final landform for the landfill will have a minimum gradient of 5%; and
- The final landform will utilise existing surface water management features, where possible, to manage local surface water runoff.

6.2 Concept Engineered Lining System

6.2.1 Barrier System

The proposed leachate containment system for the landfill comprises a basal barrier (to be constructed across the floor areas) and a side-wall barrier (to be constructed across the interior side-slopes). The leachate barrier system is designed using a combination of the results-driven principles and specific technical requirements.

6.2.2 Engineered Lining Scenario Summary

Two (2) leachate barrier liner scenarios were assessed, for consideration of environmental protection and value for money whilst meeting best practice performance requirements as detailed in Table 5. The leachate barrier liner scenarios are offered in increasing levels of environmental protection.

Table 5: Engineered Lining Scenario Summary

Configuration	Landfill liner performance
Basal Lining System Double composite liner and leak detection system (from top to bottom) as described below: • Soil protection layer or soft waste layer • Separation geotextile • Primary leachate collection and removal system • Protection geotextile(s) • HDPE geomembrane liner • Geosynthetic Clay Liner (GCL)* • Blanket Drainage geocomposite (Secondary leachate collection and removal system) • HDPE geomembrane liner • Low-permeability clay liner • Underlying ground water de-pressurisation system * Subject to further investigation **Side-wall Lining System** The double composite liner system (from top to bottom) is described below: • Soil protection layer or soft waste layer • Drainage geo-composite • HDPE geomembrane liner • Geosynthetic Clay liner* • Secondary Leachate Collection and Removal System (Leak Detection) • HDPE geomembrane liner • Low-permeability clay liner • Underlying ground water de-pressurisation system *Subject to further investigation	Standard 'best practice' requirements in accordance with the *Code of Federal Regulations, Title 40 Protection of Environment. Volume: 26 Part 264 – Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities*.

6.2.3 Lining System

6.2.3.1 Basal Lining System

The lining system comprises of a top liner designed and constructed of materials (e.g., a geomembrane) to prevent the migration of hazardous constituents into such liner during the active life and post-closure care period; and a composite bottom liner, consisting of at least two components, an upper primary liner and a lower secondary liner. Between the primary and secondary liners is a system for leak detection, collection, and removal of leachates. Scenario 2 includes the following components from top to bottom, as detailed within Table 6.

Table 6: Basal Lining System

Component	Description
Soft waste layer	A 600mm layer of 'soft waste' material to prevent solid waste from damaging and clogging the leachate drainage layer, yet not impede leachate flow.
Separation Geotextile Layer	A non-woven geotextile separation layer must be placed over the drainage layer to protect it from clogging as a result of solids transport, chemical precipitation and growth of biofilm.
Primary Leachate Collection and Removal System	A leachate drainage layer, comprising a 300 mm thick layer of drainage aggregate with slotted HDPE drainage pipe to allow the collection and flow of leachate out of each cell. The primary leachate drainage layer is detailed within **Section 6.3**.
Geotextile Protection Layer	The geotextile protection layer will ensure a satisfactory short and long-term hydraulic performance of the lining system. Protection geotextile/s are subject to laboratory testing method ASTM D5514 Standard Test Method for Large-Scale Hydrostatic Puncture Testing of Geosynthetics.
Primary Composite Lining System	A composite liner, comprising: • A 2 mm thick high density polyethylene (HDPE) geomembrane is to be placed over the GCL, to provide a relatively impermeable barrier to leachate migration. **AND** • A reinforced geosynthetic clay liner (GCL)* which should consist of a thin layer of bentonite 'sandwiched' between layers of geotextiles. **Subject to further investigation*
Secondary Leachate Collection and Removal System (Leak Detection)	A drainage geocomposite with nonwoven polypropylene geotextile fabric heat bonded on both sides of the geonet. The geonet will contain a minimum hydraulic transmissivity of 0.3 x 10^{-5} square metres/second. The secondary leachate collection and removal system will contain a slotted HDPE drainage pipe within each cell sump to allow the collection and flow of leachate out of the leak detection system.

Component	Description
Secondary composite Liner	A secondary composite liner, comprising: • A 2 mm thick high density polyethylene (HDPE) geomembrane, to provide a relatively impermeable barrier to leachate migration. **AND** • A 900 mm thick compacted clay layer (CCL). On-going testing is required to be conducted during construction to ensure the clay supply continues to exhibit suitable geotechnical properties. The clay is to comprise of the following properties: ○ Comprise cohesive materials of high plasticity; ○ Be relatively free of organic material; ○ An in situ co-efficient of permeability / hydraulic conductivity of less than $1x10^{-9}$ m/s when measured in a triaxial cell; ○ Liquid Limit < 50 %; ○ Plasticity Index > 15 %; ○ Maximum particle size of 50 mm; ○ > 98 % passing 19 mm sieve; ○ > 30 % passing 0.075 mm sieve; ○ > 20 % passing 0.002 mm sieve; ○ Emerson class > 3; and ○ Organic content < 2 %.
Groundwater Relief Layer	A groundwater relief layer shall provide separation between the landfill base and groundwater. The relief layer shall prevent any potential upward or outward force of groundwater through the base or sides of the landfill, which could contribute to or cause structural failure of the lining system. The groundwater relief layer will include a slotted HDPE pipe installed at least 1 metre below the subgrade. The pipe will be backfilled with drainage aggregate.

The proposed basal and sidewall lining system for Scenario 3 is shown in **Figure 1** and **Figure 2** and Drawing No. 640.11703-SK71 in **Appendix A**.

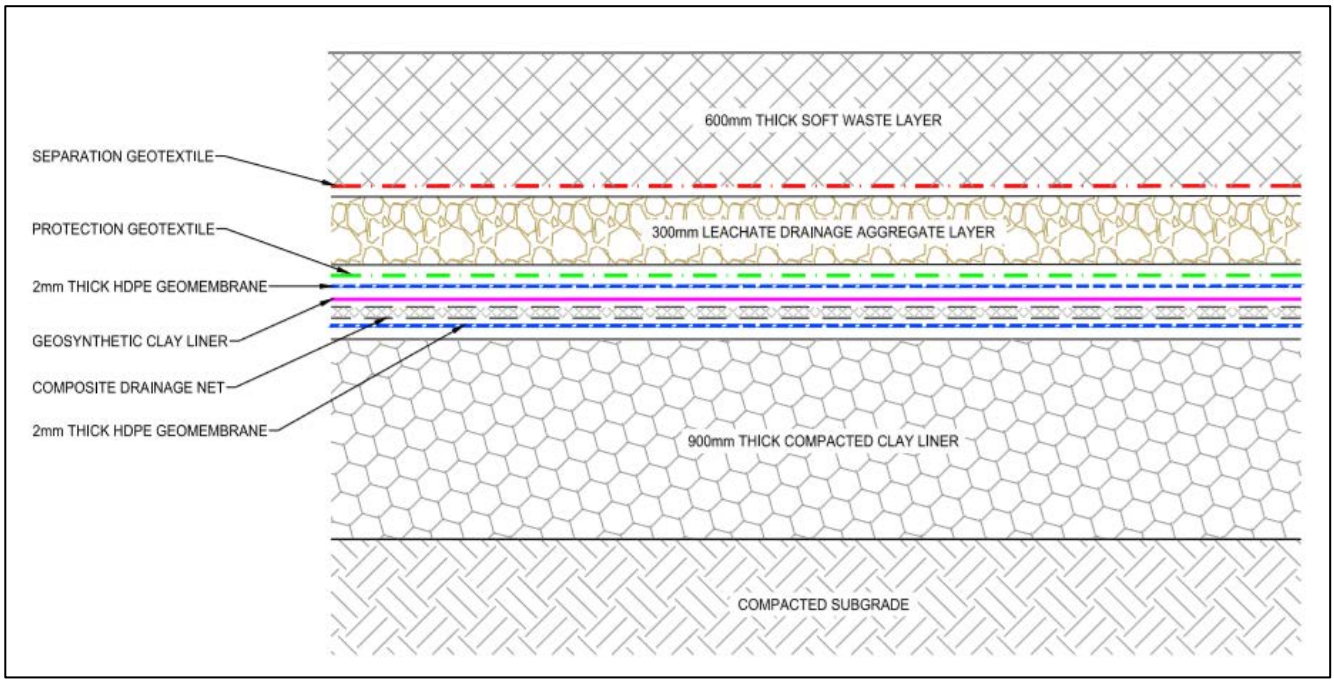


Figure 1: Basal lining system

6.2.3.2 Side-wall Lining System

The recommended side-wall lining system includes the following components (from top to bottom) as described in Error! Reference source not found..

Table 7: Side-wall Lining System

Component	Description
Soil protection layer or soft waste layer	A 600mm layer of permeable sand, gravel or other 'soft waste' material to prevent solid waste from damaging and clogging the drainage geocomposite, yet not impede leachate flow.
Primary Leachate Collection and Removal System	A drainage geocomposite with nonwoven polypropylene geotextile fabric, heat bonded on both sides of the geonet will be employed above the geotextile protection layer to act as a leachate drainage layer on the batter slope.
Primary Composite Lining System	A composite liner, comprising: • A 2 mm thick high density polyethylene (HDPE) geomembrane is to be placed over the GCL, to provide a relatively impermeable barrier to leachate migration. **AND** • A reinforced geosynthetic clay liner (GCL)* which should consist of a thin layer of bentonite 'sandwiched' between layers of geotextiles. **Subject to further investigation*

Component	Description
Secondary Leachate Collection and Removal System (Leak Detection)	A drainage geocomposite with with nonwoven polypropylene geotextile fabric heat bonded on both sides of the geonet. The geonet will contain a minimum hydraulic transmissivity of 0.3 x 10^{-5} square metres/second. The secondary leachate collection and removal system will contain a slotted HDPE drainage pipe within each cell sump to allow the collection and flow of leachate out of the leak detection system.
High Density Poly Ethylene Liner	A HDPE liner comprising of a 2 mm thick high density polyethylene (HDPE) to provide a low permeability barrier to leachate migration.
Compacted Clay Layer	A 900 mm thick compacted clay layer (CCL) in accordance with the properties listed within **Error! Reference source not found.**.

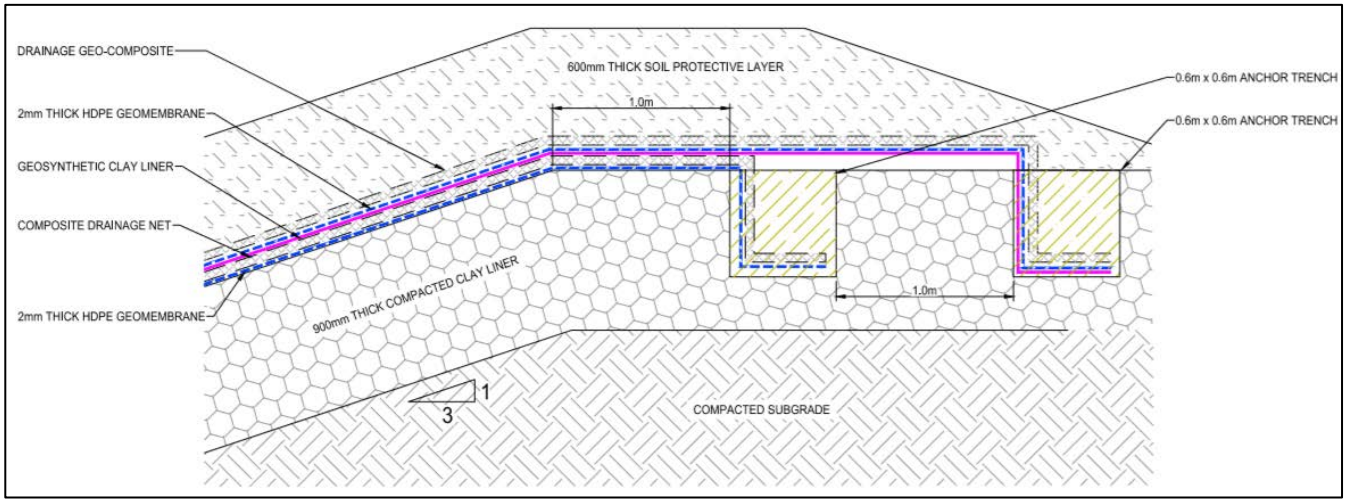


Figure 2: Sidewall Anchor Trench Detail

6.3 Perimeter Bund and Cell Division

The perimeter bund and cell division is based upon best practice, construction practicality and safety. The internal cell division bunds shall have side slopes of 1V:2H with a crest width of 5 metres and a height of 3 metres in height. The perimeter embankment shall have a width of 5 metres to allow for anchor trench construction, stormwater diversion and for site access purposes.

6.4 Leachate Collection System

Leachate is generated predominantly due to waste decomposition and rainfall infiltration within the active and capped landfill areas at the Site. Leachate is proposed to be stored and disposed of primarily by evaporation during landfilling operations or by thermal treatment. Where these measures are not available, transportation of leachate to a facility licenced to accept such waste will be utilised.

Primary sources of leachate are:

- Surface water infiltration into the waste and surface runoff into the waste mass during periods of prolonged rainfall; and
- Leachate generated by the moisture content, and decomposition of the received and emplaced waste.

The proposed leachate collection system design components include:

- The base of the leachate collection layer graded to direct leachate to specific leachate collection sumps;
- A network of perforated leachate collection pipes within the collection layer, to promote the flow of leachate to the sumps; and
- A series of submersible pumps and inclined leachate extraction pipes will be designed to facilitate removal of leachate from the collection sumps by progressive pumping to an onsite leachate storage pond.

6.4.1 Leachate Collection System

Scenario 2 will include all lining system components (from top to bottom), as detailed within **Table 8**.

Table 8: Leachate Collection System

Component	Description
Primary Leachate Collection System	
Primary Leachate Drainage Layer	A 300mm thick layer of drainage aggregate with slotted HDPE drainage pipe will be placed above the composite liner, which will assist with the flow of leachate to the leachate collection system. The leachate collection system will be graded as per the subgrade 1% longitudinally toward the leachate sump and 3% transversely towards the leachate collection pipework.
Primary Leachate Collection Pipes	Perforated leachate collection pipe network will be required within the drainage aggregate collection layer, to assist in the flow of leachate to the sump. The pipe network will comprise a central spine drain, with spur drains spaced at a minimum of 25m. The leachate spine drainage pipes will be at least 250 millimeter diameter HDPE perforated pipe. Leachate spur pipes will be constructed of HDPE and be at least 160 millimeters in diameter. Loading calculations for this pipework will be carried out in the detailed design phase to determine adequate strength to provide a pipe that is sufficient to resist buckling and deformation caused by the excessive loading from the anticipated depth of waste.
Primary Leachate Sump	The sump base will be 5 metres long by 5 metres wide and be recessed 1 meter below the base of the cell. The sump batters will be graded to 1V:3H.
Leachate Extraction Pipework	From the sump, an inclined HDPE leachate extraction pipe will be designed to draw leachate from the base of the landfill to the surface by an extraction pump. The pipe will be perforated 2.0 metres from the base.
Secondary Leachate Collection System	
Secondary Leachate Collection and Removal System	A drainage geocomposite with nonwoven polypropylene geotextile fabric heat bonded on both sides of the geonet. The drainage geocomposite will contain a minimum hydraulic transmissivity of 3 x 10^{-5} square metres/second and hydraulic conductivity of 1 x 10^{-4} m/s.

Component	Description
(Leak Detection)	The secondary leachate collection and removal system will contain a slotted HDPE drainage pipe within each cell sump to allow the collection and flow of leachate out of the leak detection system.
Secondary Leachate Collection Pipes	Perforated leachate collection pipes will be installed within a 300mm thick aggregate drainage channel installed below the primary leachate drainage spine drain, to assist with the flow of leachate to the sump. The pipe system will comprise a central spine drain. The leachate drainage pipes will be at least 110 millimetres in diameter, consisting of a HDPE perforated pipe. Loading calculations for this pipework will be carried out in the detailed design phase to determine adequate strength to provide a pipe that is sufficient to resist buckling and deformation caused by the excessive loading from the anticipated depth of waste.
Secondary Leachate Sump	The sump base will be 5 metres long by 5 metres wide and be recessed 1 meter below the base of the cell. The sump batters will be graded to 1V:3H.
Secondary Leachate Extraction Pipework	From the sump, an inclined HDPE leachate extraction pipe will be designed to draw leachate from the base of the landfill to the surface by an extraction pump. The pipe will be perforated 2.0 metres from the base and be at least 110 millimetres in outer diameter.

7 Leachate Management

7.1 General

An assessment of the potential leachate generation at the proposed landfill has been undertaken to inform the design of the proposed landfill facility and associated leachate storage systems ensuring that future demands over the operational life of the landfill will be met.

The approach of the assessment is to undertake the conceptual design to meet the requirements outlined within the *Technical Manual*, including development of the following:

1. Leachate Generation Assessment
2. Leachate Management Options Review
3. Preliminary Leachate Pond Water Balance
4. Leachate Pond Storage Design

7.2 Leachate Generation Assessment

The estimated leachate generation for the Site was modelled with the computer program Hydrologic Evaluation of Landfill Performance (HELP) model 3.95 D (Klaus Berger, 1998) and is detailed within **Appendix A**. A summary of the leachate generation output is included within Table 9.

7.3 Leachate Storage Pond Design

7.3.1 Assumptions

For the purpose of understanding worst-case leachate generation, the following assumptions are incorporated into the design of the leachate pond:

- The water balance is conducted over a period of one 90th percentile wet year, to ensure that the proposed system has sufficient capacity to deal with all leachate generated during the operational period of the landfill prior to the construction of the waste water treatment plant.
- It is assumed for worst-case conditions, prior to the construction of the WWTP, that the one-third of the landfill area (Stage 1) is filled and comprises a 300mm thick intermediate cover (final capping works are yet to commence) and an active working area of 625m^2 (25m x 25m).
- To minimise the amount of leachate produced, the landfill is assumed to be operated by minimising the exposed waste with rehabilitation occurring after each landfilled stage is complete. It is assumed all areas of the landfill will incorporate stormwater diversion where appropriate to ensure segregation of clean and dirty stormwater which minimised the contribution of leachate generation.
- The infiltration percentage varies with the characteristics of the cell cap or covering. Where areas have been temporarily capped, an infiltration rate of 25 – 30% is typically attained and infiltration rates in restored (final capping areas) are typically in the range of 2 – 10% (Environmental Protection Agency, 2000).

- As per discussions between TWM and SLR, the waste water treatment plant (WWTP) will commence operations in approximately 12 months' time and will treat approximately 3 to 27m^3 of leachate per day (91 - 851m^3/month).

7.3.2 General

The leachate pond will store leachate generated by Stage 1 and Stage 2 of landfilling. The leachate pond is sized based upon the leachate generation (HELP) modelling (See **Appendix B** for details), evaporation data and assumptions included within Section 7.3.1.

7.3.3 Input Data

A monthly rainfall and evaporation data set of greater than 50 years (from 1966 to 2017) was used for the assessment. The 90th percentile annual rainfall based upon the climate data is 1773 mm. Monthly rainfall for the year 1981 (1761mm of rainfall) is used for the purposes of this assessment.

The model accounts for all predicted leachate inputs and outputs from the leachate management system. Leachate generation (inputs) and source reduction (outputs) considered within this assessment include the following:

- Leachate generation produced from one-third of Stage 1 (including an active filling area);
- Direct leachate pond rainfall;
- Evaporation treatment system and
- Pond evaporation.

Evaporation totals are based on pan evaporation data obtained from the Silo Data Drill. A pan co-efficient (a ratio of evaporation from a large body of water to that measured in an evaporation pan) of 0.7 (NSW EPA, 2016) is included within this assessment. Monthly totals are calculated are included within **Table 9**.

Table 9: Input Data

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Inputs													
90th Percentile monthly rainfall (mm)	744.8	320.8	18	97.4	118.2	17.6	16.4	27.6	1.4	5.4	333.4	60.6	1761
Estimated monthly operational leachate production (90th percentile) (m^3)	852.0	582.5	143.7	233.0	154.1	106.3	107.5	155.5	91.8	114.3	336.4	261.2	3138.2
Outputs													
Mean evaporation (mm) for years 1966 to 2017	233.9	209.5	203.3	188.3	160.6	141.9	152.1	178.9	220.7	259.2	265.9	261.0	2475

7.4 Leachate Storage Pond Sizing

As detailed within Table 9, the model is developed using monthly time intervals, and estimates the changes in the cumulative volume with each month. The size of the leachate storage dam is based on a maximum cumulative monthly volume over a period of one wet year (90th percentile). In addition, the storage pond design allows for a 0.5 metre freeboard.

In addition to the pan coefficient, evaporation rates are lowered due to the presence of salts in aqueous solution. The liquid stored in the pond will increase in salinity as the water evaporates and salts remain in the pond, corresponding to a 10% decline in the rate of evaporation.

The surface area recommended for the evaporation of leachate produced by the landfill was calculated in accordance with the equation contained within Appendix B.5 of the Victorian EPA landfill guidelines (EPA Victoria, 2015) as shown below:

$$A = \frac{1{,}000V}{0.8E - R}$$

Where:

A = pond surface area (m^2)

V = annual volume of leachate (m^3)

E = median annual evaporation (mm)

R = median annual rainfall (mm)

The cumulative leachate pond storage volume depicted over a period of two consecutive wet years is shown within **Figure 3**.

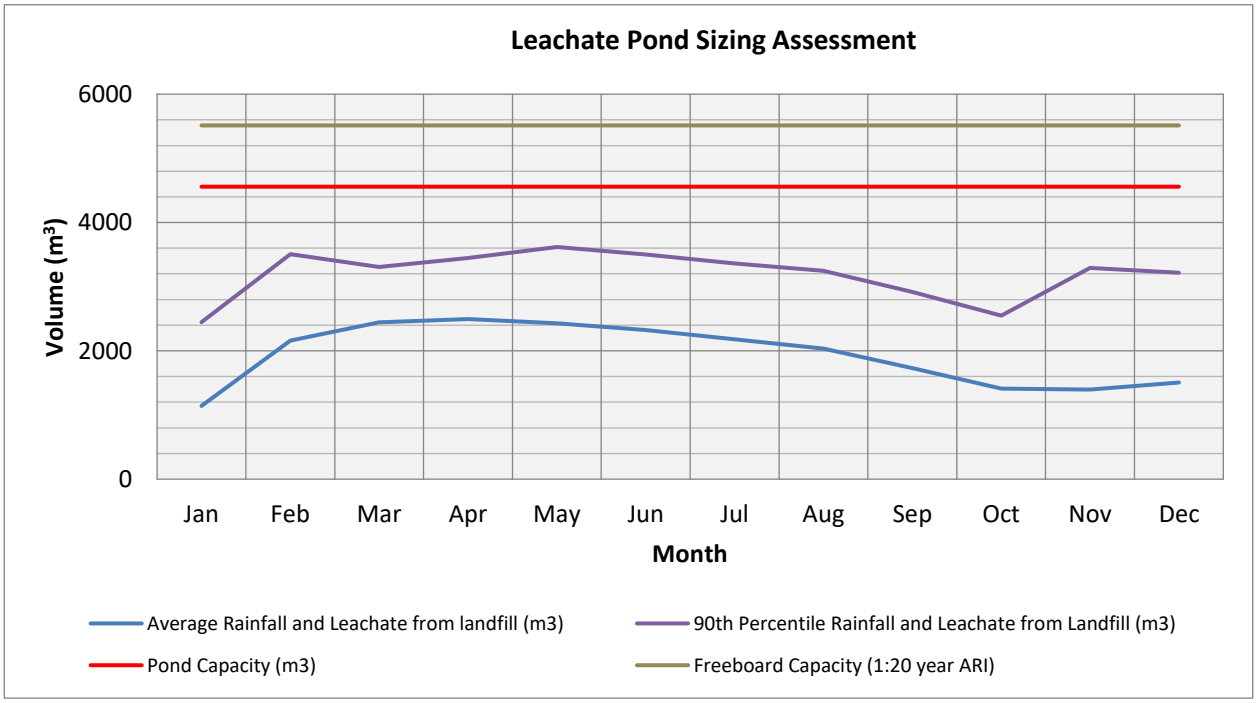


Figure 3: Leachate pond sizing assessment

7.4.1 GoldSim Modelling

As an additional assessment checks to the HELP model, a basic water balance model using GoldSim has been developed. The GoldSim model was developed to simulate daily changes in the volume of the proposed Leachate Storage Pond in response to the possible inflows (rainfall and leachate from the landfill) and possible outflow (evaporation).

The following design criteria and assumptions were incorporated in the GoldSim model:

- Daily time steps over a simulation length (year 1981) were used for the analysis. Daily time steps were chosen based on the daily rainfall data extracted from the Scientific Information for Land Owners (SILO) for Townsville Aero (gauge number 32040). This is a database of Australian climate data from 1889;
- A freeboard volume required is based on the 5% AEP 24 hour rainfall;
- The rainfall volume inflow was calculated using the maximum surface area of 2,744 m^2;
- The storage pond does not have any external catchments draining into the storage pond and does not have cover to prevent rainfall entering the pond;
- No allowance of water extraction from the storage pond has been accounted for in the model;

Due to the limited historical rainfall records for Port Moresby, there are uncertainties in the suitability of Townsville data for 90th percentile rainfall. Therefore, in addition to the 90th percentile rainfall from the Townsville Aero data, sensitivity of the required volume of storage to rainfall were tested. The three scenarios were:

- **Base Case** – Rainfall as per Townsville Aero's year 1981 (90th percentile) rainfall;
- **Sensitivity Case 1** - 50% increase to the 90th percentile rainfall; and
- **Sensitivity Case 2** - 100% increase to the 90th percentile rainfall.

7.4.2 Results

The GoldSim modelling shows that the Base Case scenario volume is slightly higher than the required storage volume calculated through the monthly timestep excel-based water balance model. This is mainly due to the difference in timestep where GoldSim model was daily compared to monthly timesteps in the excel-based water balance model.

Figure 4 below shows the storage volume in each of the scenarios assessed for the year 1981. This shows that the maximum volume of the storage pond in the Base Case scenario is 3,800 m^3 while the two sensitivity cases were at 5,100 m^3 and 7,00 m^3 respectively. In addition to this, a freeboard volume of 950 m^3 is also required for all three scenarios.

The assessment showed that the volumes peaked mid-year with general trending downwards due to evaporation until mid-November. Figure 5 shows the Base Case scenario Pond volume compared to the inflows and outflow.

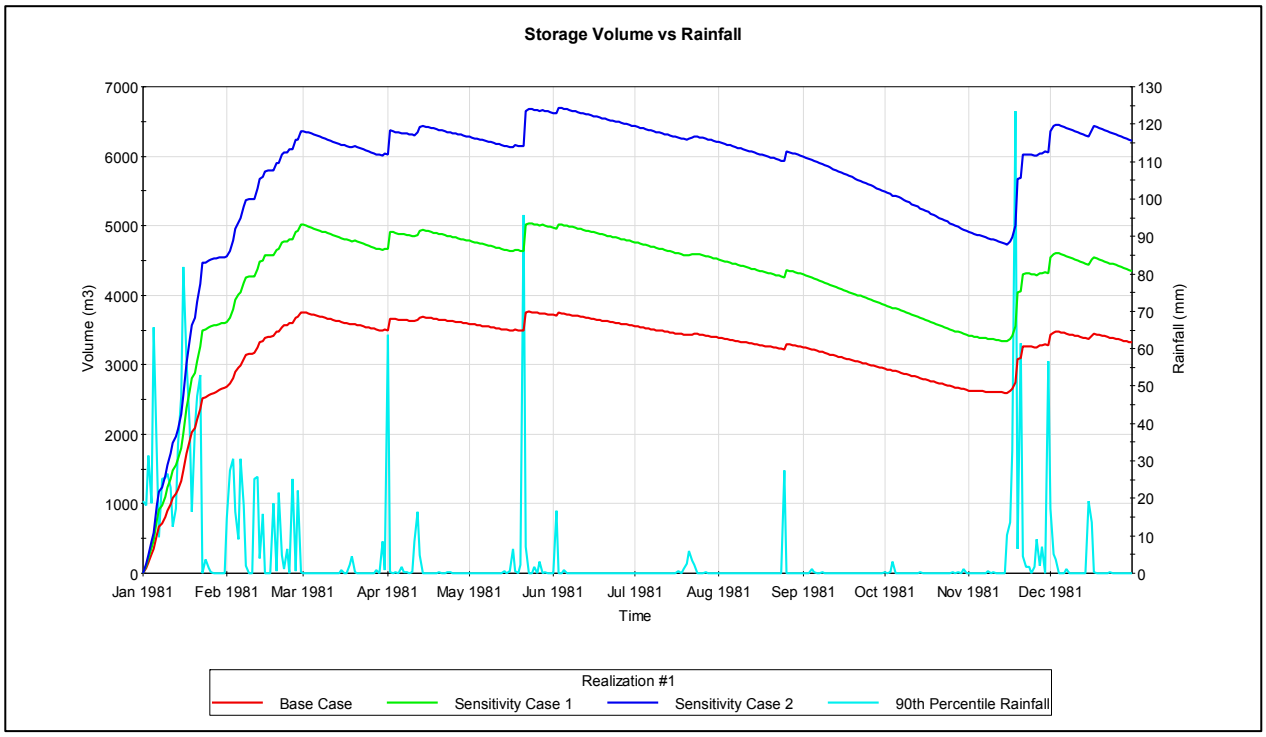


Figure 4: GoldSim Storage Volume Results

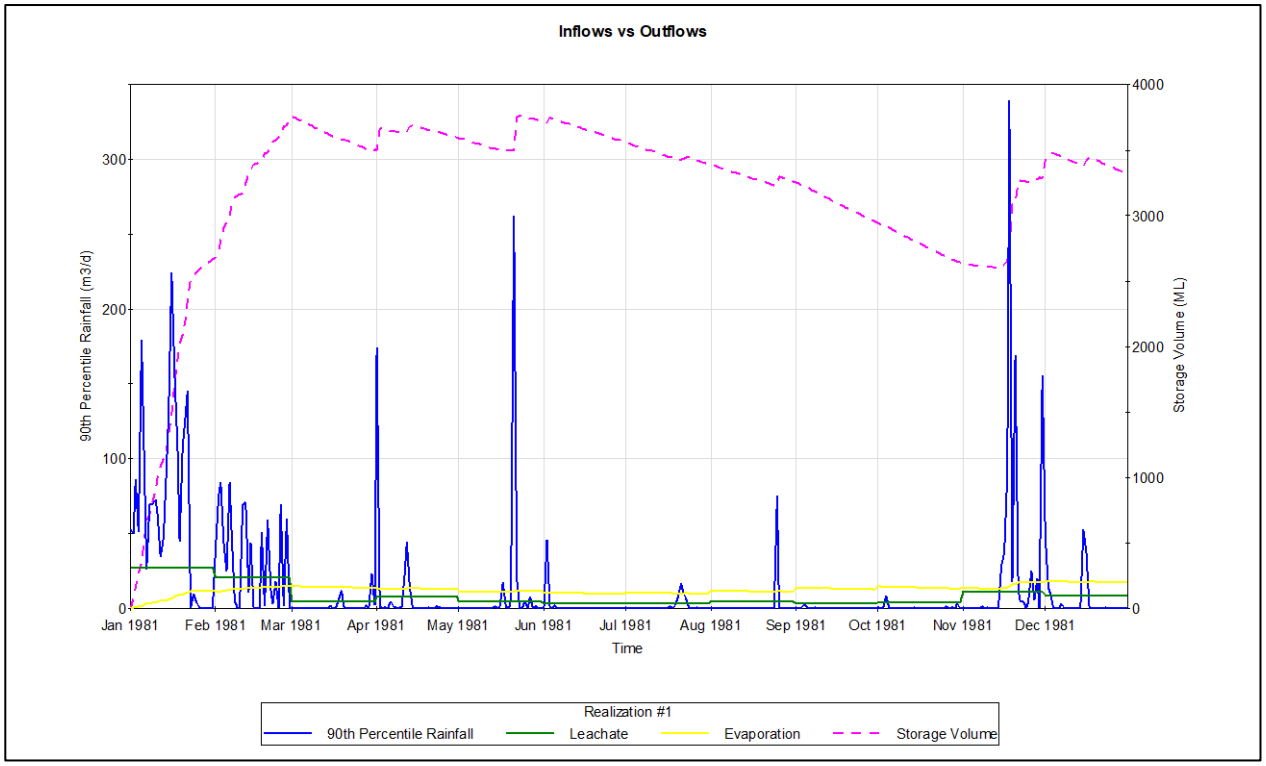


Figure 5: Base Case Pond Inflows vs Outflows

7.5 Conceptual Leachate Storage Pond Geometry

7.5.1 General

The leachate pond will store leachate generated within the landfill and conveyed through the leachate collection system. The leachate pond will be sized based upon the leachate generation (HELP) modelling (See **Appendix B** for details) and assumptions included within Section 7.3.1. The leachate storage pond is proposed to be located to the east, outside of the proposed Stage 1 landfill footprint. The leachate storage pond will be in compliance with best practice guidelines allowing for the level of leachate in the storage dam to be maintained such that there is no overflow.

The location of the pond is detailed in Drawing C03 included within **Appendix A.** The leachate storage pond geometry is summarized below in Table 10.

Table 10: Leachate Pond Geometry

Pond Length (m)	Pond Width (m)	Pond Depth (m)	Top of pond surface area (m^2)	Total Volume (ML)
45	45	5.5	1,675	4.0

7.5.2 Leachate Pond Lining Configuration

The leachate pond shall be lined to the equivalent performance standard as the landfill and constructed of the following components (from top to bottom) as described in Table 11**.**

Table 11: Lining System

Component	Description
Floor ballast	The floor area is to be covered with permanent ballast at the internal pond toe. As the Leachate Pond may be empty on occasion, the HDPE lining system may be exposed for short time periods. Therefore, a nominal ballast permanent ballast system is included in the design to reduce the risk of wind uplift.
High Density Polyethylene Liner	A 2 mm thick double textured high density polyethylene (HDPE) geomembrane, is to be placed over the clay liner, to provide a relatively impermeable barrier to leachate migration.
Compacted Clay Liner	A 600mm compacted clay liner (CCL) will be constructed in accordance with the properties listed within Table 6. The CCL will be compacted to provide a firm, stable, smooth surface of high bearing strength on which to install the HDPE liner.
Prepared Subgrade	A 200 mm thick subgrade compacted to provide a firm, stable, smooth surface of high bearing strength on which to install the composite liner.

8 Concept Capping Design

The proposed final cover system comprises a barrier system, which is designed using a combination of the results-driven principles and specific technical requirements provided in the Technical Guidelines. The proposed capping design shall be in accordance with the following elements (from top to bottom):

- A topsoil revegetation layer 150 millimetres thick
- A sub-soil layer at least 450 millimetres thick
- A drainage geo-composite
- A sealing layer comprising:
    a. A Linear Low Density Poly-Ethylene (LLDPE) Liner
    b. A Geosynthetic Clay (GCL) Liner
- A seal-bearing layer at least 300 millimetres thick
- A passive landfill gas depressurisation layer, comprising:
    a. A geo-composite panel drain
    b. Drainage aggregate

The proposed final cover system components for the Landfill as defined in drawing C12 and described in Table 12 (from top to bottom) is to be constructed over the seal-bearing layer.

Table 12: Final Cover System

Component	Description
Topsoil Layer	A 150 millimetre thick topsoil layer should be constructed which can include compost to help with vegetation establishment and growth.
Sub-soil Layer	A 450 millimetre thick sub-soil layer comprising clean soils, to protect the sealing layer from damage.
Geo-Composite Drainage Net	A drainage geocomposite with nonwoven polypropylene geotextile fabric, heat bonded on both sides of the geo-net, will be employed above the sealing layer. The geo-composite drainage net will act to drain away water that passes through the sub-soil layer, enhancing the stability of the slope by reducing pore water pressures at the interface to the underlying barrier layer. Stormwater collected within the drainage net shall discharge to a 'toe drain' drainage channel.
Linear Low Density Poly-Ethylene (LLDPE) Liner	A 1.5mm thick LLDPE geomembrane liner is to be installed across the upper surface of the geosynthetic clay liner. The LLDPE forms the first component of the sealing layer. It will be secured to the geosynthetic clay liner via anchor trenches.
Geosynthetic Clay Liner	A low-permeability GCL will be laid directly upon the prepared landfill seal-bearing layer. The GCL forms the second component of the sealing layer. The GCL shall be new and comprise a layer of bentonite distributed over a highly porous reinforcing layer, sandwiched between woven and non-woven geotextile material.

Component	Description
Seal-bearing Layer	The subgrade shall comprise of site-won earthen materials at least 300 millimetres thick, compacted to provide a firm, stable, smooth surface of high bearing strength on which to install the composite liner. The final sub-grade shall be rolled to provide an even, firm and unyielding foundation sufficient to permit the movement of vehicles without causing rutting or other deleterious effects. The sub-grade shall have no sudden, sharp or abrupt changes in grade and shall be free from areas excessively softened by high water content.
Passive landfill gas depressurisation layer	The subsurface landfill gas drainage system will be designed to: • Prevent the pressurisation of the liner system from below causing blow-outs do not occur. • Direct landfill gas from Cell 1 towards a bio-window landfill gas treatment system • Gas collection and extraction infrastructure is required to be installed below the leachate barrier of the 'piggyback' to collect and vent LFG. The landfill gas drainage system shall comprise of the following elements: • A geocomposite high density polyethylene (HDPE) panel drain comprising of a layer of filter geotextile thermally bonded to the panel drain • The panel drain shall be surrounded by a clean drainage aggregate layer of at least 400mm wide by at least 300mm deep with a hydraulic conductivity of greater than 1 x 10^{-4} m/s. • A separation geotextile shall be placed around the gravel drainage aggregate to prevent intrusion of fines. The passive gas depressurisation layer shall ventilate to the atmosphere.

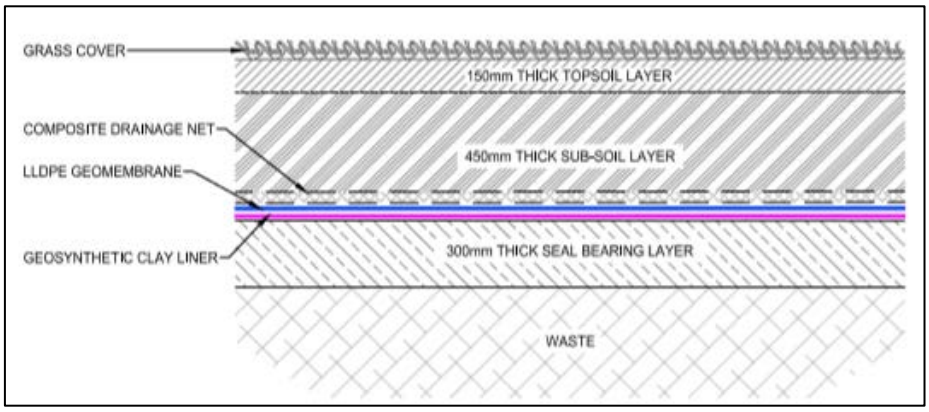


Figure 6: Capping Design

9 Landfill Gas Management

9.1 Landfill Gas Management System

Landfill gas management measures will comprise a passive landfill gas depressurisation system, which will discharge LFG via designated ventilation points.

9.1.1 Landfill Gas Drainage System

The subsurface landfill gas drainage system has been designed to prevent the pressurisation of the liner system from below to ensure blow-outs do not occur.

The landfill gas drainage system shall comprise the following elements:

- A geo-composite high density polyethylene (HDPE) panel drain with a layer of filter geotextile thermally bonded to the panel drain
- The panel drain will be surrounded by a clean drainage aggregate layer of at least 300mm wide by at least 300mm deep with a hydraulic conductivity of greater than 1 x 10^{-4} m/s.
- A separation geotextile will be placed around the gravel drainage aggregate to prevent intrusion of fines. The passive gas depressurisation layer will ventilate to a gas ventilation system.

10 Surface Water Management

10.1 Site Description

The surface water management strategy has been developed to ease construction of future development at the site.

10.2 Characterisation of Site Water

Three different types of surface water will be encountered at the site:

1. **'Dirty' water** - which is defined by any runoff that would originate or pass through operational areas (but not coming into direct contact with wastes), and runoff from rehabilitation areas such as external landfill batters. The dirty water system will also pick up toe drain water seeping down the landfill batter above the liner. Dirty water generally has a sediment load, but is free from other contaminants;

This type of runoff will be managed as discussed in this section using erosion and sediment controls. Dirty runoff requires erosion and sediment control type treatments prior to discharge off-site.

2. **'Clean' water** - which simply defines runoff from existing vegetated areas which are undisturbed;

Typically, this type of runoff is diverted around the disturbance area preventing it from becoming 'dirty' and therefore does not require any treatment..

3. **Leachate** - Rainfall that would directly fall onto dedicated waste cells is considered as 'leachate' and is managed separately to the surface water as it requires further treatment.

Please see the relevant section of the report for more information on leachate management.

10.3 Erosion and Sediment Control

All runoff from disturbed areas or operational areas where water may become 'dirty', needs to be managed appropriately to avoid any uncontrolled discharge and potentially pollute the downstream environment. Conventionally surface water management includes three aspects being erosion controls such as revegetation, surface drains to direct runoff, and sediment controls – typically a Sediment Basin where water is captured and treated prior to discharge.

The sediment dam sizing component of this surface water management investigation was undertaken using the requirements laid out in the IECA *'Best Practice Erosion and Sediment Control'* (2008) guidelines, which require containment of a 5 day 90th percentile rainfall event (or equivalent).

SLR proposes the following general arrangement to manage runoff at the site:

- All clean water runoff will be diverted by clean water diversion drains away from the stormwater system. Two clean water diversion drains are proposed:
    - Along the top of the southern cut batter to prevent water running-onto the batter and exacerbating erosion
    - A drain located between the landfill cell and leachate pond, to convey clean water from a catchment to the south past the landfill
- Progressive revegetation of batters during earthworks to limit erosion.
    - All batters will be hydro-mulched as soon as practicable following formation to promote vegetation growth and help reduce erosion risks.
    - In the case of the north east batter (west of the proposed leachate pond) is located close to the site boundary and the topography makes it impractical to drain this area to a sediment basin. To ensure an effective vegetative cover is provided in this area as soon as possible, the batters should be hydro-mulched progressively and at least very 5m in height as the landform is built up. Sediment fencing downstream of this batter will be implemented to provide sediment control.
- Surface water runoff from the fully capped but still disturbed (not fully revegetated) Cell is managed by three contour banks. These contour banks will have a 1.25% longitudinal grade to carry runoff from the Cell down to surface drains at the toe of batter in a controlled manner. The spacing between benches is approximately 40m, which is within the maximum spacings for erosion control on disturbed slopes recommended in the IECA guideline.
- Toe drains at the base of batters will convey potentially sediment-laden runoff to the sediment basin located to the north-west of the landfill cell
- The sediment basin. This basin should be constructed prior to commencing stripping and bulk earthworks for the landfill cell
- Sediment fencing should be placed downstream of the sediment basin site prior to commencing construction of the sediment basin

The proposed sediment dam size was calculated using the IECA guideline requirements (and engineering judgement to best replicate Papua New Guinea storm intensities) and considered the Cell being fully capped but still disturbed (not fully revegetated). This investigation found that the proposed sediment dam should have at least 3.17ML of capacity to adequately manage runoff during a 5 day 90th percentile rainfall event.

10.4 Sediment Dam Maintenance and Operation

The storage capacity of the proposed sediment dam, which is made up of the 'settling zone' and the 'sediment storage zone', will need to be actively managed in order to comply with the Blue Book requirements. The following operations and maintenance actions will be required to ensure compliance with these requirements:

- The dam must be dewatered, within 5 days following rainfall, to ensure the available storage capacity is equal to the 'settling zone' volume; and
- The dam must be desilted when the storage capacity is reduced by the 'sediment storage zone' volume. How often this occurs is subject to the amount of sediment being delivered into the dam.

It is recommended that the following actions be undertaken to assist in the operation and maintenance of the dam:

- Determine the minimum dewatering pump rate to comply with the Blue Book requirements;
- Install depth markers (volume-stage) to not only indicate the level the dam needs to be drawn down to but also when the sediment storage zone is reached; and
- Regular inspections of the dam batters and overflow should be undertaken, especially following heavy rainfall and overflow events, to monitor for signs of erosion and undertake additional protection works, where required.

11 Conceptual Design Drawings

The conceptual design drawings included within **Appendix A** are to be considered alongside this report, the drawings are summarised in **Table 13**.

Table 13: List of Design Drawings

DWG No.	Drawing Name
620.12961.C01	Locality Plan and Schedule of Drawings
620.12961.C02	Existing Site Features and Survey
620.12961.C03	General arrangement plan - excavation
620.12961.C04	General arrangement plan - cap
620.12961.C05	Typical cross sections
620.12961.C06	General arrangement plan – Excavation & Typical Sections Option 2
620.12961.C07	General arrangement plan – Excavation & Typical Sections Option 3
620.12961.C08	Concept Engineered Basal Design - Scenario 1 and Scenario 2 Typical Details
620.12961.C09	Concept Leachate Collection System Overview
620.12961.C10	Concept Leachate Collection and Extraction System Typical Details - Scenario 1
620.12961.C11	Concept Leachate Collection and Extraction System Typical Details - Scenario 2
620.12961.C12	Concept Landfill Capping Design Geometry - Scenario 1
620.12961.C13	Concept Leachate Storage Pond Design - Details
620.12961.C14	Concept Landfill Gas Overview and Gas Venting Details
620.12961.C15	Concept Stormwater management Overview – Stage 1
620.12961.C16	Concept Stormwater management Overview – Stage 2
620.12961.C17	Concept stormwater management - Typical Details
620.12961.C18	Access Track overview and Typical Details
620.12961.C19	Concept Groundwater Drainage Overview and Detail

APPENDIX A

Concept Design Drawings

APPENDIX B

Concept Leachate Generation Modelling

1 HELP MODELLING

1.1 Modelling Parameters

In order to assess quantities of leachate likely to be generated from the construction and subsequent filling of the Cell 1 landfill footprint, a leachate generation model has been developed.

The leachate generation modelling was undertaken with the computer program HELP 3.95 D (Klaus Berger, 1998), which involves input of:

- Climatic data (including rainfall, runoff area and evapotranspiration);
- Anticipated thickness/depth and type of waste in the Cell 1 waste mass;
- Information on materials likely to be used in the final capping of Cell 1 (e.g. soil type, permeability, porosity); and
- Waste mass thickness and type; and
- Consideration of leachate disposal (e.g. re-circulation, removal for off-site disposal).

Leachate generation modelling was conducted on a monthly basis over a 50-year period where the landfill is progressively filled at a constant rate in a period of approximately 30 years.

1.2 Climate Data

Climate data for the model was obtained from SILO (Scientific Information for Land Owners) which contains a database of historical climate records for Australia, hosted by the Science Delivery Division of the Department of Science, Information Technology and Innovation. SILO contains Australian climate data from 1889 to the present date of this assessment. SILO datasets are constructed from observational records provided by the Bureau of Meteorology. SILO was utilized to process the raw data, which may contain missing values, to derive a dataset for the Site which is both spatially and temporally complete.

SILO data set of over 50 years (between 1966 to 2017) was obtained was obtained for the Townsville Aero (Station 32040), maximum and minimum temperature, pan evaporation, vapor pressure, and relative humidity.

1.2.1 Evaporative zone depth

The evaporative zone depth is the maximum depth from which water may be removed by evapotranspiration. The value specified influences the storage of water near the surface and therefore directly affects the computations for evapotranspiration and runoff. Where surface vegetation is present, the evaporative depth should at least equal the expected average depth of root penetration. The depth specified should be characteristic of the maximum depth to which the moisture changes near the surface due to drying over the course of a year, typically occurring during peak evaporative demand or when peak quantity of vegetation is present. It is assumed that the evaporative zone depth for the purpose of this assessment is 30 cm.

1.2.2 Maximum leaf area index

Leaf area index (LAI) is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. The LAI for this assessment is 0.0 (no vegetative cover, operational area), 1.0 (poor stand of grass, intermediate cover) and 3.5 (good stand of grass, final cover).

1.2.3 Growing Season

The start of the growing season is based on mean daily temperature and plant species. Typically, the start of the growing season for grasses is the Julian date (day of the year) when the normal mean daily temperature rises above 10 to 13 degrees Celcius. For the purpose of this assessment, the growing season is considered to be year-round.

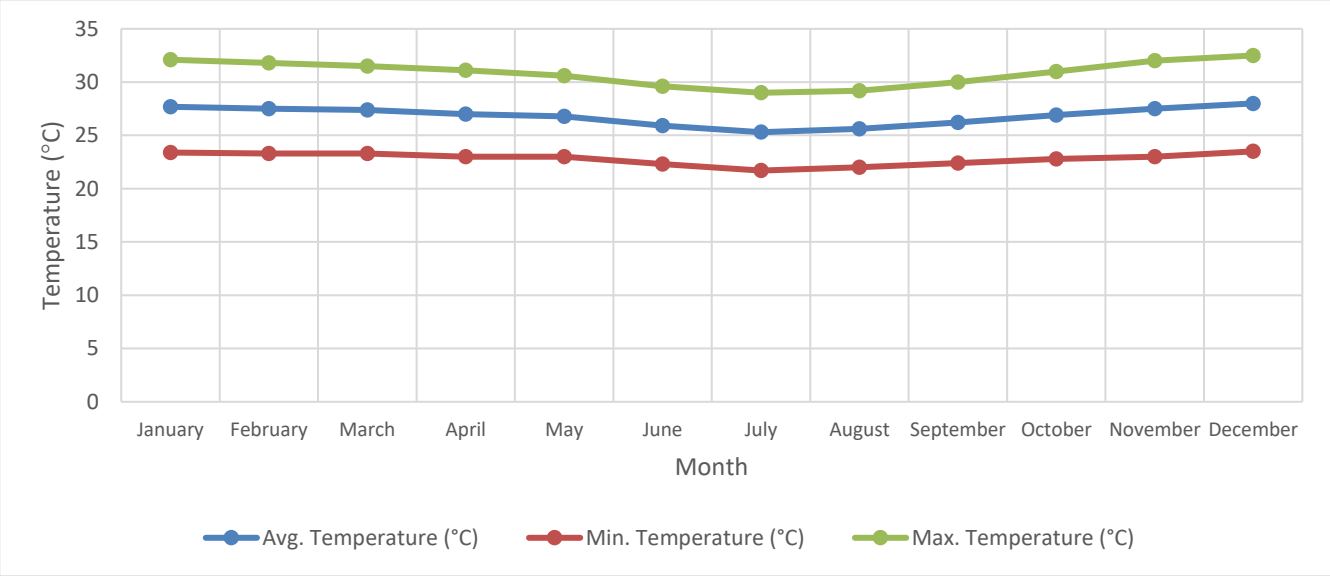


Figure 7: Temperature Data – Port Moresby

1.2.4 Other Climate Data Inputs

The average yearly average wind speed is 12.5 km/hr and the average relative humidity for the area is described within Table 14:

Table 14: Average relative humidity

Quarter	Average Relative Humidity (%)
First Quarter	77
Second Quarter	81
Third Quarter	74
Fourth Quarter	74

1.3 Capping Layer Inputs

In accordance with the *Technical Manual*, the following cover components shall be constructed as described below.

- Daily Cover: Throughout the landfilling operations, the allowable daily-cover footprint area is assumed to be 625m^2.
- Intermediate Cover: An intermediate cover is assumed to be constructed as soon as possible, post filling. The intermediate cover will be in place up to 24 months prior to construction of the final landfill cover.
- Final Cover: The final landfill cap will be constructed within 24 months, post landfilling.

The infiltration percentage varies with the characteristics of the cell cap or covering. Where areas have been temporarily capped, an infiltration rate of 25 – 30% is typically attained and infiltration rates in restored (final capping areas) are typically in the range of 2 – 10% (Environmental Protection Agency, 2000). The following cover types, thicknesses, areas and timeframes are assumed for the purpose of leachate generation modelling as described below. The daily cover properties are detailed within Table 15.

Table 15: HELP model Inputs – Daily Cover

Layer	Layer Type	Soil Texture Number	Depth (m)	Pore Volume	Field Capacity	Wilting Point	Hydraulic Conductivity (m/s)
Daily Cover	Vertical percolation layer	4 - Sandy Gravel	0.15	0.45	0.19	0.085	1 x 10^{-4}
Waste	Vertical percolation layer	18 - Municipal Waste	19.5	0.671	0.292	0.077	1.0 x 10^{-5}

Where cells cannot be fully rehabilitated due to the layout of the site and the sequencing of filling, intermediate (temporary) capping must be installed. For the purposes of this assessment, a 300mm intermediate capping layer with a grassed topsoil cover is assumed, as detailed within Table 16.

Table 16: HELP model Inputs – Intermediate Cover

Layer	Layer Type	Soil Texture Number	Depth (m)	Pore Volume	Field Capacity	Wilting Point	Hydraulic Conductivity (m/s)
Topsoil	Vertical percolation layer	4 – Sandy gravel	0.05	0.437	0.105	0.047	1 x 10^{-5}
Intermediate Layer	Barrier layer	28 – Silty Clay (Moderately Compacted)	0.3	0.452	0.411	0.311	1.0 x 10^{-7}
Waste	Vertical percolation layer	18 – Municipal Waste	19.5	0.671	0.292	0.077	1 x 10^{-5}

1.3.1 Runoff curve number

HELP model computed runoff curve number based on surface slope, slope length, soil texture of the top layer in the landfill profile, and vegetation has been utilized for this model as described within Table 17. The slope length of the final cover is assumed to be reduced due to the installation of regularly spaced batter slope drains.

Table 17: HELP Computed Runoff curve number

Scenario	Slope (%)	Slope Length (m)	US Soil Texture	Vegetation	Runoff Curve Number
Daily Cover	2	30	1 – Sandy Gravel	Bare Soil	74.6
Intermediate Cover	5	50	9 – Silt loam	Poor Grass Cover	87.9

1.4 HELP Model Assumptions

For the purpose of understanding worst-case leachate generation for pond sizing purposes, it is assumed that one-third of Stage 1 is filled (3,600m^2) and comprises an intermediate-cover only (final capping works are yet to commence) and an active working area of 625m^2 (25m x 25m). Other areas of the landfill stages not yet filled will incorporate adequate stormwater diversion and will not contribute to leachate generation

1.5 Results

Leachate generation for daily and intermediate cover soils, modelled over a one-hectare area is detailed within Table 18.

Table 18: Average annual leachate generation (mm/ha/year) per cover type

Item	mm/hectare	Cubic metres/hectare (m^3/hectare)	Daily Cover (%)	Intermediate Cover (%)
Precipitation	1761.6	17,615		
Runoff	906	9064.2	8.21	51.45
Actual Evapotranspiration	287.2	2872.3	24.5	16.31
Leakage	**570.5 mm/hectare**	**5705.8 m^3/hectare**	**59.4%**	**32.4%**

1.5.1 Leachate Generation Modelling

The maximum potential area for the active generation of leachate is when the previous landfill cells adjacent to the current cell being filled, does not include a final capping system.

As described in Section 1.2, a monthly rainfall and evaporation data set of greater than 50 years (from 1966 to 2017) was used for the assessment. The 90th percentile annual rainfall based upon the climate data is 1773 mm. Monthly rainfall for the year 1981 (1761mm of rainfall) for Townsville aero (Site number 032040) is used for the purposes of this assessment, to determine worst-case leachate generation.

Table 19: Leachate Generation per month

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Inputs													
Decile 9 monthly rainfall (mm) for years 1966 to 2017	744.8	320.8	18	97.4	118.2	17.6	16.4	27.6	1.4	5.4	333.4	60.6	1761.6
Intermediate Cover Leachate production (90th percentile) (m^3)	1377.0	870.0	54.6	261.8	158.0	77.4	66.9	119.7	0.0	0.0	408.9	236.9	3631.1
Daily Cover Leachate production (90th percentile) (m^3)	81.4	95.7	113.1	86.6	65.7	63.0	70.1	88.5	91.8	114.3	107.6	128.6	1106.3
Total Leachate production (90th percentile) (m^3)	1458.4	965.7	167.7	348.3	223.6	140.4	136.9	208.2	91.8	114.3	516.5	365.6	4737.4

APPENDIX C

Concept Landfill Gas Generation Modelling

2 Landfill Gas Generation and Recovery Estimates

Limited modelling has been undertaken using the USEPA's *Landfill Gas Emissions Model Version 3.02* (LandGEM) to estimate the LFG generation at the landfill. LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in MSW landfills.

The LFG modelling takes into account the waste quantities and composition to provide an estimate of LFG generation. The LFG generation modelling will provide a preliminary indication to determine if active LFG extraction or passive measures would be suitable at the site.

2.1 Input Parameters

LandGEM relies on several model parameters to estimate landfill emissions.

- Methane generation rate (k);
- Potential methane generation capacity (L_o);
- NMOC concentration, and
- Methane content.

The Methane Generation Rate, *k*, determines the rate of methane generation for the mass of waste in the landfill. The higher the value of k, the faster the methane generation rate increases and then decays over time. The value of k is primarily a function of four factors:

- Moisture content of the waste mass;
- Availability of the nutrients for microorganisms that break down the waste to form methane and carbon dioxide;
- pH of the waste mass; and
- Temperature of the waste mass.

The Potential Methane Generation Capacity, L_o, depends only on the type and composition of waste placed in the landfill. The higher the cellulose content of the waste, the higher the value of L_o. The default L_o values used by LandGEM are representative of MSW. The L_o value, as it is used in the first-order decomposition rate equation, is measured in metric units of cubic meters per megagram.

The non-methane organic compound (NMOC) concentration in landfill gas is a function of the types of waste in the landfill and the extent of the reactions that produce various compounds from the anaerobic decomposition of waste.

For the purpose of this assessment, the following input parameters were used:

Table 20: LandGEM Input Parameters

Parameter	Input	Comment
Landfill Open and Closure Year	2020 – 2035 (15 years)	Opening and closure years were selected as an estimate and should be further refined within the detailed design phase.

Parameter	Input	Comment
Waste composition (%)	Oil and Gas wastes (10%), Grease trap waste (18%), WWTP sludge (9%), drilling muds (9%), fly ash and residuals (45%), hazardous wastes (9%)	Based upon summary of waste types provided to SLR (TWM, 2019)
Waste Disposal Rate per annum (t)	12,000	Based upon TWM estimates
Total landfill airspace (m^3)	145,000	Preliminary estimate
Methane generation rate (k)	0.05	Standard generation rate assumed for this conceptual generation assessment
Estimated methane generation capacity (L_o)	50 m^3/t	Standard generation rate assumed for this conceptual generation assessment
NMOC concentration	4,000 ppmv	Standard landGEM NMOC concentration
Methane content (%)	50%	Standard rate assumed for this conceptual generation assessment

2.2 Collection Efficiency

The LFG generation estimate produced by LandGEM is multiplied by a collection efficiency to estimate the volume of LFG that can be captured for flaring or use in an LFG utilisation project. Considerable uncertainty exists regarding collection efficiencies achieved at landfills because the total LFG generated is always estimated. Reported collection efficiencies at landfills typically range from 50 to 95 percent, with an average of 75 percent most commonly assumed. For the purpose of this assessment, 75 percent of the LFG generated is assumed to be captured within the LFG extraction system.

2.3 LFG Generation Results

Landfill gas generation is estimated to increase until the estimated closure year (2035) of the landfill reaching a maximum of 75.6 m^3/hour, one year after the landfill closure.

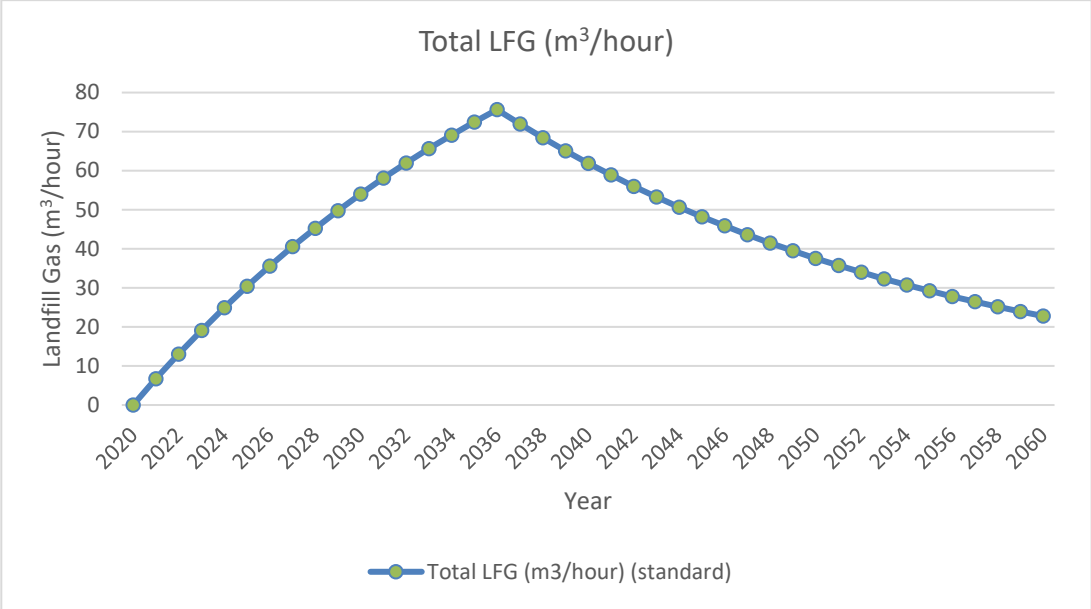


Figure 8: Landfill Gas generation rate

To refine the prediction of estimated LFG generation and capture efficiency, the model should be revised when greater detail is available regarding the waste organic content, future disposal rate, site closure date and cell expansion schedules.

2.4 Limitations of the modelling

Factors that can affect the accuracy of LFG recovery projections include:

Inaccurate assumptions - Inaccurate assumptions about variables such as organic content, future disposal rates, site closure dates, wellfield buildout, expansion schedules or collection efficiencies can result in large errors in predicting future recovery. A 'pump test' is typically conducted to confirm the available LFG volume and quality at the landfill, along with other physical information such as buried waste characteristics and leachate levels within the waste mass.

Limited or poor quality disposal data - Significant model error can be introduced if good disposal data are not available.

Poor-quality flow data or inaccurate estimates of collection efficiency used for model calibration -Model calibration requires both accurate estimates of collection efficiency and good quality flow data that are representative of long-term average recovery.

Atypical waste composition - Waste composition data are often not available to determine if unusual waste composition is a cause of model inaccuracy..

Limitations because of the structure of LandGEM - For example, LandGEM cannot accommodate changes in k or L0 values in the same model run. Changing landfill conditions that cannot be modeled as a result of this limitation include the following:

- Application of liquids to existing waste
- Variations in waste composition over time
- Installation of a geomembrane cover

APPENDIX D

Concept Slope Stability Modelling

CONCEPT STABILITY ANALYSIS

IWMF-Integrated Waste Management Facility, Roku

Prepared for:

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Total Waste Management Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.12961-R01-v1.0	13 May 2019	Anthony Rayner	Chris Meikle	Chris Meikle

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) was engaged by Total Waste Management Pty Ltd (TWM) to undertake design services for the proposed integrated waste management facility (IWMF) at Roku, approximately 8 km north west of Port Moresby in Papua New Guinea (PNG). This report presents the results of a stability assessment carried out by SLR for concept design options.

The proposed IWMF development, comprises the following:

- Composting Plant.
- Incineration Plant.
- Waste Oil Processing.
- Fixation Plant.
- Waste Water Treatment Plant.
- Quarrying.
- Engineered Landfill.
- Hazard Waste Storage.

1.2 Report Context

SLR is not aware of a set guidance requirement in PNG for undertaking stability assessments for solid waste facilities, therefore this report has been prepared in general accordance with the ANCOLD and US EPA guidelines (refer references) and UK Environment Agency's Environmental Permitting (England and Wales) Regulations Stability Risk Assessment template, and similar stability assessments of relevant projects.

This document describes the manner in which the assessment for the proposed IWMF has been carried out and presents the overall findings of the work and will be used to inform the progression of concept design options. Concept options proposed are included in **Appendix A**.

Information provided by TWM to SLR include:

- ACEM Geotechniques Baseline Environmental and Geotechnical Study for proposed integrated waste management plant at Roku, October 2018
- Recommendations after soil testing at Quarry by "Soil Engineers" of material suitability, June 2018
- Design earthquake ground acceleration for 1:500 AEP and 1:2500 AEP case
- Site photographs taken at old quarry site

It should be noted SLR have not visited the site, nor can we confirm that the information provided to us by TWM is correct, or is a true reflection of the actual site conditions. The geotechnical model presented herein, for use in this stability modelling and assessment is based on SLR's interpretation of the geotechnical information provided in relation to the SLR concept design sketches included in **Appendix A**.

1.3 Location and Topography

The proposed development site is located along the Napa Napa Road opposite the Avenell Engineering Systems Compound as shown in **Figure 1**.

The site appears to transect a low ridge and slopes down from the south east to the north west as shown by the elevations noted on the concept plans. The land around the site falls both to the east and west to low valleys running down towards the Halifax Harbour and ocean respectively. Several dry shallow valleys lead down form the ridge to the south west of site. We understand the site has a number of cleared areas as shown on **Figure 1**, with an existing office and several dwellings. A former timber yard operated at one location and there is an abandoned quarry just outside the TWM boundary with a small low height section of the quarry inside the boundary.



Figure 1 Approximate site extents and features

1.4 Previous Investigation and Assessment

A baseline Environmental and Preliminary Geotechnical Investigation report completed by ACEM Geotechniques in October 2018 was provided by TWM. A summary of the relevant pertinent information from the investigation is included below:

- Fieldwork consisted of a topographic survey, drilling of two cored boreholes to 8.0 m and excavation of six test pits to a maximum depth of 1.1 m, with associated in-situ and laboratory testing

- The soil and rock profile encountered generally consisted of:
    - Localised shallow fill, overlying;
    - Localised residual soil, consisting of clayey gravel and gravelly clay, generally stiff, overlying;
    - Bedrock, consisting of siltstone, variably weathered ranging from extremely weathered to moderately weathered;
    - Deep weathering was apparent from the borehole drilling and extremely weathered material extended to depths exceeding the extent of the investigation;
    - Rock strengths were estimated from Point Load and Schmidt Hammer testing of rock samples and ranged from very low to medium strength.

It is noted by ACEM that the rock material in the upper 8.0 m is characterised by *"bands of completely fractured and fragment(ed) rock interspersed with bands of harder rock. The rock is a siltstone of the Port Moresby Beds and varies from Qa=0.5MPa to Qa=5MPa, with much of the rock being in the range 1-2 MPa. This random profile of harder and softer rock is common to most areas of faulted Port Moresby Beds."*

Rock descriptions included in the report vary from Siltstone (logs) and Tuff (Table 4) and geology noted describes both Paga and Port Moresby Beds. Review of site photography, regional geology and core photographs suggest the rock at the site, may have undergone low grade metamorphism and may be characterised by a distinct fabric. In this case, argillite may be a more appropriate description as described under the 1;250,000 regional geological series maps. Little or no structural information regarding bedding (foliation) and discontinuity dip or surface condition is described.

In such cases this is likely to affect the rock strength and stability of slopes, the lack of detailed information in this instance is likely to result in a conservative approach to rock mass strength parameters being adopted. Furthermore, it should be noted where the rock, is distinctly weathered (L-M strength) or stronger, slope failure is expected to be influenced, if not solely controlled by kinematic (structurally controlled) failure. It is recommended these features are determined for consideration in the detailed stability analysis.

1.5 Geology

1.5.1 Local Geology

The 1:250,000 Geological Sheet for Port Moresby -Kalo-Aroa, indicates that the rock in the area is classified as Tep (Paga Beds). These deposits are described as follows;

- Tep – Partly calcareous, siliceous argillite and shale, calcilutite, chert, minor calcarenite and dolomite, overlain in places by;
- Qa – Quaternary sediments

1.5.2 Structural Geology

The 1:250,000 geological map series indicates a series of south east to north west striking faults, located west of site. The regional dip of the Paga beds is indicated to dip steeply to the west north west. Photographs of the old quarry face provided, as well as rock descriptions in the ACEM report suggest the rock may have undergone brittle deformation associated with regional faulting and hence the rock mass may be characterised by a highly fractured rock mass in places. Observations of available information would agree with this interpretation.

2 Conceptual Site Model

2.1 Adopted Geological Model

The following geological model has been adopted based on interpretation of the geotechnical information at hand as well as concept sketches provided.

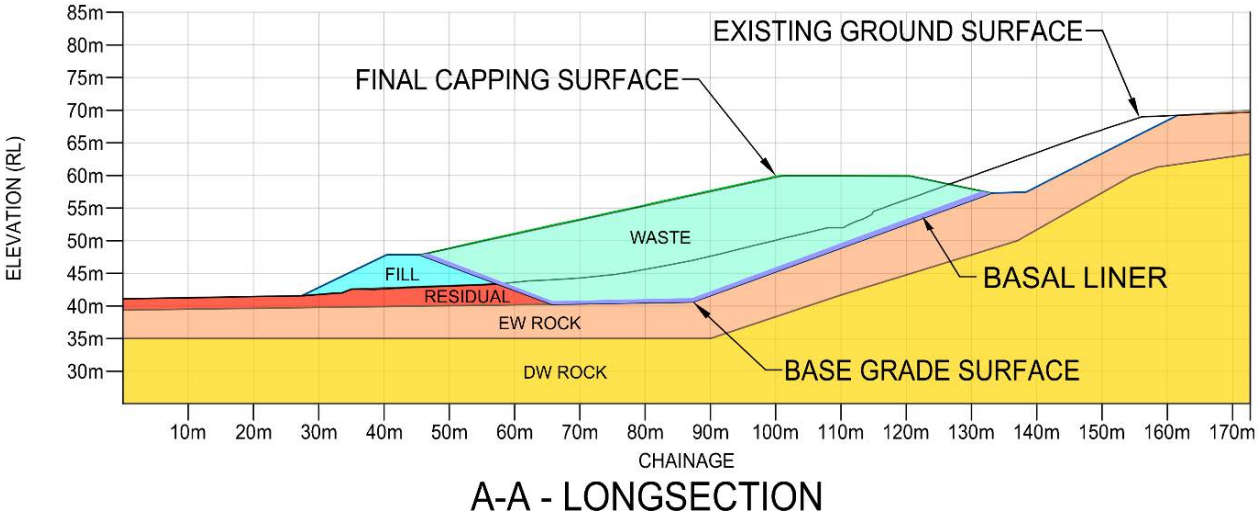


Figure 2 Conceptual Geological Site Model

Based on this information the geological model adopted consists of:

- Isolated residual soil (clayey gravel), <2 m thick overlying;
- Extremely weathered rock (meta-siltstone / argillite) exposed across site, very low strength, with intact UCS estimated at 1 MPa, up to 8.0 - 10.0 m thick overlying;
- Distinctly weathered rock (meta-siltstone / argillite) of low to medium strength, intact UCS estimated at 2.5 MPa
- Embankment fill is assumed to be well compacted, granular material with an internal angle of friction of minimum 36^{o}
- Preliminary waste fill and liner properties are used based on similar recent experience and recent research literature (refer references)

2.2 Rock Mass

The site is expected to be underlain predominantly by weathered bedrock, consisting of low-grade metamorphosed siltstone (argillite) of the Paga Beds. Weathering is expected to be variable, with localised zones of residual soil overlying extremely weathered, very low strength argillite.

Observations from rock exposed in the old quarry face suggest the upper 8.0 – 10.0 m is characterised by heavily fractured, blocky and locally disintegrated rock mass with varying degree of weathering and infill along discontinuities. Rock mass parameters for the upper extremely weathered rock have been estimated using the Hoek & Brown (2018) failure criterion to provide equivalent Mohr Coulomb parameters.

The Generalized Hoek-Brown criterion is non-linear and relates the major and minor effective principal stresses (sigma1 and sigma3) according to the following equation:

$$\sigma_1' = \sigma_3' + \sigma_{ci}\left(m_b \frac{\sigma_3'}{\sigma_{ci}} + s\right)^a$$

where:

- Sigma 1 and Sigma 3 are the axial (major) and confining (minor) effective principal stresses respectively
- Sigma ci is the uniaxial compressive strength (UCS) of the intact rock material (estimated from field descriptions, Point Load and Schmidt Hammer tests on rock samples)
- mb is a reduced value (for the rock mass) of the material constant mi (for the intact rock)
- s and a are constants which depend upon the characteristics of the rock mass

In most cases it is practically impossible to carry out triaxial tests on rock masses at a scale which is necessary to obtain direct values of the parameters in the Generalized Hoek-Brown equation. Therefore, some practical means of estimating the material constants mb, s and a is required. According to the latest research, the parameters of the Generalized Hoek-Brown criterion (Hoek & Brown, 2018), are given by the following equations:

$$m_b = m_i \exp\left(\frac{GSI - 100}{28 - 14D}\right)$$

$$s = \exp\left(\frac{GSI - 100}{9 - 3D}\right)$$

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{-GSI/15} - e^{-20/3}\right)$$

where:

- **GSI** (the Geological Strength Index) relates the failure criterion to geological observations in the field, taken as **20**, which represents a disintegrated, poorly interlocking rock mass with poor surface condition (clay filled)
- **mi** is a material constant for the intact rock, taken as **13** for argillite / low grade metamorphic rocks
- the parameter **D** is a "disturbance factor" which depends upon the degree of disturbance to which the rock mass has been subjected by blast damage and/or stress relaxation. It varies from 0 for undisturbed in situ rock masses to 1 for very disturbed rock masses. D was taken as **0**.

The deeper lying distinctly weathered Paga beds of low to medium strength, appear distinctly stratified or weakly metamorphosed with a distinct pervasive fabric, which is locally folded. Failure within the distinctly weathered material is expected to be structurally controlled, however a conservative fit to the Hoek Brown failure criterion has been adopted to provide Mohr Coulomb parameters at this stage of the analysis. As discussed in later sections a kinematic analysis is recommended for slopes within distinctly weathered, more competent rock where failure is expected to be structurally controlled.

The extremely weathered rock mass strength is expected to control global stability within the upper 8.0 - 10.0 m. Additional detailed geotechnical information is recommended to refine the material parameters and to increase confidence in the current model.

The Hoek Brown classification outputs are included in **Appendix C**.

2.3 Landfill Design

The conceptual site model has been developed from information gathered from SLR's interpretation of the preliminary geotechnical report, site photographs, regional geology and the concept sketches provided. At current, no specific liner or capping details have been provided.

We understand the basal liner system under consideration may include a combination of compacted clay and HDPE geomembrane. A nominal thickness of the liner system of 1.0 m has been adopted.

We understand a leachate collection system will be incorporated which should limit the leachate level to 0.3m above the base of the lining system. No details have been provided of the system at the time of the analysis and hence a worst-case scenario of 2.0 m above the base of the lining system has been adopted. Additionally, we understand the landfill will have a groundwater drainage cell beneath the lining system ensuring the maximum groundwater level beneath the cell will be approximately 1.2 m below the base of the liner.

2.4 Waste Mass

For the purpose of the model, the waste slopes are proposed/modelled at a gradient of approximately 1V:4.7H (12^{o}), to maximum restoration height. The potential maximum height of the waste slope will be approximately 20 m. As stated in Section **2.3**, leachate levels on the landfill base (and waste mass) are expected to be maintained as low as reasonably practicable through regular extraction.

2.5 Capping and Restoration

To minimise the long term environmental and public health risks associated with the landfill, capping and restoration will be undertaken at the Site. Details on the capping and restoration for the site have not yet been confirmed and will be addressed the detailed design stage.

3 Components Assessment

The principal components of the conceptual stability site model have been considered and the various elements of that component have been addressed regarding stability.

The principal components considered are:

- The basal and side slope subgrade;
- The toe embankments;
- The basal and side slope lining system;
- The waste fill.

The principal components relating to stability and integrity of the proposed development have been subject to review to determine the need to undertake further detailed geotechnical analyses.

3.1 Basal Subgrade

3.1.1 Deformability

Site investigation works, are documented in the ACEM, October 2018 geotechnical investigation report. Limited Standard penetration tests (SPT) SPT's were undertaken within boreholes as well as Schmidt Hammer and Point Load testing on weathered rock samples. Gravel and shallow rock appear to have resulted in shallow refusal of test pits and prevented completion of DCPs and SPT's at several locations.

Schmidt Hammer and Point Load Testing was completed on a limited number of weathered bedrock (meta-siltstone / argillite) core samples. The number of blows / point load Index $Is_{(50)}$ can be utilised for the correlation of strength of rock however due to the inherent variability of the rock mass, these results provide a wide range of values. Furthermore, due to a lack of Unconfined Compressive Strength (UCS) and/or Triaxial strength testing for correlation, relatively conservative material strength parameters have been adopted.

3.1.2 Cavities in the subgrade

Quarrying is known to have occurred in the vicinity of the proposed landfill footprint. Supervision and quality control procedures during construction and subsequent placement and compaction of the basal subgrade should be undertaken to address the risk of near surface voids being present.

3.2 Side Slope Subgrade

The upper side slopes are to be cut into the weathered bedrock at batter angles between 1V:2H and 1V:3H depending on the adopted concept option. The lower side slope which forms part of the basal subgrade is to be a combination of cut and fill at 1V:2H depending on location (i.e. cut/fill at old quarry face). The side slope stability analysis will be undertaken in terms of drained conditions. Further discussion on cut and fill considerations at the old quarry face are included in section **6.1.**

Where filling is conducted against the existing side slopes, fill material should comprise well compacted, durable (98% standard compaction as a minimum) granular fill to limit the risk of settlement beneath the waste mass with a drained friction angle of minimum 36^{o} being adopted for design purposes.

3.2.1 Deformability

As per the basal subgrade (section **3.1**) the side slope subgrade comprises in-situ, extremely weathered to distinctly weathered meta-siltstone/argillite and is considered comparatively incompressible in relation to the imposed stress from the waste mass. Material parameters for the rock mass are discussed in section **2.2**.

3.2.2 Groundwater

The underlying ground water level from the initial investigation is at an approximate level around 8.0 m below ground level. No superficial or perched groundwater were identified during the drilling works, or seepage noted in the trial pits site investigation works; however, further monitoring and investigation including results from existing standpipe monitoring and future ground water investigations is required to better define the ground water level.

3.3 Fill Embankments

The toe embankments are to be formed over the existing ground surface at batter angles of 1V:2H and appear to be up to a maximum height of 6.0 m based on the concept sketches. The toe embankment stability analysis will be undertaken in terms of drained conditions.

For the purpose of the stability analysis embankment fill is assumed to comprise well compacted, durable (98% standard compaction as a minimum) granular fill with a drained friction angle of minimum 36^{o}.

3.4 Basal & Side Slope Lining System

We understand the side slope liner will be placed to the full height of the side slope subgrade. A nominal liner system has been adopted for analysis, which consists of 1.0 m of compacted clay with an incorporated HDPE membrane. Shear strength parameters adopted are based on relevant recent research and manufacturer specifications and are outlined in section **4.2**.

Liner stability is considered as being related to the waste mass stability and examines the influence of the confined side slope lining system on the overall stability of the waste mass.

The aspect of the side slope and basal lining system performance needs to be addressed for the potential build-up of tension within the basal lining geosynthetics and is not included in this scope of works.

3.5 Waste Mass

For the purpose of the model, the final waste slopes have been modelled at a gradient of 1V:4.7H, to a potential maximum height of 20m above the basal sub grade. Waste mass strength parameters have been adopted based on recent research on waste fill shear strength and are outlined in section **4.2.**

3.6 Leachate Collection System

Leachate collection from the base of landfill will be provided however the details of the system have not yet been finalised. Once these details are available an assessment of the leachate system will be undertaken as part of the detailed stability analysis.

4 Slope Stability Modelling

4.1 Modelling Approach & Software

The stability assessment undertaken represents the considered concept scenarios and for the different modelled components of the landfill lifecycle for both confined and unconfined conditions (where appropriate).

Methods used in this Stability Risk Assessment include:

- Limit equilibrium stability analyses for the derivation of factors of safety for the side slope and outer embankment and toe embankment.

The stability analysis program SLOPE/W by GeoStudio has been used to undertake the limit equilibrium using the Bishop simplified and Morgenstern-Price for circular and non-circular forms of analysis for the various components and life stages of the facility.

Jones and Dixon (2003) states 'circular surfaces are seldom appropriate in the study of landfills, with recorded failures for lined landfill sites defined by Koerner and Soong, (1998b), as translational. The limit equilibrium analyses for the waste mass modelling has therefore been undertaken using the Janbu corrected, Spencer and Morgenstern-Price non-circular forms of analysis.

4.2 Design Parameters

The following data are required as input for the analyses undertaken for this Stability Risk Assessment:

- Material unit weight.
- Drained and undrained shear strength of soils and waste.

Limited laboratory and in-situ testing on soil samples was undertaken as part of the preliminary geotechnical investigation by ACEM. As there is currently no direct measurement of encountered soil strength properties available, reference has been made to relevant experience from the same or similar materials, with a conservative approach adopted, to be considered a worst-case scenario.

The geotechnical parameters for limit equilibrium analysis include the shear strength and unit weight of each material within the model, plus porewater. Shear strength has largely been defined using the effective shear strength parameters of cohesion, (c'), and the angle of shearing resistance, (ø') based on engineering judgement and similar recent experience and is based on the geotechnical information provided to date.

As described in section **2.2**, rock mass parameters have been estimated using the Hoek Brown criterion, based on engineering judgement of the rock mass, with a conservative approach adopted, to be considered as a worst-case scenario.

In terms of waste strength, conservative values of effective shear strength parameters as derived from a study of geotechnical properties of municipal waste by Van Impe and Bouazza (1996), these values being backed up in later work by Kavazanjian et al (2000) and later confirmed in a research summary by Jotisankasa (2001). The values for c' and ø' adopted throughout the modelling were 1kPa and 25°, respectively.

As discussed in section **2.3** the liner system is yet to be finalised and hence a nominal thickness of 1.0 m has been adopted for concept design. Based on previous experience and relevant recent literature, an interface friction angle of 14^{O} and drained cohesion of 1 kPa have been adopted.

Interface friction test data for similar relevant liner systems, including textured HOPE and GCL may have mean peak friction angle parameters in the order of 18 to 23^{o} together with apparent cohesion up to 30 kPa. Such systems would significantly increase the stability of the liner system. This is further discussed in section **4.5.2.**

Table 1 Material Parameters

Material	Bulk Unit Weight, y (kN/m3)	Effective Cohesion, c' (kPa)	Angle of Shearing Resistance, ø' (o)	Typical Description
Fill	19	0	36	Well compacted granular material
Residual Soil	17	1	28	Gravelly CLAY
XW Rock	18	5	24	Extremely weathered argillite, very low strength
DW Rock	22	20	30	Highly weathered argillite, low to medium strength
Liner	19	1	14	Compacted clay and HDPE
Waste	10	1	25	Municipal solid waste

4.3 Seismic Conditions

SLR are not aware of a set guidance requirement in PNG for assessing seismic conditions for solid waste facilities. ICOLD 'Selecting Seismic Parameters for Large Dams Guidelines', calculates total risk factor based on capacity, height, evacuation requirements and potential downstream damage.

For a low (risk class) category dam, ANCOLD March 2017 'DRAFT - Guidelines for Design of Dams and Appurtenant Structures for Earthquake Table 2.1' recommended deterministic analysis seismic design ground motions for Operating Base Earthquake (OBE), and Safety Evaluation Earthquake (SEE) return periods are 1:475 and 1:1000, respectively.

The PNGS 1001-1982 Earthquake Coding (4.6.2 PNGS 1001 – Fig 3.2 - Seismic Zone) indicates that the IWMF Site is located within Zone 4 with the basic seismic coefficient for the site classified as "**Firm**" by ACEM (2018).

TWM has advised that the peak ground acceleration (PGA) for design consideration of the site are:

- 0.13 for a 500-year earthquake.
- 0.22 for a 2500-year earthquake.

Correlating the "**Firm**" classification from PNGS 1001-1982 with AS1170.421 Structural design actions Part 4: Earthquake actions in Australia, the site is considered to represent a sub-soil class of the site as Class Ce – Shallow Soil. The normalised response spectra for the site sub-soil class indicates an amplification of 1.25 for a period of 0.0s.

Horizontal seismic load coefficients for the pseudo-static seismic return periods based on the amplification factor of 1.25 are as follows:

- OBE 1:500. PGA 0.13g with an amplification of 1.25 relates to a horizontal seismic load coefficient of 0.16.
- 1:2500 AEP. PGA 0.22g with an amplification of 1.25 relates to a horizontal seismic load coefficient of 0.28.

Pseudo-static seismic return periods considered within the analysis were:

- 1:500 – Operating Base Earthquake (OBE).
- 1:2500 AEP – beyond the 1:1000 AEP, Safety Evaluation Earthquake (SEE).

4.4 Factors of Safety

SLR is not aware of any set guidance requirement in PNG for minimum factors of safety (FoS) for solid waste facilities, factors of safety have been established based on internationally accepted guidance and similar stability assessments of projects. The UK Environment Agency document TRI222 states "*Slopes should be designed to obtain factors of safety in the region of 1.3 to 1.5*".

ANCOLD Guidelines on Tailings Dams (2012) indicates recommended minimum factors of safety for tailings dams as 1.0-1.2 for pseudo-static loading conditions. For the limit state equilibrium analyses, a factor of safety of ≥1.5 is considered appropriate when using peak shear strength parameters under static loading. A factor of safety of ≥1.1 under earthquake loading for an operating base earthquake (OBE), and a factor of safety of ≥1.0 for a safety evaluation earthquake (SEE). In this instance the 1:2500 AEP seismic load case is considered, in accordance with TWM recommendations.

For temporary slopes/ conditions where the high-water conditions exist over a short period of time a factor of safety of ≥1.3 is considered appropriate when using peak shear strength parameters under static loading.

4.5 Modelling Results

4.5.1 Basal & Side Slope Analysis

The analysis considered the 1V:2H to 1V:3H benched side slope cut into the weathered bedrock prior to waste mass filling. The inferred normal ground water level is taken as approximately 8.0 m below the exiting ground level with a maximum seasonal high piezometric surface considered between 1.0 – 2.0 m below ground level as a worst-case scenario. Scenarios 1-3 and sections A-A and B-B have been included in the analysis, as shown on the concept sketch plans included in **Appendix A**.

The long-term condition has been addressed, should the placement of waste against the liner be delayed for some reason. As such, conservative peak effective shear strength parameters are adopted for the various components for the side slope. It is unlikely that post peak conditions will develop in the side slope lining system as the waste will buttress the slope in the long term during the phased operational filling.

The summary of the circular and non-circular analysis for the side slope are presented in **Table 2 to Table 4**. The model results for side slopes are presented in **Appendix B**.

Table 2 Summary of Stability Analysis for Scenario 1 Side Slope

Scenario 1	Conditions	Method	Factor of Safety	Comments
A-A Side Slope Global No Seismic Loading	Normal	Drained Non-Circular	1.94 (2.11)	Acceptable FOS > 1.5
A-A Side Slope Global No Seismic Loading	High Water	Drained Non-Circular	1.69 (1.81)	Acceptable FOS > 1.3
A-A Side Slope OBE 1:500 Seismic Loading	Normal	Drained Non-Circular	1.33 (1.42)	Acceptable FOS > 1.1
A-A Side Slope OBE 1:500 Seismic Loading	High Water	Drained Non-Circular	1.18 (1.21)	Acceptable FOS > 1.1
A-A Side Slope 1:2500 Seismic Loading	Normal	Drained Non-Circular	1.07 (1.13)	Acceptable FOS > 1.5
A-A Side Slope 1:2500 Seismic Loading	High Water	Drained Non-Circular	0.98 (0.97)	Marginally acceptable FOS ~ 1.0
B-B Side Slope Lower Batter No Seismic Loading	Normal	Drained Circular	2.03	Acceptable FOS > 1.5
B-B Side Slope Lower Batter No Seismic Loading	High Water	Drained Circular	1.62 (3.16)	Acceptable FOS > 1.3
B-B Side Slope OBE 1:500 Seismic Loading	Normal	Drained Non-Circular	2.79	Acceptable FOS > 1.1
B-B Side Slope OBE 1:500 Seismic Loading	High water	Drained Non-Circular	2.24	Acceptable FOS > 1.1
B-B Side Slope 1:2500 Seismic Loading	Normal	Drained Non-Circular	2.17	Acceptable FOS > 1.0
B-B Side Slope 1:2500 Seismic Loading	High Water	Drained Non-Circular	1.95	Acceptable FOS > 1.0

() denotes long term FoS against top batter failure

Table 3 Summary of Stability Analysis for Scenario 2 Side Slope

Scenario 2	Conditions	Method	Factor of Safety	Comments
A-A Side Slope No Seismic Loading	Normal	Drained Non-Circular	2.54	Acceptable FOS > 1.5
A-A Side Slope No Seismic Loading	High Water	Drained Non-Circular	2.24	Acceptable FOS > 1.3
B-B Side Slope No Seismic Loading	Normal	Drained Circular	3.66	Acceptable FOS > 1.3
B-B Side Slope No Seismic Loading	High Water	Drained Non-Circular	3.29	Acceptable FOS > 1.5

Table 4 Summary of Stability Analysis for Scenario 3 Side Slope

Scenario 3	Conditions	Method	Factor of Safety	Comments
A-A Side Slope No Seismic Loading	Normal	Drained Non-Circular	3.28	Acceptable FOS > 1.5
A-A Side Slope No Seismic Loading	High Water	Drained Non-Circular	3.04	Acceptable FOS > 1.3
B-B Side Slope No Seismic Loading	Normal	Drained Circular	3.85	Acceptable FOS > 1.5
B-B Side Slope No Seismic Loading	High Water	Drained Non-Circular	3.30	Acceptable FOS > 1.3

The calculated factor of safety for the unconfined side slopes are greater than 1.5 and 1.1 for the static and OBE scenarios and are considered acceptable. For the Scenario 1 A-A side slope under high water conditions subject to the 1:2500 AEP seismic load the FoS indicates the slope may be marginally stable (~1.0) under the ANCOLD guidelines.

4.5.2 Waste Mass and Liner Stability Analysis

The limit equilibrium analyses for the waste mass modelling has been undertaken using the Janbu corrected, Spencer and Morgenstern-Price non-circular forms of analysis, for the 1V:4.7H waste slopes up to a maximum height of 20 m overlying the nominal, 1.0 m thick compacted clay and HDPE basal liner system. Scenario 1 section A-A was analysed as shown on the concept sketch plans included in appendix A. Stability for the waste and liner system is considered consistent between section A-A and B-B, based on concept sketches.

Waste mass stability has been considered for the following:

- Final waste slope profile; and
- Interface along the lining system.

The waste mass stability summary is presented in **Table 5**. The model results for waste slopes are presented in **Appendix B**.

Table 5 Summary of Stability Analysis for Waste Mass and Liner Analysis Results

Scenario 1	Conditions	Method	Factor of Safety	Comments
A-A Waste Mass No Seismic Loading	High Water	Drained Non-Circular	3.05	Acceptable FOS > 1.5
A-A Waste Mass OBE 1:500 Seismic Loading	High Water	Drained Non-Circular	1.72	Acceptable FOS > 1.1
A-A Waste Mass 1:2500 Seismic Loading	High Water	Drained Non-Circular	1.30	Acceptable FOS > 1.0
A-A Sliding on Liner No Seismic Loading	High Water	Drained Non-Circular	2.40	Acceptable FOS > 1.5

Scenario 1	Conditions	Method	Factor of Safety	Comments
A-A Sliding on Liner OBE 1:500 Seismic Loading	High Water	Drained Non-Circular	1.19	Acceptable FOS > 1.1
A-A Sliding on Liner 1:2500 Seismic Loading	High Water	Drained Non-Circular	0.85	Unacceptable FOS < 1.0
A-A Sliding on Liner Improved 1:2500 Seismic Loading	High Water	Drained Non-Circular	1.19	Acceptable FOS > 1.0

Under the ANCOLD guidelines the calculated factor of safety for the waste slopes and liner are greater than 1.5 and 1.1 for the static and OBE scenarios and are considered acceptable. A FoS of <1 for the 1:2500 AEP seismic loading scenario is considered potentially unacceptable. An acceptable FoS of >1 is achieved however when using improved liner strength parameters for the 1:2500 AEP seismic loading scenario.

4.5.3 Toe Embankment Analysis

The analysis considered the 1V:2H toe embankment at a maximum height of 6.0 m at the completion of waste mass filling. The inferred normal ground water level is taken as approximately 8.0 m below the exiting ground level (i.e. 8.0 m below the embankment foundation). As the waste mass is to be lined, with leachate collection drainage, the regional groundwater levels are not expected to rise above 2.0 m above the base of the liner, (behind the embankment).

As a sensitivity analysis, localised increases in pore pressure within the toe embankment due to surface run off across the waste mass have been modelled, with a maximum seasonal high piezometric surface considered between 2 – 3m below the embankment crest as a worst-case scenario. Scenario's 1-3 for section A-A was analysed as shown on the concept sketch plans included in **Appendix A**. The summary of the circular analysis for the toe embankment are presented in **Table 6 - Table 8**. The model results for waste slopes are presented in **Appendix B**.

Table 6 Summary of Stability Analysis for Scenario 1 Toe Embankment

Scenario 1	Conditions	Method	Factor of Safety	Comments
A-A Toe Embankment No Seismic Loading	Normal	Drained Circular	1.49	Acceptable FOS ~ 1.5
A-A Toe Embankment No Seismic Loading	High Water	Drained Circular	1.21	Unacceptable FOS < 1.3
A-A Toe Embankment OBE 1:500 Seismic Loading	Normal	Drained Circular	1.00	Unacceptable FOS < 1.10
A-A Toe Embankment 1:2500 Seismic Loading	Normal	Drained Circular	0.81	Unacceptable FOS < 1.0

Table 7 Summary of Stability Analysis for Scenario 2 Toe Embankment

Scenario 2	Conditions	Method	Factor of Safety	Comments
A-A Toe Embankment No Seismic Loading	Normal	Drained Circular	1.85	Acceptable FOS > 1.5

Scenario 2	Conditions	Method	Factor of Safety	Comments
A-A Toe Embankment No Seismic Loading	High Water	Drained Circular	1.44	Acceptable FOS > 1.3
A-A Toe Embankment OBE 1:500 Seismic Loading	Normal	Drained Circular	1.32	Acceptable FOS > 1.10
A-A Toe Embankment OBE 1:500 Seismic Loading	High Water	Drained Circular	1.02	Unacceptable FOS < 1.10
A-A Toe Embankment 1:2500 Seismic Loading	Normal	Drained Circular	1.08	Acceptable FOS > 1.0
A-A Toe Embankment 1:2500 Seismic Loading	High Water	Drained Circular	0.83	Unacceptable FOS < 1.0

Table 8 Summary of Stability Analysis for Scenario 3 Toe Embankment

Scenario 3	Conditions	Method	Factor of Safety	Comments
A-A Toe Embankment No Seismic Loading	Normal	Drained Circular	2.25	Acceptable FOS > 1.5
A-A Toe Embankment No Seismic Loading	High water	Drained Circular	1.72	Acceptable FOS > 1.5
A-A Toe Embankment OBE 1:500 Seismic Loading	Normal	Drained Circular	1.50	Acceptable FOS > 1.10
A-A Toe Embankment OBE 1:500 Seismic Loading	High Water	Drained Circular	1.16	Acceptable FOS > 1.10
A-A Toe Embankment 1:2500 Seismic Loading	Normal	Drained Circular	1.21	Acceptable FOS > 1.0
A-A Toe Embankment 1:2500 Seismic Loading	High water	Drained Circular	0.93	Unacceptable FOS > 1.0
A-A Toe Embankment - Improved 1:2500 Seismic Loading	High water	Drained Circular	1.02	Acceptable FOS > 1.0

Under the ANCOLD guidelines, the calculated FoS for the Scenario 1 toe embankment slope under normal conditions are marginally acceptable at about 1.5 for the static condition and unacceptable (<1.3, 1.1 and 1) for high water conditions, OBE and 1:2500 AEP seismic loading case.

An acceptable FoS for scenario 2 and 3 under normal conditions is achieved under all scenarios, static, OBE and 1:2500 AEP seismic loading. Under high water conditions for Scenario 2 the FoS is unacceptable for the OBE and 1:2500 AEP seismic cases.

Under scenario 3 the FoS is unacceptable under the 1:2500 AEP seismic loading. An acceptable FoS is achieved for the 1:2500 AEP scenario under improved conditions whereby the residual soil in the foundation is removed and replaced with compacted granular fill.

Further discussion regarding the critical components of the toe embankment is included in section **5.4**.

5 Assessment Summary

5.1 Seismic Conditions

ANCOLD states if a pseudo-static analysis is undertaken, a factor of safety greater than 1.0 may be taken as indicative of limited deformation being caused by the design earthquake. The US EPA 'Seismic Design Guidance for Municipal Solid Waste Landfill Facilities' states "If the minimum factor of safety, FS_{min}, exceeds 1.0 and 0.3m (1 ft) of deformation is acceptable, the seismic stability analysis is completed." All analysed scenarios with regards to the OBE and 1:2500 AEP are expected to be able to achieve a FoS >1 therefore, no deformation analysis is expected to be required. This should be confirmed during the detailed design stage.

5.2 Basal & Side Slope Assessment

The analyses demonstrate acceptable factors of safety for drained conditions, under static, OBE and 1:2500 AEP seismic conditions under both normal and high-water conditions. For the Scenario 1 A-A side slope under high water conditions subject to the 1:2500 AEP seismic loading the FoS indicates the slope may be marginally stable under the ANCOLD and US EPA guidelines. An acceptable FoS may be achieved by maintaining a lower water table under this scenario and/or by adopting scenario 2 or 3 shallower side slope angles.

Refinement of the adopted geological model and material parameters is recommended as part of the detailed stability analyses. With addition of detailed geotechnical information to the model, increased confidence may be applied to material strength parameters, which would be expected to increase the FoS of side slopes.

5.3 Waste Mass Stability

The calculated factor of safety for the waste slopes and liner are greater than 1.5 and 1.1 for the static and OBE scenarios. A FoS of <1 for sliding along the basal liner under the 1:2500 AEP seismic loading scenario is considered unacceptable under the ANCOLD and US EPA guidelines.

To provide an acceptable factor of safety under the 1:2500 AEP scenarios (FoS >1.0) the liner would be required to have improved strength properties. For example, an increased cohesion and friction angle by using textured liners, or similar improved strength liner systems, for example HOPE / GCL liners. This should be confirmed with laboratory testing and/or relevant research during detailed design. An improved liner scenario was tested as an example, using increased effective cohesion and friction angle of 3 kPa and 18^{o} respectively, and provides an acceptable FoS against the 1:2500 AEP seismic loading scenario.

5.4 Toe Embankment Stability

Under the ANCOLD guidelines, the calculated FoS for the Scenario 1 toe embankment slope under normal conditions are marginally acceptable at about 1.5 for the static condition and unacceptable (<1.3, 1.1 and 1) for high water conditions, OBE and 1:2500 AEP seismic loading case.

An acceptable FoS for scenario 2 and 3 under normal conditions is achieved under all scenarios, static, OBE and 1:2500 AEP seismic loading. Under high water conditions for Scenario 2 the FoS is unacceptable for the OBE and 1:2500 AEP seismic cases.

Under scenario 3 the FoS is unacceptable under the 1:2500 AEP seismic loading. An acceptable FoS is achieved for the 1:2500 AEP scenario under improved conditions, whereby the residual soil in the foundation is removed and replaced with compacted granular fill.

Scenario 2 and 3 provide an acceptable factor of safety under normal conditions for all cases. If a high groundwater table is modelled within the embankment as a worst-case scenario, then the FoS under seismic loading is generally unacceptable for the 1:2500 AEP case. Under these conditions the toe embankment would require an alternate geometry and/or improved construction to provide an acceptable FoS. This may be achieved by flattening batter angles and increasing the height, to provide a larger buttress for the waste fill or improving the strength of the fill material.

Batter angles in the order of 1H:3V (Scenario 3) with the residual soil removed from the foundation and replaced with compacted granular fill have been modelled as an improved scenario, maintaining the assumed angle of shearing resistance of 36^{o} for fill. In this case which an acceptable FoS (>1) under the 1:2500 AEP seismic loading is achieved.

The toe embankment is considered a critical component of the global stability of the waste mass post filling. The stability analysis indicates that the embankment is sensitive to rise in pore water pressure and hence it will be critical to ensure the embankment remains well drained at all times. This should be maintained to some degree by the lining system proposed for the landfill restricting a rise in water table behind the toe. Additionally, providing a drain at the toe of the waste slope to ensure surface run-off does not infiltrate the embankment is recommended. Furthermore, strict selection criteria must be applied to ensure suitable embankment materials are used for construction which are not susceptible to significant softening with increased moisture content. If high water conditions are controlled (i.e. do not occur) then Scenario 2 and 3 provide an acceptable FoS under all load cases.

It will be imperative to ensure the engineering properties of the fill used for embankments is suitable for the purpose and strict selection criteria must be applied to ensure suitable embankment materials are used for construction with appropriate strength properties. Construction control should be implemented to ensure materials meet specification requirements, including shear strength and compaction effort. Further discussion regarding material suitability is provided in section 5.5.1.

Any unsuitable materials including soft or loose soils, topsoils and uncontrolled fill should be removed from the foundation. This may include the residual soil shown in section A-A. In this case the soil would be recommended to be stripped back and removed and the embankment founded on competent bedrock. Based on the existing geotechnical information residual soil may be up to 1 – 2.0 m thick in isolated locations.

6 Further considerations

6.1 Old quarry face

As indicated in section B-B under all scenarios (1-3), the waste mass is proposed to be filled over the old quarry face located at the north east edge of the site (**Figure 1**). The quarry face appears up to 25 m high and exposes extremely weathered Paga bed, meta-siltstone / argillite up to 8.0 – 10.0 m thick, overlying distinctly weathered meta-siltstone / argillite (**Figure 3**). Section B-B indicates the top half of the quarry face is to be removed to form the base grade surface prior to waste filling and the lower portion filled in to provide a base grade surface of 1V:2H (refer concept sketch section B-B).

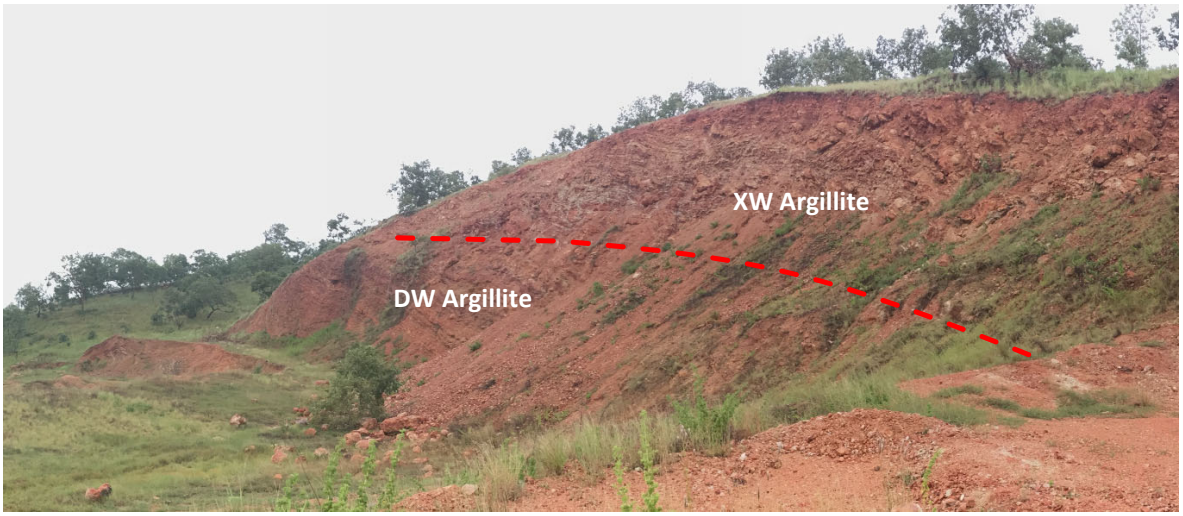


Figure 3 Old Quarry Face

Filling against the quarry face is recommended to be undertaken by benching the remaining lower quarry face at 1.5 m high intervals (i.e. 1.5 m high benches with 1.5m wide berms) to provide a suitable "key" to fill against.

Controlled filling should then continue up to and overlying the benched profile up to the finished profile.

6.2 Material Suitability

The ACEM preliminary geotechnical report included a high-level assessment of the suitability of the bedrock material for re-use as select fill and road base, and states:

"*the CWR bedrock will be suitable for side wall construction of the landfill and is also likely to produce road pavement material including, ordinary and select fill, basecourse and subbase"*, and,

"*Depending on the quarrying methods and screening used, the type of material that is produced will vary. However, it is considered that the quarry is likely to yield suitable ordinary fill, select fill and subbase with limited or no screening. With more selective screening, it may also yield basecourse material."*

Soil Engineers (the company) undertook subsequent testing of material obtained from the quarry area, which indicated the material tested did not meet specification for road sub base and base course. Some of the material did meet the specification for particle size distribution and plasticity index. The following recommendations were provided to improve the material to meet specification:

"*The test results indicate that the proposed material potentially suitable however it needs to be further improved for the intended purpose as both road and sub base course. The following recommendation below is considered to improve the material properties to meet DOW requirements.*

I. Freshly crushed material is recommended and will be needed for a retest to verify strength

II. Blend with granular material from another quarry/source to increase compaction density and strength and will reduce fines."

Based on the existing information and testing, site won rock fill may be considered suitable however for use as select fill within embankments. The material would be expected to breakdown under compaction, and as illustrated in the ACEM particle size distribution and Atterberg limit testing, the material may be considered as a Clayey Sandy GRAVEL for engineering purposes.

Further assessment of the material properties is recommended to confirm suitability for select embankment fill and material strength parameters. As discussed in section **5.4**, embankment stability is sensitive to increased pore pressure and material should be relatively free draining and have an angle of internal shearing resistance of at least 36^{o} to replicate conditions used in this analysis.

6.3 Recommended Further Investigation

As discussed in section **2.2**, we recommend further detailed geotechnical information to be gathered to refine the geological model and material strength parameters. Additional investigation recommended includes:

- Mapping of structural features exposed within the quarry face and surrounding site.
- Additional cored boreholes with structural measurements of discontinuities (dip, dip direction, surface shape, roughness and infill).
- Strength testing on recovered core samples for both XW and DW rock including:
    - Point load testing;
    - Unconfined compressive strength testing;
    - Triaxial strength testing (XW rock).
- Material testing on XW and DW rock including:
    - Slake durability testing;
    - Weathering pre-treatment by compaction;
    - Particle size distribution pre and post compaction.

7 Monitoring & Risk Management

As part of the future development and ongoing landfilling operations a monitoring scheme should be conducted as part of normal operations, to confirm assumptions made in the stability risk assessment remain valid.

7.1 Groundwater

To ensure compliance with the assumed screening and calculations within the report, groundwater monitoring should continue and be compared to current inferred levels to ensure all future development and basal offsets above the seasonal high groundwater table are maintained.

7.2 Construction Quality Assurance

Monitoring during construction will comprise construction quality assurance to ensure earthworks and geosynthetic material compliance with the construction specification.

Construction quality assurance during earthworks operations is also required to confirm the absence of near surface voids, unsuitable material in the foundation and monitor for any perched 1:2500 Seepage/groundwater and to ensure minimum compaction requirements are met.

7.3 Material Balance & Parameters

The stability assessment assumes that volumes of materials of suitable quality are available throughout the full lifetime of the landfill operation for engineering and restoration works. If the specific type and quantity of material is not available on site, then alternative designs will need to be addressed or the stability assumptions reviewed.

7.4 Waste Mass Monitoring

Monitoring required for the waste mass shall entail waste elevation and temporary waste slope gradients across each cell. Leachate level monitoring should also be undertaken to assist in defining potential pore water pressures within the waste mass.

7.5 Capping

Monitoring during construction will comprise construction quality assurance to ensure compliance with the construction specification.

Surface washout is not considered as part of this report, and although erosion protection may be required to prevent scouring of the restoration soils until vegetation can be established on the rehabilitated capping surface. Due to the possible heavy rainfall events in the PNG region, consideration should be given to the potential for soil erosion, washout and gullying. It is recommended that if erosion/gullying is identified, it is remediated as soon as practicable to prevent damage to the geosynthetic capping.

8 Closure

We trust this submission meets your requirements. We are happy to discuss our recommendations with you further and work collaboratively with you to refine your concepts, undertake additional investigations and develop a detailed design.

We also draw your attention to our standard limitations (**Section 10**) which provides additional detail about the utilisation of this report.

9 References

ANCOLD, 'Guidelines on Tailings Dams (2012). – Planning, Design, Construction, Operation And Closure'.

AS1170.4, Australian Standard (2007). – 'Structural design actions Part 4: Earthquake actions in Australia'. 2nd Edition.

E. Hoek, E.T. Brown. (2018) The Hoek–Brown failure criterion and GSI – 2018 edition, Journal of Rock Mechanics and Geotechnical Engineering, 2018, ISSN 1674-7755, https://doi.org/10.1016/j.jrmge.2018.08.001. (http://www.sciencedirect.com/science/article/pii/S1674775518303846)

ICOLD (International Commission on Large Dams). (2009) Selecting Seismic Parameters for Large Dams Guidelines.

Jones, D.R.V. & Dixon, N. (1998). 'The stability of geosynthetic landfill lining systems' Geotechnical Engineering of Landfills, Thomas Telford, London.

Jones, D.R.V. & Dixon, N. (2003). 'Stability of landfill lining systems: Literature review, Environment Agency Research and Development Project P1-385', Report 1.

Kavazanjian Jr. E. (1999). 'Seismic Design of Solid Waste Containment Facilities' Proceedings of the Eight Canadian Conference on Earthquake Engineering, Vancouver, BC, pp. 51-89.

Koerner, R.M. & Soong, T.-Y. (1998b). 'Analysis and critique of ten large solid waste landfill failures', GRI Report No. 22, Geosynthetic Research Institute, December 1998.

Pieters, P. 1:250 000 Geological Series, Sheets SC/55-6,7,11, *Port Moresby – Kalo- Aroa Papua New Guinea*, Department of Mineral and Energy.

PNG Standard 1001 – (1982) Part 4 Earthquake Loading.

RCRA Subtitle D (258) (1995). 'Seismic Design Guidance for Municipal Solid Waste Landfill Facilities'. US EPA, EPA600/R-95/051.

Shaqour F. J., 'Shear strength of naturally cemented calcrete soil compared to artificially cemented and un-cemented sand' Geol Geophys 2017, 6:6(Suppl) DOI: 10.4172/2381-8719-C1-014

Van Impe, W. F. and Bouazza, A. (1996). 'Geotechnical properties of MSW', draft version of keynote lecture, Osaka.

Jotisankasa, A. (2001). 'Evaluating the Parameters that Control the Stability of Municipal Solid Waste Landfills', Master of Science Dissertation, University of London, September.

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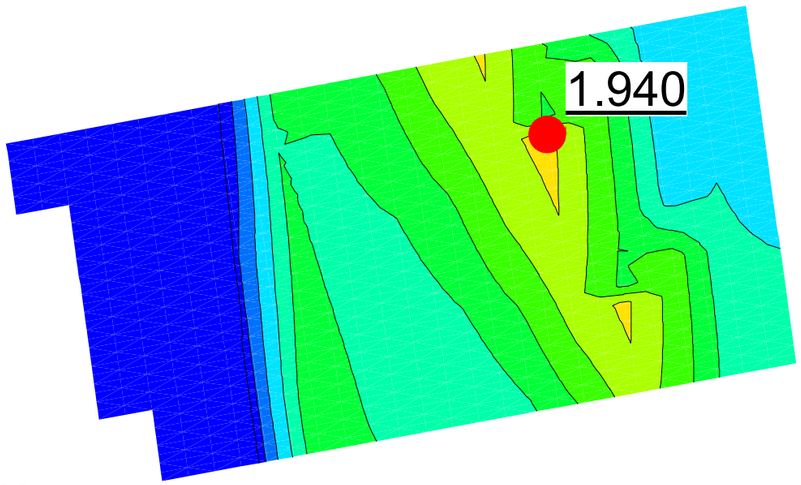
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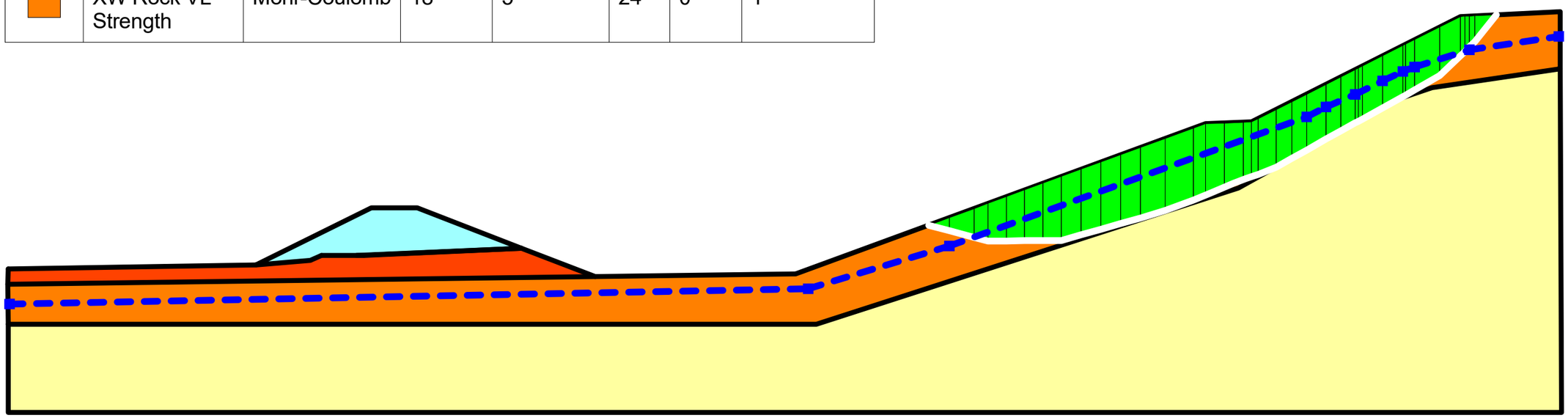
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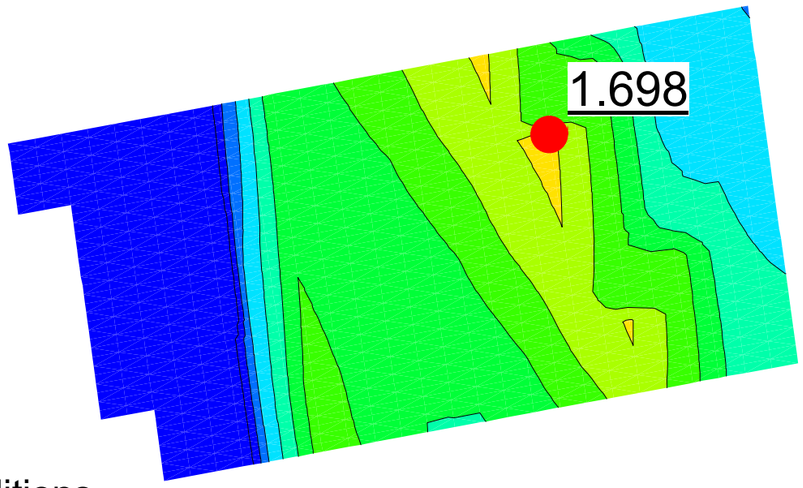


Scenario 1 A-A - No Seismic Loading
Global failure of sidewall under normal conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

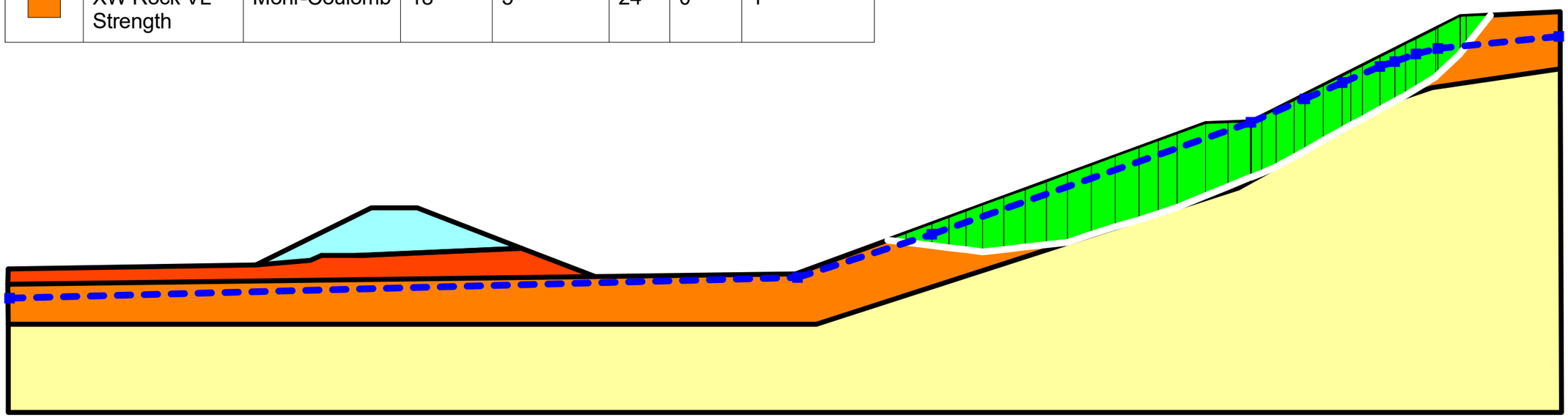


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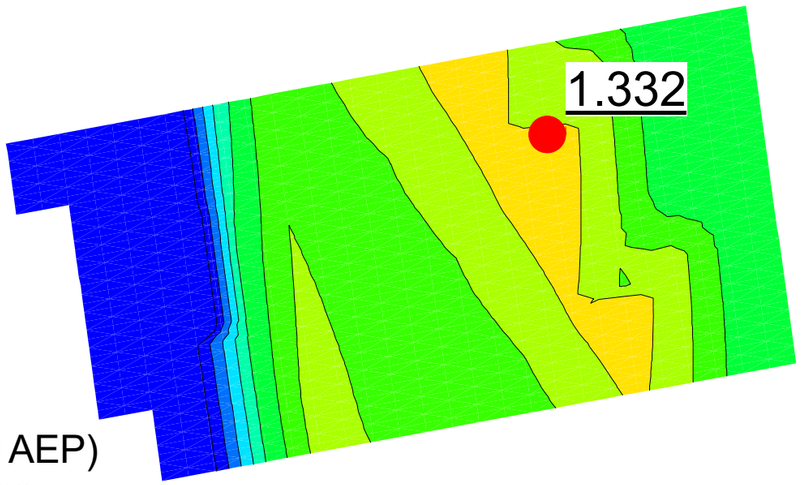


Scenario 1 A-A - No Seismic Loading
Global failure of sidewall under high water conditions

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	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

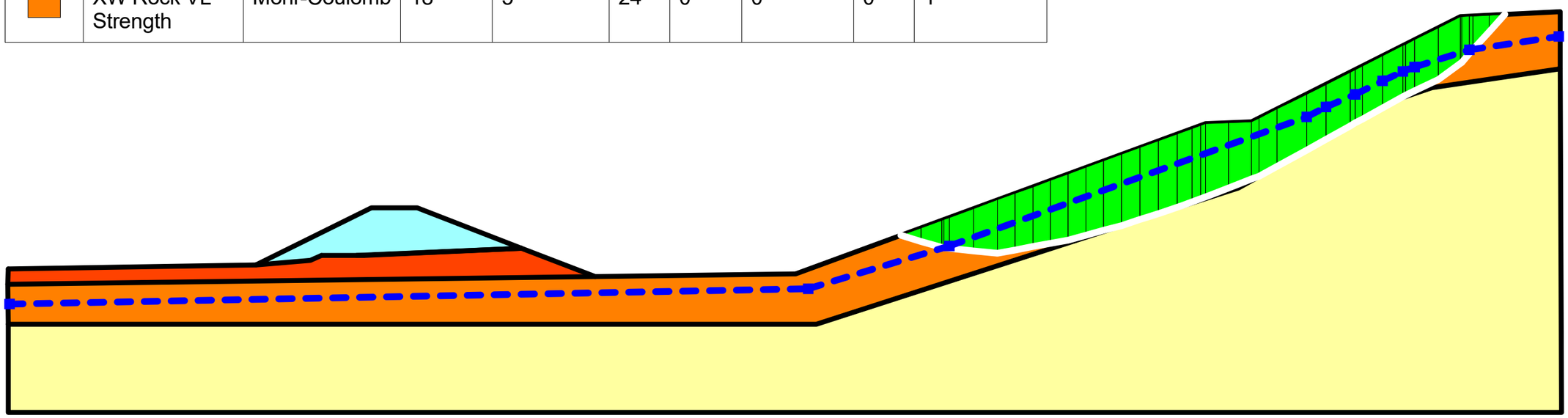


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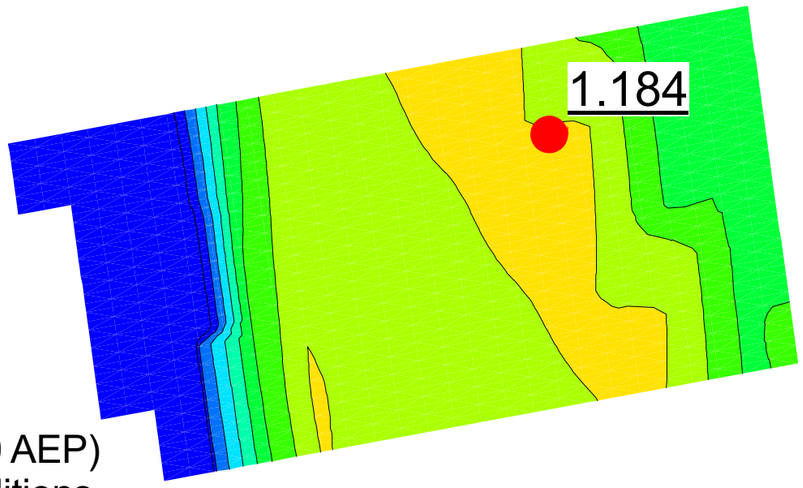


Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Global failure of sidewall under normal conditions

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	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

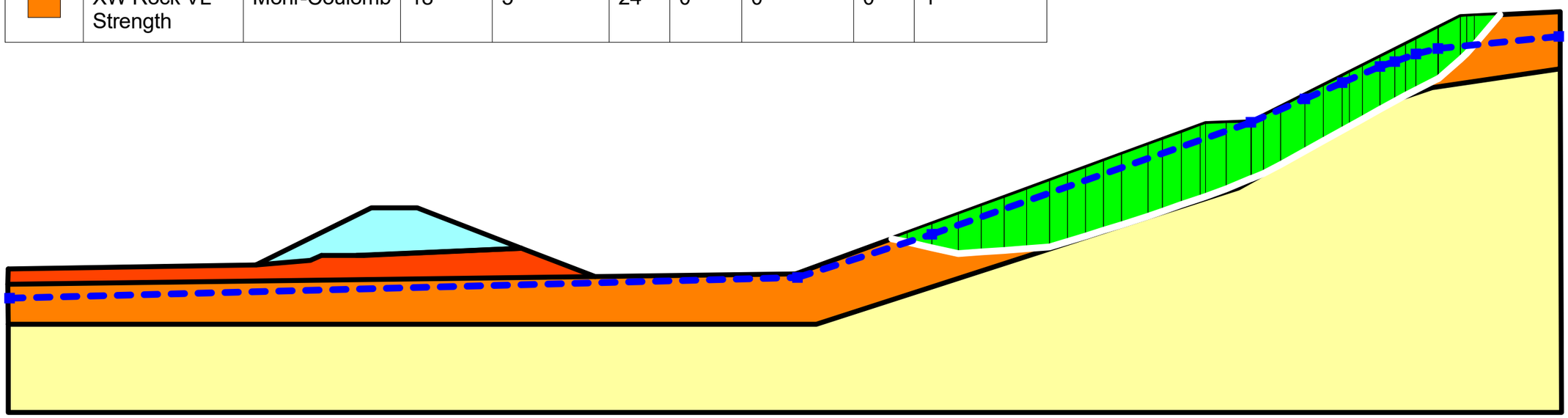


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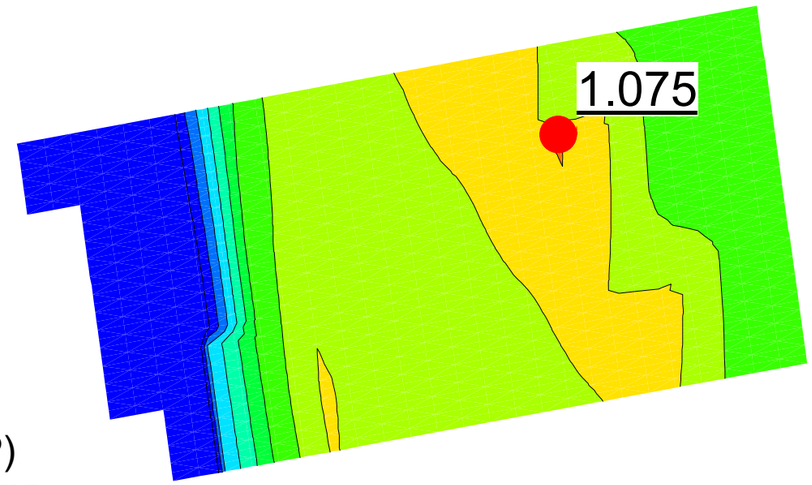


Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Global failure of sidewall under high water conditions

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	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

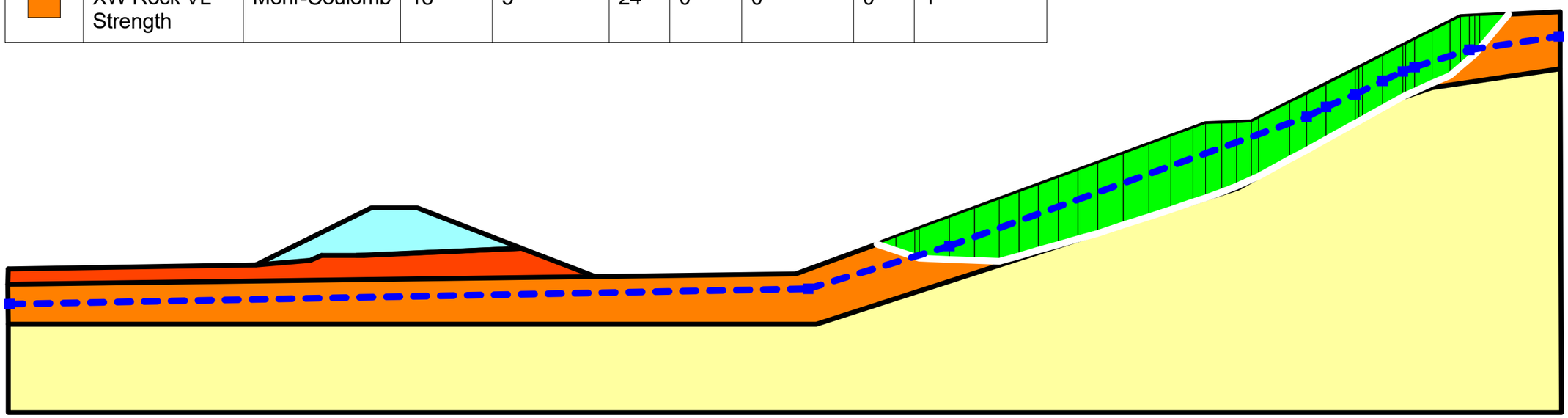


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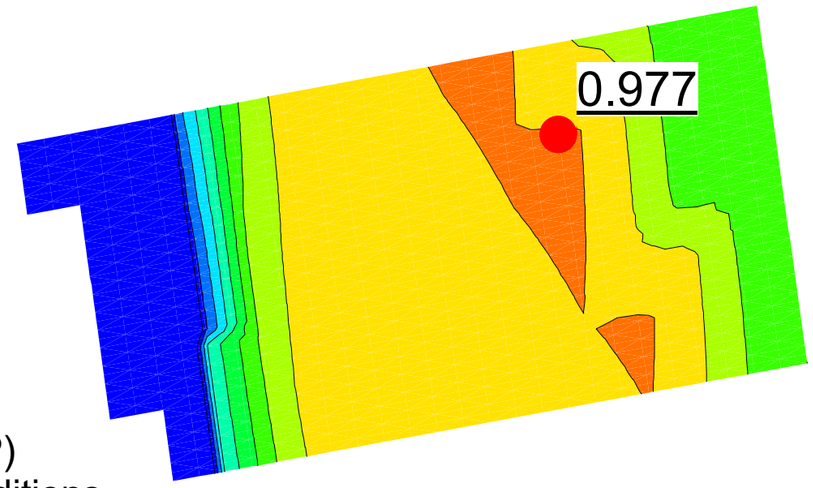


Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Global failure of sidewall under normal conditions

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	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

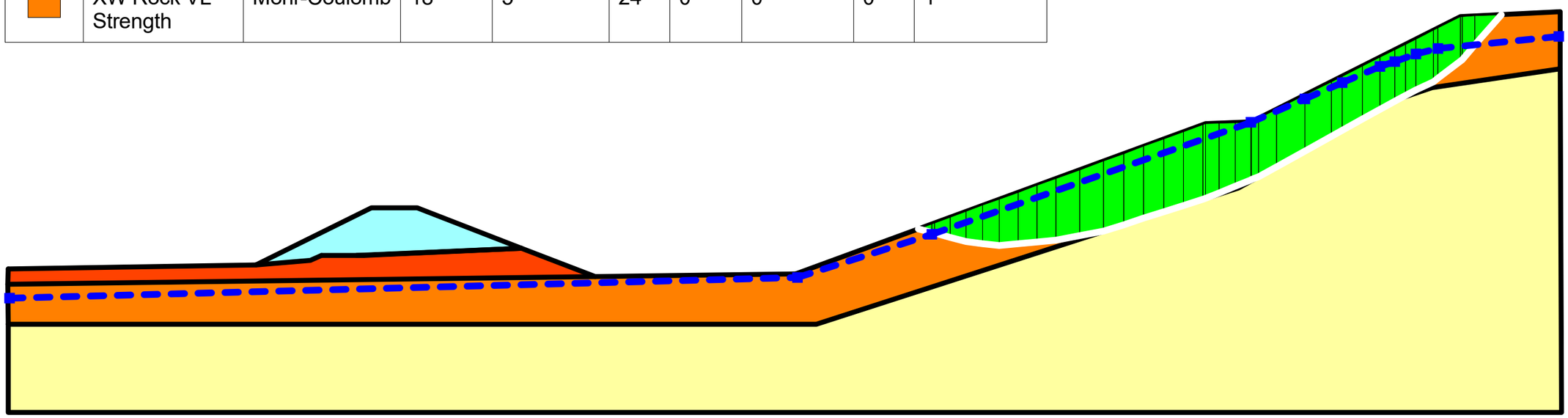


Normal Conditions	
Scenario 1 A-A.gsz	
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Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Global failure of sidewall under high water conditions

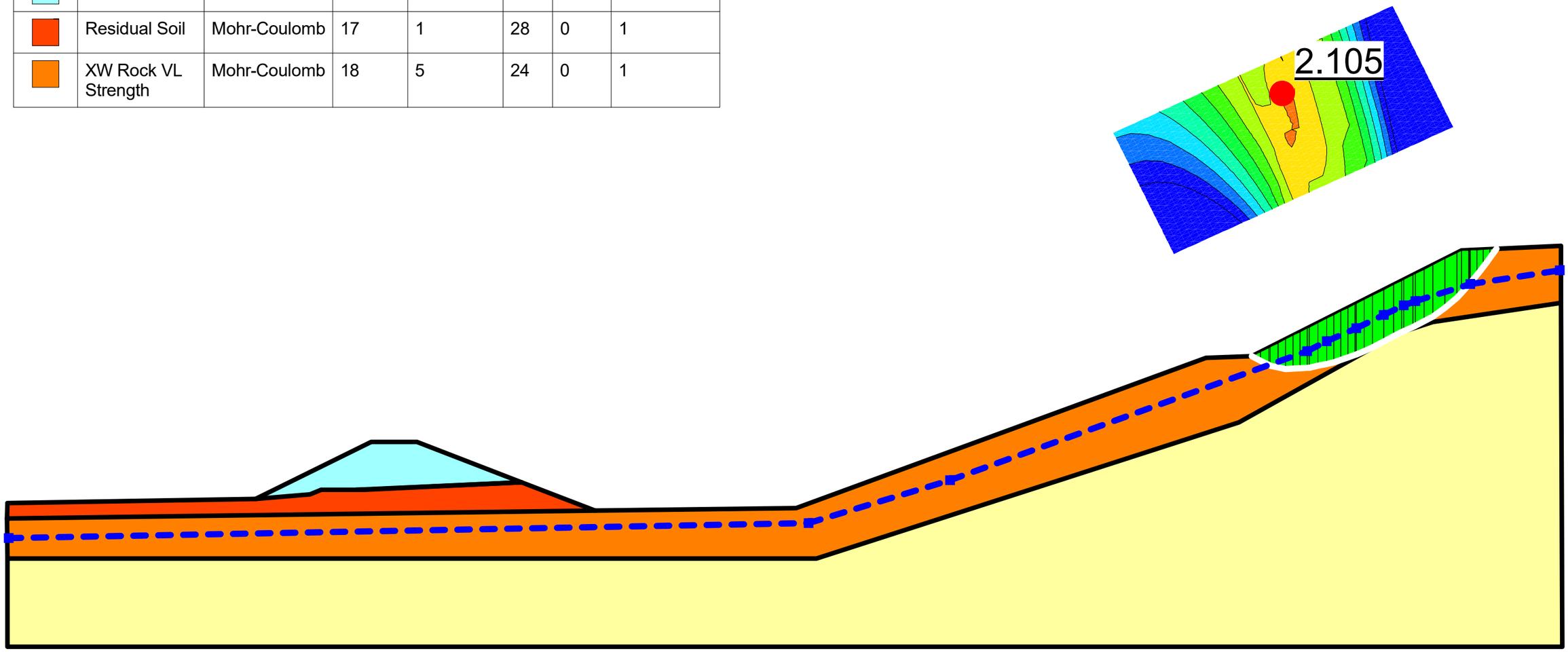
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	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



High water
Scenario 1 A-A.gsz
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Scenario 1 A-A - No Seismic Loading
Critical failure within top batter side slope, prior to filling under normal conditions

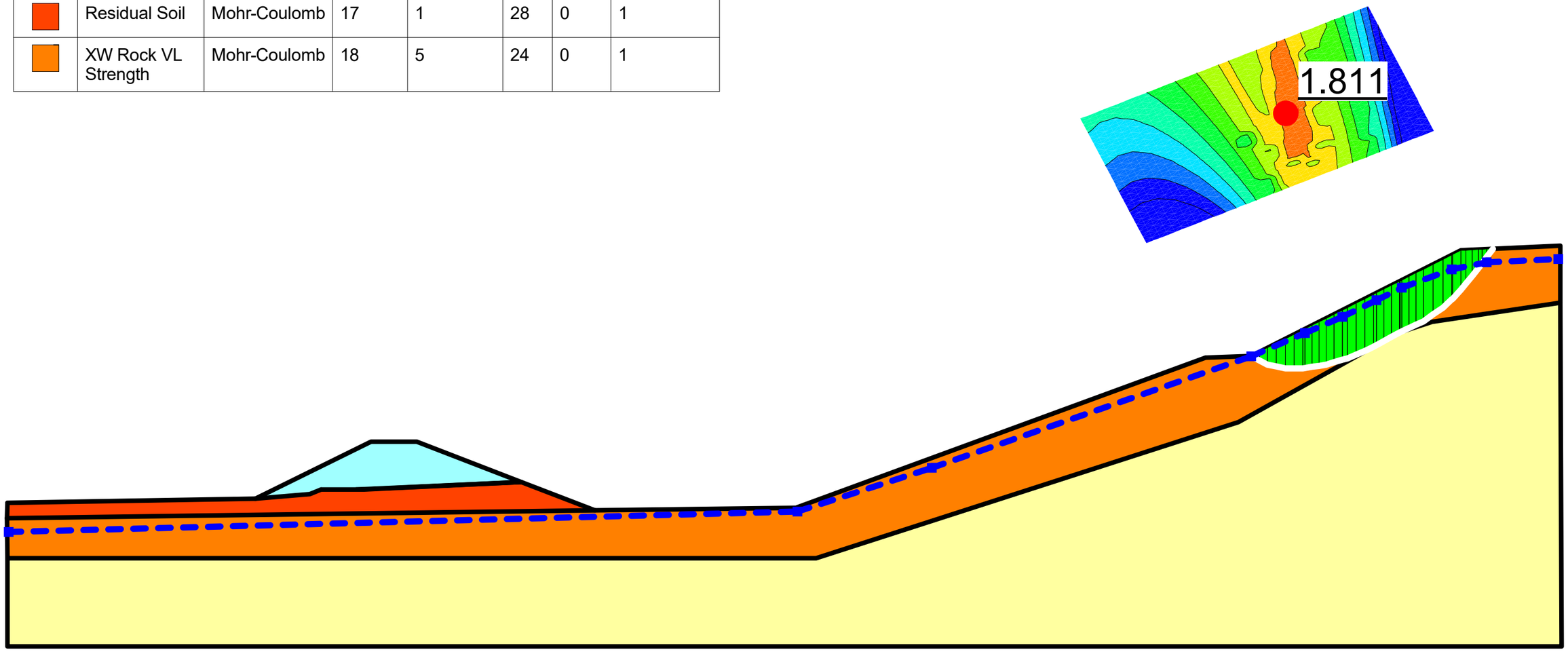
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L-M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	18	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



Normal Conditions
Scenario 1 A-A_rev 1.gsz
08-May-2019 1:74

Scenario 1 A-A - No Seismic Loading
Critical failure within top batter side slope, prior to filling under high water conditions

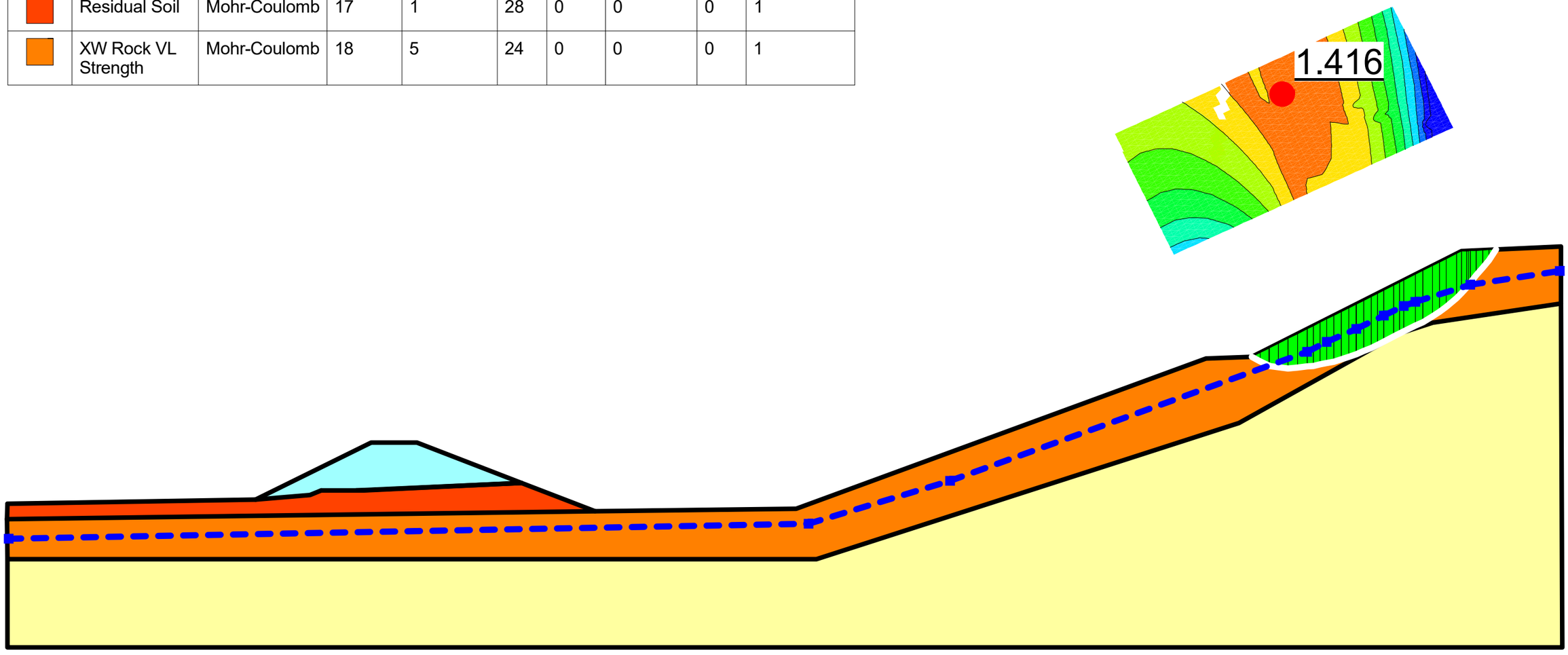
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L-M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	18	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



High water
Scenario 1 A-A_rev 1.gsz
08-May-2019 1:74

Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical failure within top batter side slope, prior to filling, under normal conditions

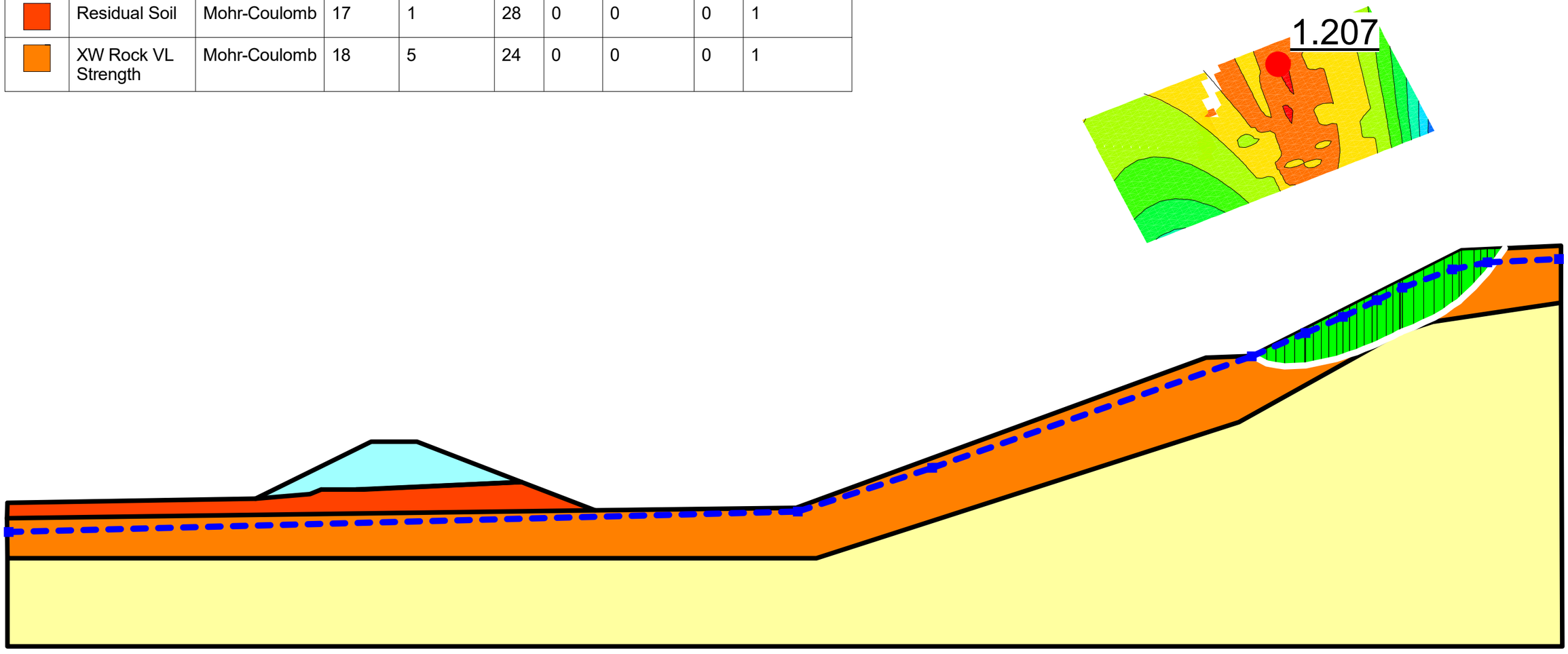
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L-M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	18	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



Normal Conditions	
Scenario 1 A-A_rev 1.gsz	
08-May-2019	1:74

Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical failure within top batter side slope, prior to filling, under high water conditions

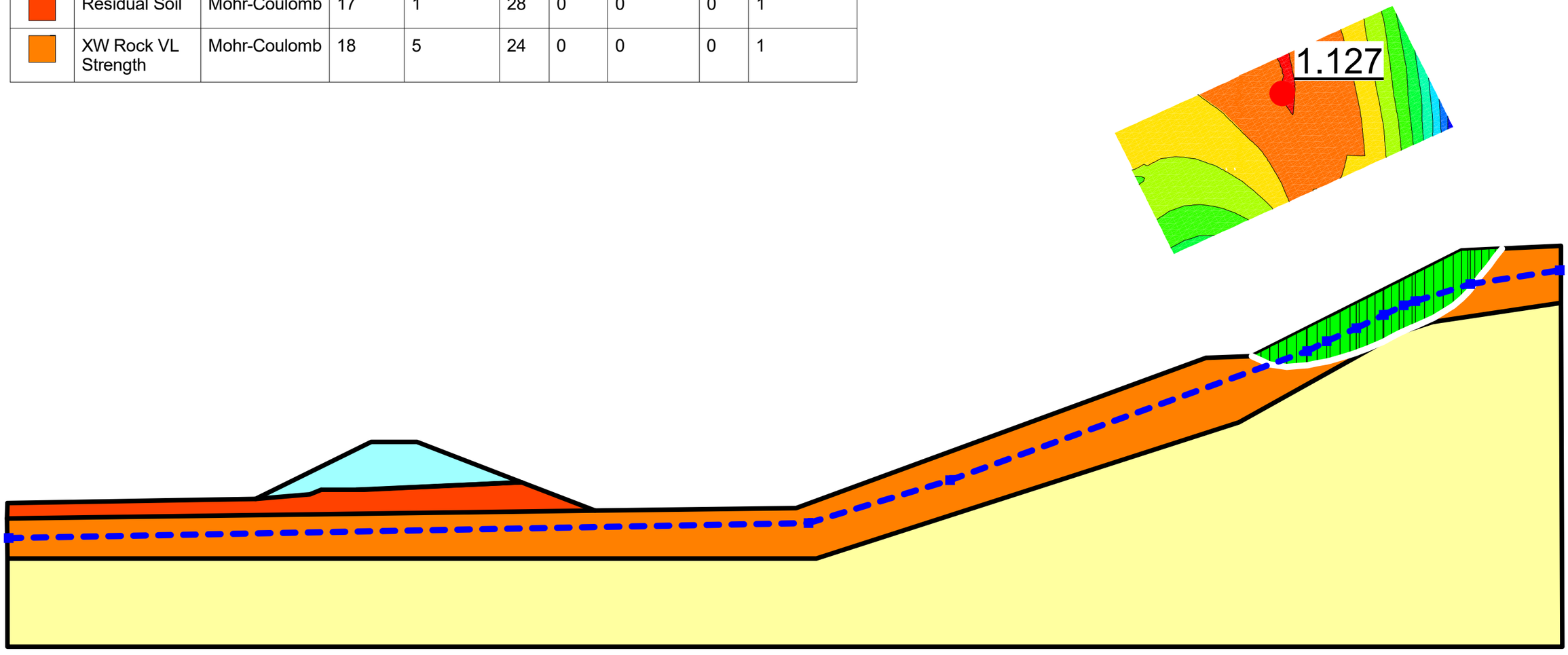
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L-M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	18	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



High water
Scenario 1 A-A_rev 1.gsz
08-May-2019 1:74

Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Critical failure within top batter side slope, prior to filling, under normal conditions

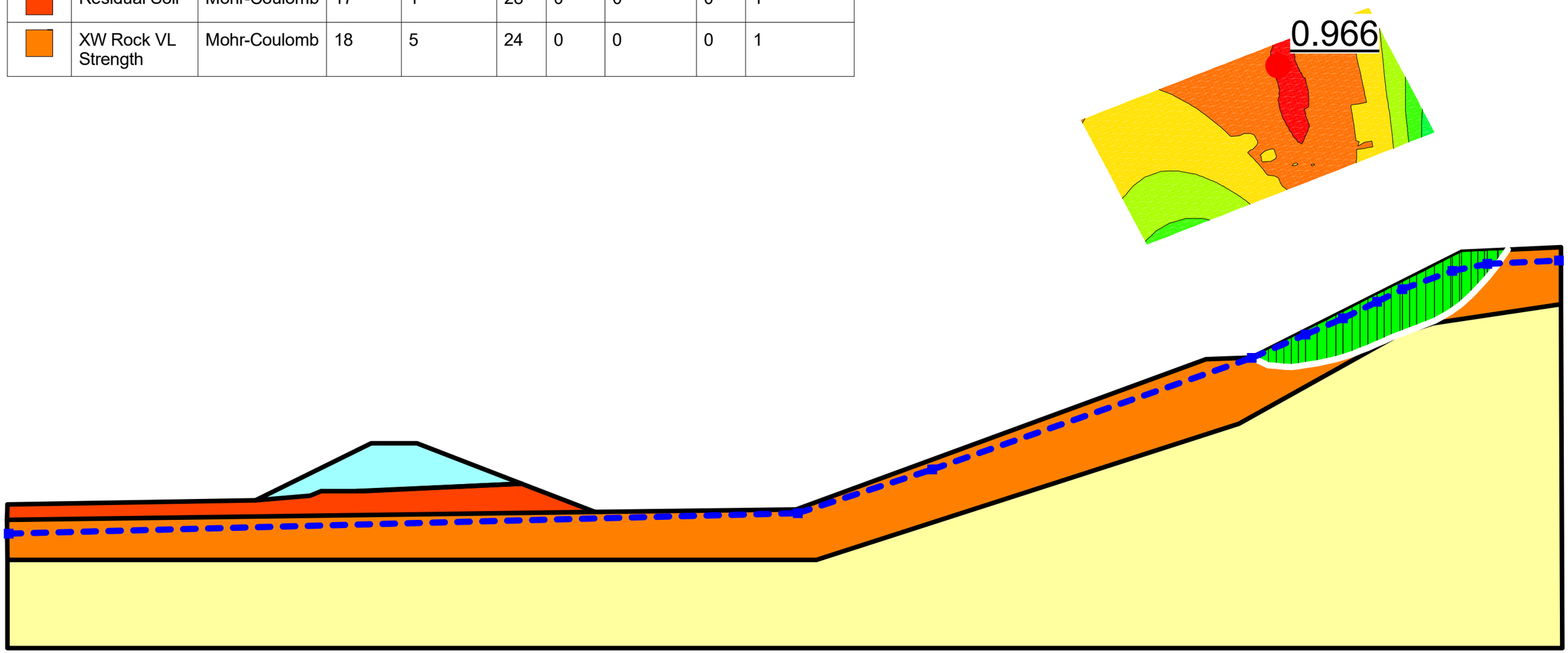
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L-M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	18	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



Normal Conditions	
Scenario 1 A-A_rev 1.gsz	
08-May-2019	1:74

Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Critical failure within top batter side slope, prior to filling, under high water conditions

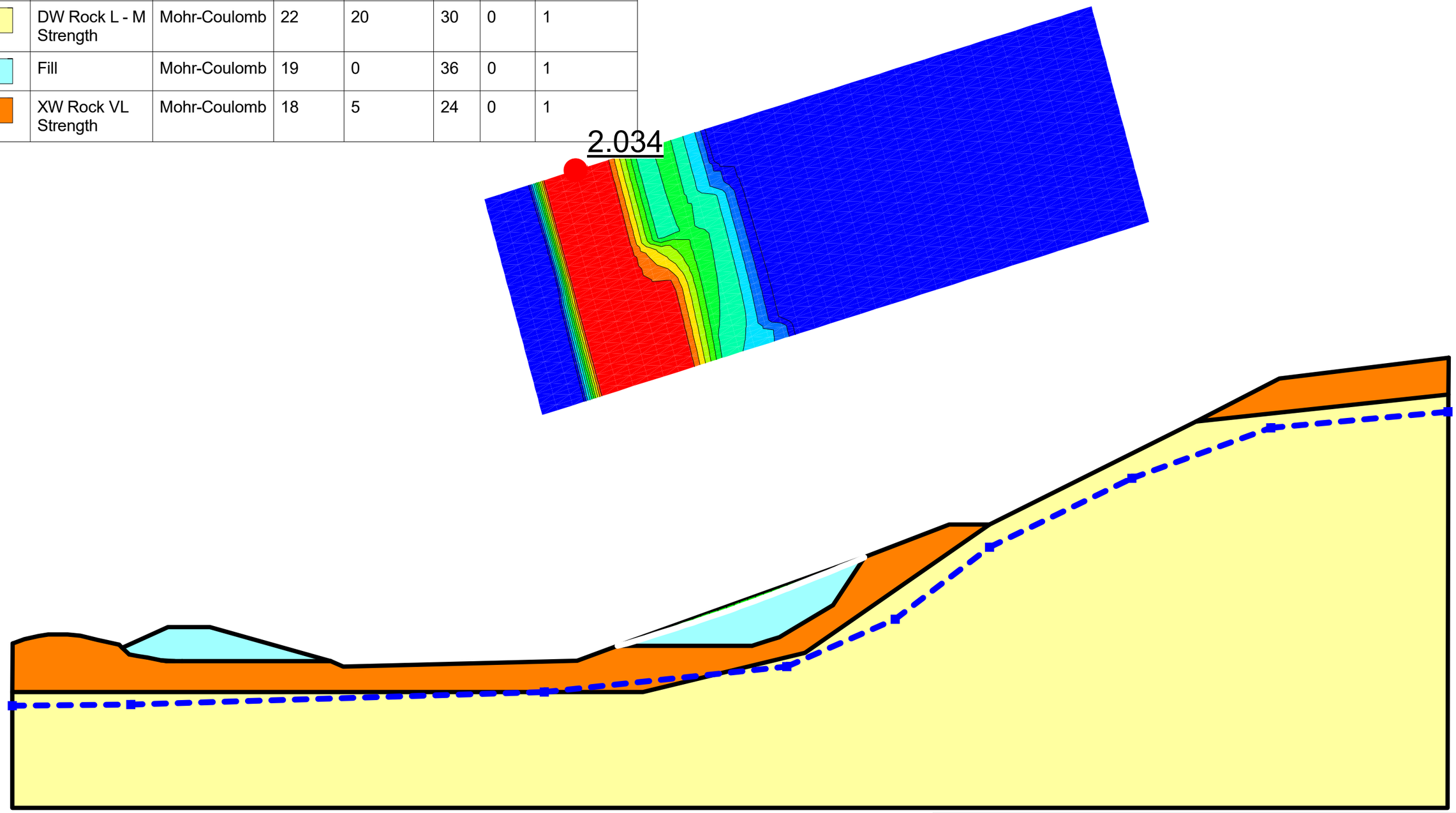
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L-M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	18	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



High water	
Scenario 1 A-A_rev 1.gsz	
08-May-2019	1:74

Scenario 1 B-B No Seismic Loading
Critical failure plane for cut/fill batter prior to filling under normal conditions

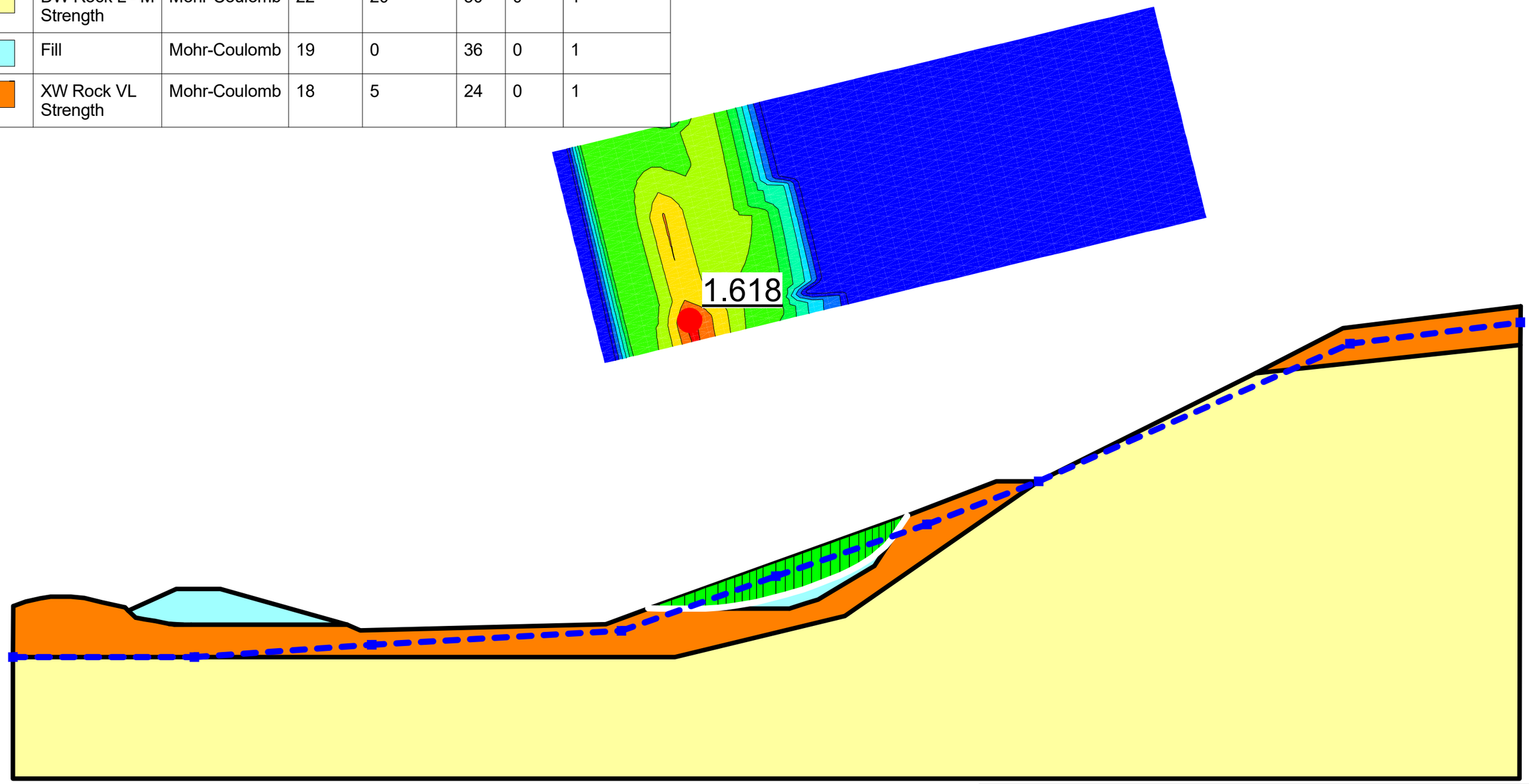
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



Normal Conditions
Scenario 1 B-B.gsz
08-May-2019 1:81

Scenario 1 B-B No Seismic Loading
Critical failure plane for cut/fill batter prior to filling under high water conditions

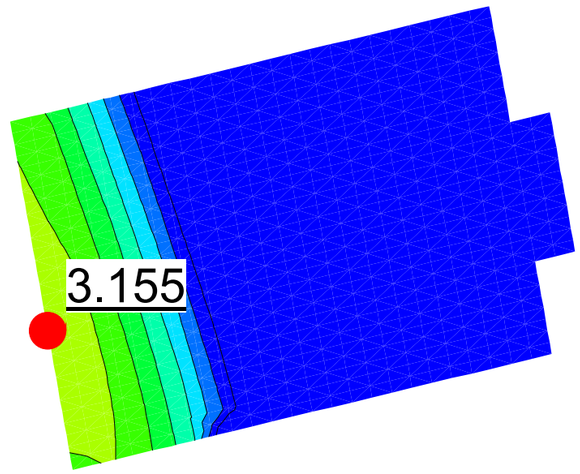
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

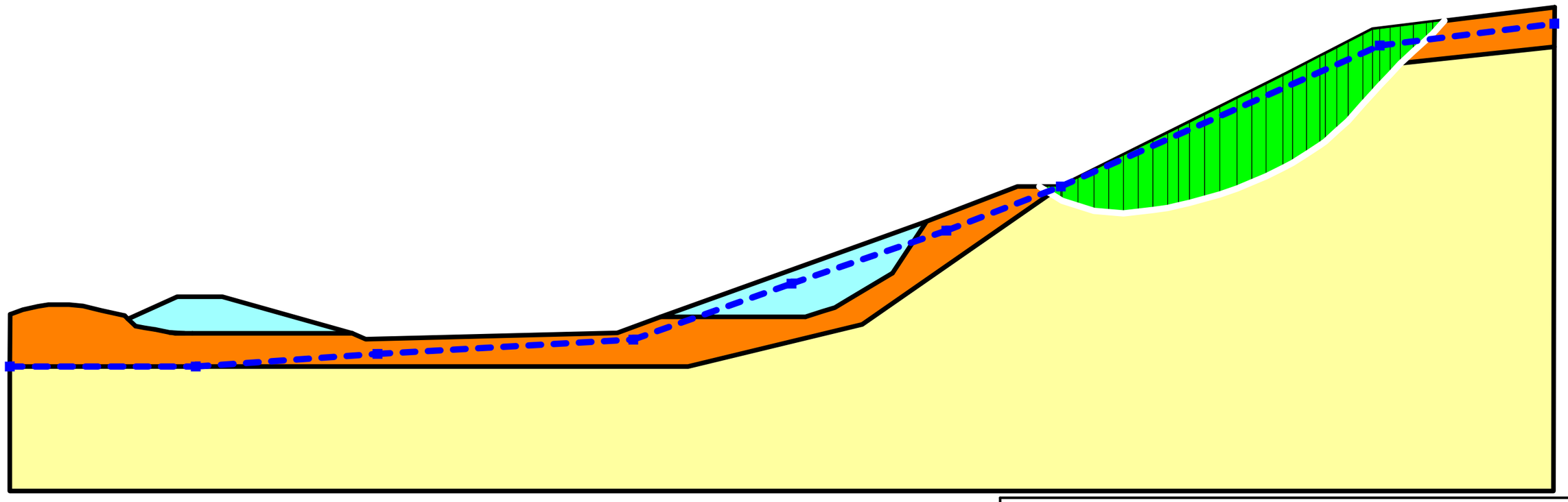


High water	
Scenario 1 B-B.gsz	
08-May-2019	1:81

Scenario 1 B-B No Seismic Loading
Critical failure plane for cut/fill batter prior to filling under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

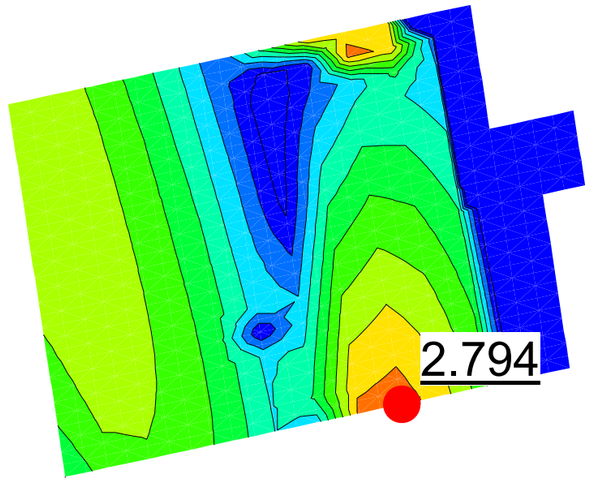


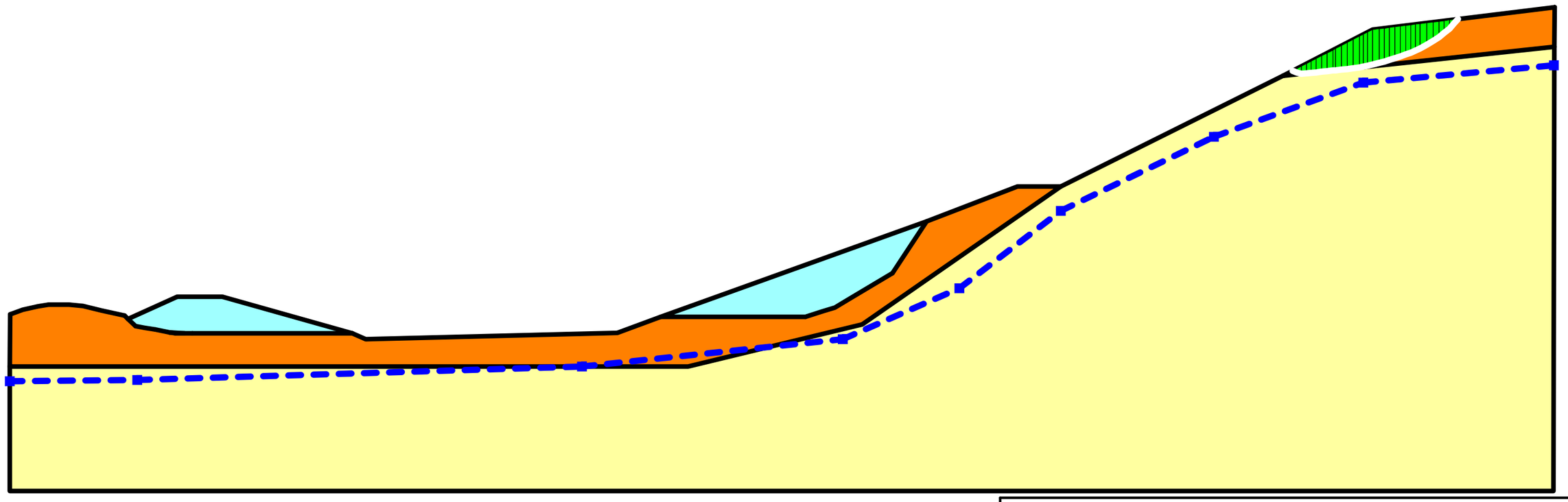


High water	
Scenario 1 B-B.gsz	
08-May-2019	1:81

Scenario 1 B-B Seismic Loading - (OBE - 1:500 AEP)
Critical failure plane for cut/fill batter prior to filling under normal conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

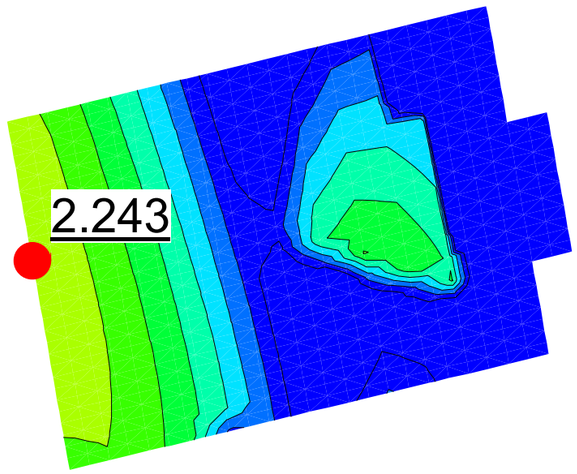


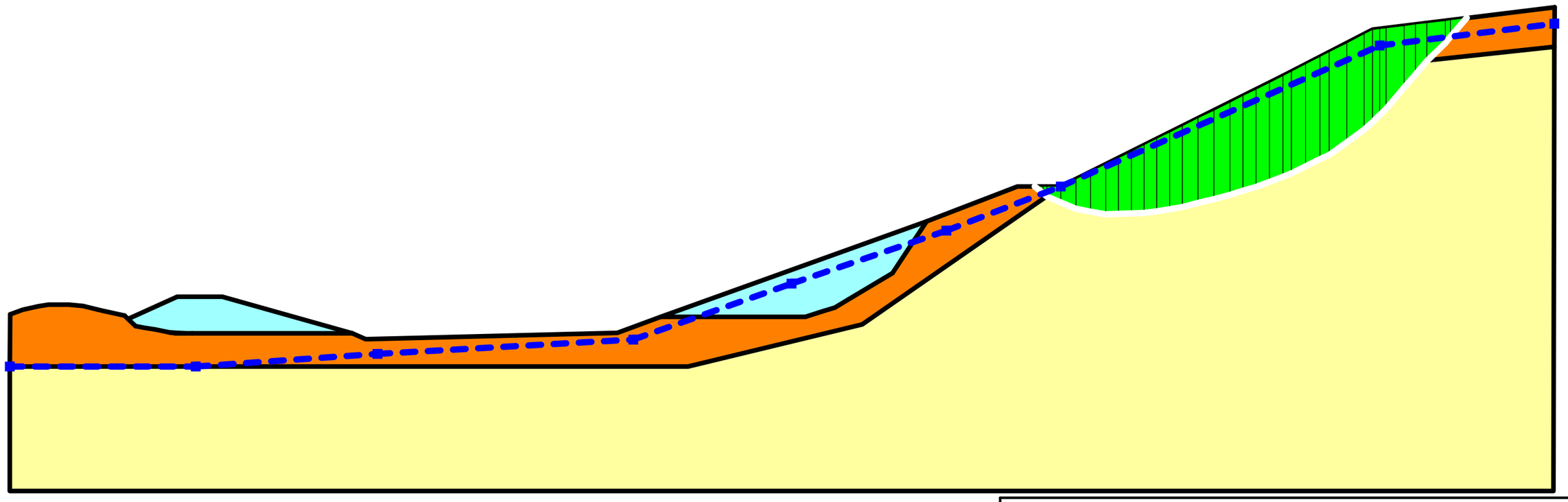


Normal Conditions	
Scenario 1 B-B.gsz	
08-May-2019	1:81

Scenario 1 B-B Seismic Loading - (OBE- 1:500 AEP)
Critical failure plane for cut/fill batter prior to filling under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

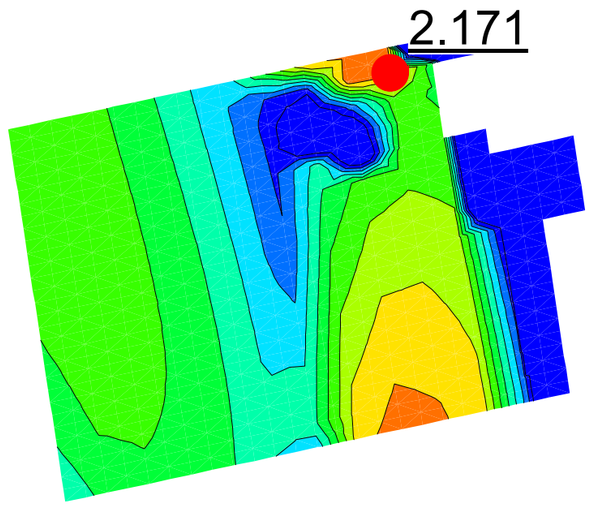


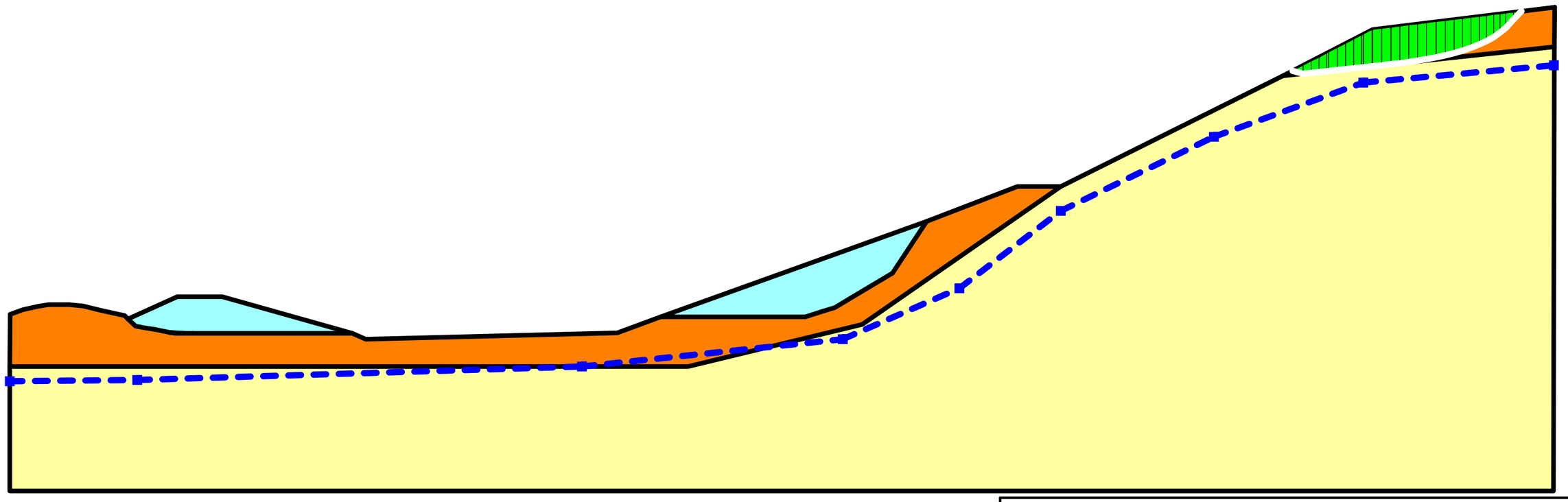


High water
Scenario 1 B-B.gsz
08-May-2019 1:81

Scenario 1 B-B Seismic Loading - (1:2500 AEP)
Critical failure plane for cut/fill batter prior to filling under normal conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

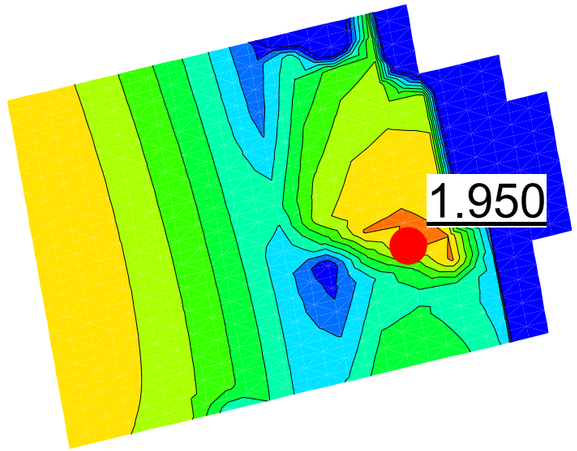


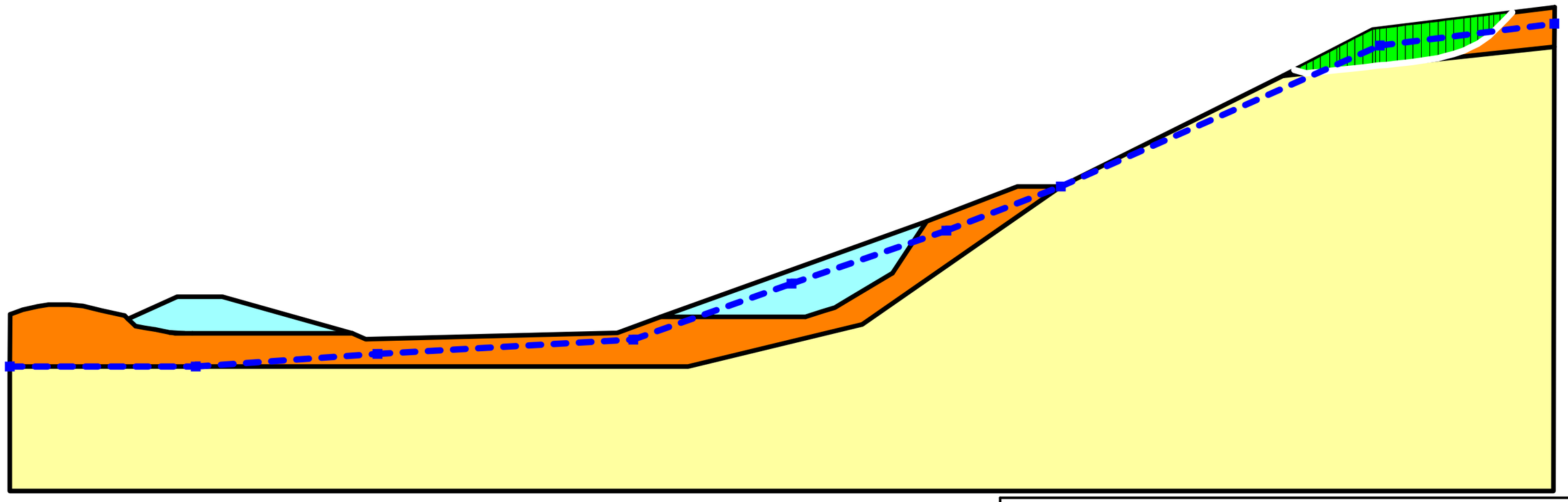


Normal Conditions	
Scenario 1 B-B.gsz	
08-May-2019	1:81

Scenario 1 B-B Seismic Loading - (1:2500 AEP)
Critical failure plane for cut/fill batter prior to filling under high water conditions

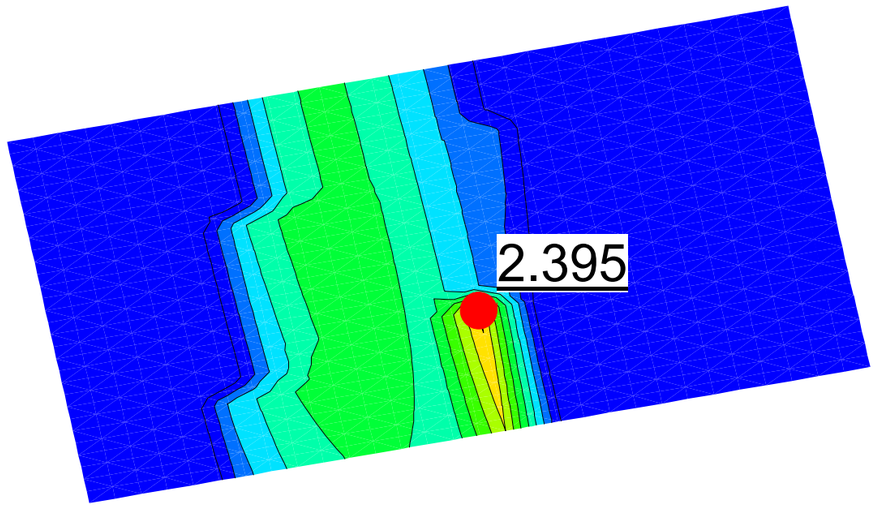
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



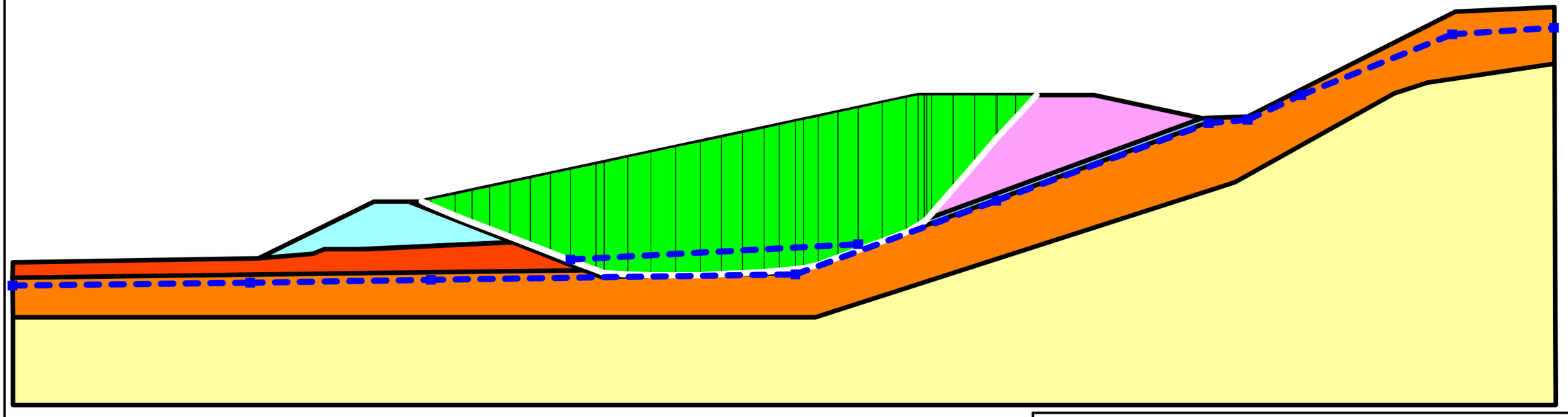


High water
Scenario 1 B-B.gsz
08-May-2019 1:81

Scenario 1 A-A - No Seismic Loading
Critical global failure for sliding on liner



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



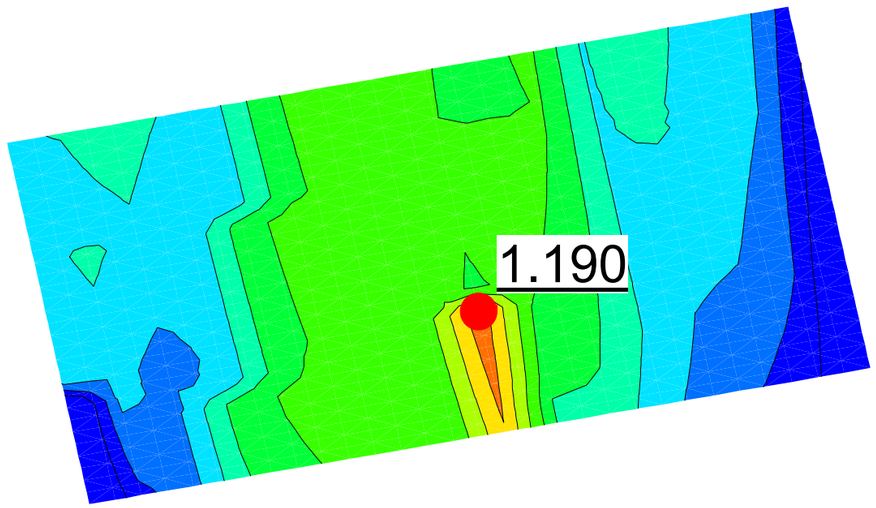
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical global failure for sliding on liner

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

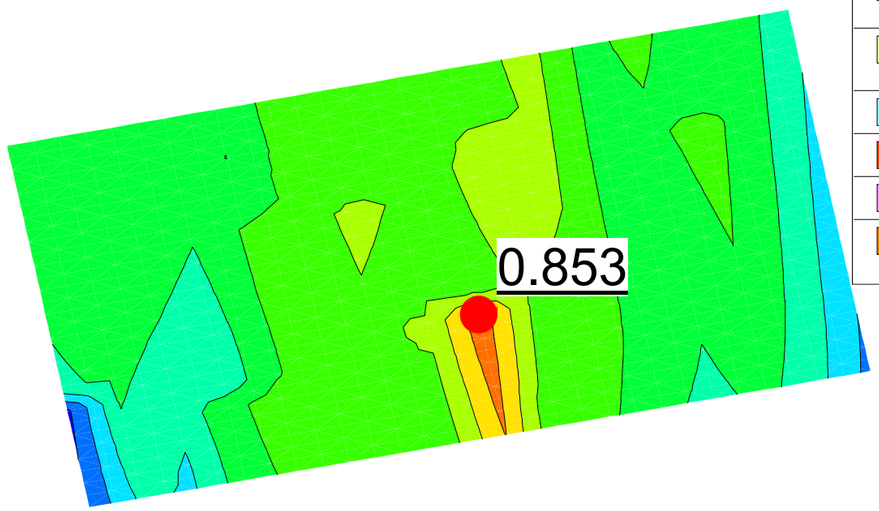


Filled - High water

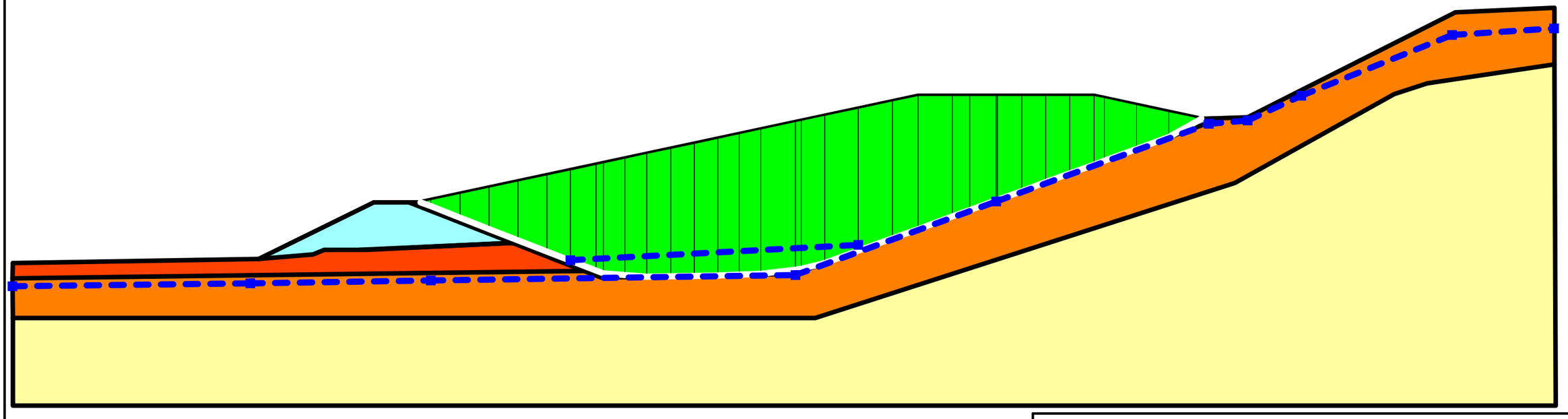
Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Critical global failure for sliding on liner



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezom Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



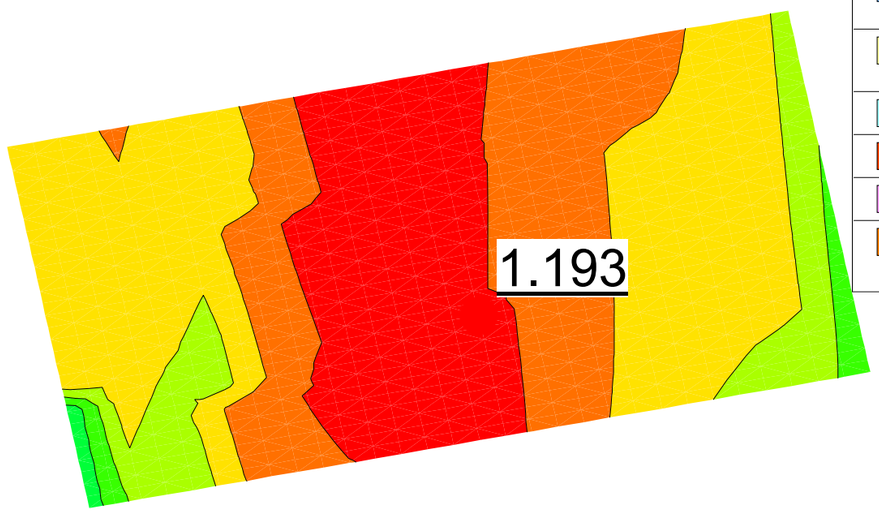
Filled - High water

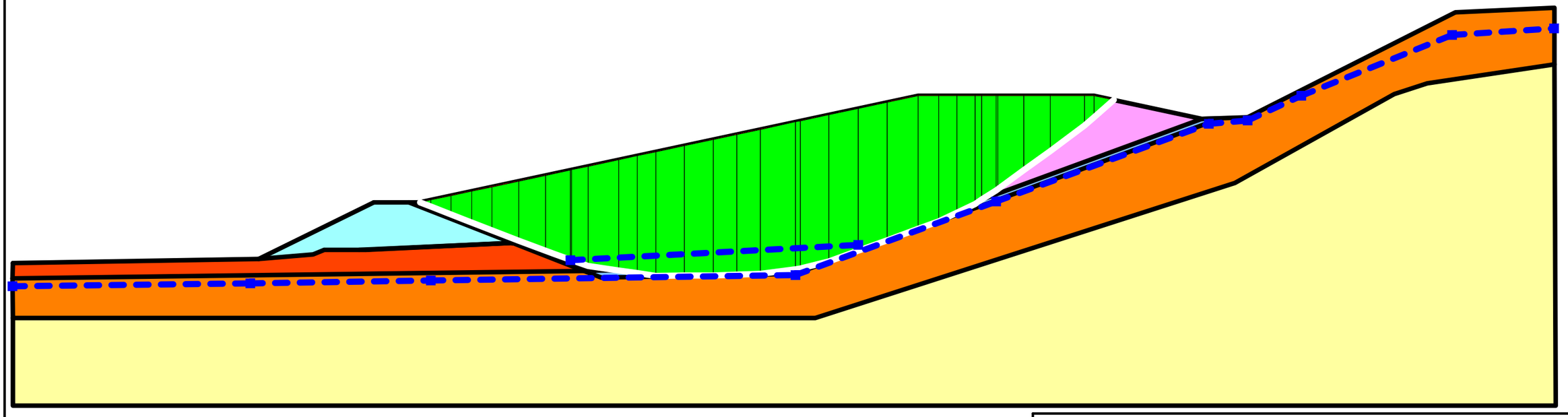
Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Critical global failure for sliding on liner- improved

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezom Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	3	18	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



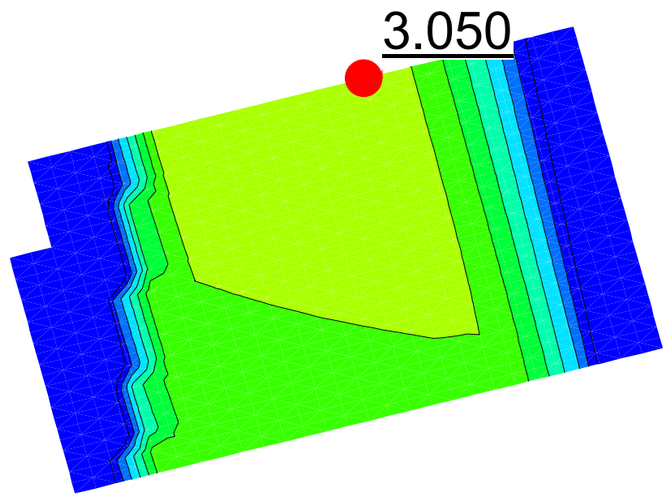


Filled - High water

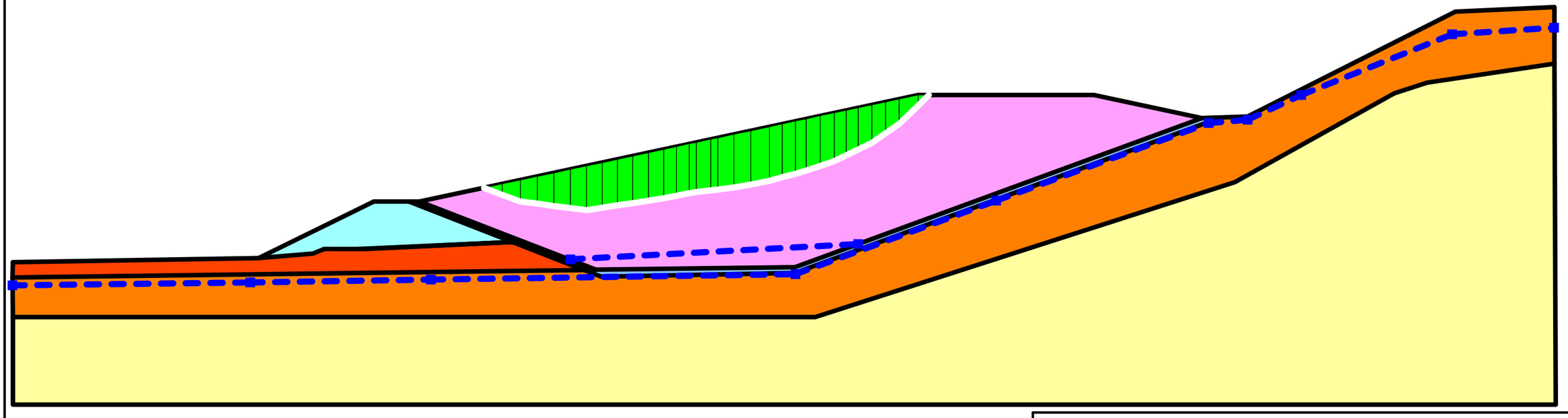
Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - No Seismic Loading
Critical global failure of waste mass



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

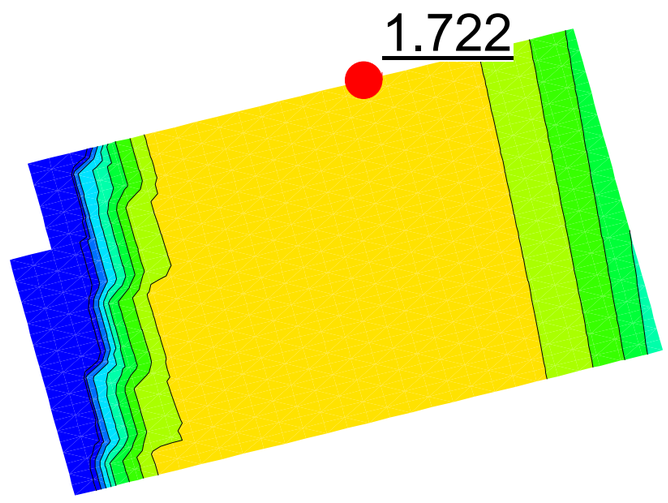


Filled - High water

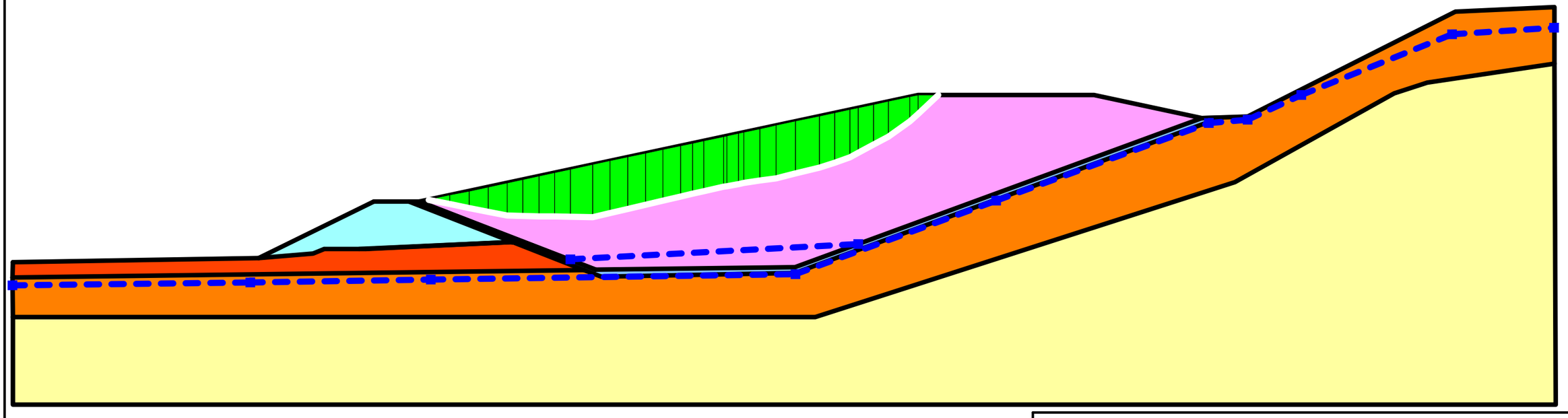
Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical global failure of waste mass



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

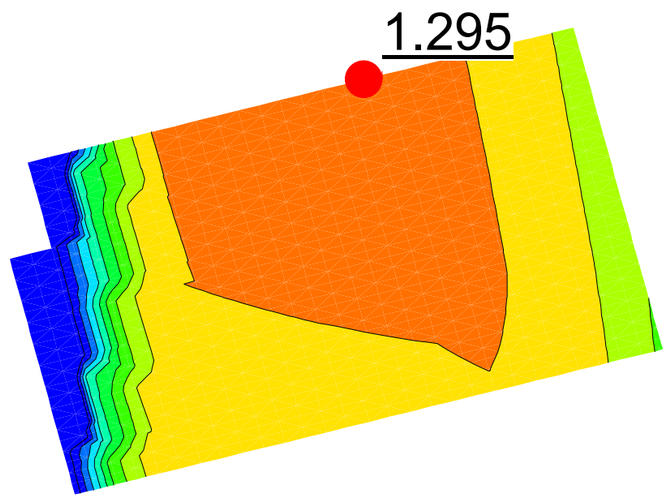


Filled - High water

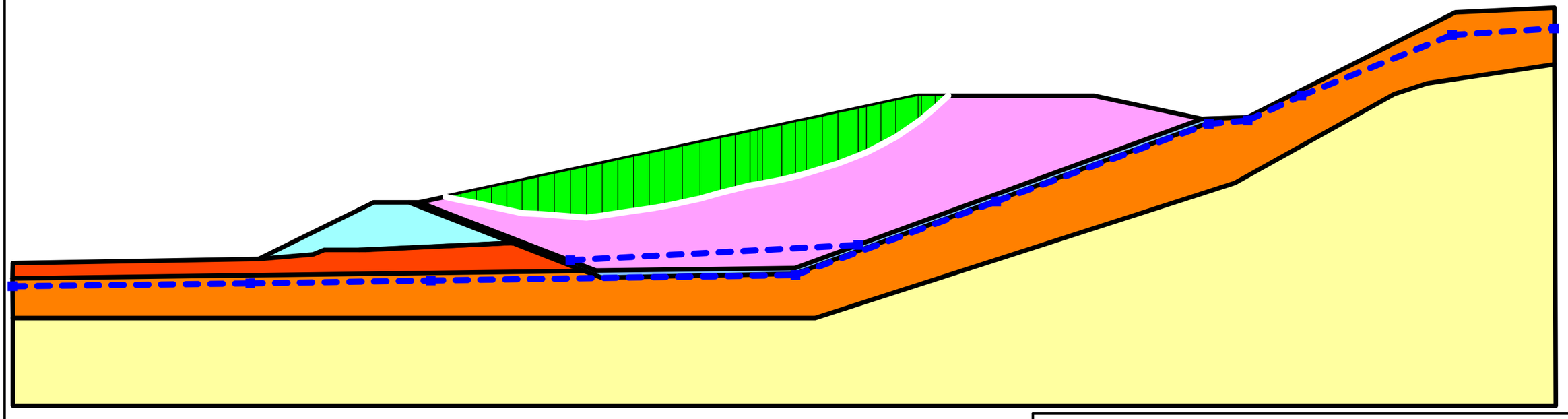
Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Critical global failure of waste mass



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



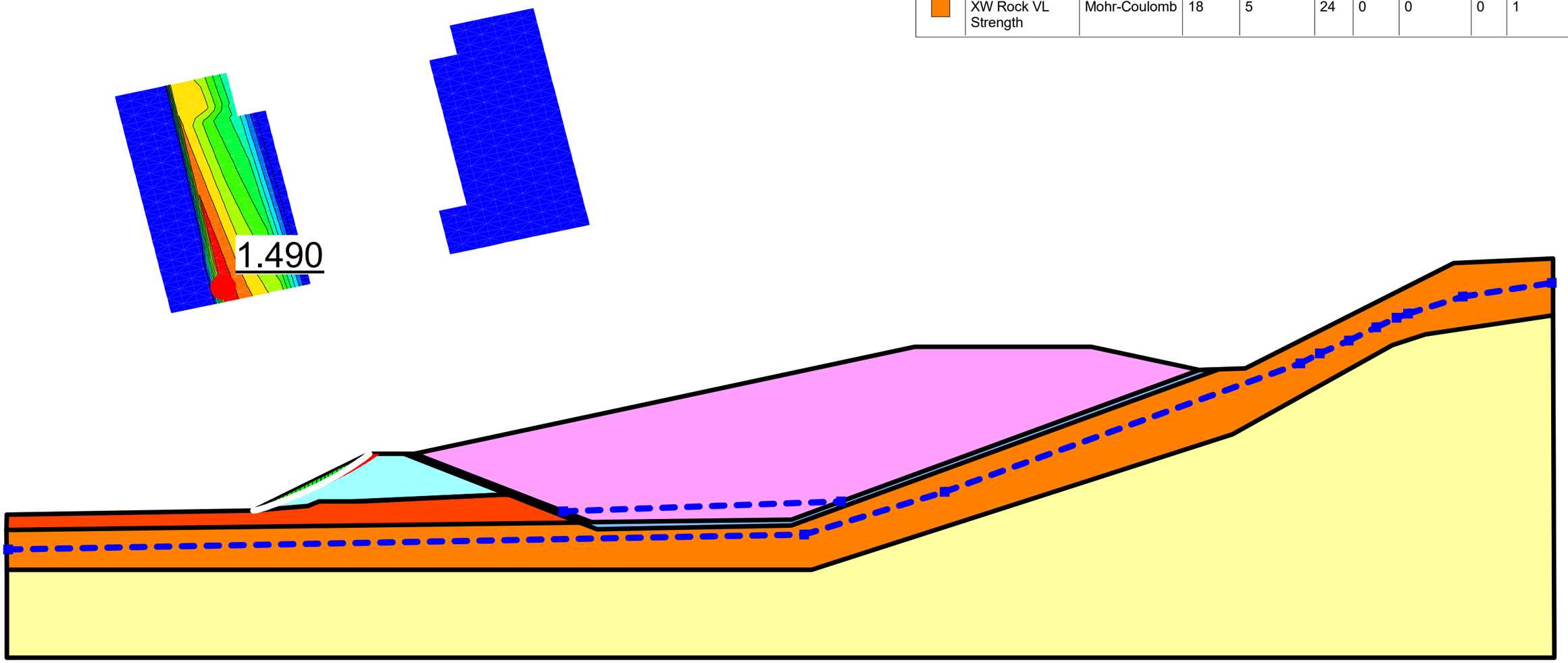
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

09-May-2019 1:74

Scenario 1 A-A - No Seismic Loading
Critical failure at toe embankment

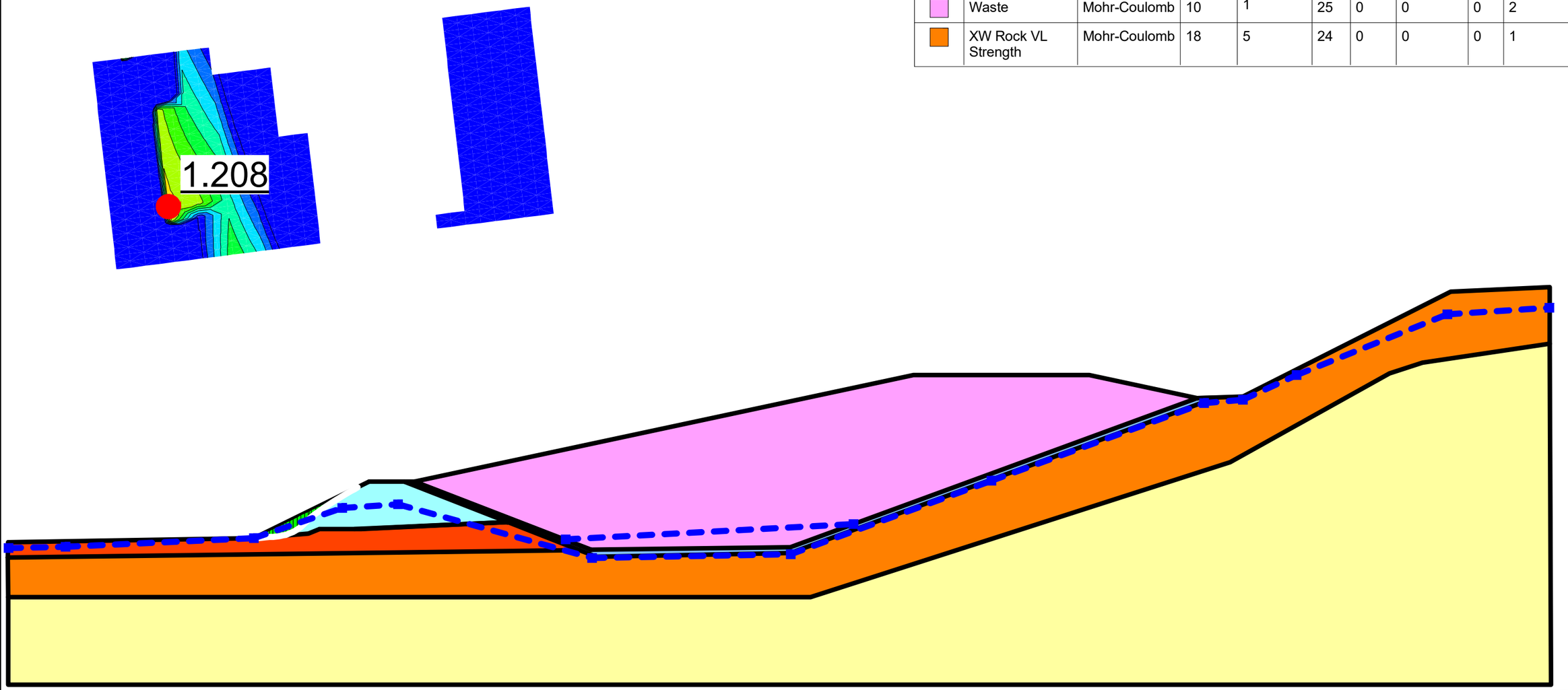
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



Filled - Normal Conditions	
Scenario 1 A-A_Filled.gsz	
08-May-2019	1:74

Scenario 1 A-A - No Seismic Loading
Critical failure at toe embankment

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



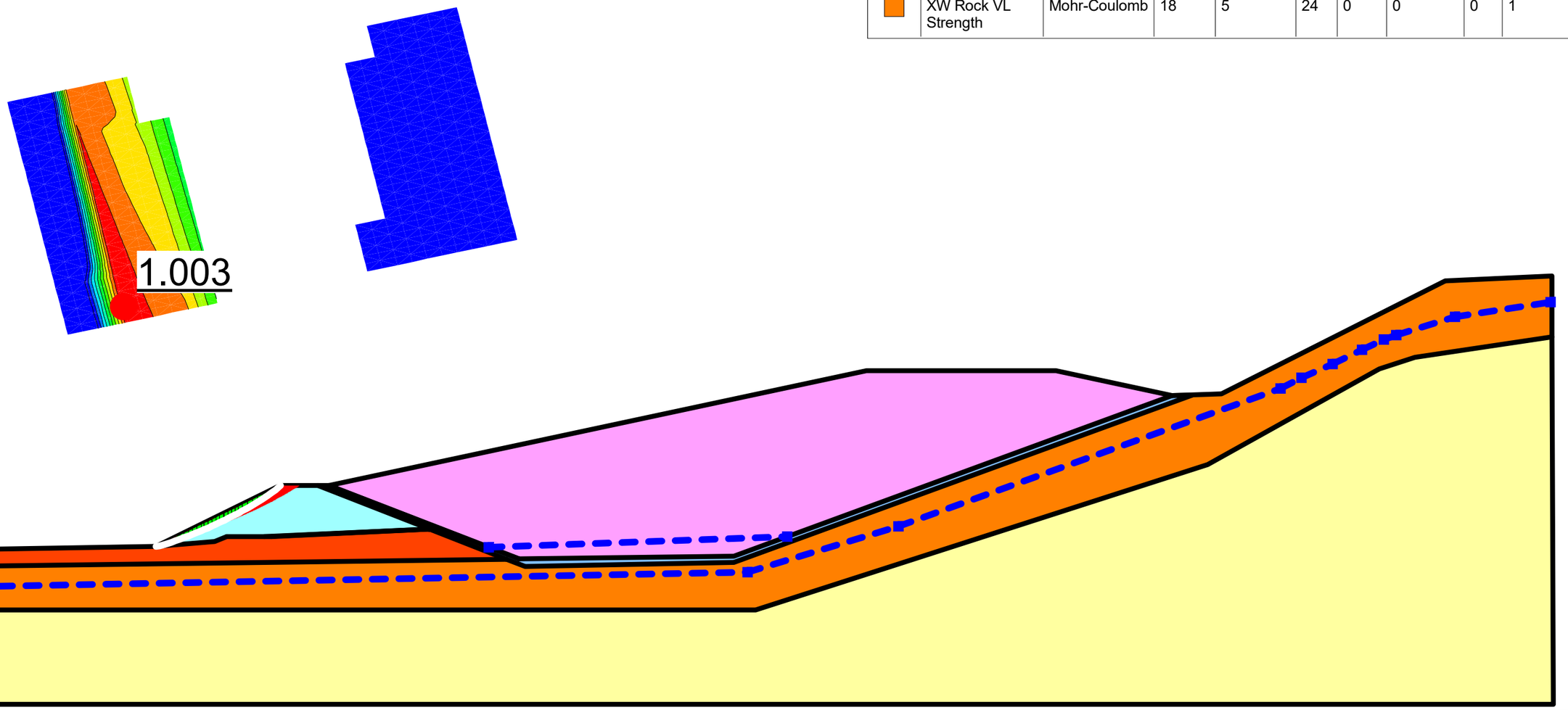
Filled - High water

Scenario 1 A-A_Filled.gsz

08-May-2019 1:74

Scenario 1 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical failure at toe embankment

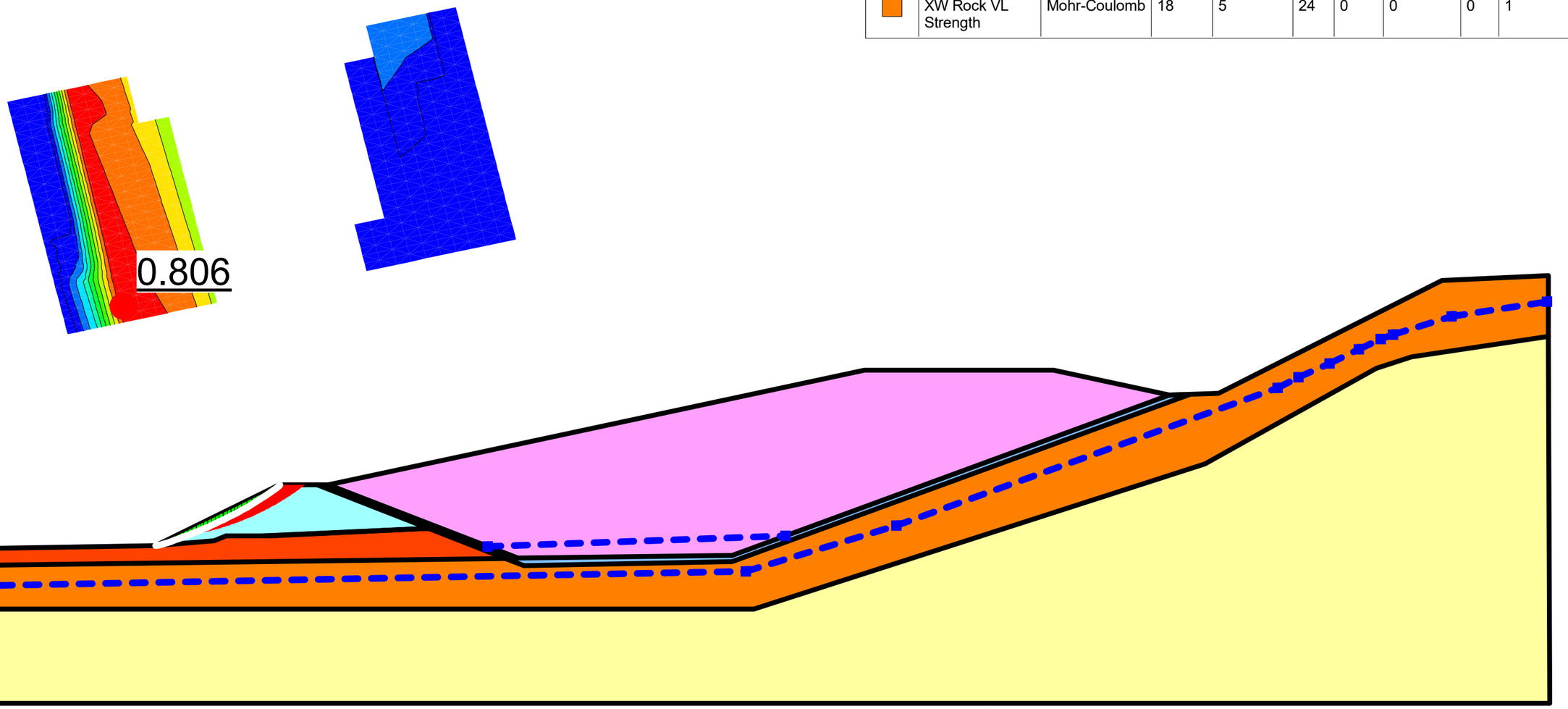
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



Filled - Normal Conditions	
Scenario 1 A-A_Filled.gsz	
08-May-2019	1:74

Scenario 1 A-A - Seismic Loading (1:2500 AEP)
Critical failure at toe embankment

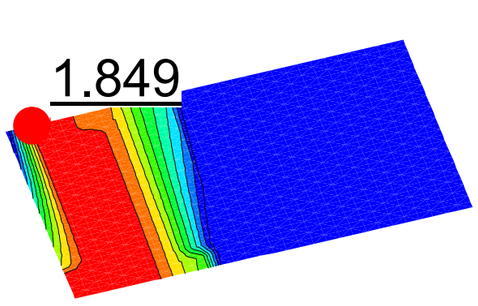
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1

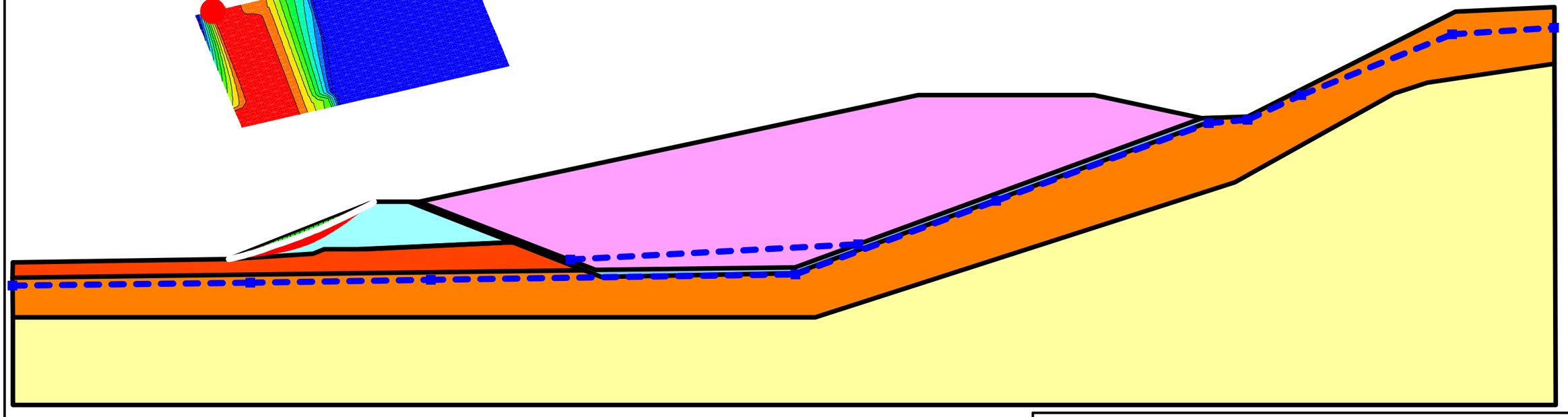


Filled - Normal Conditions	
Scenario 1 A-A_Filled.gsz	
08-May-2019	1:74

Scenario 2 A-A - No Seismic Loading
Critical global failure of toe embankment

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1





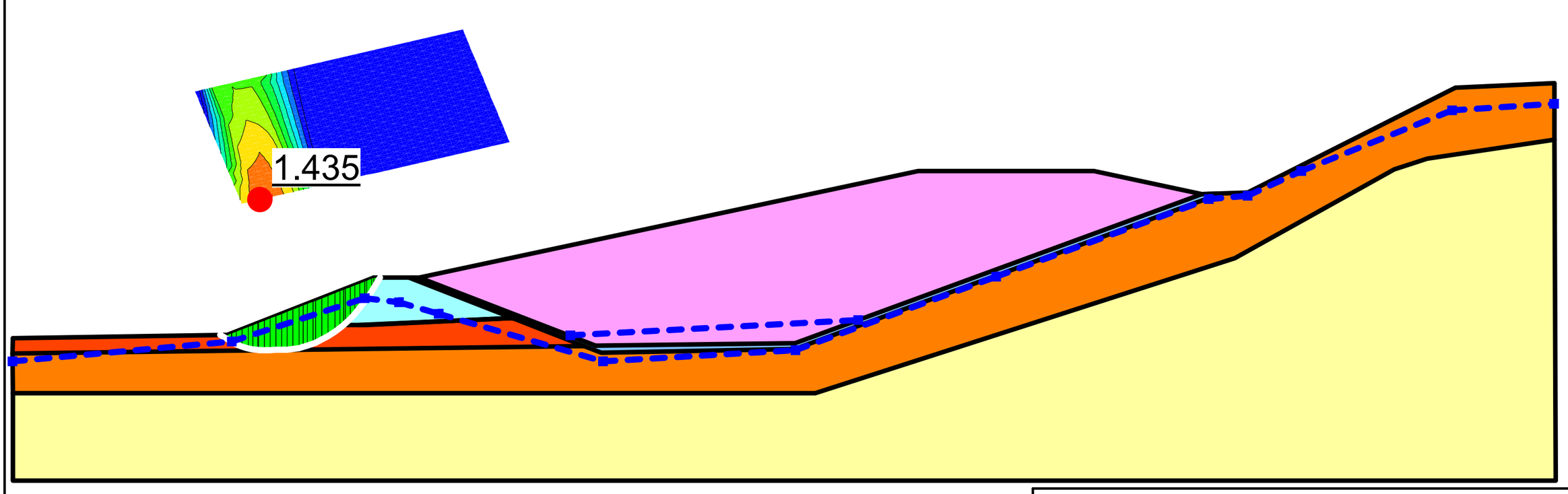
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 2 A-A - No Seismic Loading
Critical global failure of toe embankment under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



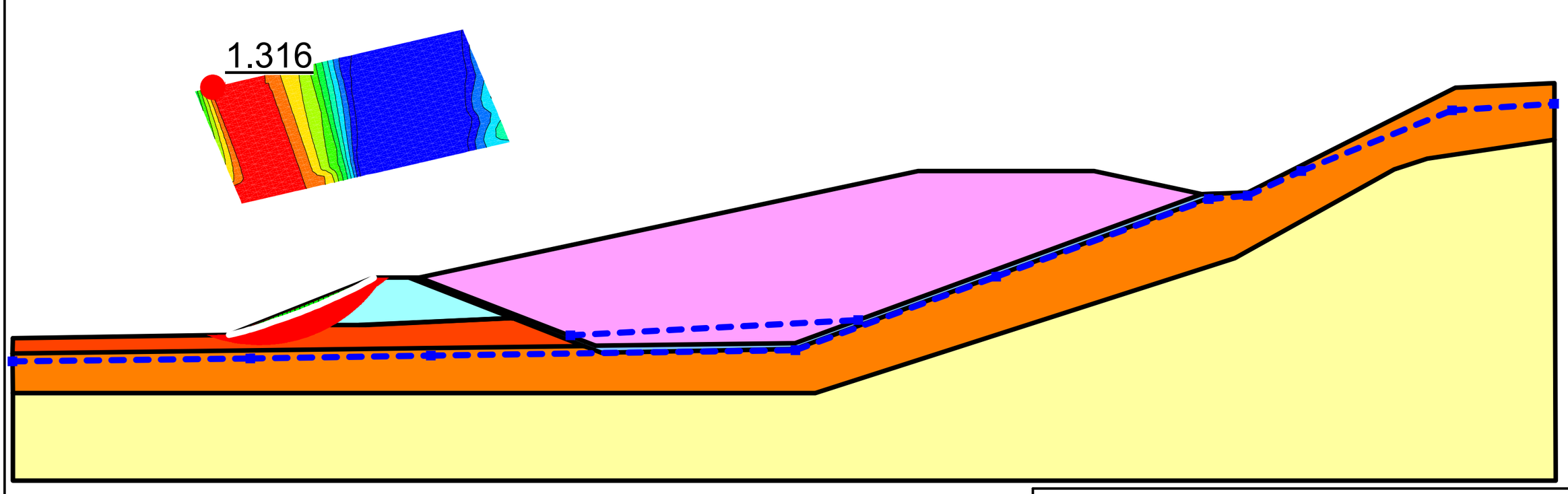
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 2 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical global failure of toe embankment

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



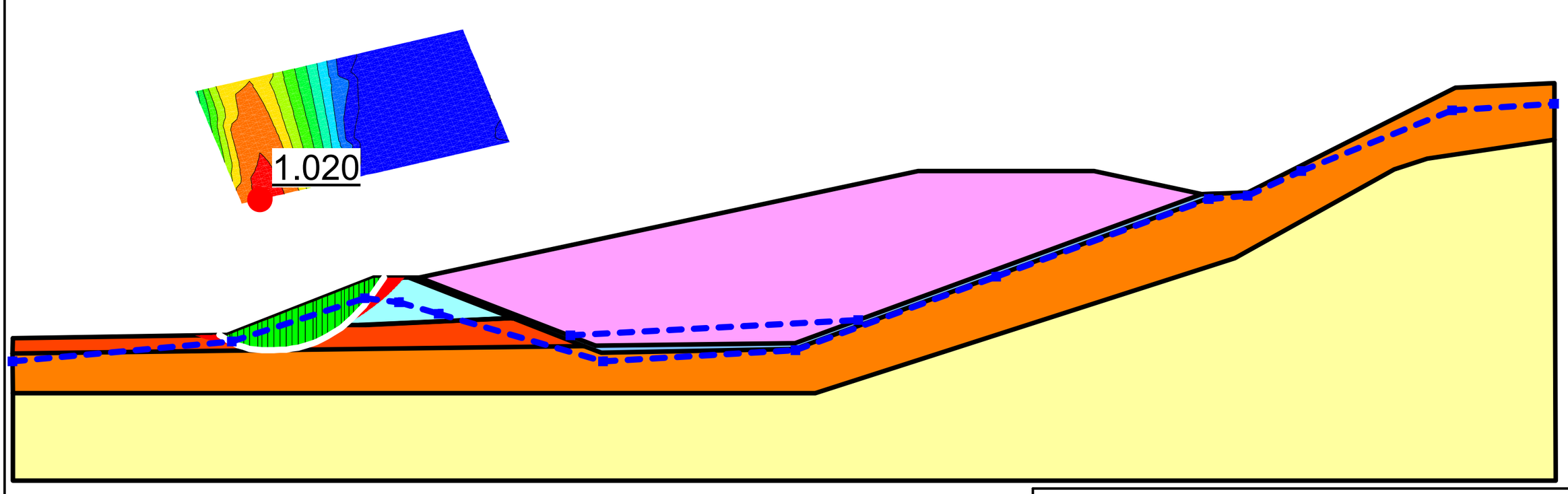
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 2 A-A - Seismic Loading (OBE - 1:500 AEP)
Critical global failure of toe embankment under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



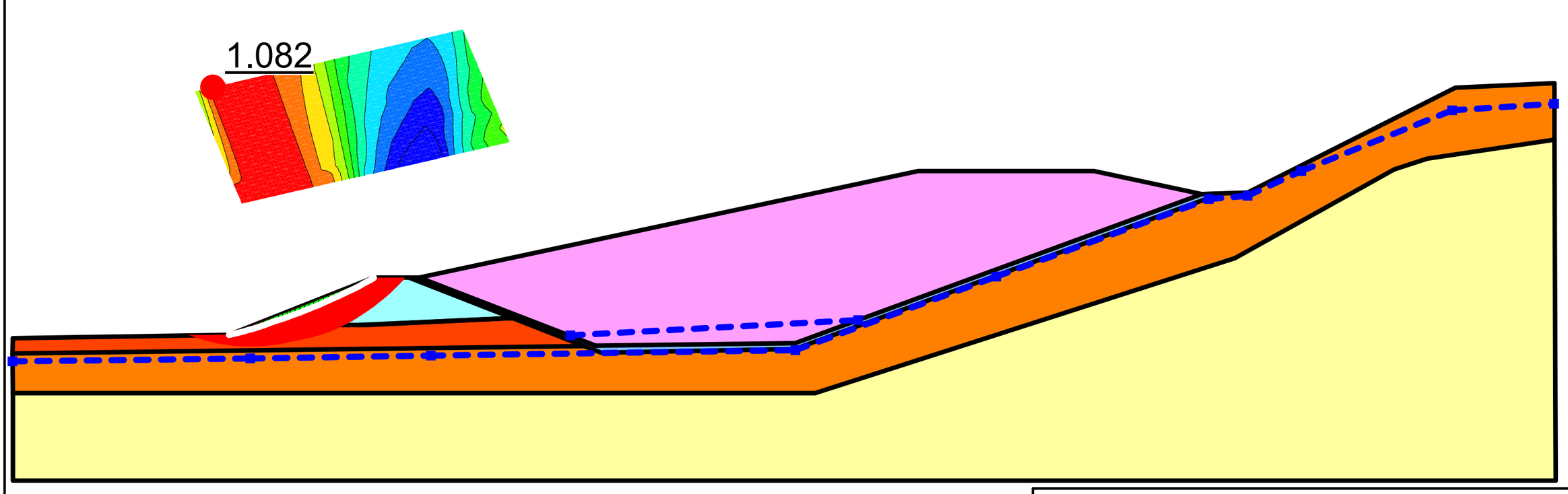
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 2 A-A - Seismic Loading (1:2500 AEP)
Critical global failure of toe embankment

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



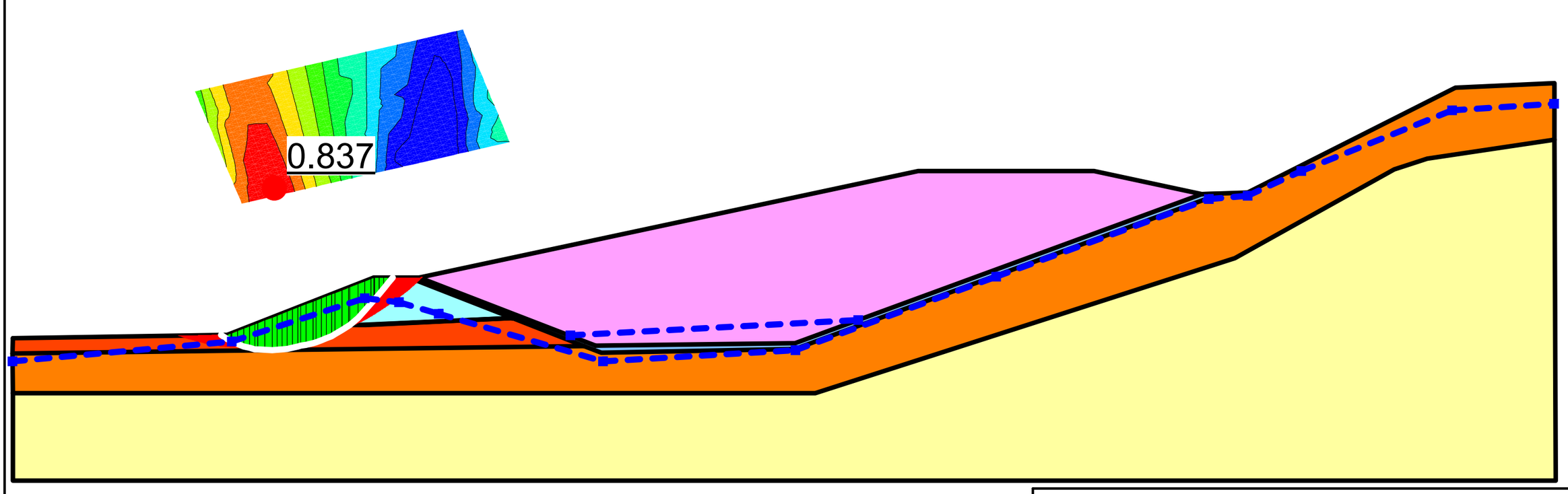
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 2 A-A - Seismic Loading (1:2500 AEP)
Critical global failure of toe embankment under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



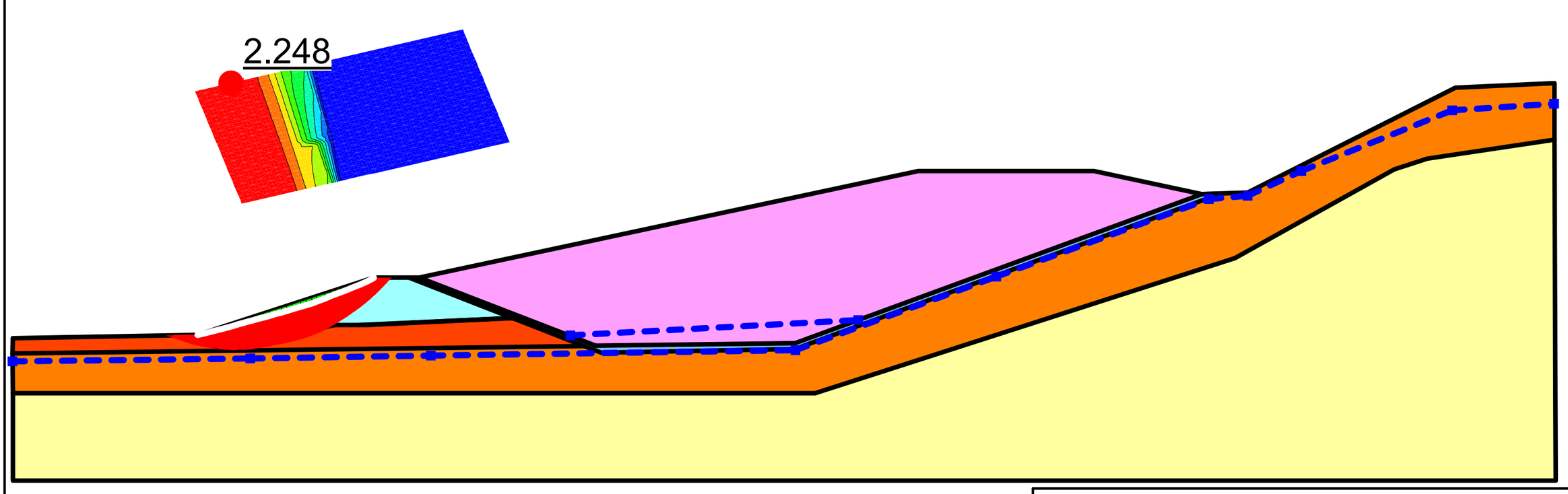
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 3 A-A - No Seismic Loading
Critical global failure of toe embankment

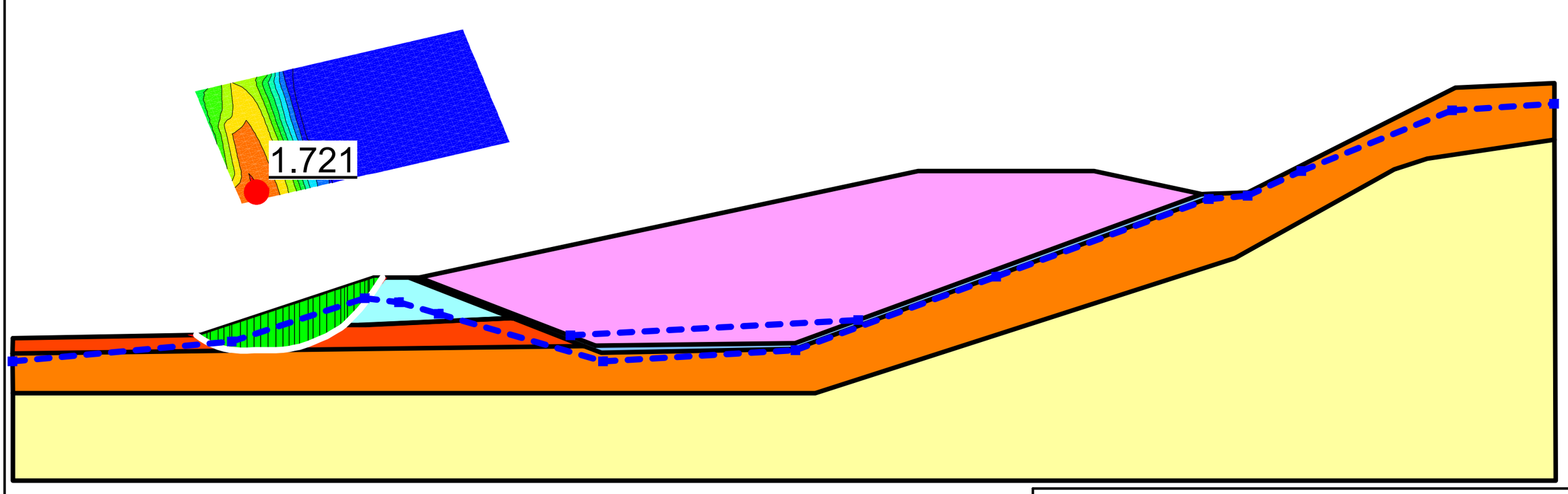
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



Filled - High water	
Scenario 1 A-A_Filled_Seismic.gsz	
13-May-2019	1:74

Scenario 3 A-A - No Seismic Loading
Critical global failure of toe embankment under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	Waste	Mohr-Coulomb	10	1	25	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



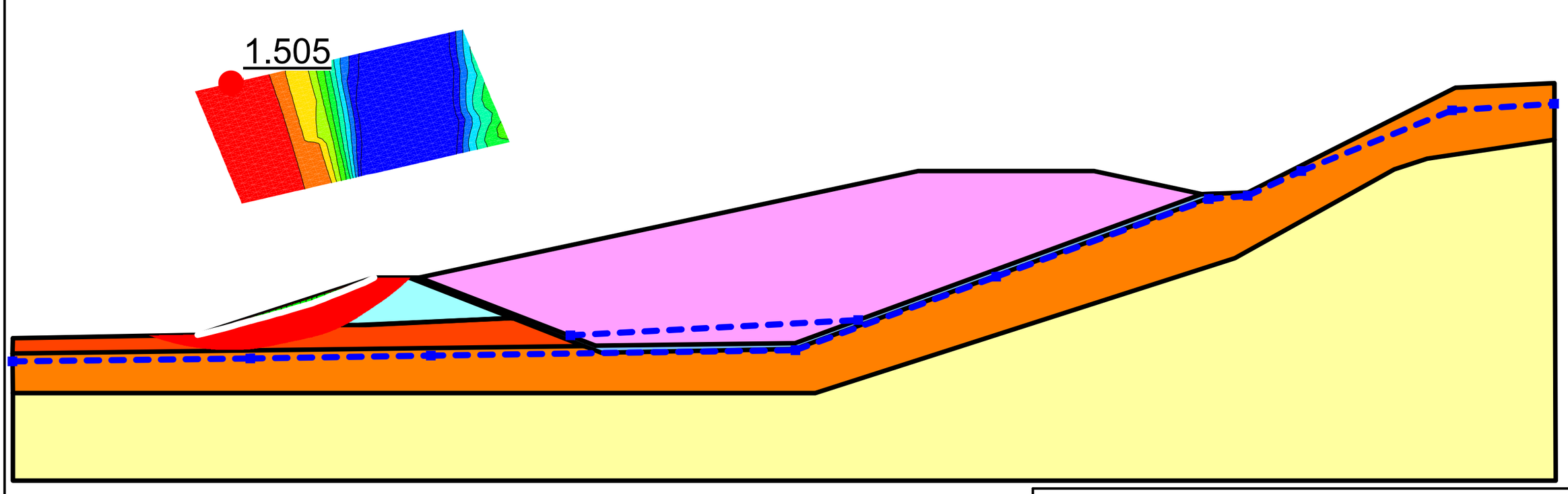
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 3 A-A - Seismic Loading (OBE 1:500 AEP)
Critical global failure of toe embankment

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



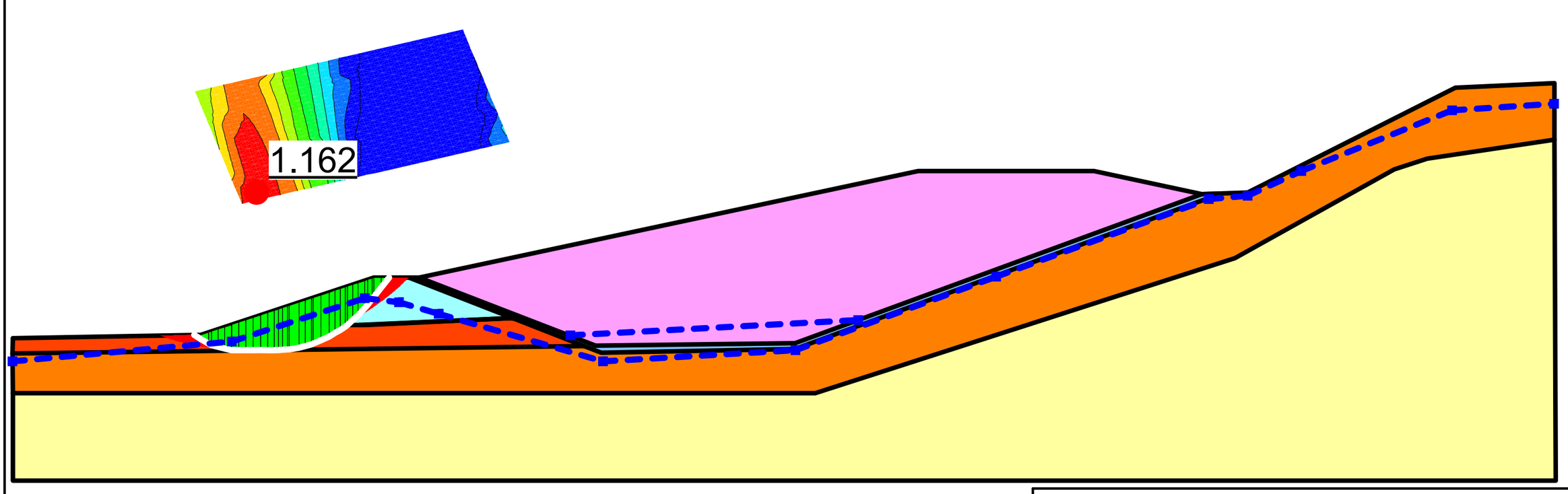
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 3 A-A - Seismic Loading (OBE 1:500 AEP)
Critical global failure of toe embankment under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



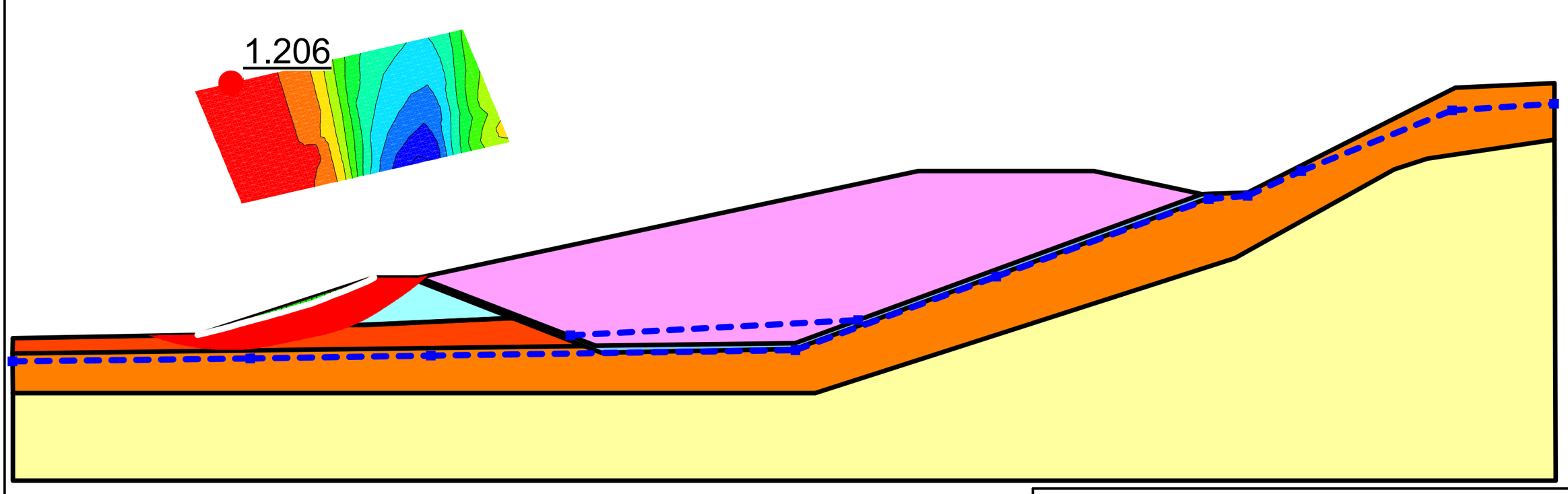
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 3 A-A - Seismic Loading (1:2500 AEP)
Critical global failure of toe embankment

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



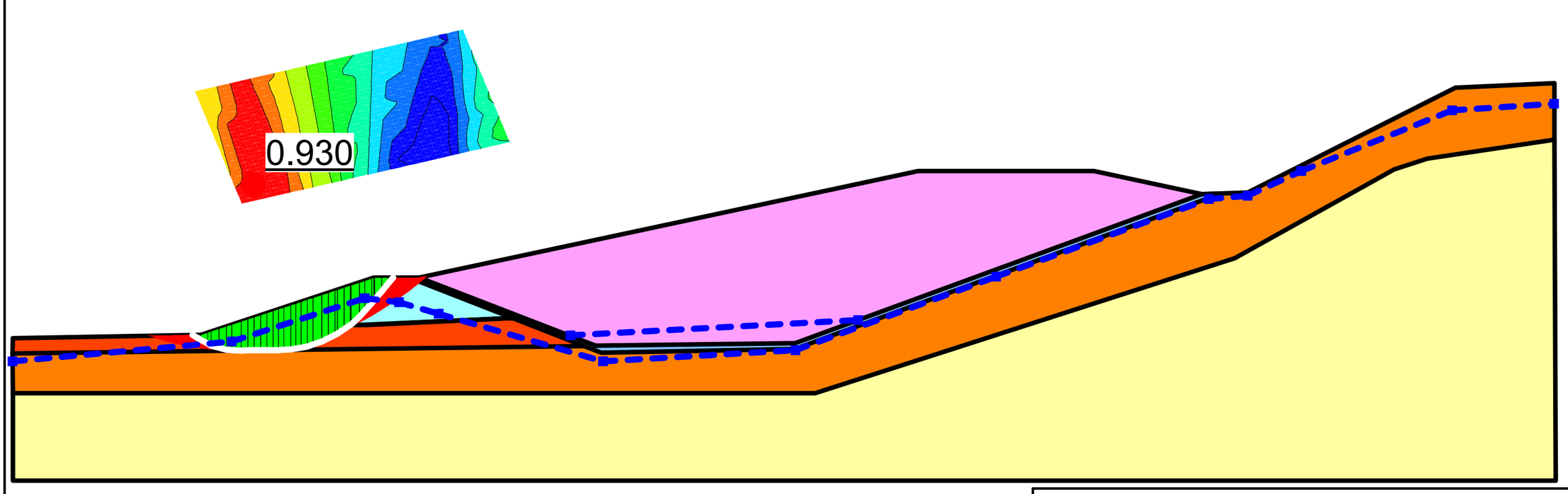
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 3 A-A - Seismic Loading (1:2500 AEP)
Critical global failure of toe embankment under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



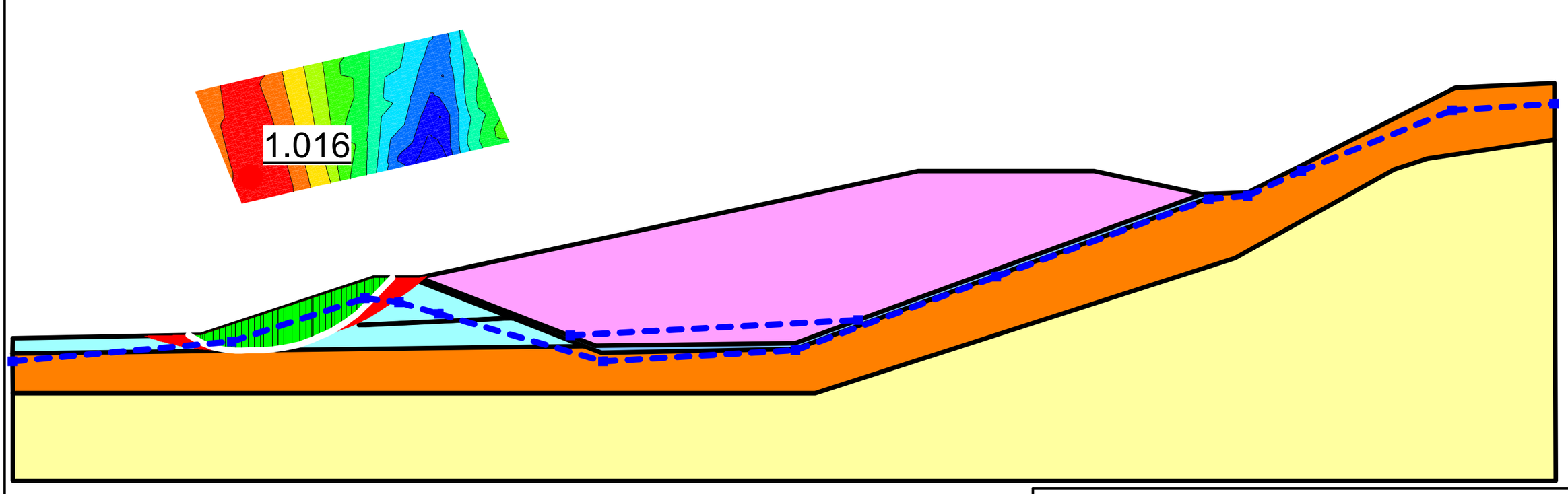
Filled - High water

Scenario 1 A-A_Filled_Seismic.gsz

13-May-2019 1:74

Scenario 3 A-A - Seismic Loading (1:2500 AEP)
Critical global failure of toe embankment under high water conditions - improved

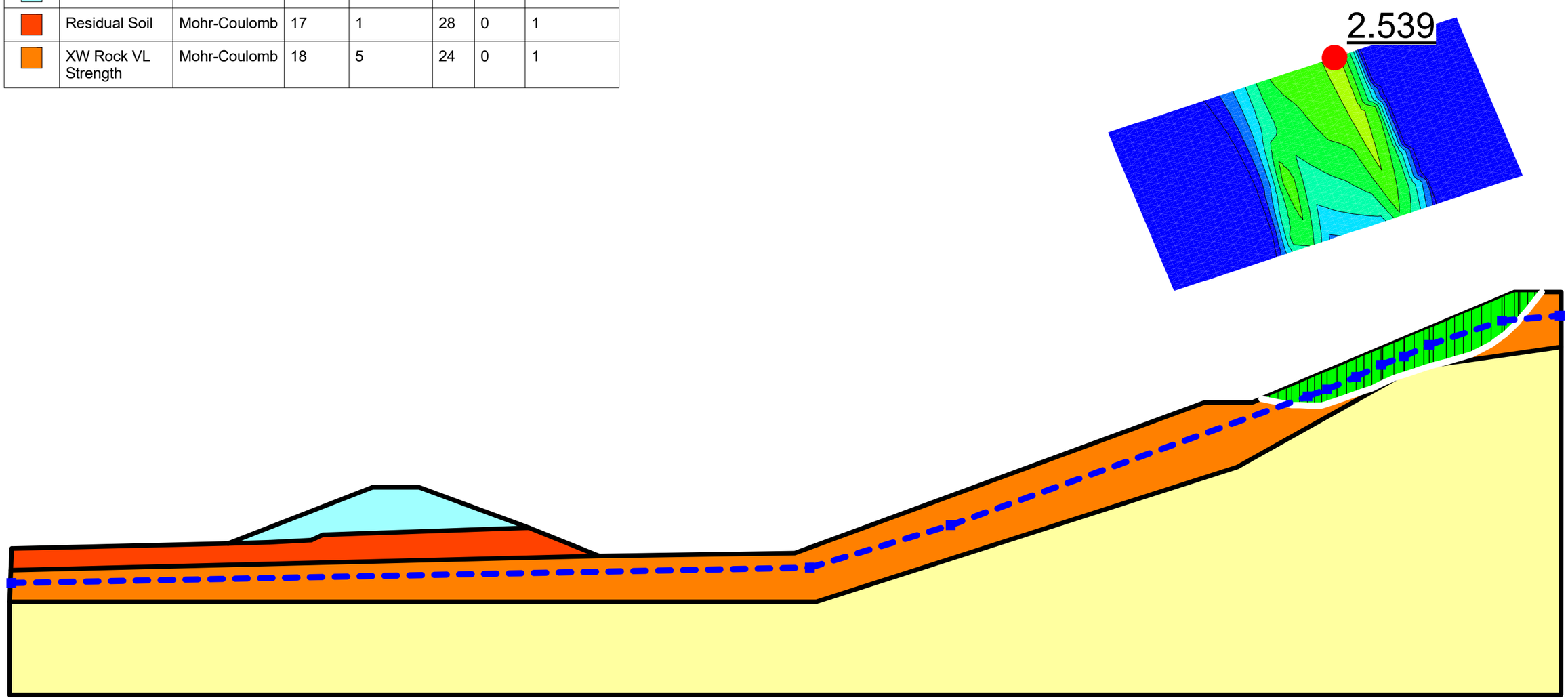
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion R (kPa)	Phi R (°)	Piezometric Line
	Compacted Clay Liner + HDPE	Mohr-Coulomb	19	1	14	0	0	0	1
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	0	0	1
	Fill	Mohr-Coulomb	19	0	36	0	0	0	1
	Waste	Mohr-Coulomb	10	1	25	0	0	0	2
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	0	0	1



Filled - High water	
Scenario 1 A-A_Filled_Seismic.gsz	
13-May-2019	1:74

Scenario 2 A-A No Seismic Loading
Critical failure for top batter sidewall prior to filling under normal conditions

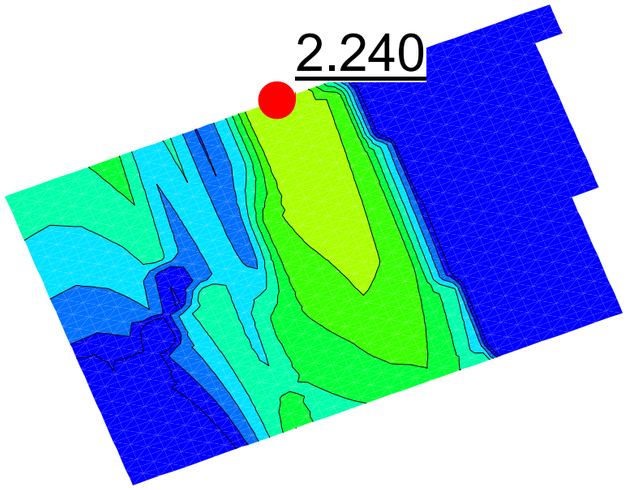
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

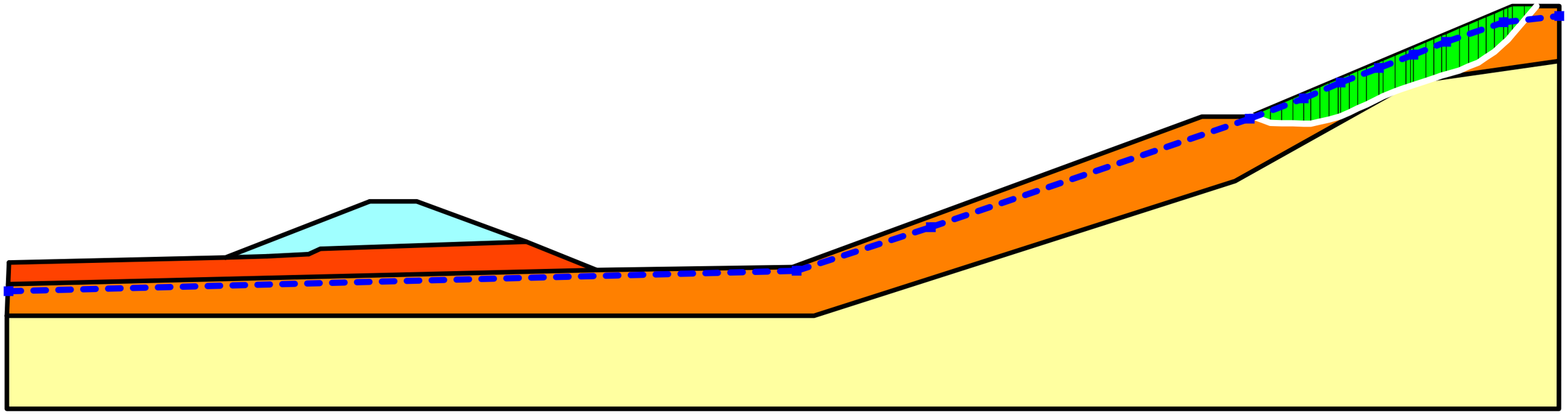


Normal Conditions
Scenario 2 A-A.gsz
08-May-2019 1:74

Scenario 2 A-A No Seismic Loading
Critical failure for top batter sidewall prior to filling under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

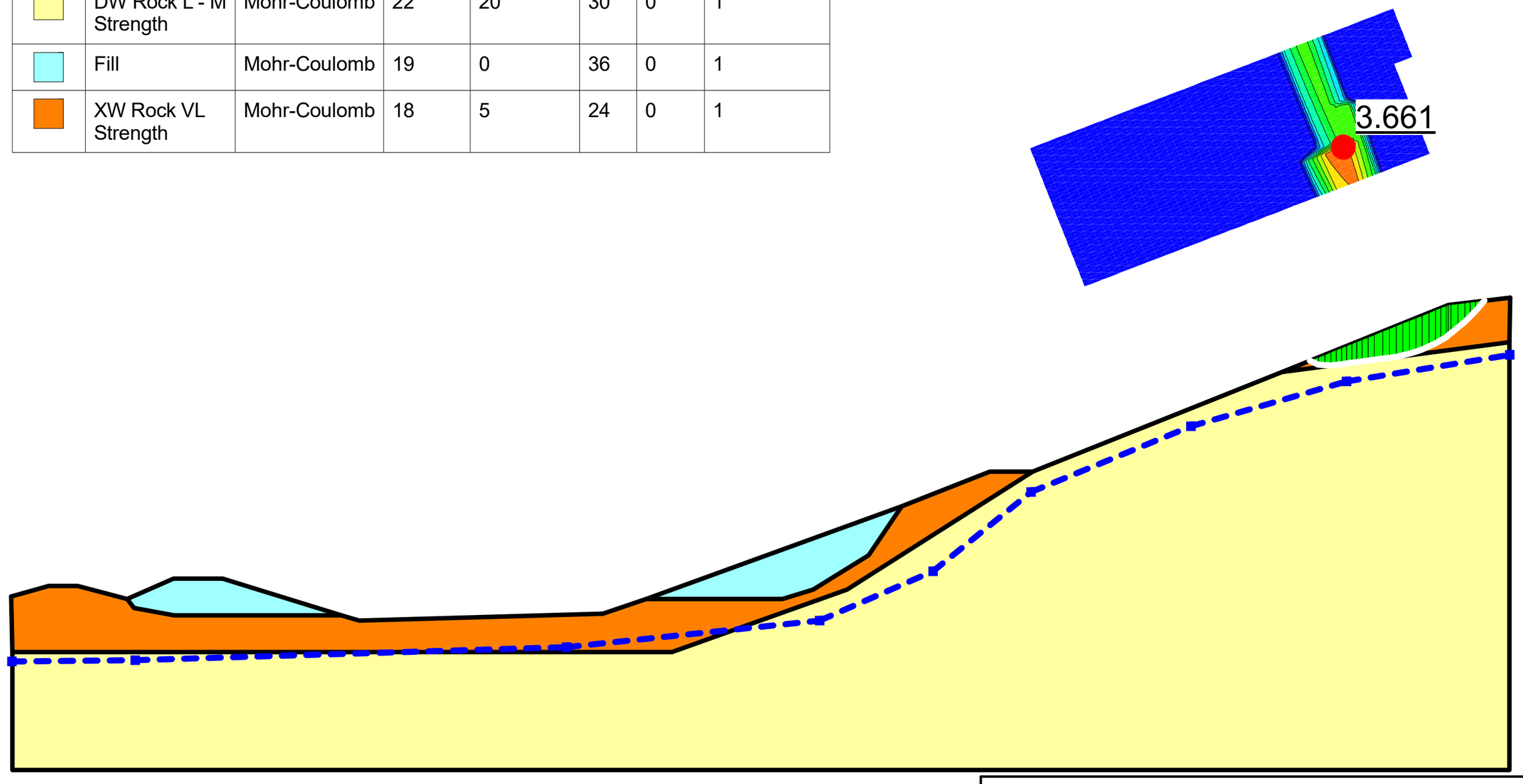




High water	
Scenario 2 A-A.gsz	
08-May-2019	1:74

Scenario 2 B-B - No Seismic Loading
Critical failure within top batter prior to filling under normal conditions

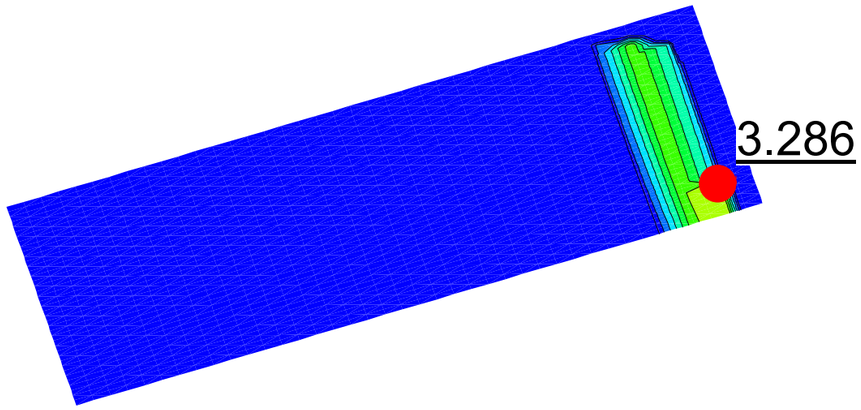
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

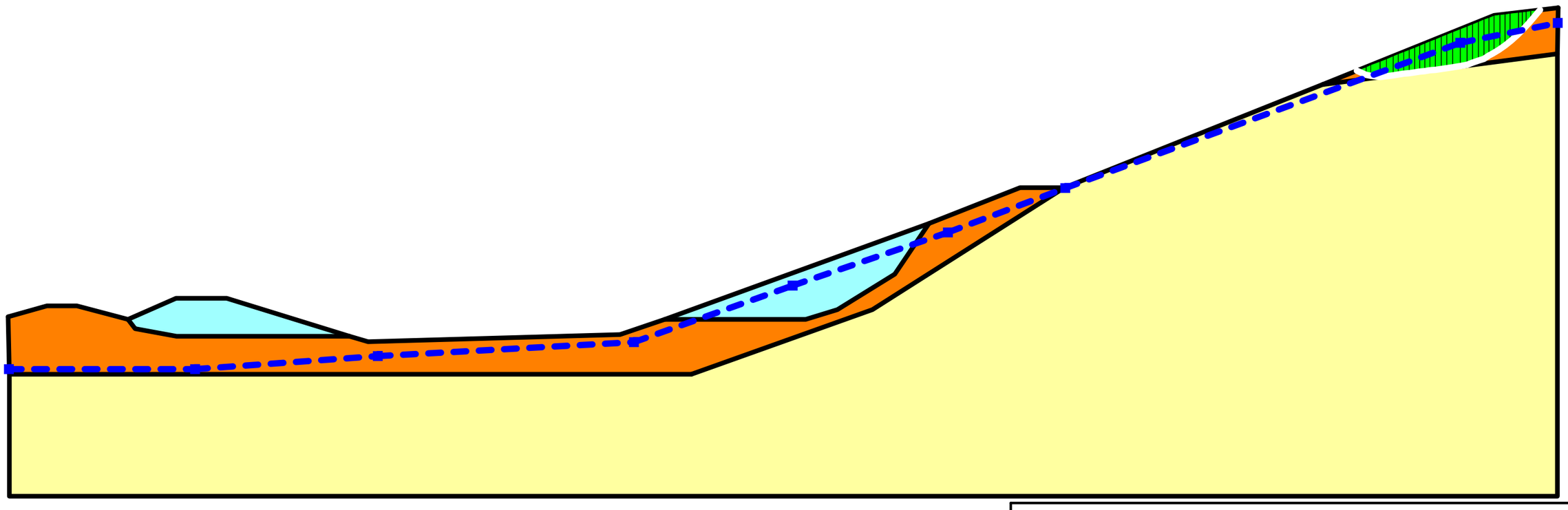


Normal Conditions
Scenario 2 B-B.gsz
08-May-2019 1:81

Scenario 2 B-B - No Seismic Loading
Critical failure within top batter prior to filling under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

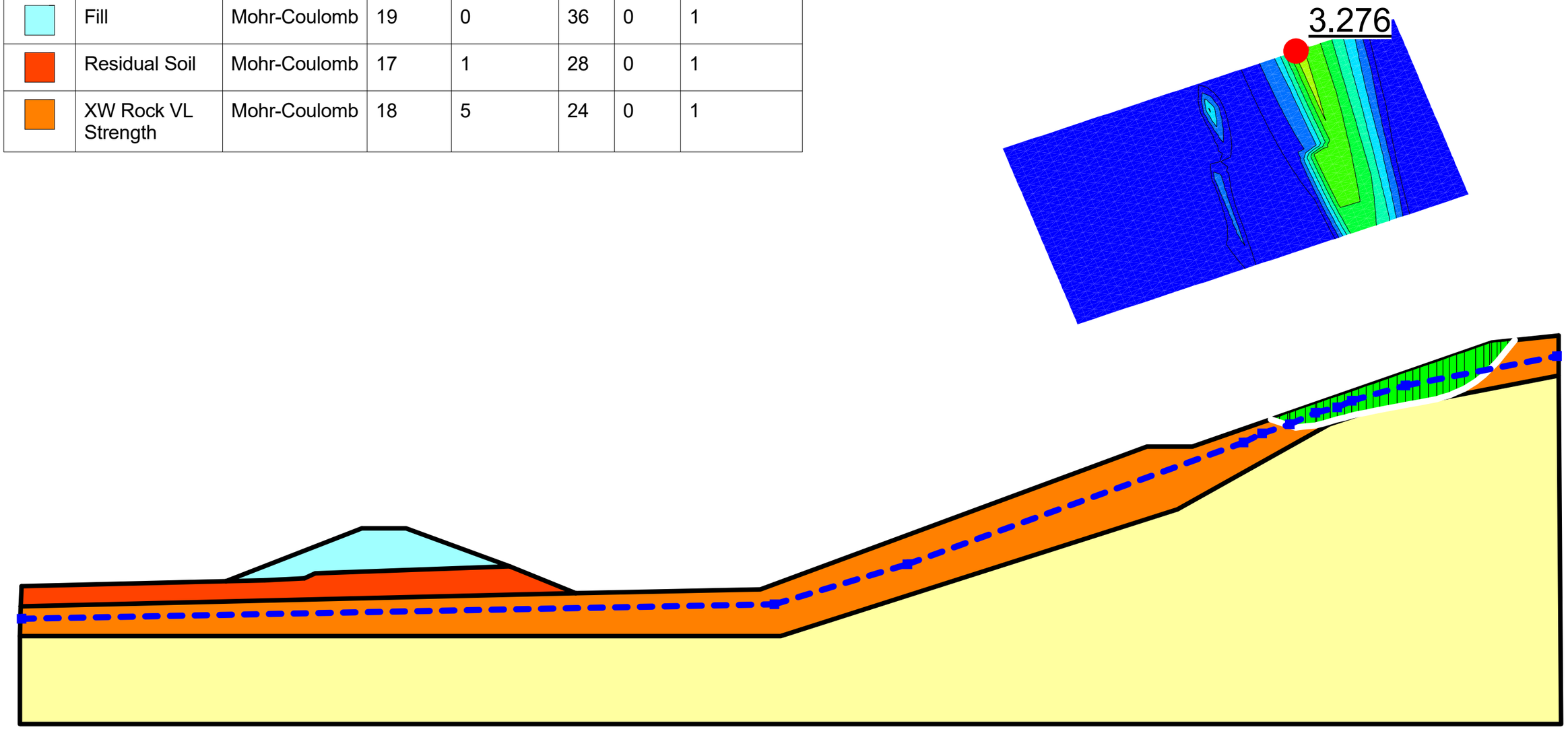




High water	
Scenario 2 B-B.gsz	
08-May-2019	1:81

Scenario 3 A-A - No Seismic Loading
Critical failure within top batter prior to filling under normal conditions

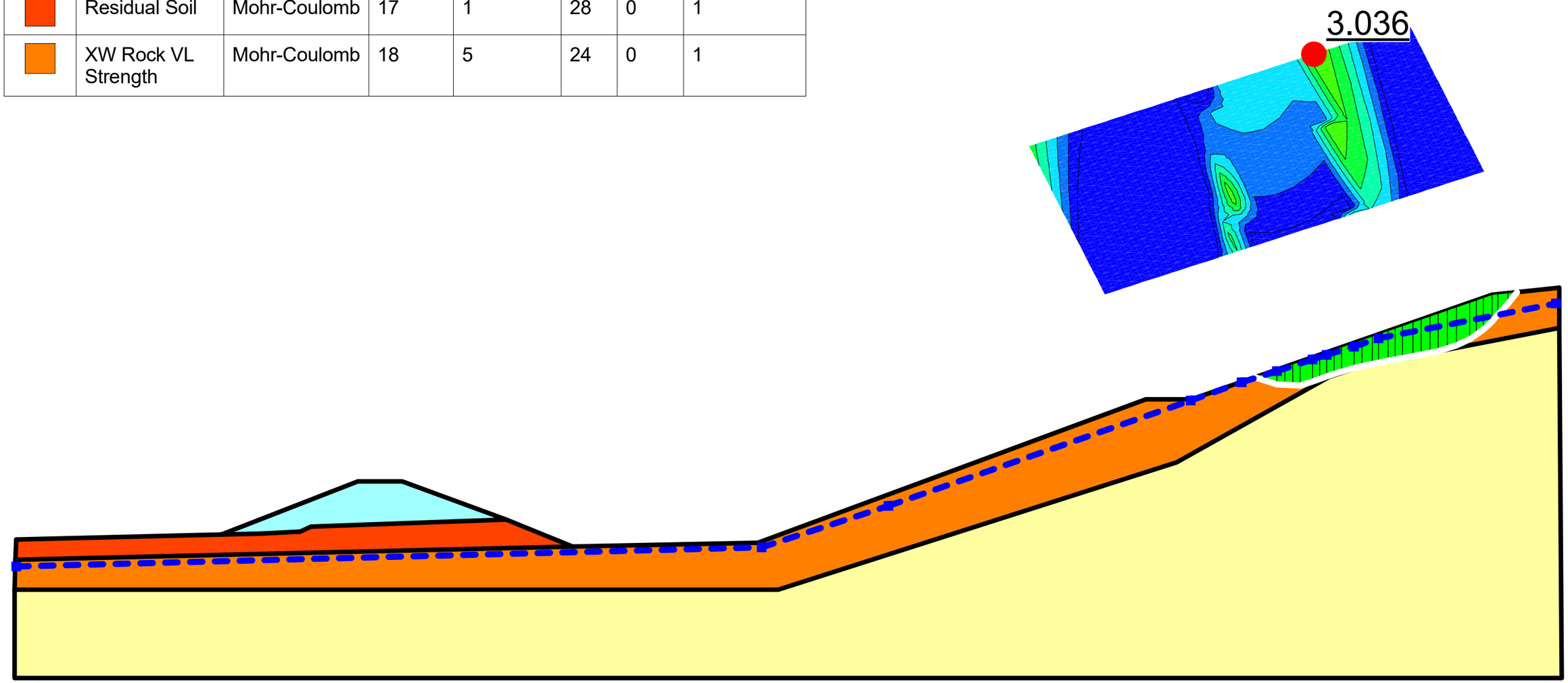
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



Normal Conditions
Scenario 3 A-A.gsz
08-May-2019 1:78

Scenario 3 A-A - No Seismic Loading
Critical failure within top batter prior to filling under high water conditions

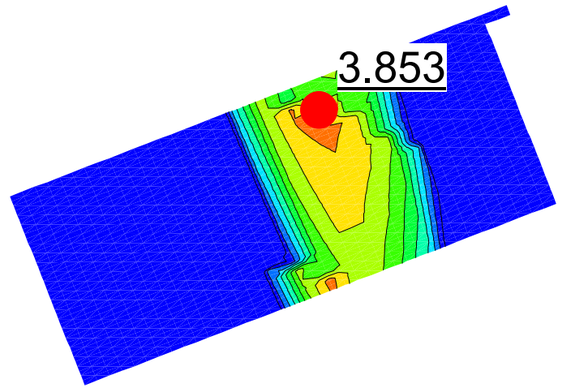
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	Residual Soil	Mohr-Coulomb	17	1	28	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

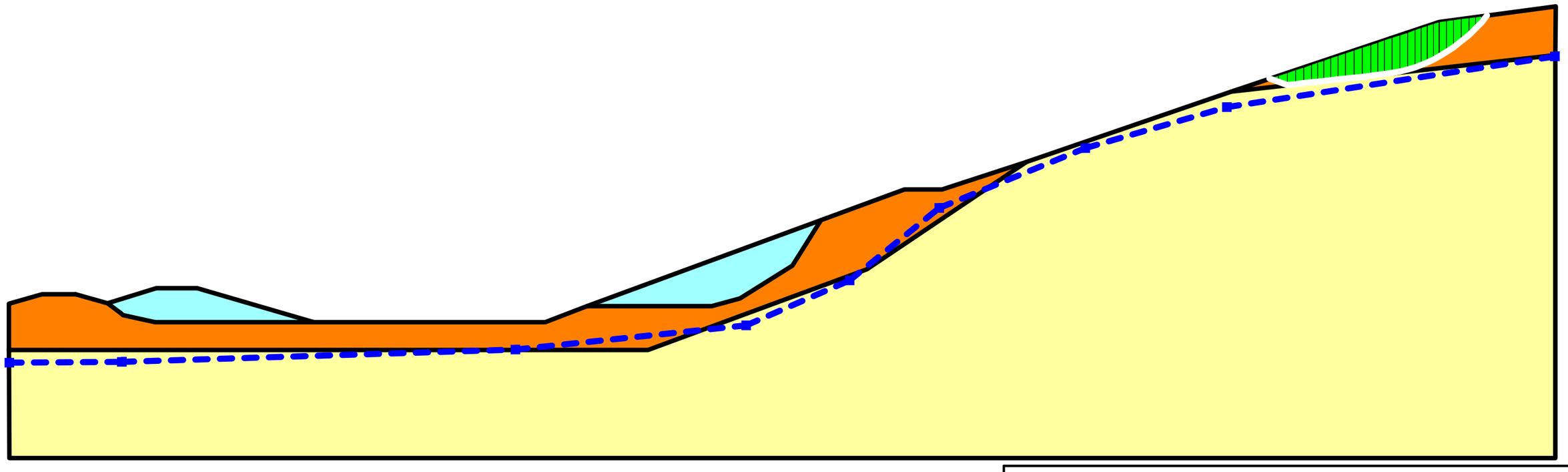


High water	
Scenario 3 A-A.gsz	
08-May-2019	1:78

Scenario 3 B-B - No Seismic Loading
Critical failure within top batter prior to filling under normal conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1

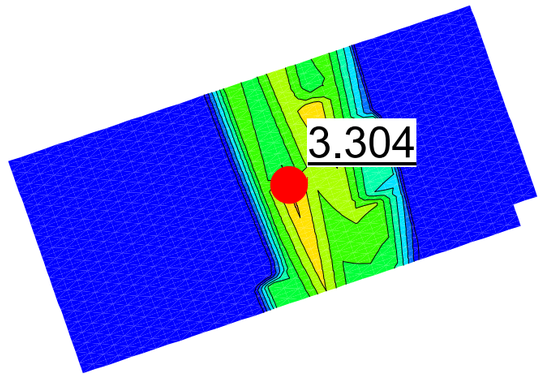


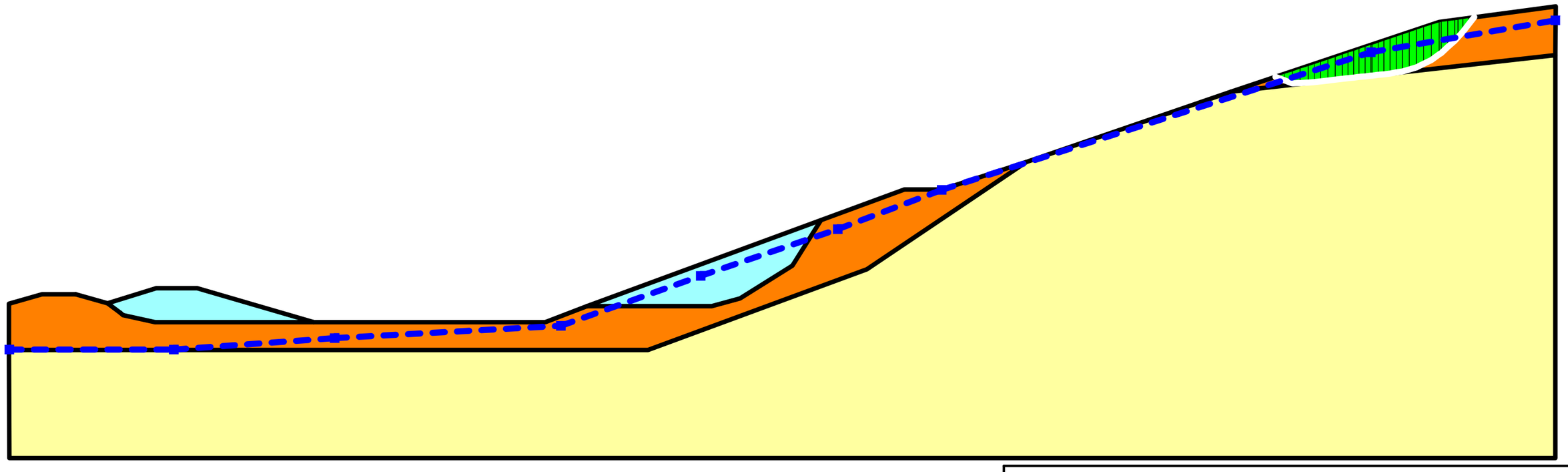


Normal Conditions
Scenario 3 B-B.gsz
08-May-2019 1:89

Scenario 3 B-B - No Seismic Loading
Critical failure within top batter prior to filling under high water conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	DW Rock L - M Strength	Mohr-Coulomb	22	20	30	0	1
	Fill	Mohr-Coulomb	19	0	36	0	1
	XW Rock VL Strength	Mohr-Coulomb	18	5	24	0	1



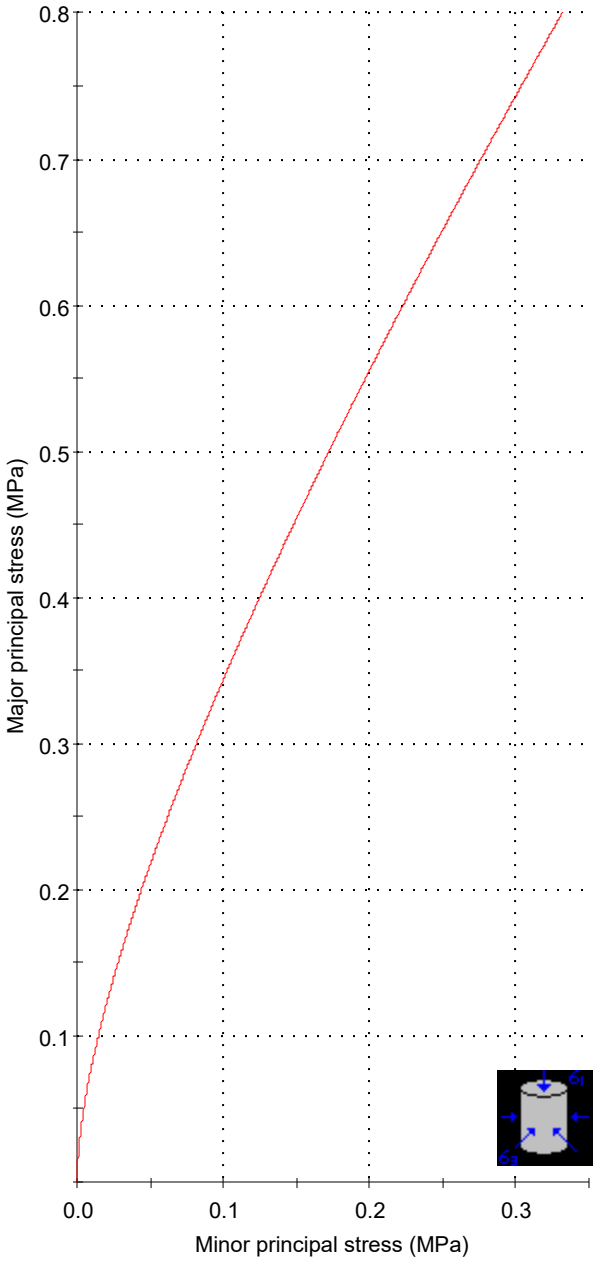


High water	
Scenario 3 B-B.gsz	
08-May-2019	1:89

APPENDIX C

Material Strength Parameters

Analysis of Rock Strength using RocLab

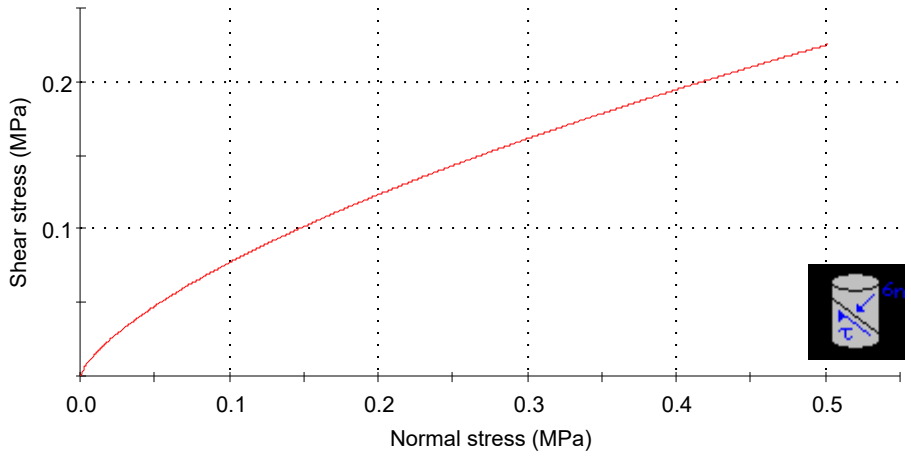


Hoek-Brown Classification
intact uniaxial compressive strength = 1 MPa
GSI = 20 mi = 13 Disturbance factor = 0

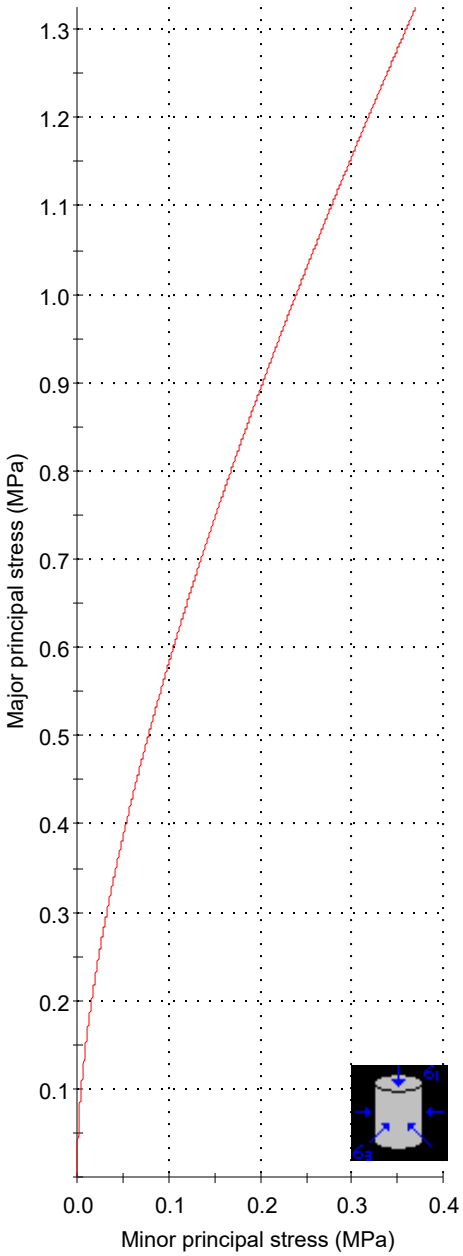
Hoek-Brown Criterion
mb = 0.747 s = 0.0001 a = 0.544

Mohr-Coulomb Fit
cohesion = 0.037 MPa friction angle = 21.68 deg

Rock Mass Parameters
tensile strength = -0.000185 MPa
uniaxial compressive strength = 0.008 MPa
global strength = 0.094 MPa
modulus of deformation = 177.83 MPa



Analysis of Rock Strength using RocLab

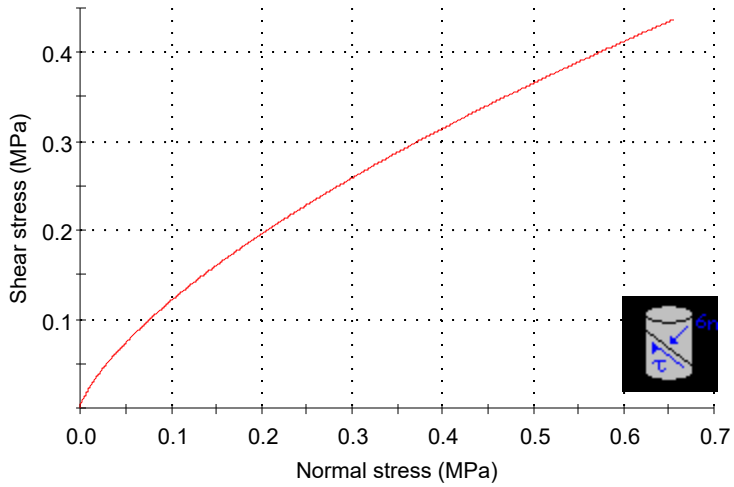


Hoek-Brown Classification
intact uniaxial compressive strength = 2.5 MPa
GSI = 30 mi = 13 Disturbance factor = 0

Hoek-Brown Criterion
mb = 1.067 s = 0.0004 a = 0.522

Mohr-Coulomb Fit
cohesion = 0.068 MPa friction angle = 30.81 deg

Rock Mass Parameters
tensile strength = -0.001 MPa
uniaxial compressive strength = 0.043 MPa
global strength = 0.314 MPa
modulus of deformation = 500.00 MPa



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12 Limitations of this Report

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A conceptual design is intended to illustrate concepts only and is not intended to be a full design for each package of works. The conceptual design does not provide the level of detail required for regulatory approval or construction and is subject to further investigations and assessments.

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Appendix 2
(Commitments Register)

Ref. No.	Commitment
EM1	Limiting vehicle and plant movements to defined access roads and existing operational areas
EM2	Utilising land-clearing techniques that preserve the rootstock of removed vegetation, where practicable
EM3	Limiting ground disturbance and vegetation clearing to the extent prescribed in landfill development plans by demarcating areas that require clearing on Project mapping/design drawings and by flagging or signage in the field
EM4	Delineating areas of vegetation to be protected
EM5	Undertaking major earthworks and ground disturbance activities during the drier months, wherever practicable when exposed surfaces will be less prone to rainfall erosion and avoiding such works during high rainfall periods
EM6	Installing diversion drains, swales, slope breakers, and berms to reduce erosion and subsidence where necessary from landfill construction and operations activities
EM7	Developing and implementing an Erosion and Soil Management Plan, during landfill construction and IWMF operations
EM8	Identifying the methods and locations of erosion and sediment control measures on site layout plans
EM9	Rehabilitating batters progressively during earthworks to limit erosion and
EM10	Regenerating previously damaged and newly disturbed areas with native flora
EM11	Reducing time between clearing and revegetation of sites as far as practical to limit exposure of the site soils and subsoils to potential erosion
EM12	Hydromulching batters as soon as practicable following formation to promote vegetation growth and reduce erosion potential
EM13	Inspecting and monitoring site restoration and rehabilitation works and the progress of soil stabilisation and rehabilitation measures
EM14	Monitoring and maintaining the effectiveness of the erosion and sediment control systems
EM15	Conserving topsoil (where practicable) in designated topsoil stockpile areas for later reuse in rehabilitation of disturbed areas
EM16	Storing fuels, lubricants and process reagents in covered areas or in bunded and lined areas. Bunding will be implemented in accordance with relevant standards and guidelines including AS 1940 Storage and handling of flammable and combustible liquids and the Australian Dangerous Goods Code
EM17	Refuelling on impermeable hardstand areas with spill prevention and spill containment kits available in close proximity
EM18	Ensuring workshop activities and fuel storage facilities comply with the minimum requirements in the PNG Code of Practice for Vehicle/Machinery Workshops and Petroleum (Hydrocarbons) Storage/Resael/Usage Sites (DEC, 1997)
EM19	Providing spill kits and safety data sheets (SDS) appropriate to the spill risk at the Project site and within vehicles as necessary. All fuel tankers and those tankers transporting hazardous materials shall carry appropriate spill kits
EM20	Providing emergency services the IWMF Emergency Response Plan
EM21	Inspecting, maintaining and repairing fittings, pipes and hoses regularly
EM22	Displaying emergency contact details and spill management procedures in prominent positions in all operating areas
EM23	Training personnel in the handling, transportation and storage of hazardous materials and providing training to an appropriate number of staff in the handling of emergency response and release scenarios

EM24	Clearly labelling vessels with name or description of hazardous material with accompanying SDS to be stored in close proximity and readily available in case of a spill or leak
EM25	Testing permanent storage vessels and enclosures intended for hazardous materials storage for leaks prior to installation and operation
EM26	Routinely inspecting vessels, tanks and secondary containment for leaks. If a leak is identified activate appropriate actions as per the Emergency Spill Operation
EM27	Developing and implementing a service and maintenance schedule according to manufacturer's specifications
EM28	Using pesticides and herbicides that are low in human toxicity, effective on target species and that have minimal effects on non-target species and the environment.
EM29	Operating the hazardous waste storage facility in accordance with AS 1940-2004 Storage and Handling of Flammable and Combustible Liquids, the Papua New Guinea and Australian Standards for the Storage of Hazardous Substances (*PNG Inflammable Liquids Act 195*3) and PNG/AS3780-2008-storage and handling
EM30	Collecting spills from the WOPU, fixation bays and industrial services area and returning this water to the IWWTP for treatment
EM31	Collecting waters from operational areas in blind sumps for transfer and processing at the IWWTP
EM32	Conducting weekly inspections of the hazardous waste storage facility and initiating immediate remedial action where required
EM33	Pumping leachate from the collection sumps via HDPE risers to a central collection well, before being pumped and conveyed to the leachate storage pond or IWWTP
EM34	Monitoring and maintaining the Industrial landfill leachate collection system
EM35	Monitoring leachate levels in the leachate pond to maintain a minimum design freeboard. If this freeboard level is reached, the leachate pond will be immediately pumped out and either sent to the IWWTP or taken offsite for disposal at an approved and licensed facility
EM36	Monitoring of landfill leachate leak detection system
EM37	Reducing disturbance of natural drainage channels during earthworks where practicable and ensuring stockpiles are not placed within natural drainage channels
EM38	Conducting routine inspections of stormwater management systems (after high rainfall events in particular) to ensure that drains, sumps and other structures are maintained in good working condition to allow free and unobstructed flow of
EM39	Designing the stormwater management system to minimise as far as practicable any changes to natural direction and flow rate in downstream catchment
EM40	Designing and constructing surface water controls in accordance with the appropriate guidelines as applied to site features and conditions
EM41	Installing sediment fencing downstream of the sediment dam footprint prior to commencing construction of the sediment dam
EM42	Controlling sediment runoff from stockpiles by installing sediment control structures to prevent sediment release to watercourses
EM43	Avoiding stockpiling spoil and/or topsoil close to existing drainage lines, maintaining a minimum distance of approximately 50 m, where practicable
EM44	Installing sediment control devices downstream of the landfill northeast batter (where drainage to a sediment basin is not practicable due to the proximity to the site boundary and topography)
EM45	Installing sediment controls including sedimentation ponds and siltation fences prior to the commencement of landfill construction activities
EM46	Conducting routine groundwater monitoring of at least four landfill monitoring bores to be located around the landfill to detect potential contamination and initiate

EM47	Conducting routine groundwater monitoring of the IWMF monitoring bores (see BH1, MB05, MB06, MB07, Figure 8.1) to detect potential contamination and initiate remedial action
EM48	Using a bentonite mix on unpaved roads and watering of the unpaved haul route within the landfill and quarry area
EM49	Using a bentonite mix on unpaved roads and watering paved/unpaved roads within the IWMF site
EM50	Using wet handling of ash from the incinerator, or alternatively handling the ash in a fully enclosed system or using vacuum trucks
EM51	Ensuring the secondary combustion chamber of the incinerator maintains a temperature above 850°C to reduce dioxin and furan emissions
EM52	Maintaining vehicle speed limits on-site at 20 km/h, or below.
EM53	Develop and implement an Air Quality Management Plan
EM54	Scheduling activities involving potential dust generation to avoid wind conditions above 60 km/h
EM55	Using tarps or covers for trucks and trailers transporting materials to and from the
EM56	Using a bentonite seal on unsealed roads and spraying water on unsealed roads between the site entrance and site office in dry conditions to reduce dust from vehicle movements
EM57	Operating and maintaining plant and equipment appropriately and in accordance with manufacturers specifications.
EM58	Watering of materials prior to loading for haulage, where appropriate
EM59	Avoiding the spraying herbicides and pesticides during windy conditions
EM60	Minimising the size of stockpiled materials and using water suppression systems, where necessary
EM61	Considering energy efficiency as a criterion when selecting diesel and electric powered motors and other equipment for purchase
EM62	Using biodiesel for mobile plant, where practicable
EM63	Installing light sensitive switches and motion sensors to switch on lighting throughout the Project site, where practicable and safe
EM64	Using large haul trucks where practical, to decrease diesel consumption by reducing the number of trips
EM65	Reusing cleared vegetation as timber produce or hydromulch for rehabilitation, to reduce emissions due to decay of vegetation, where practicable
EM66	Establishing vegetation buffers in the direction of the nearest sensitive receptors and Napa Napa Road, using mulch form cleared vegetation
EM67	Rehabilitating disturbed land as soon as practicable to allow subsequent growth of vegetation to provide an offset sink for CO2
EM68	Using production monitoring systems and payload management to maximise the loads of each bucket dug by excavators and each load carried by trucks
EM69	Using production monitoring systems to minimise fuel-burn rates and reduce the time when trucks are idling
EM70	Maintaining equipment to retain energy efficiency
EM71	Compacting haul roads to minimise vehicle rolling resistance, for reductions of diesel consumption
EM72	Recycling water in processing operations to reduce off site pumping requirements
EM73	Undertaking regular checking of compressed air tubing to identify and repair leaks
EM74	Providing training for operators of mobile plant in how to minimise fuel consumption, including no unnecessary idling
EM75	Using local personnel to reduce transport emissions, where practicable
EM76	Obtaining construction materials and ongoing consumables from local suppliers to reduce fuel consumption, as far as practicable

EM77	Undertaking an internal energy audit and energy mass balance following completion of annual reporting to ensure that the activities are using best practice for minimisation of energy consumption
EM78	Developing a system for tracking, monitoring and optimising energy use across the
EM79	Monitoring of landfill gas extraction wells monthly for pressure, temperature, methane, carbon dioxide and oxygen levels using hand held single reading
EM80	Maximising the offset distance between noisy plant items (including fixed construction plant) and nearby noise sensitive receptors, where practicable
EM81	Selecting construction plant and equipment based on industry good practice and reducing the amount of equipment and machinery operating simultaneously, where practicable
EM82	Maintaining construction vehicles and equipment in order to limit noise emissions
EM83	Maintaining noise suppression devices on construction vehicles and equipment
EM84	Using engineering controls to diffuse or minimise the noise at the source, such as fitting exhaust mufflers or fixing damping materials to reduce vibration
EM85	Limiting construction and operations to daylight hours where possible and providing advanced notice to neighbouring operations and/or residents if work is proposed outside normal operating hours.
EM86	Managing all waste in a manner that avoids impacts to the environment, including appropriate segregation for storage, treatment and disposal
EM87	Informing all personnel of their responsibility to reduce waste where possible by the use of colour coded and labelled bins
EM88	Considering waste in procurement decisions
EM89	Applying cover daily at the landfill to suppress odour and prevent wind-blown litter while minimising the opportunity for mosquito infestation and discouraging bird and animal foraging.
EM90	Installing litter fences where required to catch and collect windblown litter to stop it from leaving the site
EM91	Conducting weekly inspections around the IWMF and surrounding area and conducting regular clean-ups of litter as required
EM92	Developing and implementing a Biodiversity Management Plan, during landfill construction and IWMF operation
EM93	Felling large trees in a manner that minimises harm to wildlife and damage to surrounding vegetation, e.g. felling away from existing stands taking into account safety factors
EM94	Stockpiling cleared vegetation in a manner that facilitates re-spreading or salvaging for later use during rehabilitation
EM95	Employing low-impact vegetation clearing methods that minimise disturbance to adjoining intact vegetation and allow for movement of mobile fauna into adjoining intact areas before the area is cleared
EM96	Conduct regular site inspections to ensure that works do not exceeding the approved disturbance boundaries
EM97	Reducing damage to stockpiled topsoil and hydromulch with sterile medium, where practicable, to protect seed resource
EM98	Avoiding the use of fire for weed management at all times
EM99	Updating and implementing Fire and Emergency Response Plan Operating
EM100	Ensuring that the 'Person in Charge' and site and process personnel are fully trained in the implementation and practice of the Fire and Emergency Response Plan Operating Instructions
EM101	Ensuring that all TWM staff and contractors undergo training for the Fire and Emergency Response Plan Operating Instructions

EM102	Ensuring the effectiveness of training is regularly assessed through Emergency Spill Response practice and drill
EM103	Ensuring the Fire and Emergency Response Plan Operating Instructions are regularly reviewed and updated following lessons learned and with development of new or upgraded waste handling processes and technologies, and updates are incorporated into training
EM104	Ensuring that fire-fighting equipment is maintained and available on site
EM105	Spraying for weeds and pests to be undertaken on a routine basis to control the spread of invasive species.
EM106	Prohibiting disturbance and or harassment of terrestrial wildlife, hunting of fauna, or collection of bushfoods by Project staff or contractors whilst employed on Project work activities
EM107	Implementing appropriate inductions and education to ensure personnel comply with hunting and bush food collecting requirements
EM108	Ensuring site traffic flows are designed to minimise risk of collision
EM109	Inspecting and washing down all vehicles, machinery and equipment coming from within the local area (i.e., NCD) prior to arrival on site, or if washing down on site, ensuring material washed from machinery and equipment is collected and either treated prior to discharge or disposed of appropriately
EM110	Ensuring all vehicles, machinery and equipment brought from outside of Papua New Guinea or brought into the Project area from elsewhere in Papua New Guinea are verified to be weed-free before arrival on site
EM111	Prohibiting washing of equipment, vehicles or machinery near or within drainage channels
EM112	Limiting work vehicles and machinery to designated access and work site areas
EM113	Implementing accepted weed control measures where weeds are established and obtaining expert advice from CEPA or a qualified aquatic ecologist.
EM114	Providing training to relevant personnel in weed prevention and management
EM115	Updating and implementing the IWMF spill prevention and emergency response
EM116	Developing and implementing appropriate warning, evacuation and response procedures
EM117	Including horizontal benches, where necessary, to allow space for machinery
EM118	Using inspection test plans to verify construction quality control
EM119	Undertaking weekly surveys, including slope movements and drone inspections
EM120	Requiring the landfill construction contractor to develop and implement a safe work method statement
EM121	Completing a geotechnical stability assessment for the landfill for input into landfill
EM122	Monitoring slope instability
EM123	Constructing stabilisation works, as required
EM124	Ensuring operating procedures have spill prevention mechanisms
EM125	Providing training to relevant staff in emergency spill response responsibilities
EM126	Ensuring sufficient material between the operating equipment and the lining system
EM127	Defining adequate materials within technical specification
EM128	Adhering to technical specification by operator
EM129	Venting of landfill gas to the environment to prevent gas build-up
EM130	Considering installation of a gas flare system if gas generation levels alter over time
EM131	Installing gas monitoring wells outside the perimeter of the landfill to detect landfill gas migration
EM132	Monitoring of gas, using a hand-held monitor, in building or enclosures that are adjacent to the landfill

SM1	Reviewing and implementing the existing TWM project grievance procedure to receive, record, respond to and to address any grievances made regarding Project activities. Monitor the progress of grievances and provide updates to aggrieved parties and other relevant stakeholders
SM2	Undertaking ongoing engagement with local community and businesses, providing clear, factual and accurate information relating to potential impacts, in an open and transparent manner
SM3	Maximising the employment and training of PNG and local citizens in all job categories where appropriate and in accordance with PNG law
SM4	Maintaining good relations and continue to engage with host communities most impacted by the Project on issues/concerns raised by these communities (to be regularly updated consistent with the Stakeholder Engagement Plan)
SM5	Continuing to work with local communities (particularly Roku, Tatana, Kogerika and Baruni) on ongoing community development and capacity building opportunities. Examples may include: – Napa Napa road maintenance. – Community-level waste collection and management. – Support for the Roku Women's Fellowship activities, particularly those aimed at increasing women's tertiary education and entrepreneurial business opportunity
SM6	Implementing traffic controls including detailed signage, driver training, speed limits and vehicle speed controls and ensuring compliance from staff and contractors
SM7	Limiting the transportation of hazardous waste at peak traffic hours (e.g. school start/finish times and shift changes) where possible
SM8	Maintaining pedestrian access points to/along the Napa Napa Road
SM9	Engaging with Central Government and other businesses to maintain upkeep of Napa Napa Road
SM10	Undertaking ongoing engagement with local community and businesses relating to Project traffic and any potential impacts
SM11	Investigating community grievances and undertaking noise monitoring where
SM12	Providing advance notice to neighbouring operations and/or residents where temporary high-intensity noise events are planned and advising of the intended type and duration of works to be undertaken
SM13	Making wood cleared from within the IWMF boundary available to Roku residents for use as building material or firewood
SM14	Reducing traffic congestion at peak periods where possible
SM15	Engaging with local residents and industrial neighbours on likely peak periods for traffic congestion during construction, and where possible, identifying opportunities to minimise construction traffic during these periods
SM16	Implementing operating procedures and staff training to identify artefacts and manage the reporting of cultural heritage
SM17	Stopping all works immediately and implementing the Chance Finds Procedure if suspected indigenous or non-indigenous culturally significant material or artefacts are found within 50 m
SM18	Establishing and maintaining an exclusion zone around identified potential heritage items observed on site
SM19	Notifying the Senior Leadership Team immediately if potentially culturally significant items are found on site
SM20	Seeking written confirmation from the National Museum if required prior to work recommencing in the area.
SM21	Implementing cultural awareness training for personnel and contractors before commencing Project activities
SM22	Discouraging in-migration of persons in search of employment opportunities

ED1	Ensuring the gradient of landfill batters are designed with a maximum slope ratio of 1 m vertical to 3 m horizontal
ED2	Including textured HDPE geomembranes in landform final design to provide adequate interface shear strength
ED3	Locating Project infrastructure in previously disturbed areas where practicable
ED4	A hazardous waste storage facility with impervious concrete bunds capable of holding at least 110% of the chemical storage capacity
ED5	A purpose-built decontamination area within the bunding of the hazardous waste storage area to ensure waste is not tracked outside of the store and collection of wastes and associated cleaning liquids generated through the decontamination process for treatment at the IWTTP.
ED6	Constructing bunds and impermeable drainage with blind collection sumps or enclosed and weatherproof facilities with impermeable floor lining draining to a blind collection sump for all waste handling and treatment areas
ED7	Designing and constructing the industrial landfill with multiple high-density polyethylene (HDPE) geo-membrane barriers combined with clay liners and a leachate collection system which will drain leachate to collection sumps (with a 2%
ED8	Constructing a network of perforated leachate collection pipes within the collection layer, to promote the flow of leachate to the primary and secondary (leak detection)
ED9	Designing submersible pumps, vertical extraction pipework (primary) and inclined leachate extraction pipe (secondary) to facilitate the removal of leachate from the collection sumps by progressive pumping to the leachate storage pond or IWWTP
ED10	Designing a leachate leak detection system, i.e., the secondary leachate collection and removal system which will allow the collection and flow of leachate out of the leak detection system
ED11	Diverting clean stormwater away from the landfill to minimise the ingress of rainfall runoff into the landfill thereby reducing the volumes of leachate generated
ED12	Designing the leachate storage pond considering worst-case leachate generation conditions to minimise the chance of overflow including: – Using leachate water balance modelling based on maximum cumulative volume over a one-year period, using a 90th percentile wet year. – Assuming that one third of the Stage 1 landfill area is filled with waste, and comprises a 300 mm thick intermediate cover, and has an active working area of 625 m^2
ED13	Design of the leachate holding pond freeboard volume based on the 5% annual exceedance probability (AEP) for 24-hour rainfall period
ED14	Designing and constructing the leachate storage pond to the equivalent performance standard as the landfill which will include a 2 mm thick HDPE liner, compacted clay liner, composite drainage net, geosynthetic clay liner and prepared
ED15	Using clean water diversions drains to direct clean rainfall runoff away from the landfill to minimise the volumes of potentially sediment-laden water generated and installing a level spreader at the on-site termination of the clean water diversion drain to limit erosion and mobilisation of soils.
ED16	Construction of a sediment dam for both Stage 1 and Stage 2 industrial landfill operations prior to the commencement of landfill cell construction works (e.g., stripping and bulk earthworks). The sediment dam has been designed to contain water from an extreme rainfall event (a 5 day 90th percentile rainfall event), with a storage capacity of 2.24 ML in Stage 1 operations and 3.08 ML for Stage 2.
ED17	Installation of toe drains at the base of batters to convey sediment-laden runoff to the sediment dam

ED18	A stormwater management system designed to capture, divert and treat stormwater that has come into contact with operational areas and reticulate it to collection sumps and the IWWTP for processing and beneficial reuse.
ED19	Designing pit and dump haul roads and ramps to limit the travel time and duty cycle for trucks especially when fully loaded
ED20	Installation of a flue gas treatment as the incinerator pollution control system, for burning of hazardous emissions
ED21	Closure of landfill cells will include a gas capture system, comprising horizontal collection piping and vertical gas extraction wells installed into the deposited wastes to collect landfill gases
ED22	Design of landfill gas management system for venting of landfill gases to the environment, and installation and gas extraction wells and gas monitoring probes installed
ED23	Considering use of solar energy and other clean energy sources in Project design
ED24	Constructing a benched landform profile, with intermediate slope faces separated by flat benches of 5 m width
ED25	Design of he leachate holding pond to include 0.5 m freeboard
ED26	Installation of a subsurface landfill gas drainage system to prevent build-up of pressure below the liner system
ED27	Design considers landfill gas generation and prevention of ‘whales’ forming on the final landfill capping system

Appendix 3
(Baseline Environmental and Geotechnical Study)

OCTOBER 2018

BASELINE ENVIRONMENTAL & GEOTECHNICAL STUDY

REV 0 FOR

PROPOSED INTEGRATED WASTE MANAGEMENT PLANT AT ROKU



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ABBREVIATIONS

Symbols and abbreviations that have been used throughout the report are listed below:

ACEM	*ACEM Geotechniques*
BGL	*Below Ground Level*
FMC	*Field Moisture Content*
AL	*Atterberg Limits*
LL	*Liquid Limit*
PL	*Plastic Limit*
PI	*Plasticity Index*
LS	*Linear Shrinkage*
PSD	*Particle Size Distribution*
MDD	*Maximum Dry Density*
OMC	*Optimum Moisture Content*
CBR	*California Bearing Ratio*
ABC or Qa	*Allowable Bearing Capacity*
HA	*Hand Auger Borehole*
TP	*Hand Auger Borehole*
BH	*Borehole*
DL	*Dead Loads*
LL	*Live Loads*
EQ	*Earthquake Loads*

SOIL SYMBOLS

CL/CI/CH	Clay of low/Intermediate/High Plasticity
ML/MI/MH	Silt of low/Intermediate/High Plasticity
GC	Gravelly Clay
GW	Well Graded Gravel
SM	Sandy Silt
SC	Sandy Clay

ROCK SYMBOLS

RS/CWR	Residual Soil or completely weathered rock (Saprolite)
XW	Extremely weathered rock
DW	Distinctly weathered
SW	Slightly weathered

Rock Strength and approximate Qa;

XL	Extremely low 0-0.25 MPa
VL	Very low 0.25-0.5 MPa
L	Low 0.25-0.5 MPa
M	Medium 1.2-2.5 MPa
H	High 2.5-5 MPa
VH	Very High 5-10 MPa
EH	Extremely High 10+ MPa

FIELD TESTING

DCP	Dynamic Cone Penetrometer
SPT & N	Standard Penetration Test and blow count N
PP	Pocket Penetrometer
FSV	Field Shear Vane

LABORATORY TESTING

UCS	Unconfined Compressive Strength (UCS=2Cu)
Cu	Undrained Cohesive Strength
Is	Point Load Index for Rock (MPa)

PILING

fsu	Ultimate shaft friction
Qu	Ultimate End Bearing Capacity

GENERAL

TWM	TWM PNG Limited - Total Waste Management
IWMF	Integrated Waste Management Facility
CEPA	Conservation Environment Protection Authority
Rhodes	Rhodes Projects Pty Ltd
NRA	NRA Environmental Consultants
ASK	ASK Consulting Engineers Pty Ltd
WHO	World Health Organisation
TSP	Total particulates suspended in air

1 INTRODUCTION

1.1 Background

This report presents the results of an investigation carried out by ACEM Geotechniques at the site of the proposed IWMF at Roku. The report is in response to the TWM issued Specification and Conditions and is based on the RFQ and proposal letter from ACEM dated 14th September 2018 and its acceptance by TWM. The ACEM proposal sets out the extent to which the RFQ covers the initial enquiry document RFQ No.TWMPNG-RFQ001.

The proposed IWMF development, as shown on the Master Site Plan in Appendix A, comprises;

- Composting Plant
- Incineration Plant
- Waste Oil Processing
- Fixation Plant
- Waste Water Treatment Plant
- Quarrying
- Engineered Landfill
- Hazard Waste Storage

1.2 Aim of Investigation

The aims of the investigation or Baseline Studies were to provide;

- preliminary geotechnical information for the proposed site works
- baseline soil conditions at the site including any contamination at the former timber yard
- baseline groundwater level and water quality
- baseline Noise levels and Air Quality

For the geotechnical investigation the aims include;

- Classification of soil classes to AS1170.4
- Site classification to PNG Earthquake Code
- Site Classification to AS 2870-1996 and expected soil shrink/swell movement
- Comment on possible construction problems

The report contains details of site investigations methodology and approach, laboratory testing program and the engineering and environmental assessment.

The report must be read in conjunction with our attached ***"General Notes"*** and the ***ASFE*** publication ***"Important Information about Your Geotechnical Engineering Report"***

1.3 Scope of Works

The works comprise drilling 2 BH (two boreholes) to 8m and 6 TP (six test pits) together with both Geotechnical and Environments laboratory testing and a report. Laboratory tests to include;

Geotechnical

- Moisture Content
- Particle Size Distribution
- Atterberg Limits
- Linear Shrinkage
- Point Load Index or Schmidt Hammer testing on Rock

Environmental

- A suite of tests on 12 soil samples
- A suite of tests on 4 water samples

The report to cover fieldwork, laboratory test results and recommendations for the items listed above.

2 SITE CONDITIONS, GEOLOGY & TOPOGRAPHY

2.1 Site Description

The proposed development site is located along the Napa Napa Road opposite the AES Compound as shown on Figure 2 and Figure 3.

As shown in Figure 3, the site is on a low ridge and slopes down from the South to the North as shown by the elevations noted. The land around the site falls to the west from elevation 103m to a low valley EL 22 towards the ocean. The land also falls to the North from EL 49 at the site boundary to a dry valley at EL 19, which runs out into Halifax Harbour. The land also falls towards the AES compound to the East from site EL55 or EL 112 to EL45 to EL 68 at the AES boundary and then on down to RL 0 at the harbour.

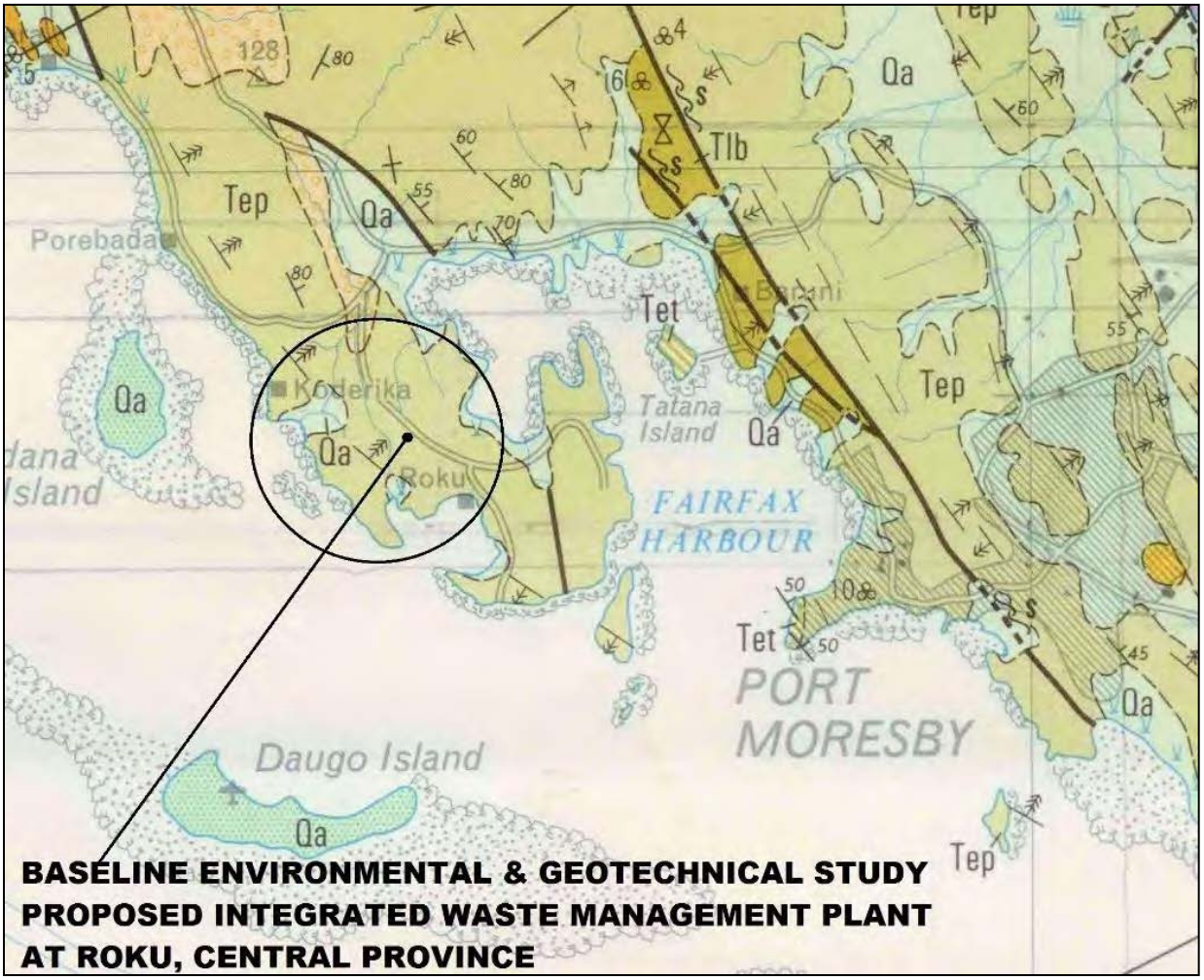
Elevations shown on Figure 2 and Figure 3 are based on data from Google Earth and it should be noted that a different datum has been used for the reduced levels by Heading Associates shown on Figure 1. ACEM checked the Google Earth elevations using a GPS which showed much the same readings as Google Earth.

The site has a number of cleared areas as shown on Figure 3, with an existing office and a number of dwellings. A former timber yard operated at one location and there is an abandoned quarry just outside the TWM boundary with a small low height section of the quarry inside the boundary.

2.2 Site Geology

The 1;250,000 Geological Sheet, reproduced below, shows that the rock in this area is classified as Tep (Paga Beds). These deposits are described as follows;

Tep – Partly calcareous, siliceous argillite and shale, calcilutite, chert, minor calcarenite and dolomite



2.3 Site Topography & Potential Runoff

A GPS survey was completed covering the IWMF and its surrounds and the results are presented in Figure 2 (extending to Roku and AES) and on Figure 3 for the IWMF.

The site occupies a ridge running roughly North South (actually NW to SE) with its highest elevation at the signal tower at EL 112m to the South and its lowest point at EL 49m to the North. Surface water can run off to the North where the ground slopes down to EL 35m. The land also falls to the West sloping down to EL 20m into the stream in a small valley which flows out to Halifax Harbour to the East.

From the Eastern boundary the land slopes to the East towards the AES facilities.

From the Northern boundary the land slopes to the North across the neighbouring "Rhodes Projects" yard and then on down to the small creek.
A more detailed survey of surface runoff is provided on Figure 1 which has arrows showing the direction of runoff from each part of the site.

Although there is the potential for surface runoff to particularly to the North and the East, there were no signs of erosion. This is largely because the perimeter ground is well vegetated. Hence it may be concluded that as long as the perimeter remain well vegetated that surface erosion will not be an issue. However it is recommended that every effort be made to ensure that the vegetation is kept up and that water is prevented from leaving the site by the use of drainage ditches or bunds.

It may be noted that a drainage intersecting ditch is not required to the East as one already exists along Napa Napa Road.

Surface water can also leave the site to the west where there is nothing but virgin scrub and to the South down to Roku Village. Again an inspection of the slope between the Southern boundary and Roku shows that it is well vegetated with no signs of any erosion. The GPS survey shows that the IWMF Southern Boundary is 500m from the Roku nearest house with a fall from EL 112 to EL 7. This represents an average slope of 1 in 5, although the initial part is steeper and the lower part flatter.

As the catchment above and behind the Southern boundary is extremely small and as there are no planned facilities within this catchment, it is concluded that both leachates and surface water cannot reach Roku Village by surface or by saturation into the meagre topsoil.

2.4 Climate

Port Moresby has a tropical savanna climate (Köppen) with relatively constant temperatures throughout the year. Port Moresby's average yearly rainfall is just over 1,000 millimetres or 39.37 inches, making it the driest place in New Guinea.

The wet season starts in December and ends in May; the dry season covers the remaining six months, and, like the area around Townsville in Queensland, is due to the south-easterly trade winds running parallel to the coast, and the city being surrounded by high mountains. Average daily high temperatures range from 28 to 32 °C (82.4 to 89.6 °F) depending on time of year, while the average low temperature shows very little seasonal variation, hovering around the 23 °C (73.4 °F) mark. It tends to be slightly cooler in the city during the dry season.

A summary sheet of climate conditions in Port Moresby is included in Figure 5. This shows maximum wind velocities ranging from 6 knots in March and April to 10 knots in July and September. These are very light winds. As noted, because the site is predominantly vegetated or sealed, dust carried away from the site is unlikely to be a significant problem. The very light winds are predominantly North-Westerly and any dust will be carried across the adjoining facility and on into the scrub-land beyond. During the South-Easterly winds, any dust will be carried directly into scrub-land.

Wherever possible, it is recommended that open areas be vegetated or sealed.

3 FIELD INVESTIGATIONS

The field investigations were carried out between the 5th and 10th November 2018 using a truck mounted EVH 2100 drilling rig equipped with triple barrel NMLC coring equipment, a Cat428E.backhoe with a 600mm toothed bucket and the Noise and Air monitoring equipment described below. The noise monitoring was carried out both day and night from 5th to the 10th and air monitoring during the day over the same period. TWM advised and after discussions with CEPA that the one week of monitoring would be acceptable.

The fieldwork consisted of;

- Topographic Survey (covered in Section 2.3)
- Inspection of the AES facilities

- Determining the location of AES source of water
- 2 boreholes to 8m BGL with standpipe piezometers, permeability testing and groundwater sampling for chemical analysis
- 6 test pits to obtain both geotechnical and environmental data. The test pits included the collection of environmental samples for chemical analysis usually from 0-300mm and from 300-600mm, but with these depths varied slightly to suit the actual soil strata at each location. The geotechnical data comprised soil samples of each strata for laboratory testing to determine engineering parameters and a range of insitu soil/rock tests including PP, FSV, DCP and Schmidt Hammer.

The results from the fieldwork are presented on the Geotechnical Logs in Appendix C, with the geotechnical baseline conditions discussed in Section 4 -- Geotechnical Baseline Conditions and the environmental Baseline Conditions in Section 5 for soil and in Section 6 for water.

4 GEOTECHNCIAL BASELINE CONDITIONS

4.1 Ground Profile

The geotechnical logs for the test pits, show that the ground profile varies from bare bedrock to shallow soil depths over CWR bedrock. At some locations there are shallow depths of fill covering the original ground profile. The ground profile at the 6 test pits is summarised in Table 1.

TABLE 1 – GROUND PROFILE

Depth (m)	TP1	DCP	TP2	DCP	TP5	DCP	TP4	DCP	TP3	DCP	TP6	CWR Less than Qa=0.2MPa
0.0-0.15		R		R		R		R		R		CWR Qa 0.2 to 0.5MPa
0.15-0.3												
0.3-0.4										R		CWR Qa 0.5 to 1MPa
0.4-0.5					Med							
0.5-0.6					Plastic							CWR Qa 2MPa Plus
0.6-0.7												
0.7-0.8												Topsoil (Organic)
0.8-0.9		R										
0.9-1.0								R				Red Clayey Gravel
1.0-1.1												

Table 1 shows that at all locations CWR bedrock occurs at shallow depths of from zero to 0.15m except at TP5 at the bench that contains the former timber yard, where the CWR occurs to a depth of 1m as a claybound gravel which, if extensive, could provide a potential source of clay seal material.

At TP1, TP2, TP3, TP4 and TP6 the CWR bedrock has variable Qa values ranging from just less than 0.2MPa to 1MPa. The CWR quickly becomes of higher Qa strength with Qa=2MPa plus at depths of between 0.4m and 1m.

As shown by the Geotechnical Logs for the boreholes the CWR rock continues to the full depth investigated of 8m. A summary of the data from the two boreholes is shown on Figure 7, from which it can be seen that the CWR comprises bands of completely fractured and fragment rock interspersed with bands of harder rock. The rock is a siltstone of the Port Moresby Beds and varies from Qa=0.5MPa to Qa=5MPa, with much of the rock being in the range 1-2 MPa. This random profile of harder and softer rock is common to most areas of faulted Port Moresby Beds.

It would be expected that water travelling through the rock would concentrate in the fractured bands as the intact rock is virtually impermeable. It may be noted that the degree of fracturing or fragments is much the same in both boreholes with 1,600mm of fractured rock in BH1 and 2,000mm in BH2. However as noted in the water observations BH2 was dry.

The CWR bedrock will be suitable for side wall construction of the landfill and is also likely to produce road pavement material including, ordinary and select fill, basecourse and subbase. Once quarrying commences, it is recommended that samples of both quarried material and screened material be submitted to ACEM for laboratory testing to check if they comply with current code requirements. ACEM select fill requirements are contained in Appendix E and commonly used road base and subbase criteria are shown in the DOW specification, Reference 12. These requirements are too lengthy to reproduce in this report.

Depending on the quarrying methods and screening used, the type of material that is produced will vary. However, it is considered that the quarry is likely to yield suitable ordinary fill, select fill and subbase with limited or no screening. With more selective screening, it may also yield basecourse material. It is recommended that the following tests be completed:

- PSD (Particle Size Distribution)
- Atterberg Limits
- Los Angeles Abrasion
- 10% Fines
- Wet/Dry Strength Variation

- Sodium Sulphate Soundness
- Max/Min Crushed Particles
- Flakiness Index

Only the first two tests are required for the selection of select fill.

Slope Stability and Settlement

The rocky and well-graded nature of material won from the quarry will allow fill batters ranging from 1:1 to 1V:1.5H. The 1V:1.5H batters are recommended for the landfill. Settlement of well graded select fill is likely to be on the order of 0.5% of the fill height. Settlement beneath buildings can only be estimated once the sizes and applied dead loads are available, as noted in Section 4.6. However, as the site has bedrock at very shallow depths, settlements are likely to be minimal.

4.2 Laboratory Testing

Laboratory tests were undertaken on selected bulk samples from the test pits and on selected SPT samples and on rock cores from the boreholes. These included classification tests, PSD, FMC, Atterbergs, LS and PLI (Point Load Index) tests and Schmidt Hammer tests on rock cores.

All tests were undertaken by ACEM's in-house Laboratory in Port Moresby. The laboratory test results are included in Appendix D and the results are discussed below. Laboratory testing was carried out in accordance with Australian Standard AS1289 '*Laboratory Testing for Engineering Purposes*'.

4.3 Results of Laboratory Tests

Laboratory testing was carried out to assess the reactivity of the residual soils in relation to seasonal moisture content variations and to classify them in order to determine other engineering properties. The properties of the heavily weathered and fractured CWR rock have also been tested. Engineering properties have long been correlated with soil classifications. CBR testings including compaction tests were completed to provide pavement design values and Point Load Index tests were carried out on a range of rock cores from both boreholes.
Laboratory test result sheets are included in Appendix D and a summary of the test results follows.

4.3.1 Classification Tests

A summary of these is provided in Tables 2 where soils within the zone of moisture change are shown shaded.

TABLE 2 – CLASSIFICATION AND SHRINK/SWELL TEST RESULTS PARTICLE SIZE DISTRIBUTION, ATTERBERG LIMITS, LINEAR SHRINKAGE, MOISTURE CONTENT										
TP or BH No	Sample No	Group Symbol Description	Depth (m)	Fines %	Sand %	Gravel %	Moisture Content %	Liquid Limit %	Plasticity Index %	Linear Shrinkage %
TP1	S1	CWR	0.0-0.3	18	24	58	16.4	27	10	2.0
TP1	S2	CWR	0.3-0.6	22	31	47	15.1	28	13	6.5
TP2	S1	Topsoil	0.0-0.15	22	23	55	3.7	39	11	5.5
TP2	S2	CWR	0.15-0.35	13	16	71	3.4	37	12	4.2
TP3	S1	Topsoil	0.0-0.15	29	23	48	6.1	33	5	2.5
TP3	S2	CWR	0.15-0.3	11	20	69	7.7	28	5	2.3
TP4	S1	CWR	0.0-0.3	14	15	71	10.0	33	11	4.5
TP4	S2	CWR	0.3-0.6	10	14	76	10.9	33	6	3.0
TP5	S1	CWR	0.0-0.2	18	24	58	8.2	25	10	4.8
TP5	S2	CWRredClay	0.2-1.0	13	27	60	16.4	37	11	5.6
TP6	S1	Topsoil	0.0-0.12	26	23	51	3.8	46	10	5.0
TP6	S2	CWR	0.12-0.2	15	24	61	11.0	30	10	4.8
TP6	S3	CWR	0.2-0.8	12	32	68	10.0	31	8	3.1
BH1	SPT1	Red Clay	1.0-1.45	36	35	29	26.3	35	15	7.5
BH1	SPT2	cwrCuttings	2.0-2.45	26	30	44	20.2	28	6.4	3.2
BH2	SPT2	ClayeyCWR	2.0-2.45	16	10	74	13.0	30	9	6.0

Note-Soil Plasticity and reactivity may be assessed from LL/PI/LS and is classified as Low=green; Medium=yellow; high=orange; very high=red. Soils affected by season moisture change-shown shaded grey. Gouge=Slickensided Gouge Clay.

Table 2 shows that all soil and CWR rock in this site is of low plasticity and that the site may be classified as Class "S" slightly reactive with Characteristic Surface Movement "Ys", in Table 2.3 of AS2870, of between Ys= 0 to 10mm.

4.3.2 California Bearing Ratio

Compaction and CBR results are presented in Table 3.

TABLE 3 – CALIFORNIA BEARING RATIO TEST RESULTS PENETRATION AT 5mm						
TP No	**Soil Type**	**Depth (m)**	**CBR Value (%)**	**Maximum Dry Density (t/m³)**	**Optimum Moisture Content (%)**	**Minimum Field* CBR Values (%)**
TP 1	S2 CWR as Sandy Gravel	0.3-0.6	75	1.85	11.0	80 Not reliable
TP 3	S2 CWR as Sandy Gravel	0.15-0.3	80	1.91	11.3	80 Not reliable
TP 4	S1 CWR as Sandy Gravel	0.15-0.3	85	1.93	12.0	80 Not reliable
TP 4	S2 CWR as Sandy Gravel	0.3-0.6	80	1.90	12.2	80 Not reliable
TP 5	S2 CWR sandy grv CLAY	0.3-1.0	72	1.81	13.0	80 Not reliable
TP 6	S3 CWR-claybound	0.2-0.8	53	1.79	14.0	18-50

The table suggest a minimum CBR of around 50% rising at most locations to CBR=80% or slightly greater. As many of the field DCP results were at refusal, it is not possible to estimate reliable CBR values from these.

4.3.3 Point Load Index Tests on Rock

These tests were carried out on rock cores with the results shown in Table 4

TABLE 4 – SCHMIDT HAMMER & POINT LOAD INDEX TESTS						
BH No.	**Test No.**	**Depth (m)**	**Rock**	**Schmidt Hammer MPa**	**PLI Point Load Index**	**Classification**
1	1	2.4	Tuff	18		L-M
1	2	2.5	Tuff		0.35	M
1	3	3.4	Tuff	14		
1	4	3.5	Tuff		0.2	L
1	5	4.7	Tuff		0.35	M
1	6	6.7	Tuff	15		L
1	7	6.8	Tuff		0.2	L
1	8	7.4	Tuff	18		M
1	9	7.5	Tuff		0.3	L-M
2	1	2.4	Tuff		0.2	L
2	2	2.5	Tuff	15		L
2	3	3.9	Tuff		0.2	L
2	4	3.7	Tuff	14		L
2	5	4.7	Tuff	10		L
2	6	5.5	Tuff		0.35	M
2	7	5.6	Tuff	20		M
2	8	7.7	Tuff		0.1	L
2	9	7.8	Tuff	0		-

4.4 Rock Parameters

As noted above the rock varies considerably from weak to strong, so that other rock parameters such as Young's Modulus, Modulus of Subgrade Reaction, rock density and Poisons ratio will also vary as shown in Table 4.1. For this site only the CWR/residual soil parameters apply although at depths below 40m the XW values will phase in.

TABLE 4.1 - SOME ROCK PARAMETERS

Rock Type & (SPT)	Mod Subgrade Reaction k	Young's Mod	Density	Poison's Ratio
Units	kPa/mm	MPa	t/m^3	No.
CW Rock-Residual Soil	100	60	1.6	0.4-0.5
XW rock VL strength	140	84	1.8-2.0	0.45
XW rock L strength	210	130	2.1	0.25
DW rock 2-5MPa	400	300	2.5	0.2

The values of Young's Moduli are for the vertical modulus (V). Horizontal modulus is normally taken as 0.75V and dynamic modulus as 5V. The secant modulus Gm=E/2.66.

4.5 Recommendations

It is recommended that once the final foundation drawings and pressures are available, that these be reviewed by ACEM for further comment and to allow us to check likely total and differential settlement and to advise on the choice of foundations.

The suitability of materials obtained from the quarry is covered in section 4.1 above, together with recommendations for testing of quarried material.

4.6 Earthquake Coding (PNGS 1001-1982)

4.6.1 PNGS 1001-Clause 3.4.2; Part 4

The Basic Seismic Coefficient, Clause 3.4.2 for this site is one of **"Firm"** as bedrock occurs at shallow depths across the site.

4.6.2 PNGS 1001 – Fig 3.2 - Seismic Zone

The site is classified as being within Zone 4.

5 BASELINE SOIL CONDITIONS

5.1 Introduction

With respect to environments matters ACEM engaged NRA Environmental Consultants, Cairns to assist in assessing the environmental requirements and in establishing baseline soil conditions.

NRA were consulted prior to the fieldwork being undertaken and helped set the criteria for all environmental work and the choice of chemical testing. The following sections have been provided by NRA;

- Section 5.2 -- Samples & Laboratory Tests
- Section 5.3 -- Environmental Soil Test Results
- Section 6.3 -- Groundwater Quality

5.2 Samples & Laboratory Tests

Soil samples were obtained by ACEM representatives from six sites across the proposed IWMP site. Site locations are provided in Figure 1, and sample depths are provided in results tables (Tables 5 and 6). Soil samples were analysed by ALS Laboratory (ALS) (NATA accreditation # 825) for the following analytes.

- Emerson Aggregate Test (EAT)
- pH of a 1:5 soil to water 'leach'
- Electrical conductivity (EC) of a 1:5 soil to water 'leach'
- Organic matter
- Particle size distribution
- Cation exchange capacity and exchangeable cations (calcium, magnesium, potassium, sodium, aluminium[1])
- Total metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury).
- Total recoverable hydrocarbons (fractions C6-C10, C10-C16, C16-C34 and C34-C40).

Soil Analysis Quality Assurance/Quality Control

Recommended sample holding times were exceeded for pH, EC, exchangeable cations, total mercury, organic matter and total recoverable hydrocarbons due to quarantine requirements and laboratory issues. These holding time exceedances may have impacted the analytical quality of the results for the identified analytes, however the results still provide an indication of the conditions onsite.

5.3 Environmental Soil Test Results

Complete analysis results and laboratory documentation for soil tests are provided in Appendix D. Summarised soil sample results are provided in Table 5 and Table 6.

Table 5: Emerson Aggregate Test Results

Site	Sample No	Depth (m)	Colour (Munsell)	Texture	Emerson Class Number
TP1	S1	0 - 0.3	Strong Brown (7.5YR 4/6)	Gravelly Sand	8
	S2	0.3 - 0.6	Brown (7.5YR 4/4)	Gravelly Sand	8
TP2	S1	0 - 0.15	Strong Brown (7.5YR 4/6)	Gravelly Sand	8
	S2	0.15 - 0.35	Strong Brown (7.5YR 4/6)	Gravelly Sand	8
TP3	S1	0 - 0.15	Very Dark Brown (7.5YR 2.5/2)	Sandy Loam	3
	S2	0.15 - 0.3	Dark Brown (7.5YR 3/4)	Sandy Loam	4
TP4	S1	0 - 0.3	Reddish Yellow (7.5YR 5/6)	Gravelly Sand	8
	S2	0.3 - 0.6	Brown (7.5YR 5/4)	Gravelly Sand	8
TP5	S1	0 - 0.2	Red (2.5YR 4/8)	Gravelly Sand	8
	S2	0.2 - 0.5	Yellowish Red (5YR 5/8)	Sandy Loam	3
TP6	S1	0 - 0.12	Very Dark Brown (7.5YR 2.5/2)	Gravelly Sand	8
	S2	0.12 - 0.2	Strong Brown (7.5YR 5/6)	Gravelly Sand	8

[1] Exchangeable aluminium was only analysed for acid soils (*ie* pH less than 6*)*.

TABLE 6 - ENVIRONMENTAL SOIL TEST RESULTS

Site:	TP1		TP2		TP3		TP4		TP5		TP6	
Sample No:	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Analyte **Depth (m):**	0.0-0.3	0.3-0.6	0.0-0.15	0.15-0.35	0.0-0.15	0.15-0.3	0.0-0.3	0.3-0.6	0.0-0.2	0.2-0.5	0.0-0.12	0.12-0.2
pH of 1:5 Soil/Water Leach (pH Unit)	5.5	5.8	6.4	6.8	6.5	6.4	5.2	5.4	6.3	6.3	6.3	5.6
Electrical Conductivity @ 25°C of 1:5 Soil/Water Leach (µS/cm)	3	5	21	14	34	16	6	6	10	11	32	7
Organic Matter (%)	0.5	0.9	2	1.2	4.9	1.6	<0.5	0.6	<0.5	0.8	2.3	0.6
Particle Sizing												
+75µm (%)	68	55	57	64	34	42	66	52	67	61	43	48
+150µm (%)	64	50	50	60	25	35	62	47	64	58	34	40
+300µm (%)	61	47	44	56	20	31	58	44	62	56	31	37
+425µm (%)	60	46	41	54	18	29	55	42	60	54	30	36
+600µm (%)	58	44	38	52	15	27	52	41	58	52	29	35
+1180µm (%)	50	39	30	45	12	22	43	35	50	46	26	30
+2.36mm (%)	36	30	21	33	8	18	30	27	37	36	20	20
+4.75mm (%)	17	17	12	20	4	10	15	15	21	25	11	10
+9.5mm (%)	<1	5	4	10	<1	4	4	2	8	8	<1	<1
+19.0mm (%)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
+37.5mm (%)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
+75.0mm (%)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Soil Classification based on Particle Size												
Clay (<2 µm) (%)	11	15	16	18	22	19	15	22	17	18	13	19
Silt (2-60 µm) (%)	19	29	24	16	41	35	16	24	14	17	42	30
Sand (0.06-2.00 mm) (%)	30	24	36	29	28	27	35	25	28	26	23	28
Gravel (>2mm) (%)	40	32	24	37	9	19	34	29	41	39	22	23
Cobbles (>6cm) (%)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cation Exchange Capacity and Exchangeable Cations												
Cation Exchange Capacity (meq/100g)	8.8	7.6	11.1	11.4	13.8	8	11.3	6.9	11.1	9.7	10.1	7.6
Exchangeable Aluminium (meq/100g)	0.2	<0.1	-	-	-	-	1.7	0.6	-	-	-	0.8
Exchangeable Calcium (meq/100g)	2.7	3.4	7.9	8.6	9.9	5.5	2.6	2.3	4.9	4	6.3	2.8
Exchangeable Magnesium (meq/100g)	5	3.5	2.4	2	3	2	5.8	3.3	5.5	5	3.1	2.8
Exchangeable Potassium (meq/100g)	0.3	0.4	0.2	0.2	0.8	0.4	0.3	0.2	0.4	0.3	0.5	0.4
Exchangeable Sodium (meq/100g)	0.4	0.3	0.5	0.6	0.1	<0.1	0.5	0.3	0.4	0.4	0.2	0.6
Total Metals												
Arsenic (mg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	49	24	<5	<5
Cadmium (mg/kg)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium (mg/kg)	11	9	27	24	21	29	8	30	55	26	4	6
Copper (mg/kg)	30	20	38	37	25	27	42	29	72	40	11	26
Lead (mg/kg)	8	7	18	13	15	18	10	10	68	6	<5	5
Nickel (mg/kg)	7	8	11	9	23	20	7	8	24	7	4	5
Zinc (mg/kg)	18	5	15	9	7	7	8	6	11	7	6	7
Mercury (mg/kg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Recoverable Hydrocarbons												
C6 - C10 Fraction (mg/kg)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
>C10 - C16 Fraction (mg/kg)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
>C16 - C34 Fraction (mg/kg)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C34 - C40 Fraction (mg/kg)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100

Shaded results were extracted and/or analysed outside of recommended holding times. This should be taken into consideration when viewing and interpreting results.

5.4 Conclusion on Baseline Environmental Soil Conditions

Impacts from previous industrial land uses

Comparison of arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc concentrations between the test pits identified that concentrations of arsenic, chromium, copper and lead at TP5 were elevated. The elevated concentrations primarily occurred in the top sample from the test pit (sample S1 from 0.0 – 0.2 m depth), with metal and metalloid concentrations in the deeper sample (S2 from 0.2 – 0.5 m depth) being similar to the other samples. The exception to this was arsenic, which was considerably higher in both samples from TP5 compared to other test pits.

TP5 appears to be in the vicinity of the area previously used as a timber yard. It is unclear if the elevated arsenic, chromium, copper and lead concentrations are related to the previous land use or are the product of natural enrichment.

To provide context to the arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc concentrations determined in the soil samples, none of the concentrations exceeded the health-based investigation levels for soil contaminants (from Schedule B7 Table 2) of the Australian National Environment Protection (Assessment of Site Contamination) Measure (NEPC 2011). The health-based investigation levels are the most conservative in Schedule B7 Table 2.

Erosion and sediment control

The soil samples were assessed for erosion susceptibility and fine sediment export risk using the results of the EAT and exchangeable cation testing. Note that the erosion susceptibility and fine sediment export risk assessment was based on soil properties and did not consider site features such as slopes, groundcover or rainfall intensity.

- Sodicity:
    - Sodic soils are susceptible to erosion and dispersion (dispersion is the separation of the soil into single particles – this can lead to fine sediment export). The sodicity classification is based on DNRM (1997) and uses exchangeable sodium percentage (ESP)[2].
    - The majority of soil samples tested were 'non-sodic' (*ie* had an ESP between 0% and 5%) with the exception of TP6 S2 which had an ESP of 8% ('sodic'). No soil samples tested were 'strongly sodic'.

[2] Sodicity is measured using exchangeable sodium percentage (ESP) (*ie* Exchangeable Sodium divided by Cation Exchange Capacity). Sodicity classes are 'strongly sodic' (ESP >15%), 'sodic' (ESP 7%-14%), and 'non-sodic' (ESP 0%-6%) (DRNM 1997).

- EAT results:
    - EAT classifies soil samples based on dispersion and slaking. Slaking is the physical decomposition of soil 'peds' on wetting. Both slaking and dispersion can increase a soil's susceptibility to erosion, and dispersion can lead to fine sediment export.
    - The majority of soil samples tested did not slake or disperse during the EAT (Emerson class 8). However, slaking was observed in sample TP3 S2 (Emerson class 4), and slaking and dispersion were observed in samples TP3 S1 and TP5 S2 (Emerson class 3).

Based on the assessment above, the soils from test pits TP1, TP2 and PT4, and the surface samples from test pits T5 and T6 are considered to have low erosion susceptibility and a low risk of fine sediment export.
The TP3 S2 sample appears to have an elevated susceptibility to erosion, and the TP3 S1, TP5 S2 and TP6 S2 samples appear to have elevated susceptibility to erosion and an elevated fine sediment export risk.

Disturbed soil may erode and release fine sediment if exposed to rain drop impact, channelised flows or significant sheet flow (such as during high rainfall events). Erosion risk can be increased by topographic features such as inclined surfaces and/or long uninterrupted slopes. Considering site conditions and the presence of soils with elevated erosion susceptibility and fine sediment export risk, an erosion and sediment control plan should be developed for the site that provides relevant and properly designed erosion and sediment control measures.

6 BASELINE WATER

6.1 Surface Runoff

The potential for surface runoff has been covered in Section 2.3.

6.2 Shallow Percolation

Shallow percolation is possible, but will be governed by the permeability and thickness of the very shallow surficial soils. As shown in Table 1 and on the logs, there is barely any topsoil to transmit water and at three out of the six TP locations there was no topsoil. The depth of topsoil was only 150mm at TP2 and TP3 and 120mm at TP6. Soil or CWR rock permeably may be derived from the gradings and types of fines as presented in **Table 7**.

TABLE 7 – SOIL AND ROCK PERMEABILITY (m/sec)

TP or BH No	Sample No	Group Symbol Description	Depth (m)	Fines %	Fines Class	Type Fines	1x K m/sec	Permeability Class
TP1	S1	CWR	0.0-0.3	18	CL	Clay	10^{-10}	Practically Impermeable
TP1	S2	CWR	0.3-0.6	22	CL	Clay	10^{-10}	Practically Impermeable
TP2	S1	Topsoil	0.0-0.15	22	CM	Clay	10^{-10}	Practically Impermeable
TP2	S2	CWR	0.15-0.35					
TP3	S1	Topsoil	0.0-0.15	29	OL	Silt	10^{-11}	Impermeable
TP3	S2	CWR	0.15-0.3	11	NP		10^{-8}	Poor Drainage
TP4	S1	CWR	0.0-0.3					
TP4	S2	CWR	0.3-0.6	10	OM	Silt	10^{-9}	Practically Impermeable
TP5	S1	CWR	0.0-0.2	18	CL	Clay	10^{-10}	Practically Impermeable
TP5	S2	CWRredClay	0.2-1.0	13	CM	Clay	10^{-11}	Impermeable
TP6	S1	Topsoil	0.0-0.12	26	MM	Silt	10^{-12}	Impermeable
TP6	S2	CWR	0.12-0.2	15	CM	Clay	10^{-10}	Practically Impermeable
BH1	SPT1	Red Clay	1.0-1.45	36	CM	Clay	10^{-12}	Impermeable
BH1	SPT2	cwrCuttings	2.0-2.45	26	CL	Clay	10^{-12}	Impermeable

CL=Clay LOW plasticity; CM=Clay MEDIUM Plasticity; OM=Silt LOW plasticity; OM=Silt MEDIUM plasticity; NP=non plastic

In conclusion, shallow percolation will be insignificant as a) there is little soil thickness b) the topsoil layers are not continuous and c) even where topsoil exists it is of very low permeability.

6.3 Groundwater

Groundwater at the site was investigated by drilling two water bores and the installation of standpipe piezometers. Rock permeability was established form the SPT and core samples and by doing permeability tests in each of the boreholes.

The two boreholes were completed by the 7/11/2018 and the drillers returned on 14/11/18 to collect the first set of water samples and to complete the first set of permeability tests. They returned on the 26th November 2018 to collect the second set of samples and permeability tests. During the first visit there was a small amount of water in BH1 but BH2 was dry. During this second visit, both boreholes were dry, which suggests that there is no reliable standing groundwater at the site.

There is an existing open quarry just outside the Eastern boundary and an inspection was also made of the open quarry operated by AES. The local quarry has a face of around 22m and the AES quarry around 40m although at AES this was not measured. Both of these showed no signs of seepage with the quarry faces being dry.

However standing groundwater was observed during the first return visit in BH1 at 7.2m BGL, but with no groundwater at BH2. However no groundwater was encountered in either borehole during the second visit.

Permeability testing in the boreholes carried out at the first return showed values of around 1x10-6 m/sec, with similar values obtained during the second visit. Permeabilities derived from the gradings are reported in **Table 7** above. These show that the permeability is significantly less that that shown by the borehole permeability tests, with most CWR samples classed as **"Practically Impermeable**" or **"Impermeable"**

As noted in Section 2.3 the IWMF is located on a ridge with downward land falls on all four sides. Runoff directions for all sections of the site are shown on the Heading & Associates plan in Figure 1. For leachates from the landfill to enter the bedrock they would have to permeate down through the overlying soil mantle. At TP3, which is in the area of the landfill, there is 150mm of topsoil over a mantle of claybound rock. The topsoil was classed as "Impermeable" and the CWR in the main is "Virtually Impermeable"

Because of the low permeability of the soil and rock, there would appear to be no need for a liner below the landfill. It is therefore concluded that this site is suitable as a location for the intended landfill.

Groundwater Quality

Two groundwater samples were obtained by ACEM representatives from BH1 on 14 November 2018. Groundwater samples were analysed by ALS (NATA accreditation # 825) for the following analytes.

- pH
- EC
- Total dissolved solids
- Major anions and cations (calcium, magnesium, potassium, sodium, chloride and sulfate)
- Alkalinity
- Ionic balance
- Total metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury).
- Total recoverable hydrocarbons.

Analytes tested were compared to the Water Quality Criteria for Protection of Freshwater Aquatic Life in Table 1, Schedule 1 of the PNG *Environment (Water Quality Criteria) Regulation* 2002. Summarised groundwater sample results are provided in Table 8. Complete analysis results and laboratory documentation for the groundwater samples are provided in Appendix D.

Groundwater Analysis Quality Assurance/Quality Control

Recommended sample holding times were exceeded for pH, dissolved major cations (*ie* calcium, magnesium, sodium and potassium), alkalinity and total recoverable hydrocarbons due to quarantine requirements and laboratory issues.

These holding time exceedances may have impacted the analytical quality of the results for the identified analytes, however the results still provide an indication of the conditions onsite.

Laboratory determined ionic balances for the groundwater samples were within the acceptable criteria of the analysing laboratory (ALS Environmental).

TABLE 8 - GROUNDWATER QUALITY DATA			
	Site:	BH1	
	Sample No:	S1	S2
Analyte	Water Quality Criteria[1]		
pH Value (pH Unit)	No alteration to natural condition	5.24	6.38
Electrical Conductivity @ 25°C (µS/cm)	-	589	616
Total Dissolved Solids (Calc) (mg/L)	-	383	400
Major anions and cations	-		
Sulfate as SO4 (mg/L)	400	145	117
Chloride (mg/L)	-	68	84
Calcium (mg/L)	-	41	44
Magnesium (mg/L)	-	11	14
Sodium (mg/L)	-	40	44
Potassium (mg/L)	5	3	4
Alkalinity			
Hydroxide Alkalinity as CaCO3 (mg/L)	-	<1	<1
Carbonate Alkalinity as CaCO3 (mg/L)	-	<1	<1
Bicarbonate Alkalinity as CaCO3 (mg/L)	-	6	45
Total Alkalinity as CaCO3 (mg/L)	-	6	45
Ionic Balance			
Total Anions (meq/L)	-	5.06	5.7
Total Cations (meq/L)	-	4.77	5.36
Ionic Balance (%)	-	2.94	3.08
Dissolved Metals			
Arsenic (mg/L)	0.05	0.002	0.002
Cadmium (mg/L)	0.01	0.0002	0.0002
Chromium (mg/L)	0.05	0.001	<0.001
Copper (mg/L)	1.00	0.034	0.031
Lead (mg/L)	0.005	0.002	0.003
Nickel (mg/L)	1.00	0.016	0.013
Zinc (mg/L)	5.00	1.42	2.61
Mercury (mg/L)	0.0002	<0.0001	<0.0001
Total Recoverable Hydrocarbons			
C6 - C10 Fraction (µg/L)	-	350	220
>C10 - C16 Fraction (µg/L)	-	<100	<100
>C16 - C34 Fraction (µg/L)	-	120	380
>C34 - C40 Fraction (µg/L)	-	<100	170

[1] Water Quality Criteria for Aquatic Life Protection in Table 1, Schedule 1 of the PNG *Environment (Water Quality Criteria) Regulation* 2002.
Shaded results were extracted and/or analysed outside of recommended holding times. This should be taken into consideration when viewing and interpreting results.

All groundwater quality results were below/within the values identified in the Water Quality Criteria for Aquatic Life Protection in Table 1, Schedule 1 of the PNG *Environment (Water Quality Criteria) Regulation* 2002.

6.4 AES Water

Enquiries with AES revealed that potable water is obtained from desalination of either seawater or desalination of borewater. They supplied the Google Map shown on Figure 4 which shows their single borewater source located 4km away.

7 BASELINE NOISE & AIR QUALITY

Baseline air and noise quality was undertaken by ASK Consulting Engineers Pty Ltd, with ACEM providing the equipment and assistance. ASK have provided an interpretive report which is contained in Appendix F. A summary of their conclusion follows;

7.1 Air Quality

A summary of the air pollutant concentrations is provided in **Table 9** with the relevant WHO criteria except for TSP. As shown, the average PM_{10} concentration exceeded the annual average criterion. The other particulate concentrations were high, approaching the relevant criteria.

The measured gas concentrations were below the instrument detection limit. Although the instruments used did not have sufficient sensitivity to compare to the long-term averages, the low short-term average concentrations indicate that long-term averages are also likely to be low.

Table 9 -- Summary of Air Pollutant Concentrations

Pollutant	Averaging Period	Concentrations (µg/m³)	WHO Criterion (µg/m³)
TSP	1 year	75	90 [1]
PM_{10}	24 hours	39	50
	1 year	**29**	20
$PM_{2.5}$	24 hours	10	25
	1 year	8	10
SO_2	10 minutes	< 131	500
	24 hours	< 131	20
NO_2	1 hour	< 94	200
	1 year	< 94	40

Note:

1. *Based on Queensland and New South Wales regulations.*
2. *The average measured concentrations for the monitoring period were used for the one-year averaging period.*
3. *The maximum concentrations were reported for averaging periods of less than a year.*

Overall, the background air quality during the monitoring period had high concentrations of particulates and low concentrations of combustion gases. Site observations suggest that a major source of particulates was vehicle traffic on the access road to the port, north of the site.

7.2 Noise

The subject site is located in an industrial area and noise levels on the site especially on the northern boundary close to the local road and AES site, are dominated by car and truck movements as well as industrial noise. Moving away from the local road, AES site and harbour the noise levels reduce and insects, birds and wind rustling the grass and trees are the dominant noise sources.

8 CONCLUSIONS AND RECOMMENDATIONS

The report has established baseline soil, groundwater, noise and air conditions at the site and offers some suggestions with respect to continuing monitoring.

It is concluded that this is an ideal site for a Waste Treatment Facility as the prevailing winds will carry any noise and air conditions into the surrounding bushland. The degree of noise and air pollution will be far less than those already created by the adjacent AES facility.

Yours faithfully,

Adolf Mamatta
Principal DIRECTOR

REFERENCES

1. Stockwell, M.J, 1997, *Determination of allowable bearing pressure under small structures*.

2. AS 1289 – 1997 *Methods of Testing Soils for Engineering Purposes*, Australian Standards Council.

3. AS 1726-1981 *Site Investigations*, Australian Standards Council.

4. PNG Standard 1001 – 1982, *Part 4 Earthquake Loading*.

5. Curtin, W.G, Shaw, G, Parkinson, G.I and Golding, J.M, 2000, *Structural Foundation Designers Manual,* Curtains Consulting Engineers, Blackwell Science, London, Oxford.

6. AS 2870 – 1996 *Residential Slabs and Footings,* Australian Standards Council.

7. Pieters, P. 1:250 000 Geological Series, Sheets SC/55-6,7,11, *Port Moresby – Kalo- Aroa Papua New Guinea*, Department of Mineral and Energy.

8. Tomlinson, MJ, 2001, *Foundation Design and Construction 7th Edition, Prentice Hall.*

9. Hough, BK, 1957, *Basic Soils Engineering, The Ronald Press NY.*

10. Look B 2006, Handbook of Geotechnical Investigation and Design Tables, by Burt Look, Willey.

11. Jie Han 2015, Principles and Practice of Ground Improvement, Willey

12. DOW 1995, PNG Department Of Works, Specification For Road and Bridge Works,

FIGURES

FIGURE 1 - INVESTIGATION LOCATION PLAN

FIGURE 2 - GOOGLE MAP ROKU

FIGURE 3 - GOOGLE MAP IWMF SURROUNDS

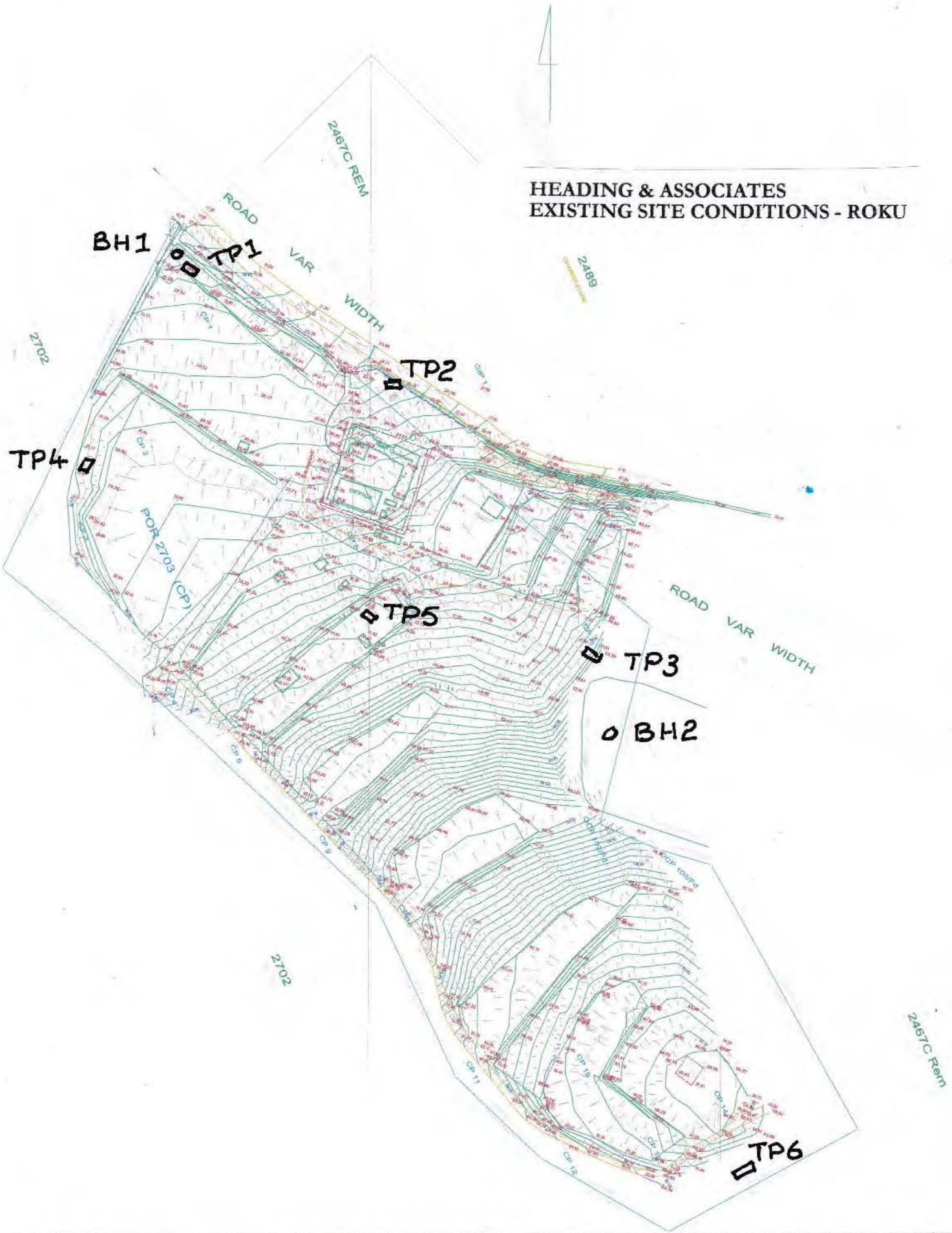
FIGURE 4 - GOOGLE MAP OF AES WATERBORE

FIGURE 5 - WIND STATISTICS

FIGURE 6 - WIND ROSE PERCENTAGES

FIGURE 7 - GROUND PROFILE BOREHOLES

HEADING & ASSOCIATES
EXISTING SITE CONDITIONS - ROKU



TWM PNG LTD-Total Waste Management				**INVESTIGATION LOCATION PLAN**	
Integrated Waste Management Facility				ACEM GEOTECHNIQUES	PROJ. EG100918
BY IKS	DATE	CHECKED	DATE 07/01/19		SK/FIG.No **FIG 1**

FIGURE 2 Google Map ROKU

TWM PNG LTD-Total Waste Management				GOOGLE MAP ROKU	
Integrated Waste Management Facility				ACEM GEOTECHNIQUES	PROJ. EG100918
BY IKS	DATE	CHECKED	DATE 07/01/19		SK/FIG.No FIG 2





TWM PNG LTD-Total Waste Management				GOOGLE MAP IWMF SURROUNDS	
Integrated Waste Management Facility				ACEM GEOTECHNIQUES	PROJ. EG100918
BY IKS	DATE	CHECKED	DATE 07/01/19		SK/FIG.No FIG 3



	TWM PNG LTD-Total Waste Management				GOOGLE MAP - AES WATERBORE	
	Integrated Waste Management Facility				ACEM GEOTECHNIQUES	PROJ. EG100918
	BY IKS	DATE	CHECKED	DATE 07/01/19		SK/FIG.No FIG 4

BACK TO MAPS

Wind & weather statistics

Port Moresby Airport

6 kts
South-Southeast

30°C
Broken

Data based on our forecast model

SUNRISE	SUNSET	LOCAL TIME	ELEVATION
05:39	18:12	10:27 (UTC +10)	45 m

(https://www.fac
app_id=16263
share&redirect
share) url=)

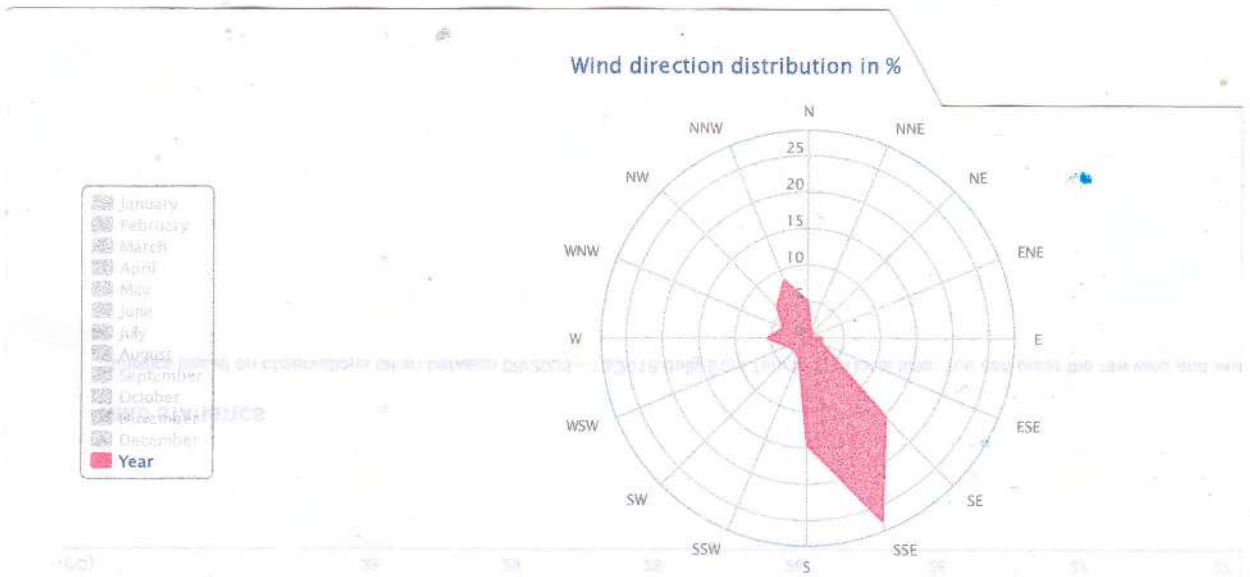
Forecast(/forecast/port_moresby) Report(/report/port_moresby) Wind statistics (/windstatistics/port_moresby)Tides(/tide/port_moresby) Webcams(/webcams/port_moresby)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
(%)	21	15	11	10	17	24	36	42	34	30	17	11	22
(kts)	8	7	6	6	7	8	10	11	10	9	7	7	8
(°C)	28	29	28	28	28	27	27	27	27	28	29	29	27

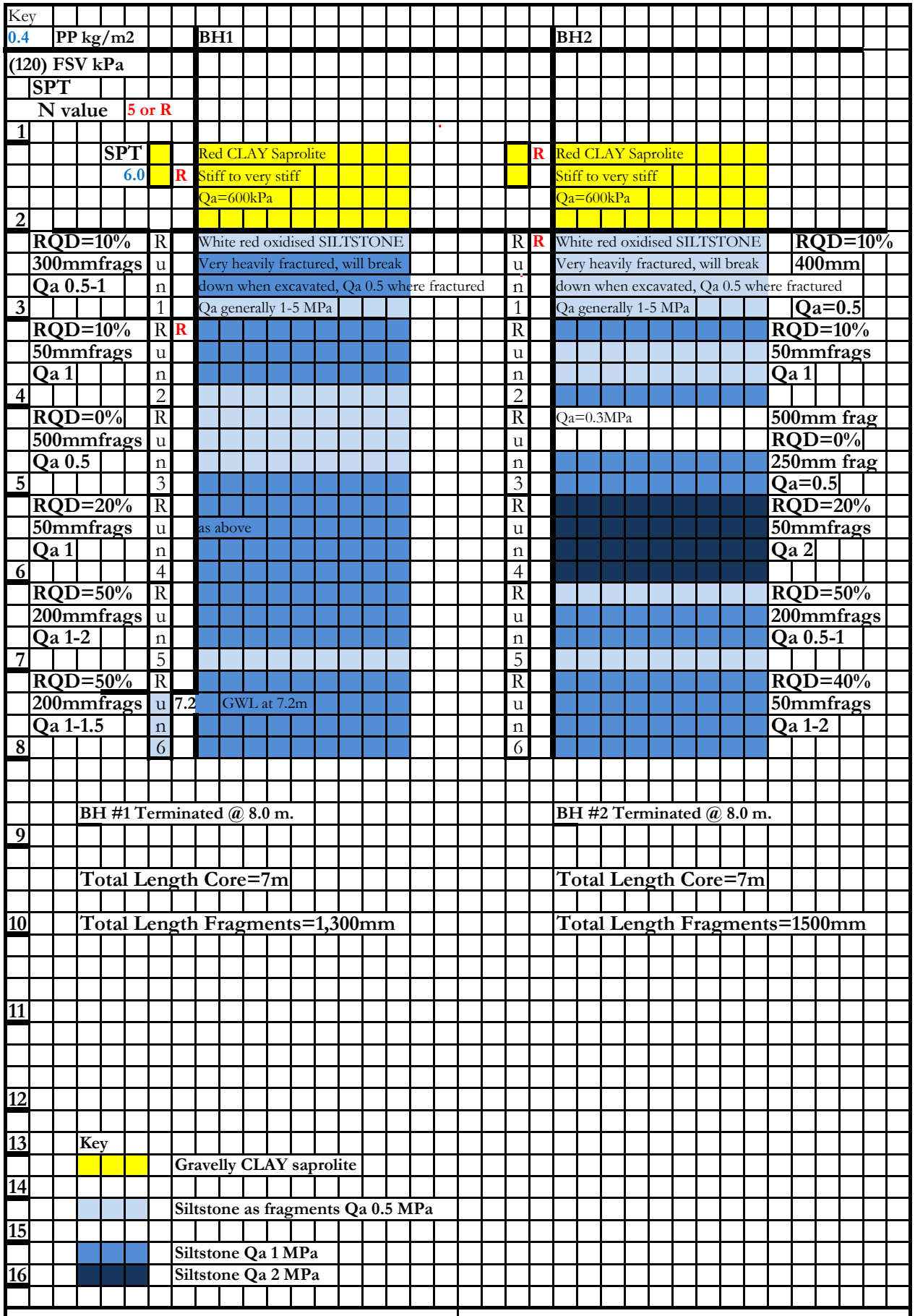
WIND STATISTICS

Statistics based on observations taken between 08/2003 - 10/2018 daily from 7am to 7pm local time. You can order the raw wind and weather data in Excel format from our historical weather data request page (/historical-weather-data/).

	TWM PNG LTD-Total Waste Management			WIND STATISTICS
	Integrated Waste Management Facility			ACEM GEOTECHNIQUES PROJ. EG100918
	BY IKS	DATE	CHECKED	DATE 07/01/19 SK/FIG.No FIG 5



TWM PNG LTD-Total Waste Management				WIND ROSE PERCENTAGES	
Integrated Waste Management Facility				ACEM GEOTECHNIQUES	PROJ. EG100918
BY IKS	DATE	CHECKED	DATE 07/01/19		SK/FIG.No FIG 6



TWM PNG LTD		GROUND PROFILE BOREHOLES	
Integrated Waste Mangement Plant		ACEM GEOTECHNIQUES	PROJ. EG100918
BY IKS	DATE 25/11/18 CHECKED iks DATE 25/11/18		SK/FIG.No FIG 7

APPENDICES

APPENDIX A DRAWINGS SUPPLIED BY TWM

APPENDIX B SITE PHOTOGRAPHS

APPENDIX C GEOTECHNICAL LOGS

APPENDIX D GEOTECHNICAL LABORATORY TEST RESULTS

APPENDIX E ACEM SELECTFILL SPECIFICATION

APPENDIX F ASK REPORT ON AIR & NOISE MONITORING

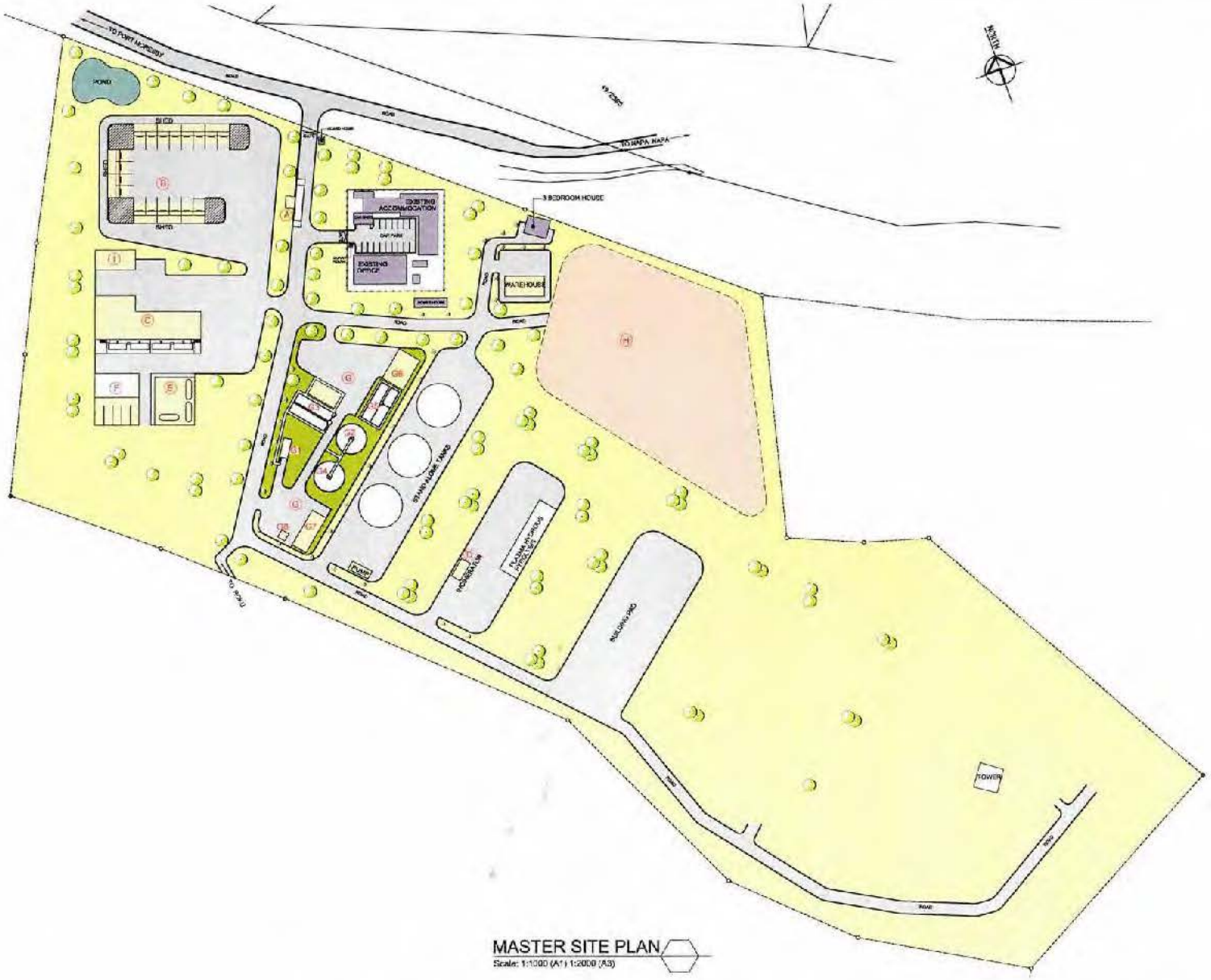
APPENDIX G GENERAL NOTES

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

APPENDIX A: DRAWINGS SUPPLIED BY TWM

MASTER SITE PLAN

HEADING ASSOCIATES-EXISTING SITE CONDITIONS - ROKU



MASTER SITE PLAN
Scale: 1:1000 (A1) 1:2000 (A3)

SCHEMATIC ISSUE

Revisions	no.	by	date	Description	Ckd
	A	AJM	09.04.18	Client Issue	JST
	B	AJM	13.01.18	Revised Site Plan Issue	JST

Client: TWM Total Waste Management

Architect: SEADOG ARCHITECTURAL DESIGN STUDIO, P.O.BOX 165, KOKOPO, NCD

job title: **TOTAL WASTE MANAGEMENT**
PROPOSED ROKU DEVELOPMENT MASTER SITE PLAN

drawn: AJM | scale: A3 SHOWN | job no: 18.03.01

architect: JST | date: A1 13.18

checked: JST | date: A1 13.18

sheet title: MASTER SITE PLAN

sheet no: A02.01 | revision no: A B

TITLE BEARING DATUM

HEADING & ASSOCIATES

ENGINEERING SURVEYORS, COMPUTER CAD DRAFTING
CONSTRUCTION SURVEYS - CIVIL & STRUCTURAL

TELEPHONE: (03) 9916 9130 FACSIMILE: (03) 9376 4831
ADDRESS: 46 STUBBS STREET, KENSINGTON, VIC 3031
EMAIL: enquiries@headingassociates.com.au

HEADING & ASSOCIATES DOES NOT WARRANT THAT THIS PLAN IS DEFINITIVE NOR FREE OF ERROR AND DOES NOT ACCEPT LIABILITY FOR ANY LOSS CAUSED OR ARISING FROM RELIANCE UPON INFORMATION PROVIDED HEREIN.

BEWARE OF UNDERGROUND SERVICES WHEN WORKS ARE DONE ONSITE. THIS SURVEY PLAN DOES NOT SHOW THE POSITION OF UNDERGROUND SERVICES AND NO ATTEMPT HAS BEEN MADE TO VERIFY OR POSITION THE LOCATION OF UNDERGROUND SERVICES IN THE AREA OF SURVEY. IT IS ADVISED THAT BEFORE ANY WORKS ARE PREFORMED ONSITE AN APPLICATION SHOULD BE MADE TO 'DIAL BEFORE YOU DIG' TO REVIEW AND VERIFY UNDERGROUND SERVICES IN THE AREA OF SURVEY. THERE IS NO GUARANTEE THAT ALL SERVICES HAVE BEEN LOCATED BY THIS SURVEY AND SHOWN ON THIS PLAN.

THE NOTES CONTAINED WITHIN THE PLAN ARE AN INTEGRAL PART OF THE INFORMATION PRESENTED, AND MUST BE INCLUDED IN ANY REPRODUCTION.

To obtain True Bearings subtract 0°44'00" FSM Bearings equate Grid Bearings
To obtain Magnetic Bearings subtract 6°44'00" approx

ENLARGEMENT NOT TO SCALE

IN 3.11m
IN 4.65m
FENCE
FENCE

ENLARGEMENT NOT TO SCALE

FENCE
IN 1.69m

ENLARGEMENT NOT TO SCALE

PIT
4.50

To Port Moresby
To Napa Napa
To Roku
Road Track
Quarry
Edge of Quarry
Approx 100m Cut
Bitumen Road
Culvert
Drain
Road
Building Pads
Workshop
Gate
Guard House
Flower Garden
Tree
Casual Staff Houses
Tower
PROPOSED BENCH ONE
PROPOSED BENCH 2
POR 2703 (CP)
OKRIDUDARE NO.1
GIP 1
CP 1
CP 2
CP 5
CP 9
CP 11
CP 12
CP 13
CP 14
CP 15
POCP 103/Fd
4927754
4927374
4923169
4923928
4923583

3.11
4.65
150° 33'
87.00po
104° 44'00"
27° 12'
1.69
84.38
207%/D 30° 04"
55.99po
25° 39'
POCP 2
205%/D 28° 24"
189.96
205%/D 16° 10'
60.70
71.34po
25° 30'
79.92po
309° 19'
155%/D 21° 34"
67.04po
311° 54' 45"
POCP 1
106° 39'40"
172.75ss
130° 33'
166.00po
129° 53'
125.94po
130.95
47%/D 20° 23"
38%/D 16° 15"
74.10ss
135° 06' 20"
154.03po
313° 19' 50"
POCP 9
120%/D 25° 32"
70.03
113.28po
335° 00' 30"
70.95po
313° 47'
322%/D 03° 40"
65.90
POCP 12
87.96po
299° 57'
183° 57' 20"
122.55po
106° 19'
32.61po
POCP 103/Fd
150° 54'
181.19po
247° 32'
128.63po
57%/D 29° 42"
45.79
POCP 14
Tower
96.85
96.61
93.63
93.49
POCP 15
322%/D 03° 40"
65.90
POCP 13
Building Pads
Building Pads
Building Pads

APPENDIX B: SITE PHOTOGRAPHS

PHOTOGRAPHIC LOGS

PLATE NO. 01: AES Facility Typical Warehouse and Unsealed Roads.



PLATE NO. 02: AES Accommodation Units.



PLATE NO. 03: AES Main Access Road and Road to Quarry.



PLATE NO. 04: AES Quarry.



PLATE NO. 05: AES Grading Plant and Laydown – all unsealed.



PLATE NO. 06: TWM Vegetated Northern Boundary.



PLATE NO. 07: TWM Red CWR Saprolite at TP3.



PLATE NO. 08: TWM Vegetated boundaries at TP1.



PLATE NO. 09: TWM Quarry Face.



PLATE NO. 10: TWM Quarry at BH2.



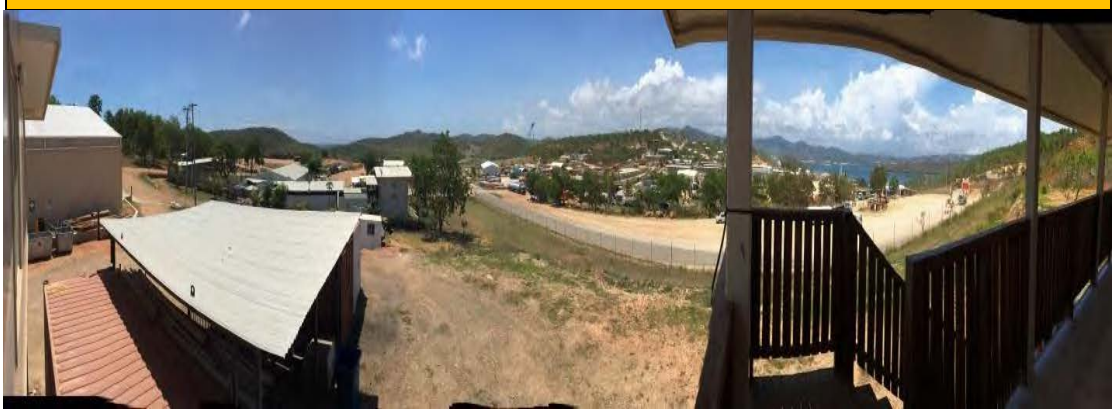
PLATE NO. 11: TWM View from TP6 to Roku Village.



PLATE NO. 12: TWM Red Soil at TP5.



PLATE NO. 13: TWM 'Panorama' of Eastern Boundary and housing at TP2.



APPENDIX C: GEOTECHNICAL LOGS

BH1

BH2

TP1

TP2

TP3

TP4

TP5

TP6

ACEM Geotechniques

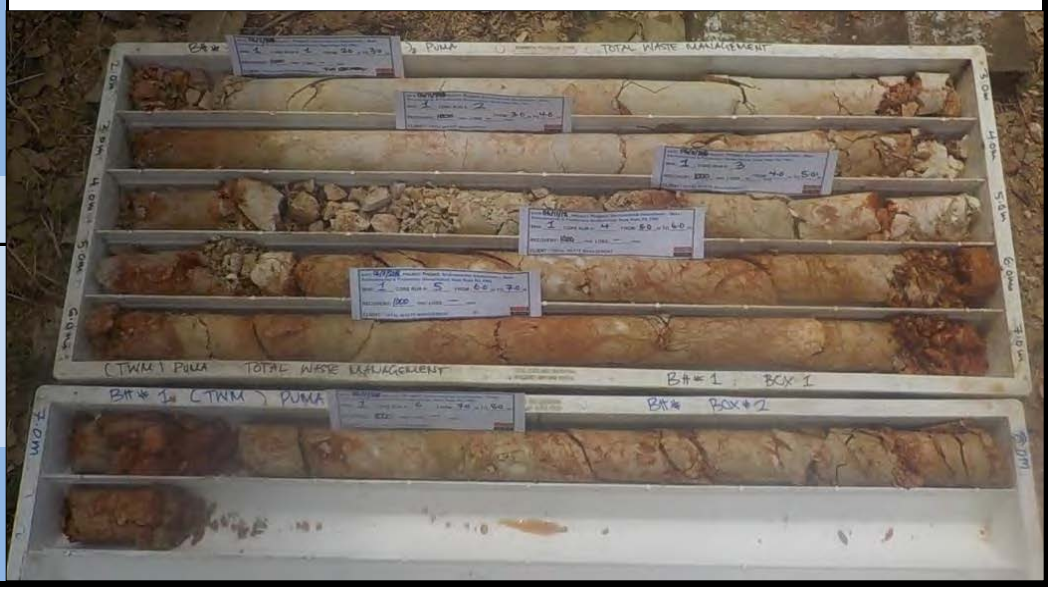
BOREHOLE CORE LOG

HOLE NO.
BH 1
SHEET 1 OF 2

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	06.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	06.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM GEOTECHNIQUES	Cordinates: Easting:	9°27.027'
Equipment Model:	EVH truck mounted	Northing:	147°04.986
		Surface RL (m):	57.0
		Datum:	

Depth (m)	Fractures Angle Run No. ABC	%Fg RQD Qa	%Core (Is50) Qschmidt	DESCRIPTION ROCK NAME/TYPE, ABC Allowable Bearing Capacity, Fractures Degree from Horz-R=Rough U=Undulating, Fg=fragments, RQD=RockQualityData, Q=Schmidt Hammer, (Is50=Pt Load Index)
0.0				*Washbore with water from 0.0m to 8m* Qa estimated MPa ***Refer to TP 1 for soil to 1m*** *Colour Key* *Red Gravelly Clay* *Siltstone as fragments Qa= 0.5 MPa* *Siltstone Qa=1MPa* *Siltstone Qa=2MPa*
0.5				
1.0				
	SPT 1.0-1.45 Refusal		220/450 ***N=R***	Gravelly Clay, red, mixture of fine to coarse gravel in clay matrix (PSD+Atterbergs) moist, stiff to very stiff
1.5				
2.0				
	SPT 2.0-2.45 380/450 (cuttings only)		1000/1000	*Cored from 2m*
2.5		Qa 0.5 *to Qa 1* 30%Fg		*White and red oxidised SILTSTONE, very heavily fractured medium strength when cored but crumbles on drying, suggesting low Los Angeles values. Will break down when excavated*
	Run 1 2.0-3.0 1,000/1,000	RQD *10%*		*Qa=0.5MPa where fragmented* *Qa generally 1MPa to 5m* Is50=0.01
3.0				
	Run 2 3.0-4.0 1,000/1,000	Qa 1 5%Fg *10%*	1000/1000	*One Joint 60°*
3.5				
4.0				
	Run 3 4.0--5.0 1,000/1,000	Qa 0.5 50%Fg *0%*		
4.5		Qa 1		
5.0				





ACEM Geotechniques

BOREHOLE CORE LOG

HOLE NO. BH 1
SHEET 2 OF 2

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	06.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	06.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM GEOTECHNIQUES	Cordinates: Easting:	Surface RL (m): 57.0
Equipment Model:	EVH truck mounted	Northing:	Datum:

Depth (m)	Fractures Angle Run No. ABC	%Fg RQD Qa	%Core (Is50) Qschmidt	DESCRIPTION ROCK NAME/TYPE, ABC Allowable Bearing Capacity, Fractures Degree from Horz-R=Rough U=Undulating, Fg=fragments,RQD=RockQualityData, Q=Schmidt Hammer, (Is50=Pt Load Index)
5.0				
	Run 4	Qa 0.5		*As above CWR White khaki with chips Calcareous Mudstone Qa=0.5MPa*
	5.0-6.0			
	1,000/1,000			
				One Joint 60 °
5.5		Qa 1		
		5%Fg		
		20%		
6.0		Qa 0.5		
	Run 5			*Cutting only retreived*
	6.0-7.0			
	1,000/1,000			
		Qa 1-2		
6.5		20%Fg		
		50%		
7.0				
	Run 6			
	7.0-8.0			
	1,000/1,000			Is50=0.02
		Qa 1-1.5		
7.5		20%Fg		
		50%		
		0%		
8.0				
				BH1 terminated @ 8.0 m



8.5
9.0
9.5
10.0

ACEM Geotechniques

BOREHOLE CORE LOG

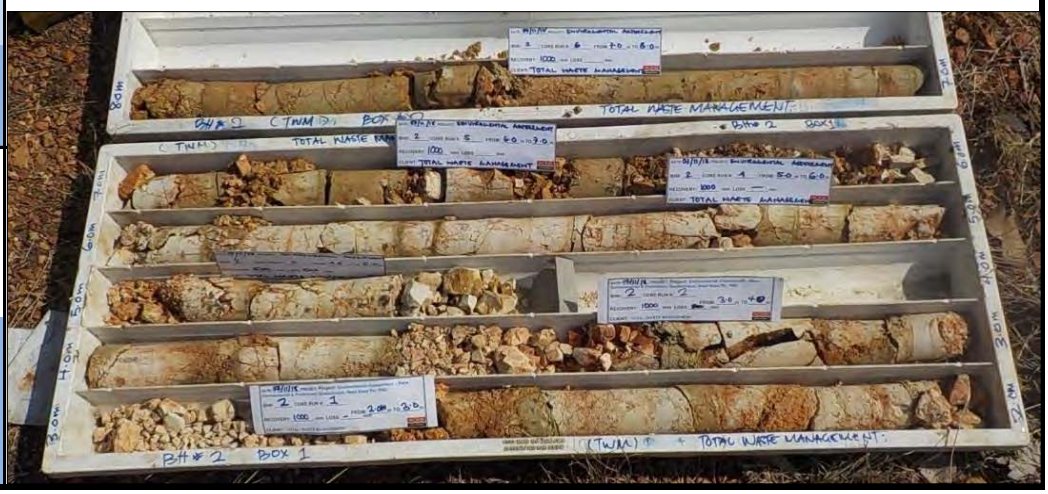
HOLE NO.
BH 2
SHEET 1 OF 2

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	7.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	7.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM GEOTECHNIQUES	Cordinates: Easting:	9°27.175'
Equipment Model:	EVH truck mounted	Northing:	147°05.138
		Surface RL (m):	88.0
		Datum:	

Depth (m)	Fractures Angle Run No. ABC	%Fg RQD Qa	%Core (Is50) Qschmidt	DESCRIPTION
0.0				ROCK NAME/TYPE, ABC Allowable Bearing Capacity, Fractures Degree from Horz-R=Rough U=Undulating, Fg=fragments,RQD=RockQualityData, Q=Schmidt Hammer, (Is50=Pt Load Index)
				Washbore with water from 0.0m to 8m
				Qa estimated MPa
				Colour Key
			FILL	*Red Gravelly Clay*
0.5				*Siltstone as fragments Qa= 0.5 MPa*
				Siltstone Qa=1MPa
				Siltstone Qa=2MPa
1.0				
				Soil from 0-1m is fill remaining from the quarry operations----GC clayey sandy gravel
	SPT			*White and red oxidised SILTSTONE, very heavily fractured*
	1.0-1.45		370450	*Qa=0.5MPa as all*
	Refusal		***N=R***	*fragmented to 2m*
	Cuttings only			
1.5				
2.0				
	SPT			*Coring Commenced*
	2.0-2.45			*White and red oxidised SILTSTONE, very heavily fractured medium strength when cored but*
	450/450		***N=R***	*crumbles on drying, suggesting low Los Angeles values. Will break down when excavated*
	(cuttings only)	Qa 0.5		*Qa=0.5MPa where fragmented*
2.5		400mm		*Qa generally 1MPa to 2 MPa where noted*
	Run 1	40%Fg		Qa=0.2--0.3MPa where no core recovered
	2.0-3.0	*10%*		
	1000/1000			
3.0				
	Run 2			
	3.0-4.0		1000/1000	
	1,000/1,000	Qa 1		
		5%Fg		
3.5		*10%*		
4.0				
	Run 3			
	4.0--5.0		***Core***	
	500/1,000	Qa 0.3	***Loss***	
		100%Fg		
4.5		*0%*		
		Qa 0.5		
		50%Fg		
		20%		
5.0				







ACEM Geotechniques

BOREHOLE CORE LOG

HOLE NO. BH 2
SHEET 2 OF 2

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	7.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	7.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM GEOTECHNIQUES	Cordinates: Easting:	Surface RL (m): 88.0
Equipment Model:	EVH truck mounted	Northing:	Datum:

Depth (m)	Fractures Angle Run No. ABC	%Fg RQD Qa	%Core (Is50) Qschmidt	DESCRIPTION ROCK NAME/TYPE, ABC Allowable Bearing Capacity, Fractures Degree from Horz-R=Rough U=Undulating, Fg=fragments,RQD=RockQualityData, Q=Schmidt Hammer, (Is50=Pt Load Index)
5.0				
	Run 4 5.0-6.0 1,000/1,000			*White and red oxidised SILTSTONE, very heavily fractured medium strength when cored but crumbles on drying, suggesting low Los Angeles values. Will break down when excavated* *Qa=0.5MPa where fragmented* *Qa generally 1MPa to 2 MPa where noted*
5.5		Qa 2 5%Fg 20%		*From 5m to 6m could produce slightly better quality soil but needs testing and sampling after* excavation Qa will reduce when CWR rock is exposed
6.0				
	Run 5 6.0-7.0 1,000/1,000			
6.5		Qa 0.5-1 20%Fg 50%		
7.0				
	Run 6 7.0-8.0 1,000/1,000			Is50=0.01
7.5		Qa 1-2 5%Fg 40%		
8.0				
				BH2 terminated @ 8.0 m
8.5				
9.0				
9.5				
10.0				



GEOTECHNICAL LOG

HOLE NO. **TP 1** SHEET 1 of 1

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD			DATE COMMENCED:	05.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY			DATE COMPLETED:	05.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU			LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm			CHECKED BY:	IKS
Contractor:	ACEM Geotechniques	Coordinates: Eastings:	9°27.033'	Surface RL (m):	58
Equipment Model:		Northings:	147°04.994	Datum:	

EXCAVATION					MATERIAL SUBSTANCE			FIELD TEST RESULTS			
METHOD	WATER	SAMPLE	RL (M)	DEPTH (M)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION NAME: grain size/plasticity, color, structure, minor components	DCP	PP	FSV	Structure & Additional Observations
				0.0							
		S1				CWR	*CWR Completely weathered Rock, heavily fractured, dry hard to excavate, Qa=0.5MPa to 1MPa*	R			*DCP refusal due rock chunks*
		S2		0.5			*Excavates as a Sandy Gravel with rock chunks to 100mm but mostly as a well graded gravel-potential basecourse/subbase/select fill*				
						CWR					
				1.0				R			

Backhoe refusal at 1m in Qa=1MPa plus rock

1.5

2.0

2.5







GEOTECHNICAL LOG

HOLE NO. **TP 2** SHEET 1 of 1

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	06.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	06.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM Geotechniques	Coordinates: Eastings: 9°27.063'	Surface RL (m): 58
Equipment Model:		Northings: 147°05.052	Datum:

EXCAVATION					MATERIAL SUBSTANCE			FIELD TEST RESULTS			
METHOD	WATER	SAMPLE	RL (M)	DEPTH (M)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION NAME: grain size/plasticity, color, structure, minor components	DCP	PP	FSV	Structure & Additional Observations
				0.0							
		S1				*OL*	Topsoil-dark brown red, organic, dry	*R*			*DCP refusal due rock chunks*
		S2				CWR	CWR				
				0.5			*CWR Completely weathered Rock, heavily fractured, dry, hard to excavate, Qa=1MPa to 0.35m and then 2MPa Plus, with* bloulders Qa=20MPa	*R*			*SH=30MPa, 25MPa SH=Schmidt Hammer*
				1.0			***Backhoe refusal at 0.3m in Qa=2+MPa plus rock, with 20+Mpa bloulders***				
				1.5							
				2.0							
				2.5							
				3.0							
				3.5							
				4.0							



GEOTECHNICAL LOG

HOLE NO. **TP 3** SHEET 1 of 1

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	05.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	05.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM Geotechniques	Coordinates: Eastings: 9°27.174'	Surface RL (m): 91
Equipment Model:		Northings: 147°05.101'	Datum:

EXCAVATION					MATERIAL SUBSTANCE			FIELD TEST RESULTS			
METHOD	WATER	SAMPLE	RL (M)	DEPTH (M)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION NAME: grain size/plasticity, color, structure, minor components	DCP	PP	FSV	Structure & Additional Observations
				0.0							
		S1					150mm deep Topsoil, organic brown with rock pieces	R			DCP refusal due rock chunks
		S2				CWR	Qa=0.2-0.5MPa	R			
				0.5			Red CWR Completely weathered Rock, heavily fractured, dry hard to excavate, Qa=0.5MPa to 1MPa Excavates as Clayey Sandy Gravel with rock chunks to 100mm but mostly as a well graded gravel-very slight potential as a claybound seal 0.15-0.3m. **Backhoe refusal at 0.3m in Qa=5MPa plus rock with boulders to Qa=20MPa**				
				1.0							
				1.5							
				2.0							
				2.5							
				3.0							
				3.5							
				4.0							





GEOTECHNICAL LOG

HOLE NO. **TP 4** SHEET 1 of 1

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD			DATE COMMENCED:	05.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY			DATE COMPLETED:	05.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU			LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm			CHECKED BY:	IKS
Contractor:	ACEM Geotechniques	Coordinates: Eastings:	9°27.099'	Surface RL (m):	67
Equipment Model:		Northings:	147°04.964	Datum:	

EXCAVATION					MATERIAL SUBSTANCE			FIELD TEST RESULTS			
METHOD	WATER	SAMPLE	RL (M)	DEPTH (M)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION NAME: grain size/plasticity, color, structure, minor components	DCP	PP	FSV	Structure & Additional Observations
				0.0							
		S1				GC	*CWR Completely weathered Rock, as silty sandy gravel, dry, dense Qa=0.1-0.2 MPa* *Excavates as a Silty Sandy Gravel with rock chunks to 40mm but*	*R*		*DCP refusal due rock chunks*	
		S2		0.5			*CWR Completely weathered Rock, heavily fractured, dry, dense* *Excavates as a Sandy Gravel with rock chunks to 100mm but mostly as a well graded gravel-potential basecourse/subbase/select fill, Qa=0.5 MPa*				
						CWR					
				1.0				*R*			

Backhoe refusal at 1m in Qa=2MPa plus rock

1.5
2.0
2.5
3.0
3.5
4.0





GEOTECHNICAL LOG

HOLE NO. **TP 5**

SHEET 1 of 1

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	06.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	06.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS
Contractor:	ACEM Geotechniques	Coordinates: Eastings: 9°27.133'	Surface RL (m): 80
Equipment Model:		Northings: 147°05.056	Datum:

EXCAVATION					MATERIAL SUBSTANCE			FIELD TEST RESULTS			
METHOD	WATER	SAMPLE	RL (M)	DEPTH (M)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION NAME: grain size/plasticity, color, structure, minor components	DCP	PP	FSV	Structure & Additional Observations
				0.0							
		S1				GC	*CWR Completely weathered Rock, as silty sandy gravel, dry, dense Qa=0.1-0.2 MPa*	R			*DCP refusal due rock chunks*
		S2		0.5		CWR	*CWR Completely weathered rock, as a claybound gravel and rock chunks, dark red brown, medium plasticity, wet, very stiff. Possible source of clay seal*				
				1.0				R			

Backhoe refusal at 1m in Qa=2MPa plus rock

1.5
2.0
2.5
3.0
3.5
4.0





GEOTECHNICAL LOG

ACEM Geotechniques

HOLE NO. TP 6

SHEET 1 of 1

CLIENT:	TOTAL WASTE MANAGEMENT-TWM PNG LTD	DATE COMMENCED:	06.11.2018
PROJECT:	BASELINE ENVORNMENTAL GEOTECHNICAL STUDY	DATE COMPLETED:	06.11.2018
LOCATION:	NAPA NAPA ROAD-ROKU	LOGGED BY:	LO
JOB NUMBER:	EG100918twmpng/dm	CHECKED BY:	IKS

Contractor:	ACEM Geotechniques	Coordinates: Eastings:	9°27.310'	Surface RL (m):	133
Equipment Model:		Northings:	147°05.146	Datum:	

EXCAVATION					MATERIAL SUBSTANCE			FIELD TEST RESULTS			
METHOD	WATER	SAMPLE	RL (M)	DEPTH (M)	GRAPHIC LOG	CLASSIFICATION SYMBOL	DESCRIPTION NAME: grain size/plasticity, color, structure, minor components	DCP	PP	FSV	Structure & Additional Observations
				0.0							
		S1				OL	0-120mm Topsoil-black, organic, dry	2			
		S2				CWR		2	6+		
		S3		0.5		CWR	*CWR Completely weathered Rock, heavily fractured, dry, hard to excavate, Qa=2MPa to 0.8m and then 3-5 Mpa, POSSIBLY CLAY* SEAL MATERIAL	2 3 8 20 25 22	6+		
				1.0			Pink White SILTSTONE, heavily fractured	14 21			
							Backhoe refusal at 1m in Qa=2+MPa plus rock	12 11 35+			





APPENDIX D: LABORATORY TEST RESULTS

CLASSIFICATION, ATTERBERG LIMITS, LINEAR SHRINKAGE

BH1 SPT S1	1.0m-1.45m
BH1 SPT S2	2.0m-2.45m
BH2 SPT S2	2.0m-2.45m
TP1 S1	0.0-0.3m
TP1 S2	0.3-0.6m
TP2 S1	0.0-0.15m
TP2 S2	0.15-0.35m
TP3 S1	0.0-0.15m
TP3 S2	0.15-0.3m
TP4 S1	0.0-0.3m
TP4 S2	0.3-0.6m
TP5 S1	0.0-0.2m
TP5 S2	0.2-1.0m
TP6 S1	0.0-0.12m
TP6 S2	0.12-0.2m
TP6 S3	0.2-0.8m

CBR & COMPACTION

TP1 S2	0.3-0.6m
TP3 S2	0.15-0.3m
TP4 S1	0.0-0.3m
TP4 S2	0.3-0.6m
TP5 S2	0.3-1.0m
TP6 S3	0.2-0.8m

POINT LOAD INDEX & SCHMIDT HAMMER TESTS

BH 1 No. 9 Tests
BH 2 No. 9 Tests

ALS TEST SHEETS

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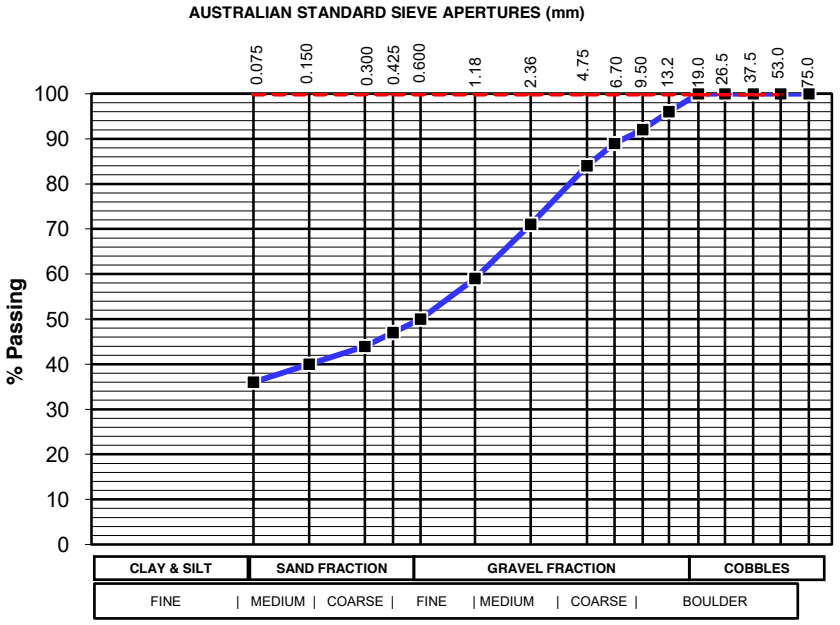
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5147
		Sample Number:	10190
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	BH1 - SPT 1	Tested Date:	19/11/2018
Test Depth (m):	1.0 - 1.45	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	100	
26.5	100	
19.0	100	
13.2	96	
9.5	92	
6.70	89	
4.75	84	
2.36	71	
1.180	59	
0.600	50	
0.425	47	
0.300	44	
0.150	40	
0.075	36	

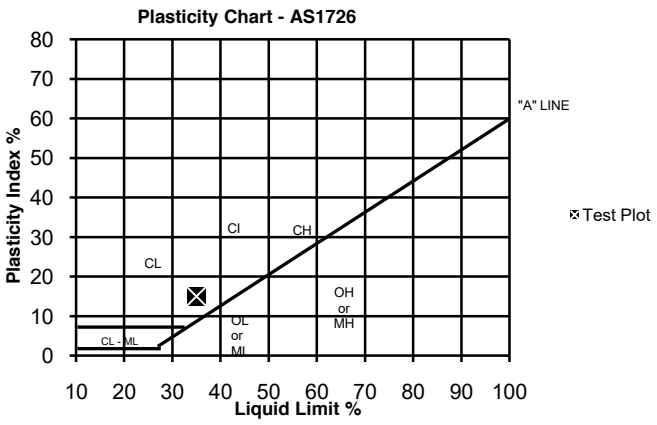


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	26.3	%
AS1289.3.1.1	LIQUID LIMIT:	35.0	%
AS1289.3.2.1	PLASTIC LIMIT:	20.0	%
AS1289.3.3.1	PLASTICITY INDEX:	15.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	7.5	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



PNGLAS Accredited Laboratory Number: 028

This laboratory is accredited by the Papua New Guinea Laboratory Accreditation Scheme. The tests reported herein have been performed in accordance with its scope of accreditation and PNGLAS requirements which include the requirements of ISO/IEC 17025. This document shall not be reproduced, except in full.

Report Authorised By
Goli Makewin Koloma

FORM: TBA

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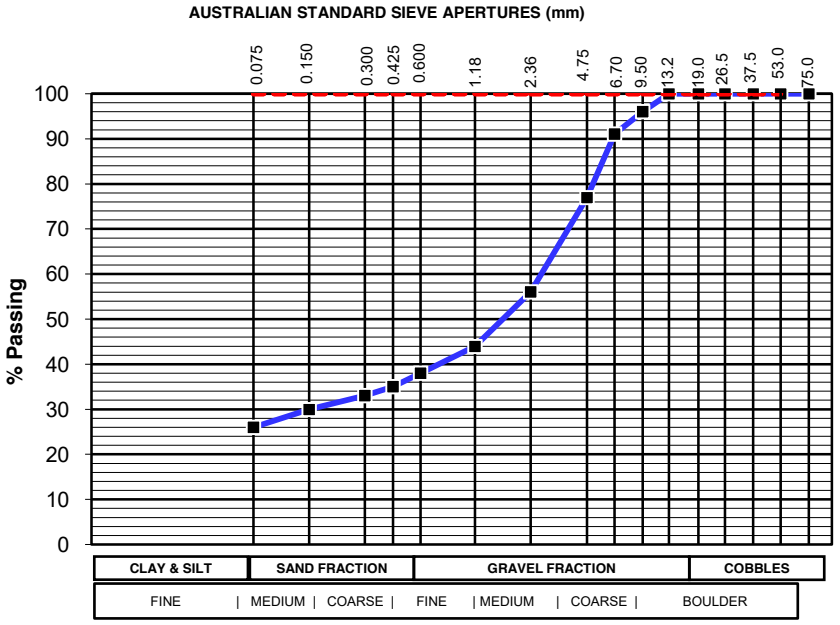
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5147
		Sample Number:	10191
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	BH1 - SPT 2	Tested Date:	19/11/2018
Test Depth (m):	2.0 - 2.45	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	100	
26.5	100	
19.0	100	
13.2	100	
9.5	96	
6.70	91	
4.75	77	
2.36	56	
1.180	44	
0.600	38	
0.425	35	
0.300	33	
0.150	30	
0.075	26	

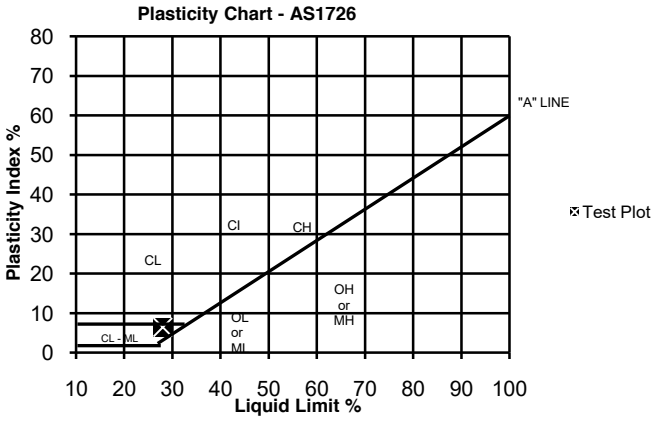


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	20.2	%
AS1289.3.1.1	LIQUID LIMIT:	28.0	%
AS1289.3.2.1	PLASTIC LIMIT:	22.0	%
AS1289.3.3.1	PLASTICITY INDEX:	6.4	%
AS1289.3.4.1	LINEAR SHRINKAGE:	3.2	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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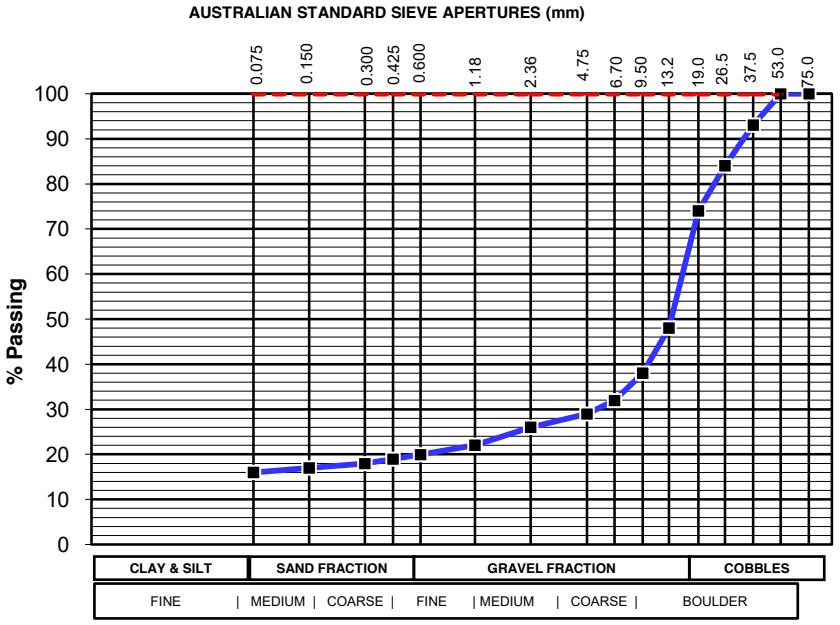
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5285
		Sample Number:	10437
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	BH2 SPT2	Tested Date:	26/01/2019
Test Depth (m):	2.0 - 2.45	Reported By:	GRR
Spec Description:	N/A	Reported Date:	26/01/2019

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	93	
26.5	84	
19.0	74	
13.2	48	
9.5	38	
6.70	32	
4.75	29	
2.36	26	
1.180	22	
0.600	20	
0.425	19	
0.300	18	
0.150	17	
0.075	16	

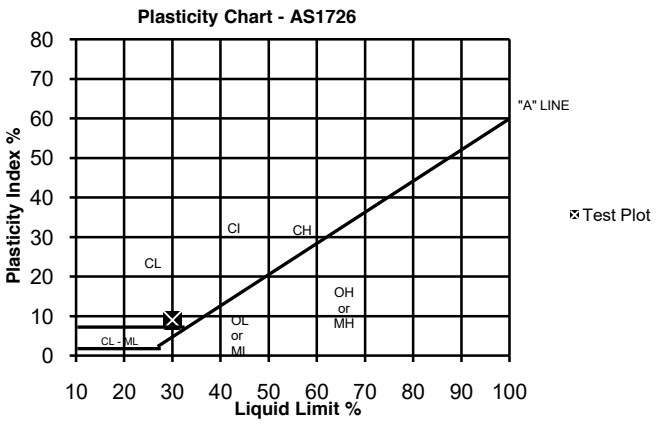


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	13.0	%
AS1289.3.1.1	LIQUID LIMIT:	30.0	%
AS1289.3.2.1	PLASTIC LIMIT:	21.0	%
AS1289.3.3.1	PLASTICITY INDEX:	9.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	6.0	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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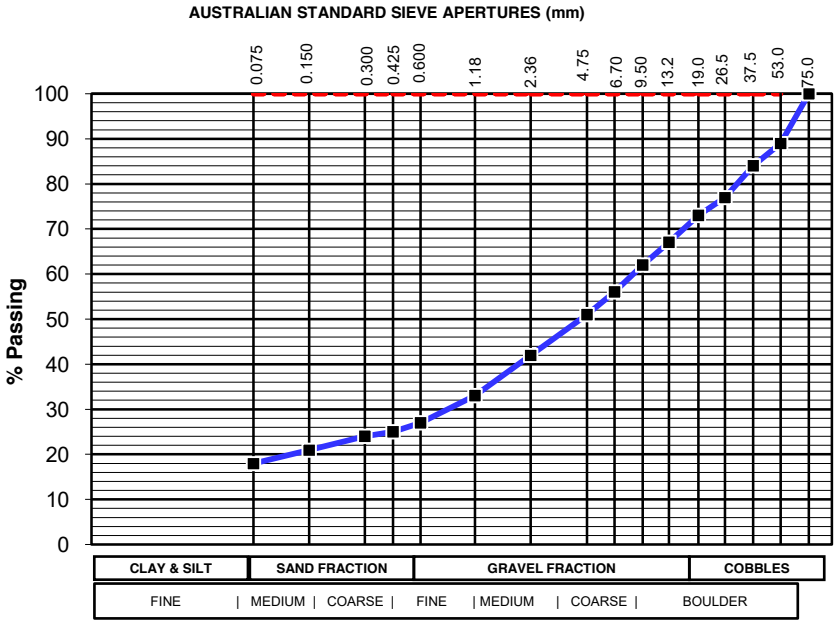
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5141
		Sample Number:	10178
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP1 - S1	Tested Date:	19/11/2018
Test Depth (m):	0.0 - 0.3	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	89	
37.5	84	
26.5	77	
19.0	73	
13.2	67	
9.5	62	
6.70	56	
4.75	51	
2.36	42	
1.180	33	
0.600	27	
0.425	25	
0.300	24	
0.150	21	
0.075	18	

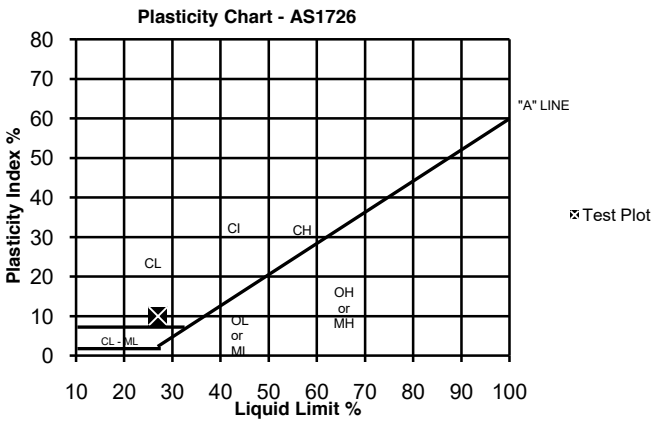


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	16.4	%
AS1289.3.1.1	LIQUID LIMIT:	27.0	%
AS1289.3.2.1	PLASTIC LIMIT:	17.0	%
AS1289.3.3.1	PLASTICITY INDEX:	10.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	2.0	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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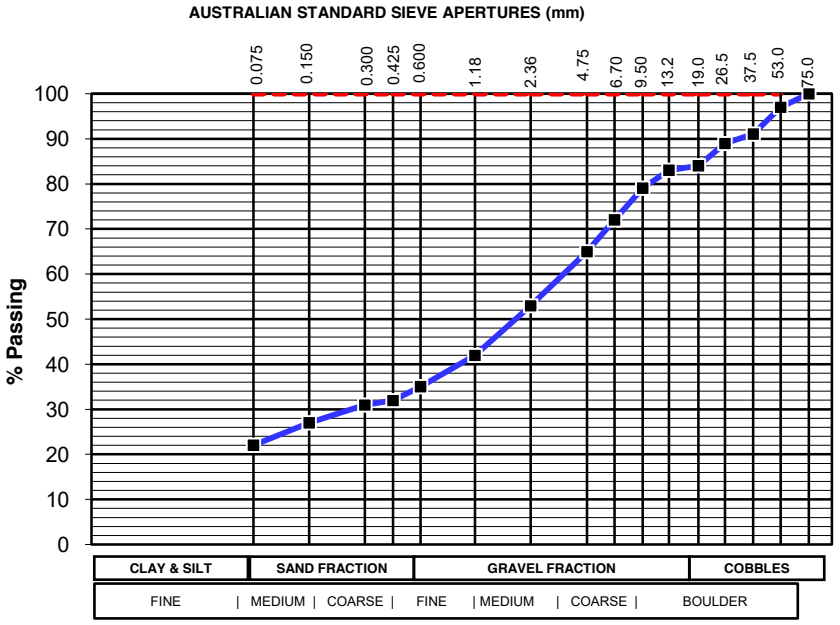
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5141
		Sample Number:	10179
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP1 - S2	Tested Date:	19/11/2018
Test Depth (m):	0.3 - 0.6	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	97	
37.5	91	
26.5	89	
19.0	84	
13.2	83	
9.5	79	
6.70	72	
4.75	65	
2.36	53	
1.180	42	
0.600	35	
0.425	32	
0.300	31	
0.150	27	
0.075	22	

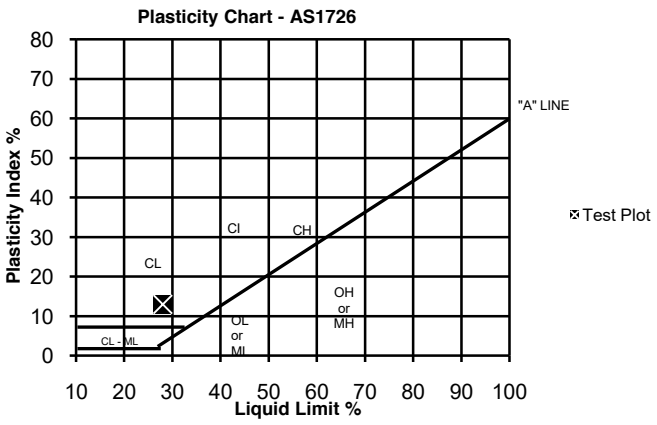


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	15.1	%
AS1289.3.1.1	LIQUID LIMIT:	28.0	%
AS1289.3.2.1	PLASTIC LIMIT:	15.0	%
AS1289.3.3.1	PLASTICITY INDEX:	13.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	6.5	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



PNGLAS Accredited Laboratory Number: 028

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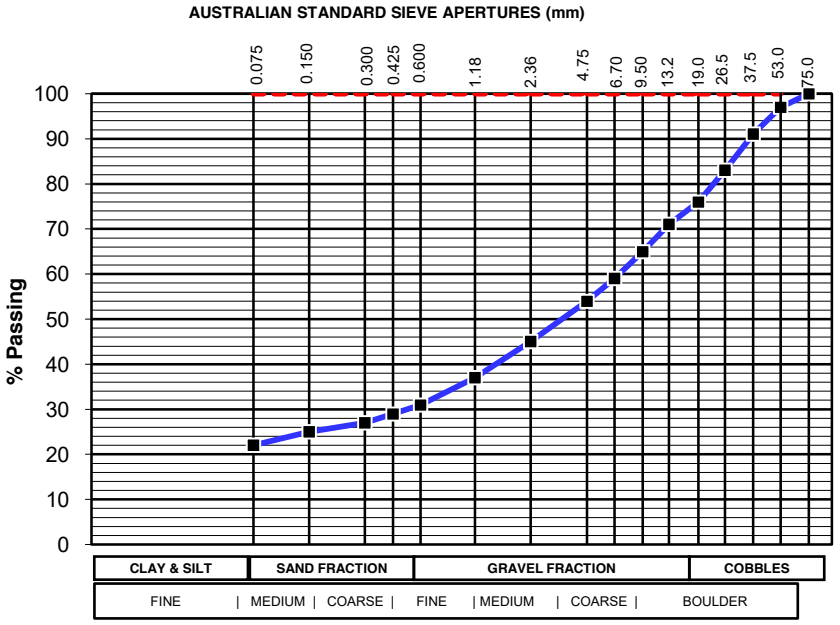
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5142
		Sample Number:	10180
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP2 - S1	Tested Date:	19/11/2018
Test Depth (m):	0.0 - 0.15	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	97	
37.5	91	
26.5	83	
19.0	76	
13.2	71	
9.5	65	
6.70	59	
4.75	54	
2.36	45	
1.180	37	
0.600	31	
0.425	29	
0.300	27	
0.150	25	
0.075	22	

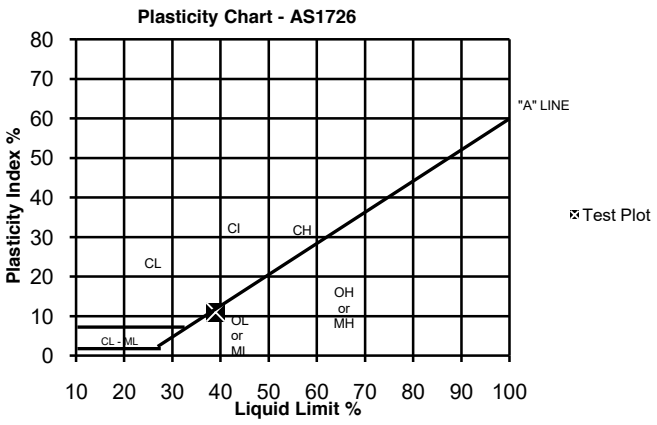


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	3.7	%
AS1289.3.1.1	LIQUID LIMIT:	39.0	%
AS1289.3.2.1	PLASTIC LIMIT:	28.0	%
AS1289.3.3.1	PLASTICITY INDEX:	11.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	5.5	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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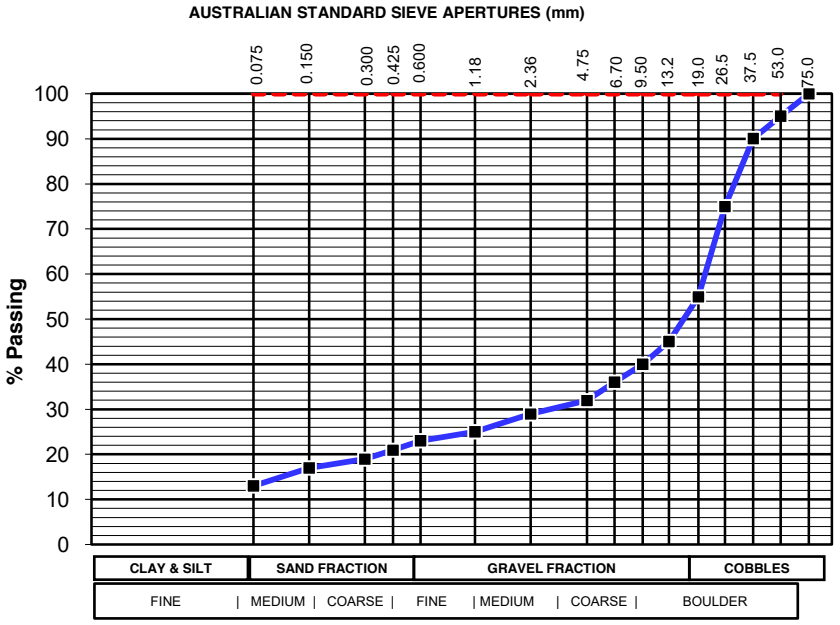
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5142
		Sample Number:	10181
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP2 - S2	Tested Date:	19/11/2018
Test Depth (m):	0.15 - 0.35	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	95	
37.5	90	
26.5	75	
19.0	55	
13.2	45	
9.5	40	
6.70	36	
4.75	32	
2.36	29	
1.180	25	
0.600	23	
0.425	21	
0.300	19	
0.150	17	
0.075	13	

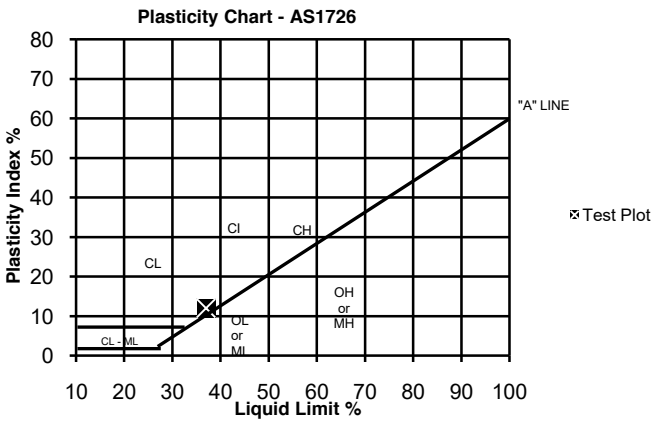


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	3.4	%
AS1289.3.1.1	LIQUID LIMIT:	37.0	%
AS1289.3.2.1	PLASTIC LIMIT:	26.0	%
AS1289.3.3.1	PLASTICITY INDEX:	12.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	4.2	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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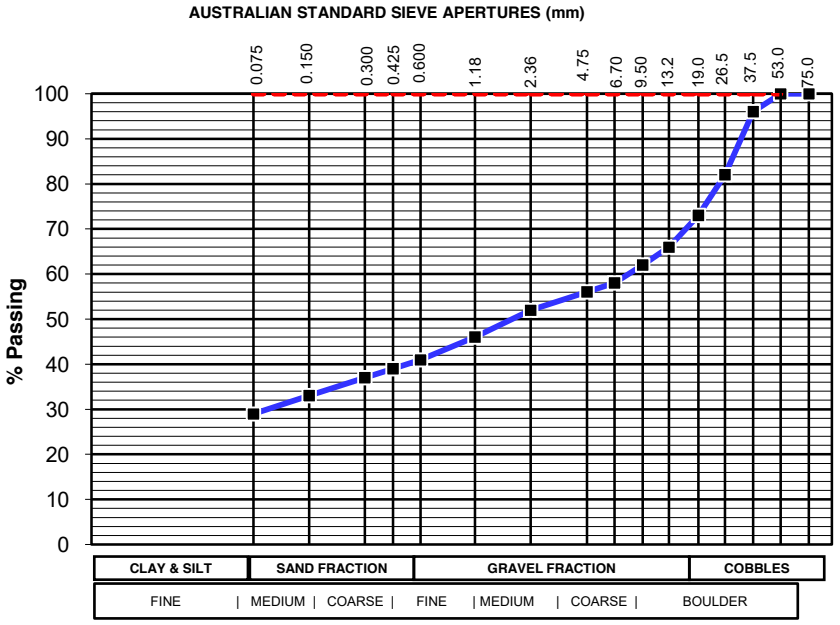
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5143
		Sample Number:	10182
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP3 - S1	Tested Date:	19/11/2018
Test Depth (m):	0.0 - 0.15	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	96	
26.5	82	
19.0	73	
13.2	66	
9.5	62	
6.70	58	
4.75	56	
2.36	52	
1.180	46	
0.600	41	
0.425	39	
0.300	37	
0.150	33	
0.075	29	

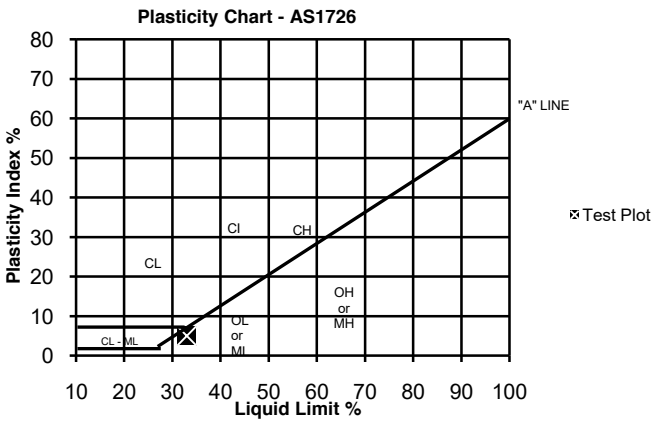


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	6.1	%
AS1289.3.1.1	LIQUID LIMIT:	33.0	%
AS1289.3.2.1	PLASTIC LIMIT:	28.0	%
AS1289.3.3.1	PLASTICITY INDEX:	5.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	2.5	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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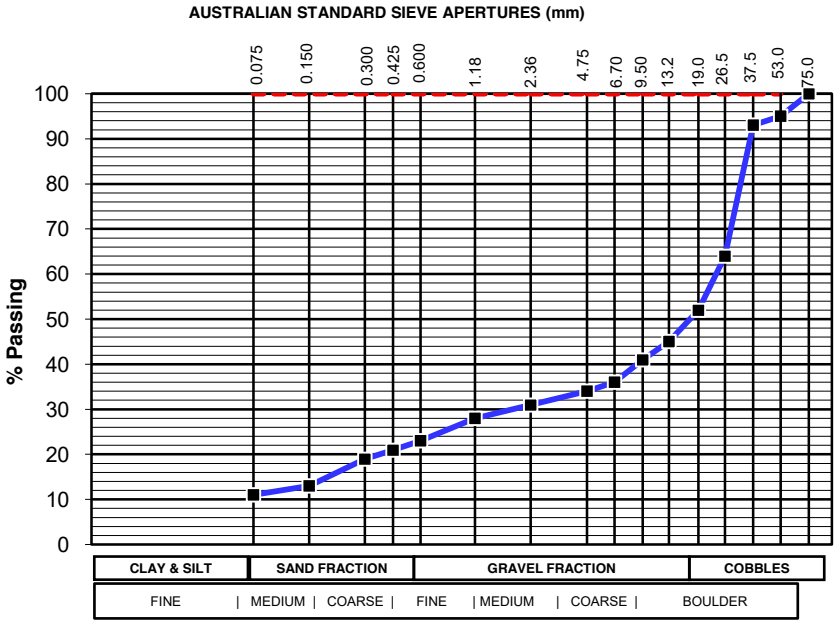
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5143
		Sample Number:	10183
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP3 - S2	Tested Date:	19/11/2018
Test Depth (m):	0.15 - 0.3	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	95	
37.5	93	
26.5	64	
19.0	52	
13.2	45	
9.5	41	
6.70	36	
4.75	34	
2.36	31	
1.180	28	
0.600	23	
0.425	21	
0.300	19	
0.150	13	
0.075	11	

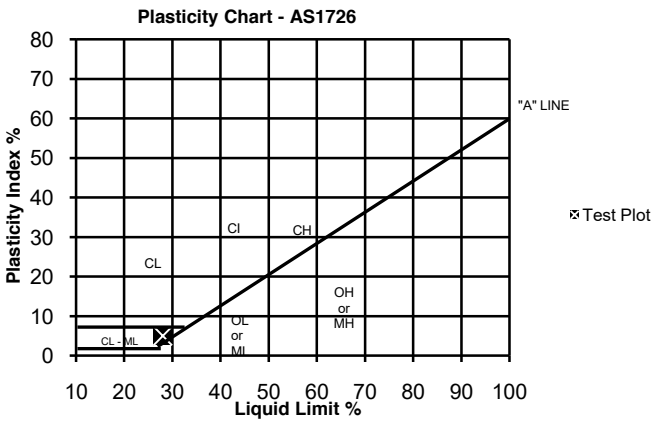


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	7.7	%
AS1289.3.1.1	LIQUID LIMIT:	28.0	%
AS1289.3.2.1	PLASTIC LIMIT:	23.0	%
AS1289.3.3.1	PLASTICITY INDEX:	5.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	2.3	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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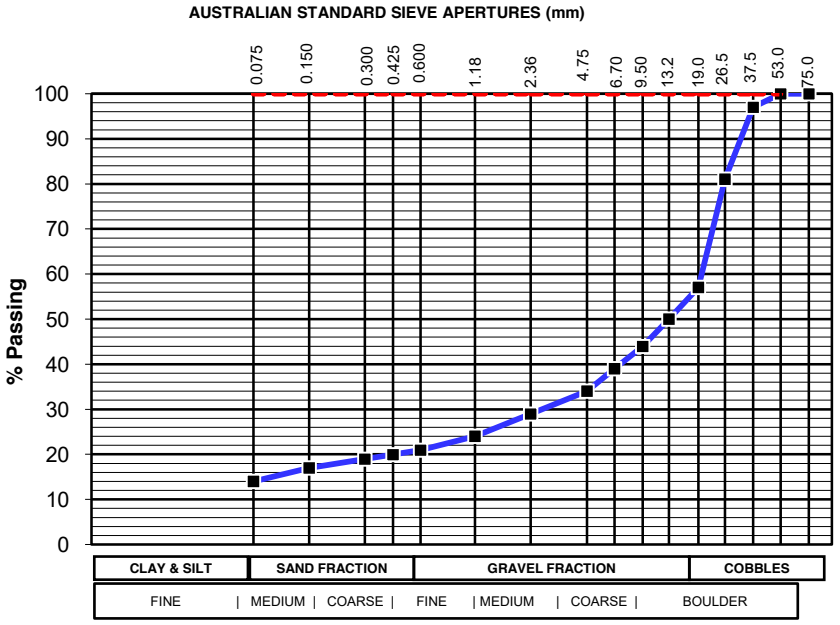
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5144
		Sample Number:	10184
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP4 - S1	Tested Date:	19/11/2018
Test Depth (m):	0.0 - 0.3	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	97	
26.5	81	
19.0	57	
13.2	50	
9.5	44	
6.70	39	
4.75	34	
2.36	29	
1.180	24	
0.600	21	
0.425	20	
0.300	19	
0.150	17	
0.075	14	

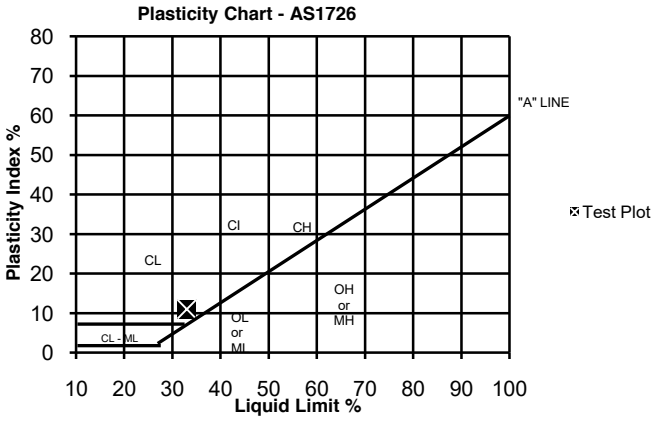


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	10.0	%
AS1289.3.1.1	LIQUID LIMIT:	33.0	%
AS1289.3.2.1	PLASTIC LIMIT:	25.0	%
AS1289.3.3.1	PLASTICITY INDEX:	11.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	4.5	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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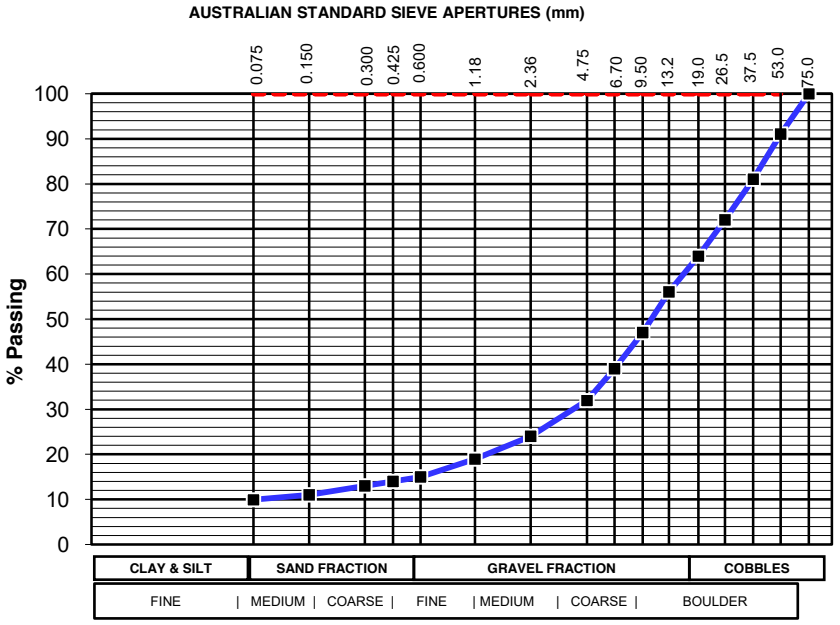
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5144
		Sample Number:	10185
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP4 - S2	Tested Date:	19/11/2018
Test Depth (m):	0.3 - 0.6	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	91	
37.5	81	
26.5	72	
19.0	64	
13.2	56	
9.5	47	
6.70	39	
4.75	32	
2.36	24	
1.180	19	
0.600	15	
0.425	14	
0.300	13	
0.150	11	
0.075	10	

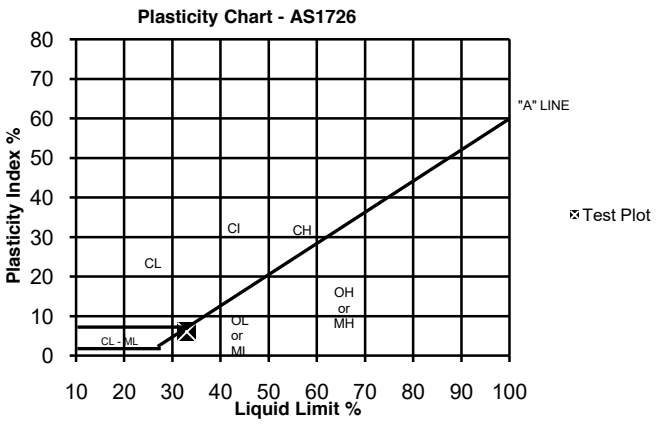


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	10.9	%
AS1289.3.1.1	LIQUID LIMIT:	33.0	%
AS1289.3.2.1	PLASTIC LIMIT:	27.0	%
AS1289.3.3.1	PLASTICITY INDEX:	6.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	3.0	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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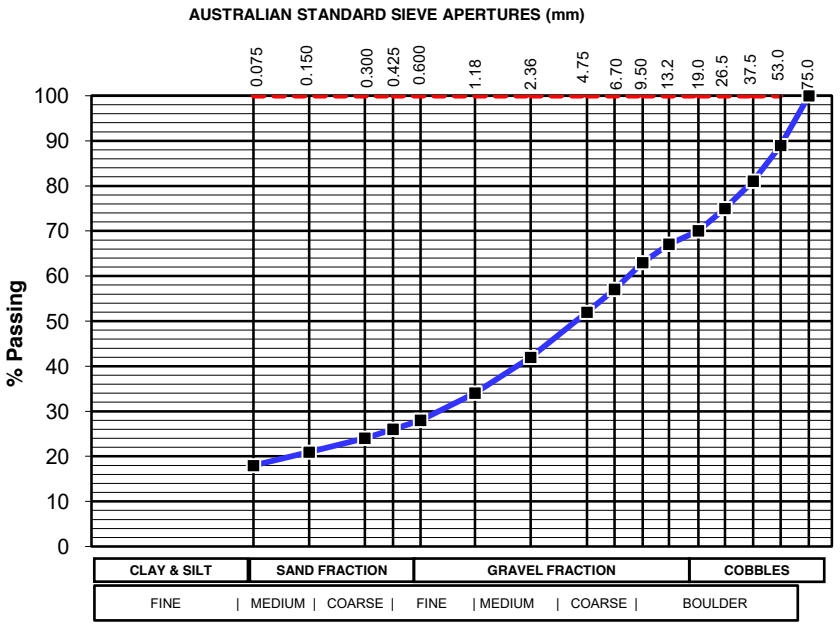
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5145
		Sample Number:	10186
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP5 - S1	Tested Date:	19/11/2018
Test Depth (m):	0.0 - 0.2	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	89	
37.5	81	
26.5	75	
19.0	70	
13.2	67	
9.5	63	
6.70	57	
4.75	52	
2.36	42	
1.180	34	
0.600	28	
0.425	26	
0.300	24	
0.150	21	
0.075	18	

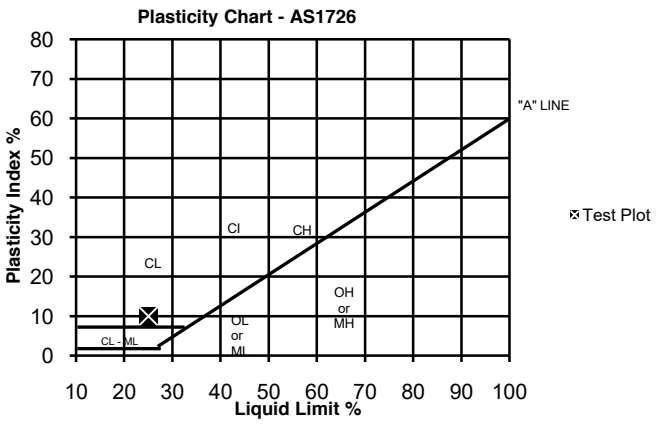


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	8.2	%
AS1289.3.1.1	LIQUID LIMIT:	25.0	%
AS1289.3.2.1	PLASTIC LIMIT:	15.0	%
AS1289.3.3.1	PLASTICITY INDEX:	10.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	4.8	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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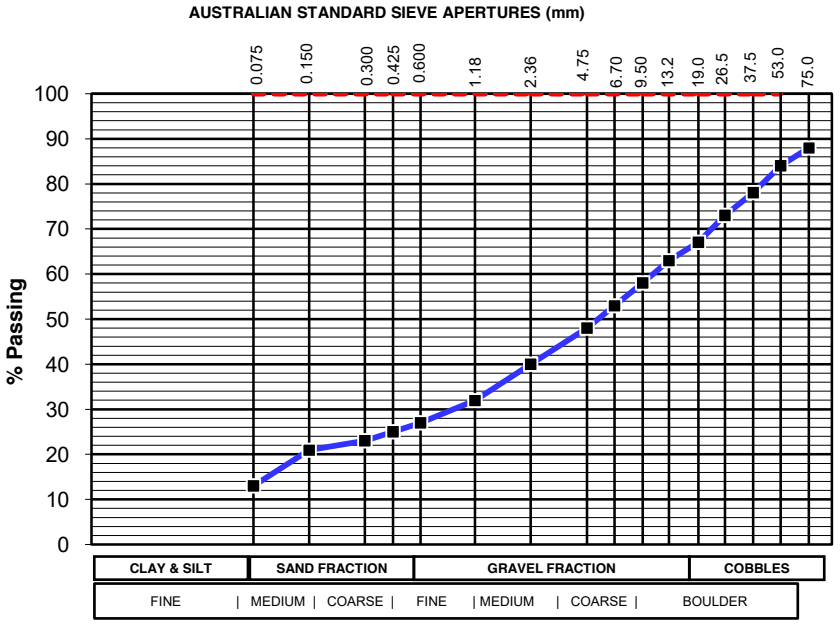
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5145
		Sample Number:	10187
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP5 - S2	Tested Date:	19/11/2018
Test Depth (m):	0.2 - 1.0	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	88	
53.0	84	
37.5	78	
26.5	73	
19.0	67	
13.2	63	
9.5	58	
6.70	53	
4.75	48	
2.36	40	
1.180	32	
0.600	27	
0.425	25	
0.300	23	
0.150	21	
0.075	13	

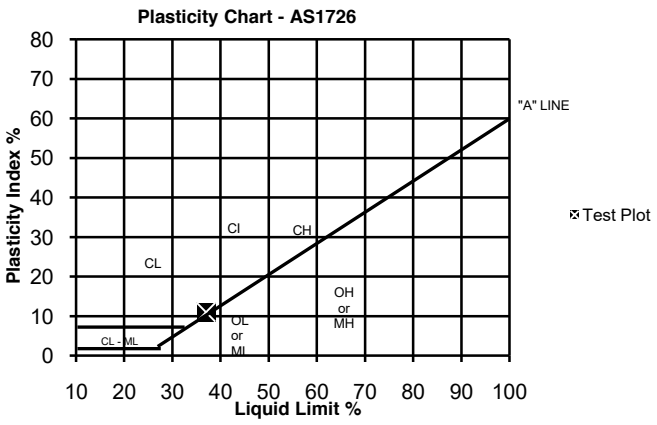


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	16.4	%
AS1289.3.1.1	LIQUID LIMIT:	37.0	%
AS1289.3.2.1	PLASTIC LIMIT:	26.0	%
AS1289.3.3.1	PLASTICITY INDEX:	11.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	5.6	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



PNGLAS Accredited Laboratory Number: 028

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FORM: TBA

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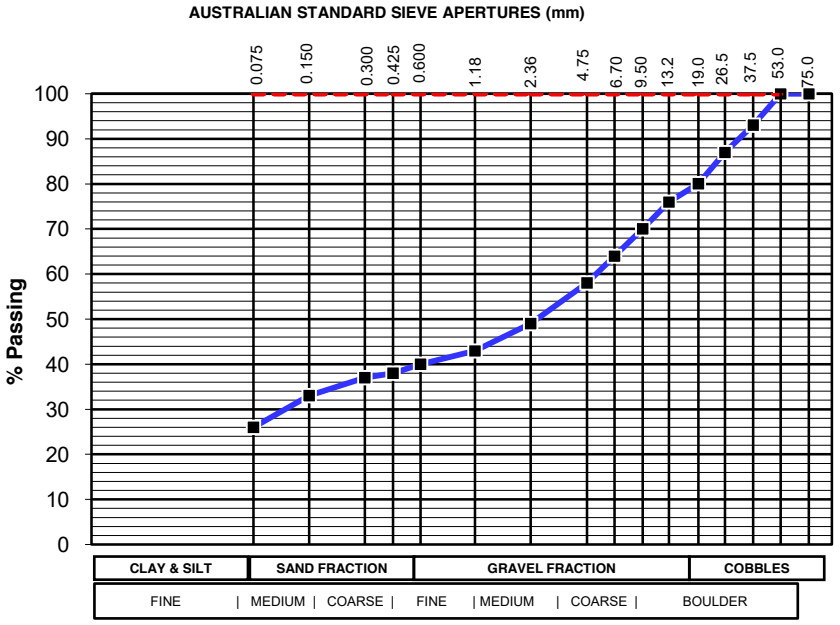
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5146
		Sample Number:	10188
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP6 - S1	Tested Date:	19/11/2018
Test Depth (m):	0.0 - 0.12	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	93	
26.5	87	
19.0	80	
13.2	76	
9.5	70	
6.70	64	
4.75	58	
2.36	49	
1.180	43	
0.600	40	
0.425	38	
0.300	37	
0.150	33	
0.075	26	

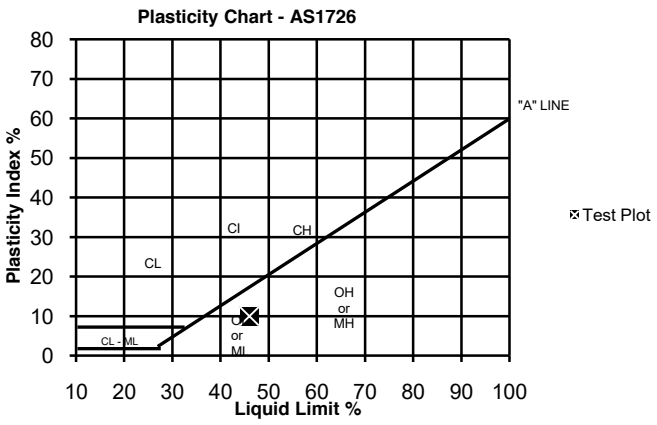


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	3.8	%
AS1289.3.1.1	LIQUID LIMIT:	46.0	%
AS1289.3.2.1	PLASTIC LIMIT:	37.0	%
AS1289.3.3.1	PLASTICITY INDEX:	10.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	5.0	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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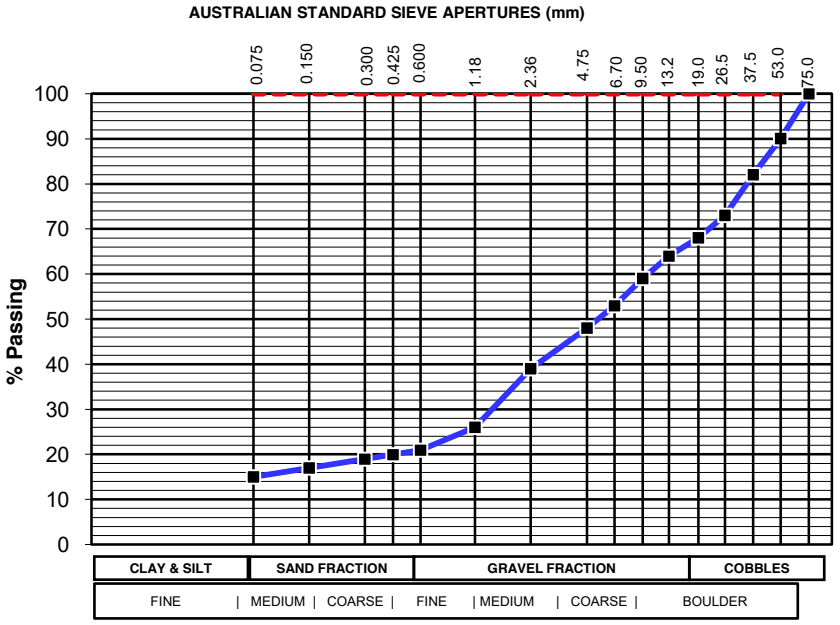
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5146
		Sample Number:	10189
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP6 - S2	Tested Date:	19/11/2018
Test Depth (m):	0.12 - 0.2	Reported By:	GRR
Spec Description:	N/A	Reported Date:	27/11/2018

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	90	
37.5	82	
26.5	73	
19.0	68	
13.2	64	
9.5	59	
6.70	53	
4.75	48	
2.36	39	
1.180	26	
0.600	21	
0.425	20	
0.300	19	
0.150	17	
0.075	15	

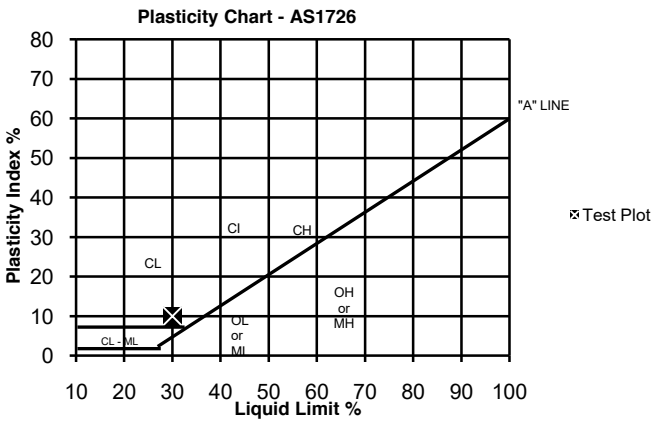


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	11.0	%
AS1289.3.1.1	LIQUID LIMIT:	30.0	%
AS1289.3.2.1	PLASTIC LIMIT:	20.0	%
AS1289.3.3.1	PLASTICITY INDEX:	10.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	4.8	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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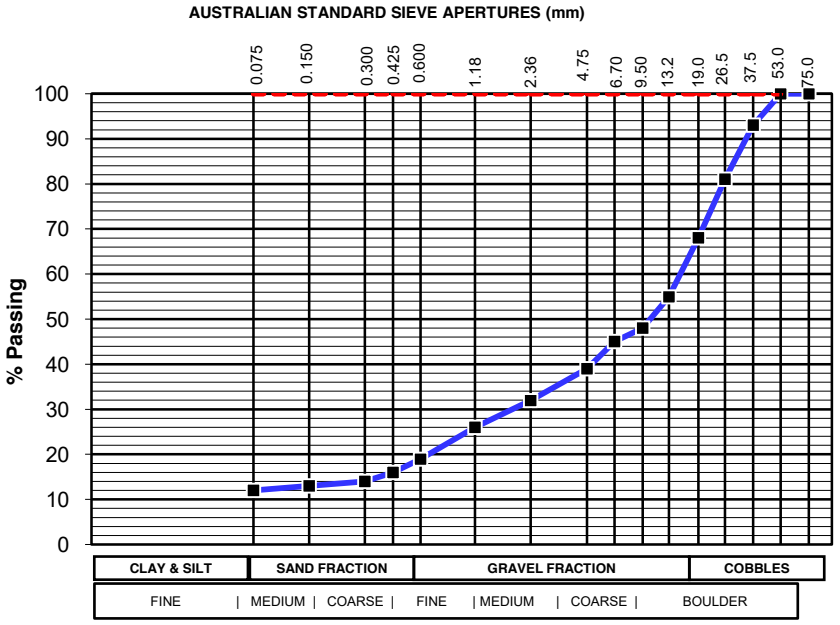
SOIL CLASSIFICATION TEST REPORT

Client:	TOTAL WASTE MANAGEMENTS	Job Number:	EG100918twmpngl|dm
Project:	ENVIRONMENTAL ASSESSMENT- BASELINE ENVIRONMENT NAPA NAPA	Report Number:	5284
		Sample Number:	10436
Material Description:	Clay Sandy GRAVEL	Sampled By:	ACEM
Material Type:	INSITU	Sampled Date:	5th - 6th | 11 | 2018
Material Source:	EXCAVATED MATERIAL	Tested By:	KM
Test Location:	TP6 - S3	Tested Date:	26/01/2019
Test Depth (m):	0.2 - 0.8	Reported By:	GRR
Spec Description:	N/A	Reported Date:	26/01/2019

PARTICLE SIZE DISTRIBUTION

Test Procedures: AS1289.3.6.1 - WET SIEVED

SIEVE SIZE (mm)	% PASSING (by mass)	
75.0	100	
53.0	100	
37.5	93	
26.5	81	
19.0	68	
13.2	55	
9.5	48	
6.70	45	
4.75	39	
2.36	32	
1.180	26	
0.600	19	
0.425	16	
0.300	14	
0.150	13	
0.075	12	

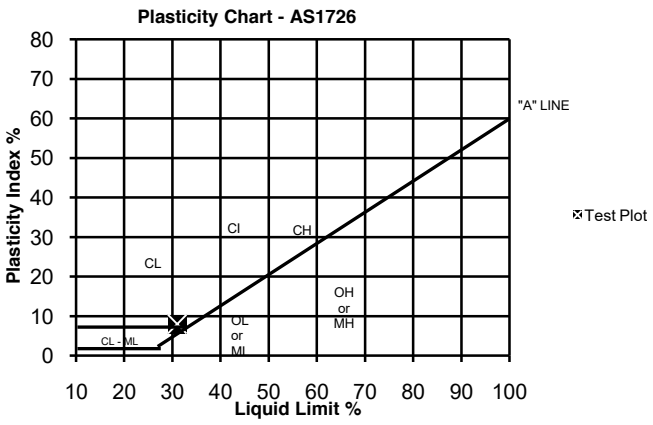


ATTERBERG LIMITS & LINEAR SHRINKAGE

Test Procedures: AS1289.2.1.1, 3.1.2, 3.2.1, 3.4.1 | Sample History: Oven Dried (45 - 50 °C) Dry Sieved

TEST RESULTS			
AS1289.2.1.1	MOISTURE CONTENT:	10.0	%
AS1289.3.1.1	LIQUID LIMIT:	31.0	%
AS1289.3.2.1	PLASTIC LIMIT:	23.0	%
AS1289.3.3.1	PLASTICITY INDEX:	8.0	%
AS1289.3.4.1	LINEAR SHRINKAGE:	3.1	%

PLASTICITY	
Descriptive Term	**Range of LL**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50



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SOIL CLASSIFICATION TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: PROPOSED INTERGRATED WASTE MANAGEMENT

JOB Number: EG100918twmpng
REPORT Number: 5286
SAMPLE Number: 10438

Date Sampled: -
Date Tested: 24/01/2019
Reported Date: 28/01/2019
Date Issued: 28/01/2019

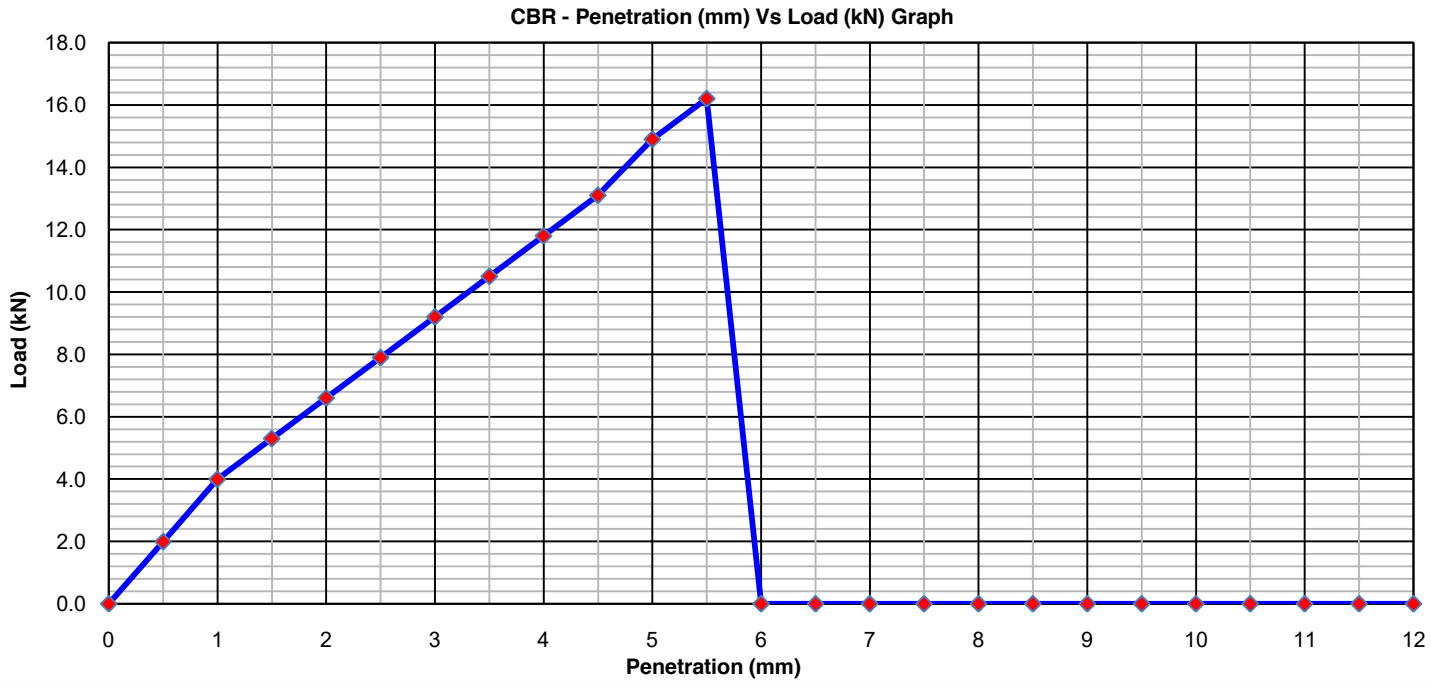
Material Source: TP1 - S2
Test Depth (m): 0.3 - 0.6
Material Description: SANDY GRAVEL

DETERMINATION OF MAXIMUM DRY DENSITY & OPTIMUM MOISTURE CONTENT — **COMPACTION EFFORT**
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.1.1** — **STD**

LABORATORY TEST RESULTS

MAXIMUM DRY DENSITY	**1.85**	MC - TOP 30mm (%)	**10.2**
OPTIMUM MOISTURE CONTENT	**11.0**	SWELL/ CONSOLIDATION (%)	**0.01**
MASS RETAINED 37.5/19.0 (MM)	**-**	Lab MOISTURE RATIO (%)	**64.0**
PERCENTAGE RETAINED (%)	**-**	Lab DENSITY RATIO (%)	**88.0**
		CBR PENETRATION (mm)	**5.0**
		CBR VALUE (%)	**75.0**

DETERMINATION OF CALIFORNIA BEARING RATIO OF A SOIL
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.2.1**



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SOIL CLASSIFICATION TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: PROPOSED INTERGRATED WASTE MANAGEMENT

JOB Number: EG100918twmpng
REPORT Number: 5287
SAMPLE Number: 10439

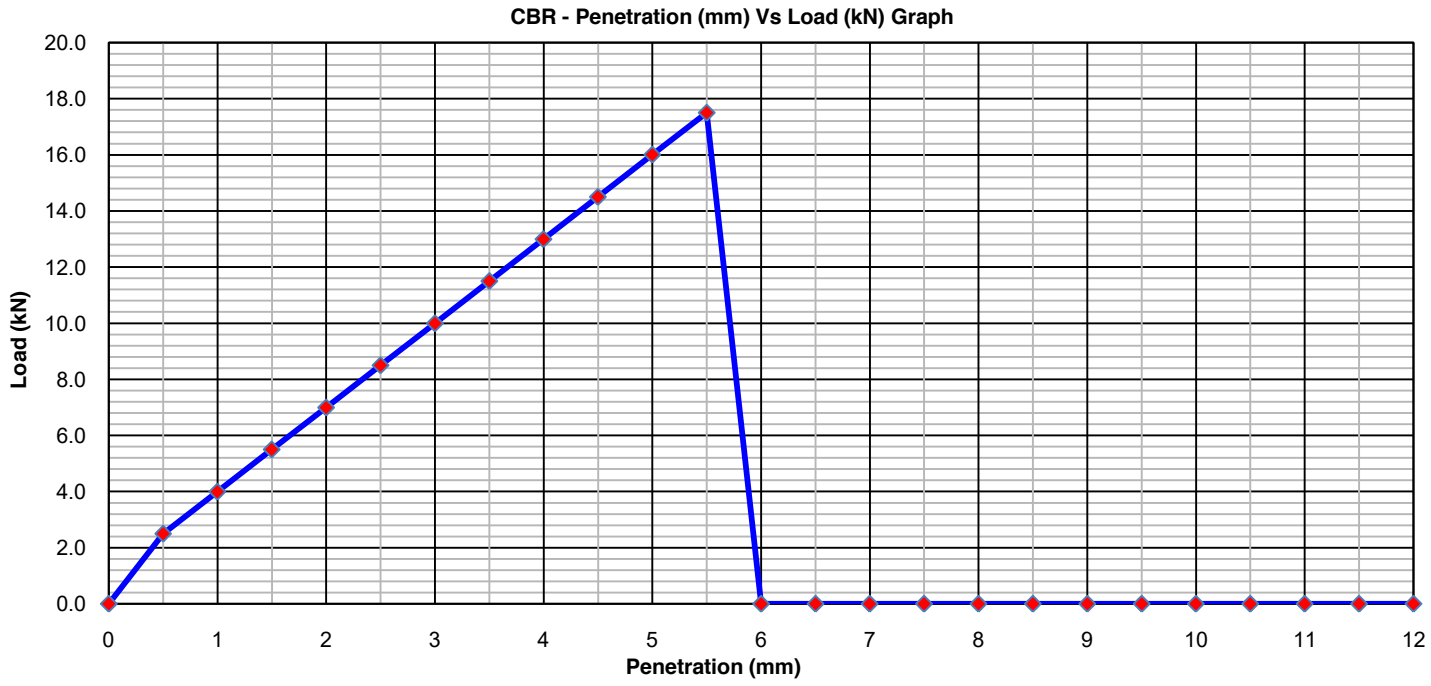
Date Sampled:	-	Material Source:	TP3 - S2
Date Tested:	24/01/2019	Test Depth (m):	0.15 - 0.3
Reported Date:	28/01/2019	Material Description:	SANDY GRAVEL
Date Issued:	28/01/2019		

DETERMINATION OF MAXIMUM DRY DENSITY & OPTIMUM MOISTURE CONTENT — **COMPACTION EFFORT**
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.1.1** — **STD**

LABORATORY TEST RESULTS

MAXIMUM DRY DENSITY	**1.91**	MC - TOP 30mm (%)	**11.2**
OPTIMUM MOISTURE CONTENT	**11.3**	SWELL/ CONSOLIDATION (%)	**-0.01**
MASS RETAINED 37.5/19.0 (MM)	**-**	Lab MOISTURE RATIO (%)	**75.0**
PERCENTAGE RETAINED (%)	**-**	Lab DENSITY RATIO (%)	**90.5**
		CBR PENETRATION (mm)	**5.0**
		CBR VALUE (%)	**80.0**

DETERMINATION OF CALIFORNIA BEARING RATIO OF A SOIL
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.2.1**



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SOIL CLASSIFICATION TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: PROPOSED INTERGRATED WASTE MANAGEMENT

JOB Number: EG100918twmpng
REPORT Number: 5288
SAMPLE Number: 10440

Date Sampled: -
Date Tested: 24/01/2019
Reported Date: 28/01/2019
Date Issued: 28/01/2019

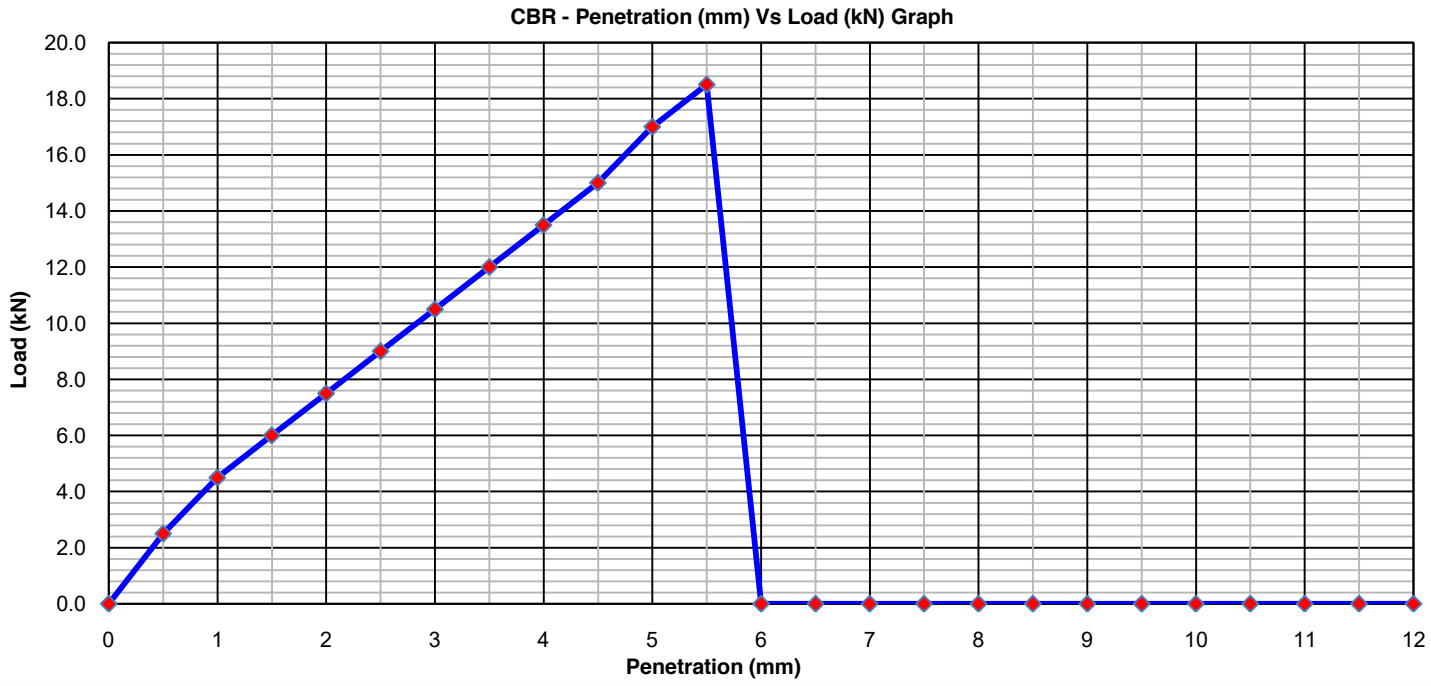
Material Source: TP4 - S1
Test Depth (m): 0.15 - 0.3
Material Description: SANDY GRAVEL

DETERMINATION OF MAXIMUM DRY DENSITY & OPTIMUM MOISTURE CONTENT — **COMPACTION EFFORT**
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.1.1** — **STD**

LABORATORY TEST RESULTS

MAXIMUM DRY DENSITY	**1.93**	MC - TOP 30mm (%)	**12.5**
OPTIMUM MOISTURE CONTENT	**12.0**	SWELL/ CONSOLIDATION (%)	**-0.02**
MASS RETAINED 37.5/19.0 (MM)	**-**	Lab MOISTURE RATIO (%)	**80.5**
PERCENTAGE RETAINED (%)	**-**	Lab DENSITY RATIO (%)	**91.0**
		CBR PENETRATION (mm)	**5.0**
		CBR VALUE (%)	**85.0**

DETERMINATION OF CALIFORNIA BEARING RATIO OF A SOIL
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.2.1**



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SOIL CLASSIFICATION TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: PROPOSED INTERGRATED WASTE MANAGEMENT

JOB Number: EG100918twmpng
REPORT Number: 5288
SAMPLE Number: 10440

Date Sampled: -
Date Tested: 24/01/2019
Reported Date: 28/01/2019
Date Issued: 28/01/2019

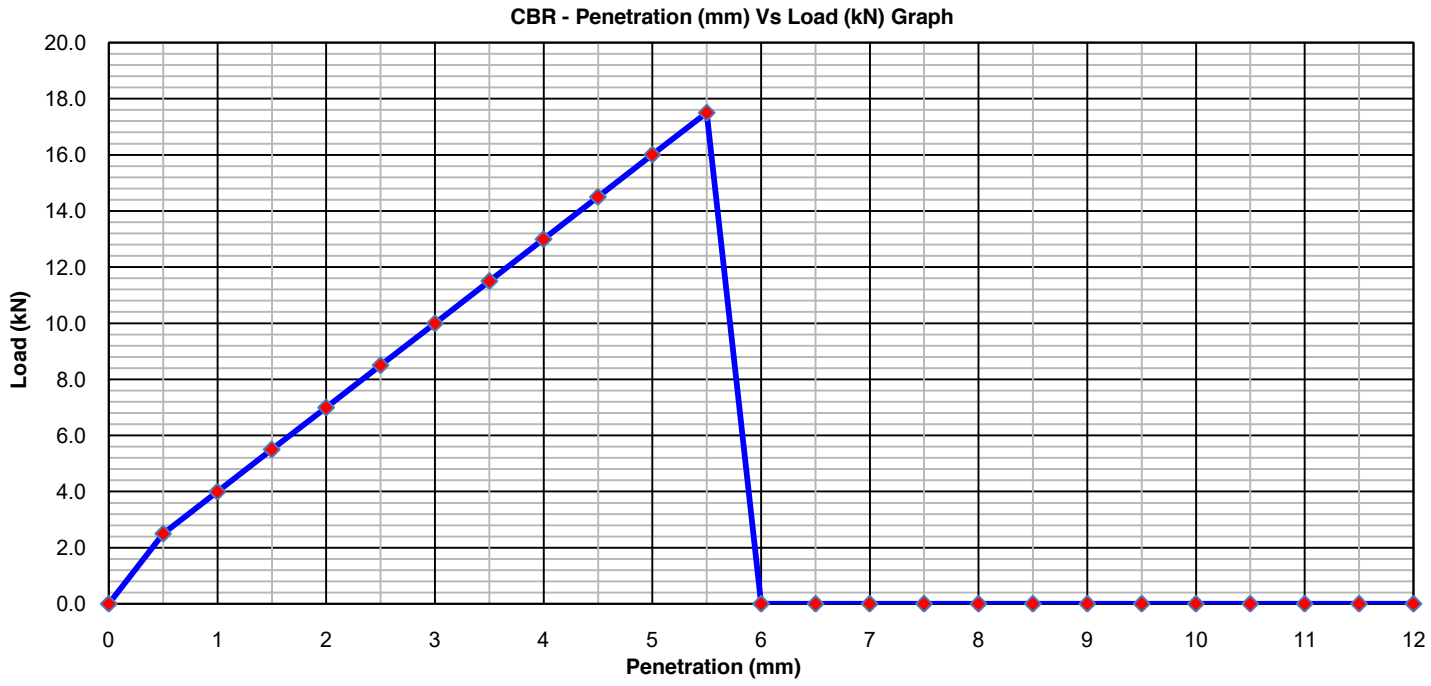
Material Source: TP4 - S2
Test Depth (m): 0.3 - 0.6
Material Description: SANDY GRAVEL

DETERMINATION OF MAXIMUM DRY DENSITY & OPTIMUM MOISTURE CONTENT — **COMPACTION EFFORT**
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.1.1** — **STD**

LABORATORY TEST RESULTS

MAXIMUM DRY DENSITY	**1.90**	MC - TOP 30mm (%)	**12.0**
OPTIMUM MOISTURE CONTENT	**12.2**	SWELL/ CONSOLIDATION (%)	**-0.01**
MASS RETAINED 37.5/19.0 (MM)	**-**	Lab MOISTURE RATIO (%)	**85.0**
PERCENTAGE RETAINED (%)	**-**	Lab DENSITY RATIO (%)	**90.4**
		CBR PENETRATION (mm)	**5.0**
		CBR VALUE (%)	**80.0**

DETERMINATION OF CALIFORNIA BEARING RATIO OF A SOIL
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.2.1**



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SOIL CLASSIFICATION TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: PROPOSED INTERGRATED WASTE MANAGEMENT

JOB Number: EG100918twmpng
REPORT Number: 5289
SAMPLE Number: 10442

Date Sampled: -
Date Tested: 24/01/2019
Reported Date: 28/01/2019
Date Issued: 28/01/2019

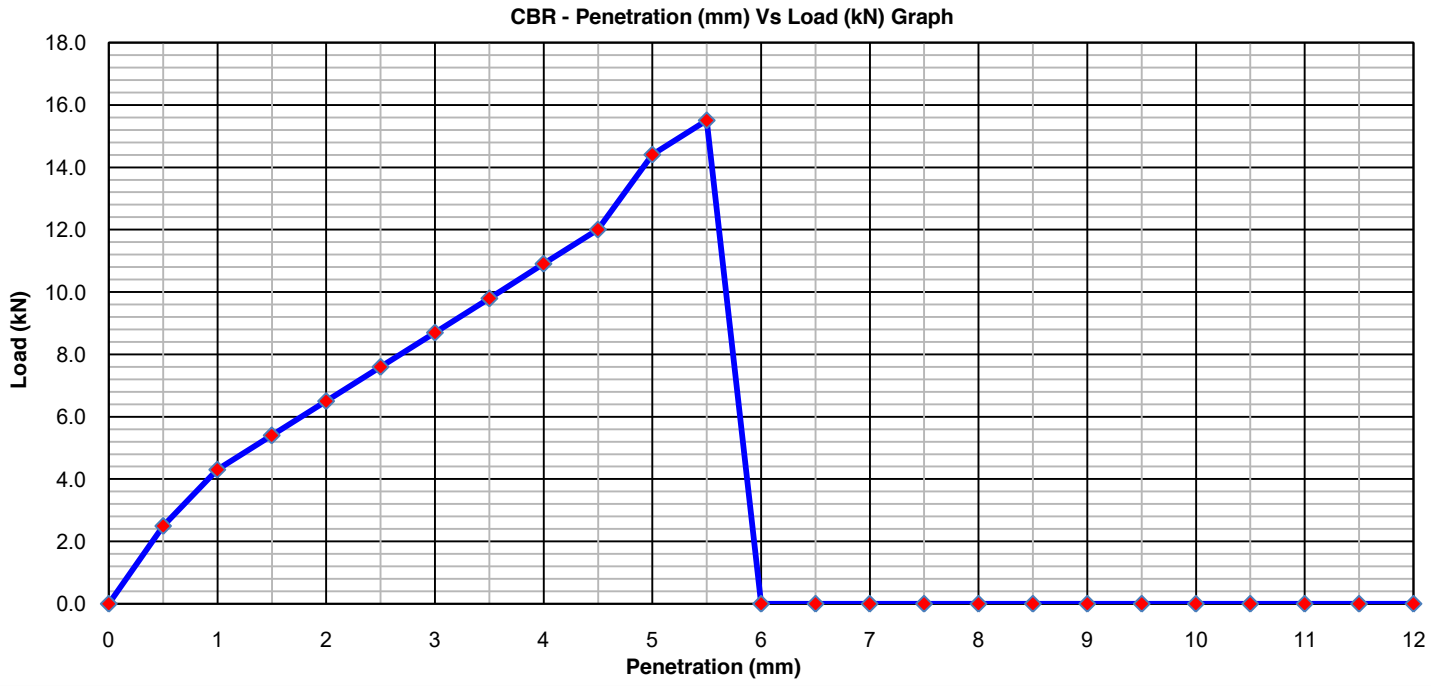
Material Source: TP5 - S2
Test Depth (m): 0.3 - 1.0
Material Description: SANDY GRAVEL

DETERMINATION OF MAXIMUM DRY DENSITY & OPTIMUM MOISTURE CONTENT — **COMPACTION EFFORT**
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.1.1** — **STD**

LABORATORY TEST RESULTS

MAXIMUM DRY DENSITY	**1.81**	MC - TOP 30mm (%)	**11.5**
OPTIMUM MOISTURE CONTENT	**13.0**	SWELL/ CONSOLIDATION (%)	**-0.02**
MASS RETAINED 37.5/19.0 (MM)	**-**	Lab MOISTURE RATIO (%)	**88.0**
PERCENTAGE RETAINED (%)	**-**	Lab DENSITY RATIO (%)	**96.0**
		CBR PENETRATION (mm)	**5.0**
		CBR VALUE (%)	**72.0**

DETERMINATION OF CALIFORNIA BEARING RATIO OF A SOIL
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.2.1**



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PNG Port Moresby
Malolo Estate 8 Mile Section 145 Lot 50
Postal Address:
PO Box 455, GORDONS- FoodWorld,NCD
T: 7411 0901 | E: laebranch@acemgeo.com.pg

Foundation Investigation Solution
Civil Works Plant Hire
CMT Equipment, Supply & Calibration

SOIL CLASSIFICATION TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: PROPOSED INTERGRATED WASTE MANAGEMENT

JOB Number: EG100918twmpng
REPORT Number: 5284
SAMPLE Number: 10436

Date Sampled: -
Date Tested: 24/01/2019
Reported Date: 28/01/2019
Date Issued: 28/01/2019

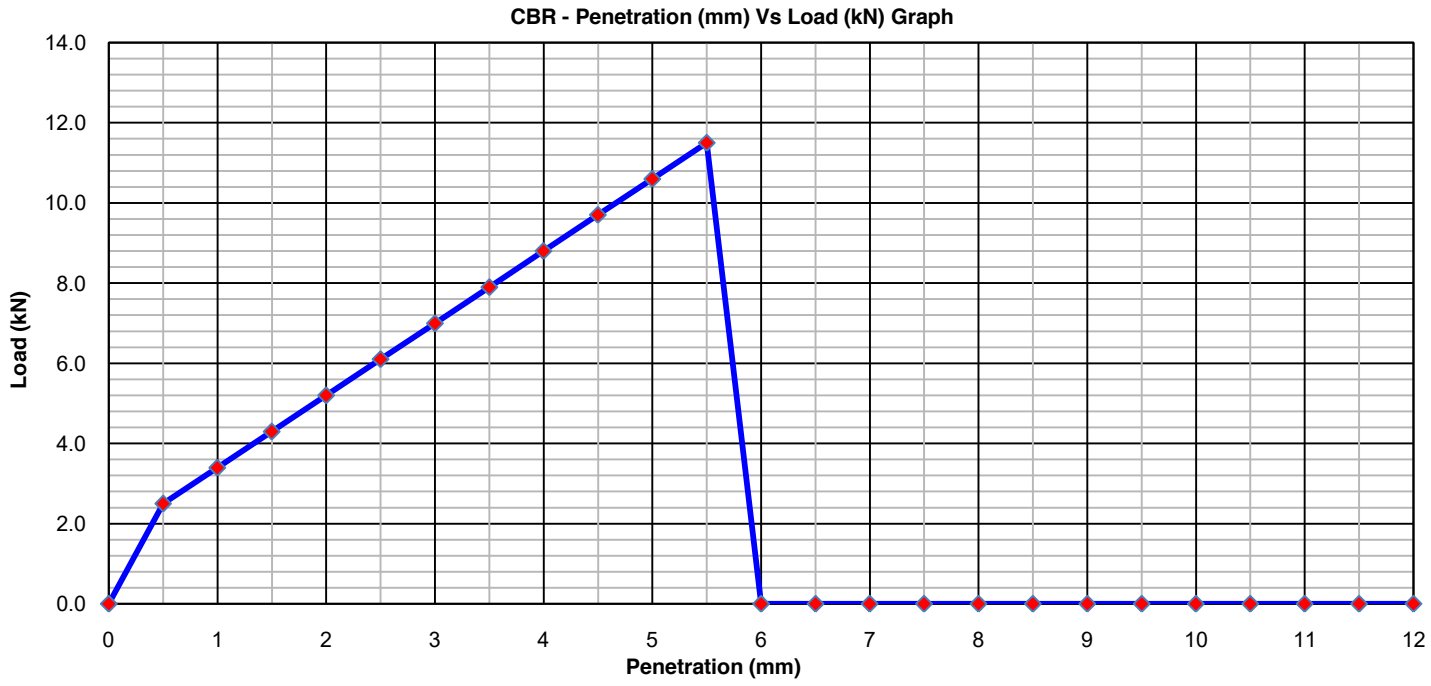
Material Source: TP6 - S3
Test Depth (m): 0.2 - 0.8
Material Description: SANDY GRAVEL

DETERMINATION OF MAXIMUM DRY DENSITY & OPTIMUM MOISTURE CONTENT — **COMPACTION EFFORT**
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.1.1** — **STD**

LABORATORY TEST RESULTS

MAXIMUM DRY DENSITY	**1.79**	MC - TOP 30mm (%)	**12.0**
OPTIMUM MOISTURE CONTENT	**14.0**	SWELL/ CONSOLIDATION (%)	**-0.01**
MASS RETAINED 37.5/19.0 (MM)	**-**	Lab MOISTURE RATIO (%)	**87.0**
PERCENTAGE RETAINED (%)	**-**	Lab DENSITY RATIO (%)	**98.0**
		CBR PENETRATION (mm)	**5.0**
		CBR VALUE (%)	**53.0**

DETERMINATION OF CALIFORNIA BEARING RATIO OF A SOIL
TEST PROCEDURE: **AS1289.6.1.1, AS1289.5.2.1**



Report Authorised By
Goli Makewin Koloma

PNGLAS Accredited
Laboratory Number: 028

This laboratory is accredited by the Papua New Guinea Laboratory Accreditation Scheme. The tests reported herein have been performed in accordance with its scope of accreditation and PNGLAS requirements which include the requirements of ISO/IEC 17025. This document shall not be reproduced, except in full.

SCHMIDTH HAMMER TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: INTEGRATED WASTE MANAGEMENT FACILITY - ROKU
BH/TP/HA No: BOREHOLE 1
ROCK TYPE: Tuff

Job Number: EG100918twmpng
Report Number: AGR19-5290

Tested By: GRR
Date: 29/01/2019

Reported By: GRR
Date: 29/01/2019

Lab Test Results:

Lab Sample Number:		10443	10444	10445	10446	
Sample Ref/ID Number:		**T1**	**T3**	**T6**	**T8**	
Core Run Depth:	(m)	-	-	-	-	
Test Sample Depth:	(m)	2.4	3.4	6.7	7.4	
Rock Type:		Tuff	Tuff	Tuff	Tuff	
Shape of Specimen:		-	-	-	-	
Direction of Loading:		Horizontal	Horizontal	Horizontal	Horizontal	
Cementation/ Weathering:		-	-	-	-	
Schmidth Hammer Strength (Mpa)		**18**	**14**	**15**	**18**	
Classification:		L-M	L	L	M	

Comments/ Remarks:

ACEM Geotechniques

Geotechnical & Geomorphology Engineering Consultants
Engineering Soils Materials Testing Laboratory Services
PNGLAS Accredited Laboratory No: 0028

Report Authorised By
Goli Makewin Koloma

PNGLAS Accredited Laboratory Number: 028

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POINT LOAD INDEX TEST REPORT - AS4133.4.1

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: INTEGRATED WASTE MANAGEMENT FACILITY - ROKU
BH/TP/HA No: BOREHOLE 1
ROCK TYPE: Tuff

Job Number: EG100918twmpng
Report Number: AGR19-5292

Tested By: GRR
Date: 29/01/2019
Reported By: GRR
Date: 29/01/2019

Lab Test Results:

Lab Sample Number:		10452	10453	10454	10455	10456
Sample Ref/ID Number:		**T2**	**T4**	**T5**	**T7**	**T9**
Core Run Depth:	(m)	-	-	-	-	-
Test Sample Depth:	(m)	2.5	3.5	4.7	6.8	7.5
Rock Type:		Tuff	Tuff	Tuff	Tuff	Tuff
Shape of Specimen:		-	-	-	-	-
Direction of Loading:		Horizontal	Horizontal	Horizontal	Horizontal	Horizontal
Cementation/ Weathering:		-	-	-	-	-
Is (50):		**0.35**	**0.2**	**0.35**	**0.2**	**0.3**
Rock Strength Term:		M	L	M	L	L-M

Comments/ Remarks:

ACEM Geotechniques
Geotechnical & Geomorphology Engineering Consultants
Engineering Soils Materials Testing Laboratory Services
PNGLAS Accredited Laboratory No: 0028

Report Authorised By
Goli Makewin Koloma

PNGLAS Accredited Laboratory Number: 028
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SCHMIDTH HAMMER TEST REPORT

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: INTEGRATED WASTE MANAGEMENT FACILITY - ROKU
BH/TP/HA No: BOREHOLE 2
ROCK TYPE: Tuff

Job Number: EG100918twmpng
Report Number: AGR19-5291

Tested By: GRR
Date: 29/01/2019
Reported By: GRR
Date: 29/01/2019

Lab Test Results:

Lab Sample Number:		10447	10448	10449	10450	10451
Sample Ref/ID Number:		**T2**	**T4**	**T5**	**T7**	**T9**
Core Run Depth:	(m)	-	-	-	-	-
Test Sample Depth:	(m)	2.5	3.7	4.7	5.6	7.8
Rock Type:		Tuff	Tuff	Tuff	Tuff	Tuff
Shape of Specimen:		-	-	-	-	-
Direction of Loading:		Horizontal	Horizontal	Horizontal	Horizontal	Horizontal
Cementation/ Weathering:		-	-	-	-	-
Schmidth Hammer Strength (Mpa)		**15**	**14**	**10**	**20**	**0**
Classification:		L-M	L	L	M	M

Comments/ Remarks:

ACEM Geotechniques
Geotechnical & Geomorphology Engineering Consultants
Engineering Soils Materials Testing Laboratory Services
PNGLAS Accredited Laboratory No: 0028

Report Authorised By
Goli Makewin Koloma

PNGLAS Accredited Laboratory Number: 028
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This document shall not be reproduced, except in full.

POINT LOAD INDEX TEST REPORT - AS4133.4.1

CLIENT: TOTAL WASTE MANAGEMENT
PROJECT: INTEGRATED WASTE MANAGEMENT FACILITY - ROKU
BH/TP/HA No: BOREHOLE 2
ROCK TYPE: Tuff

Job Number: EG100918twmpng
Report Number: AGR19-5293

Tested By: GRR
Date: 29/01/2019
Reported By: GRR
Date: 29/01/2019

Lab Test Results:

Lab Sample Number:		10457	10458	10459	10460	
Sample Ref/ID Number:		**T1**	**T3**	**T6**	**T8**	
Core Run Depth:	(m)	-	-	-	-	
Test Sample Depth:	(m)	2.4	3.9	5.5	7.7	
Rock Type:		Tuff	Tuff	Tuff	Tuff	
Shape of Specimen:		-	-	-	-	
Direction of Loading:		Horizontal	Horizontal	Horizontal	Horizontal	
Cementation/ Weathering:		-	-	-	-	
Is (50):		**0.2**	**0.2**	**0.35**	**0.1**	
Rock Strength Term:		L	L	M	L	

Comments/ Remarks:

ACEM Geotechniques
Geotechnical & Geomorphology Engineering Consultants
Engineering Soils Materials Testing Laboratory Services
PNGLAS Accredited Laboratory No: 0028

Report Authorised By
Goli Makewin Koloma

PNGLAS Accredited Laboratory Number: 028
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CHAIN OF CUSTODY

ALS Laboratory: please tick →

CLIENT: ACEM GEOTECHNIQUES	TURNAROUND REQUIREMENTS: (Standard TAT may be longer for some tests e.g. Ultra Trace Organics)	☐ Standard TAT (List due date):	FOR LABORATORY USE ONLY (Circle)
OFFICE: PORT MORESBY		☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact? Yes No N/A
PROJECT: IWMP, Roku PROJECT NO.:	ALS QUOTE NO.:	COC SEQUENCE NUMBER (Circle)	Free ice / frozen ice bricks present upon receipt? Yes No N/A
ORDER NUMBER: PURCHASE ORDER NO.:	COUNTRY OF ORIGIN:	COC: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: Ian Smith CONTACT PH: 3371 3584		OF: 1 2 3 4 5 6 7	Other comment:
SAMPLER: SAMPLER MOBILE:	RELINQUISHED BY:	RECEIVED BY: JBotira	RELINQUISHED BY: RECEIVED BY:
COC Emailed to ALS? (YES) NO) EDD FORMAT (or default):	DATE/TIME:	DATE/TIME: 9/11 10.00	DATE/TIME: DATE/TIME:
Email Reports to (will default to PM if no other addresses are listed): banaredwine@hotmail.com			
Email Invoice to (will default to PM if no other addresses are listed):			

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W) SOIL			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	TP1 S1	05/11/18		0.0-0.3m	1	As ALS Quote 11/9								
2	TP1 S2	05/11/18		0.3-0.6m	1	ditto								
3	TP2 S1	05/11/18		0.0-0.15m	1	ditto								
4	TP2 S2	06/11/18		0.15-0.35m	1	ditto								
5	TP3 S1	05/11/18		0.0-0.15m topsoil	1	〃								
6	TP3 S2	05/11/18		0.15-0.3m	1	〃								
7	TP4 S1	05/11/18		0.0-0.3m	1	〃								
8	TP4 S2	05/11/18		0.3-0.6m	1	〃								
9	TP5 S1	06/11/18		0.0-0.2m	1	〃								
10	TP5 S2	06/11/18		0.2-0.5m	1	〃								
11	TP6 S1	06/11/18		0.0-0.12m	1	〃								
12.	TP6 S2	06/11/18		0.12-0.2m	1	〃								
				TOTAL	12									

Environmental Division
Brisbane
Work Order Reference
EB1827271

Telephone : +61-7-3243 7222

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

Approved Date: 08/03/2018

CHAIN OF CUSTODY

ALS Laboratory: please tick →

ALS BRISBANE 2 Byth Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

ALS ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com

ALS TOWNSVILLE 14-15 Desma Circuit Stafford QLD 4053 Ph: 07 4796 0600 E: townsville@alsglobal.com

ALS PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com

ALS SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

ALS WOLLONGONG Unit 21 Kelly's Bush Drive, Kelly's Bush NSW 2508 Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: ACEM GEOTECHNIQUES	TURNAROUND REQUIREMENTS : ☐ Standard TAT (List due date):	FOR LABORATORY USE ONLY (Circle)	
OFFICE: PORT MORESBY	(Standard TAT may be longer for some tests e.g., Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact?	Yes No N/A
PROJECT: IWMP, Roku PROJECT NO.:	ALS QUOTE NO.:	Free Ice / frozen ice bricks present upon receipt?	Yes No N/A
ORDER NUMBER: PURCHASE ORDER NO.:	COUNTRY OF ORIGIN:	Random Sample Temperature on Receipt:	°C
PROJECT MANAGER: Ian Smith CONTACT PH: 3371 3584	COC SEQUENCE NUMBER (Circle) COC: 1 2 3 4 5 6 7 OF: 1 2 3 4 5 6 7	Other comment:	
SAMPLER: SAMPLER MOBILE:			
COC Emailed to ALS? (YES) NO) EDD FORMAT (or default):			
Email Reports to (will default to PM if no other addresses are listed): ianandedwina@hotmail.com			
Email Invoice to (will default to PM if no other addresses are listed):			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W) SOIL			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES BAGS									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1 ~~15~~	TP1 S1	5/11/18		0.0 – 0.3m	1	As ALS Quote 11/9								
2 ~~16~~	TP1 S2	5/11/18		0.3 – 0.6m	1	"								
3 ~~15~~	TP2 S1	6/11/18		0 – 0.15 Topsoil	1	"								
4 ~~16~~	TP2 S2	6/11/18		0.15 – 0.35m	1	"								
5 ~~17~~	TP3 S1	5/11/18		0.0 – 0.15m	1	"								
6 ~~18~~	TP 3 S2	5/11/18		0.15 – 0.3m	1	"								
7 ~~19~~	TP4 S1	5/11/18		0.0 – 0.3m	1	"								
8 ~~20~~	TP4 S2	5/11/18		0.3 – 0.6m	1	"								
9 ~~21~~	TP5 S1	6/11/18		0.0 – 0.2m	1	"								
10 ~~22~~	TP5 S2	6/11/18		0.2 – 0.5m	1	"								
11 ~~23~~	TP6 S1	6/11/18		0.0 – 0.12m	1	"								
12 ~~24~~	TP6 S2	6/11/18		0.12 – 0.2m	1	"								
				TOTAL	12									

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

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1827271**

Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Contact	: Customer Services EB
Address	: P.O BOX 455 GORDONS PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: ianandedwina@hotmail.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +675 342 6121	Telephone	: +61-7-3243 7222
Facsimile	: +675 343 0711	Facsimile	: +61-7-3243 7218
Project	: IWMP, Roku	Page	: 1 of 2
Order number	:	Quote number	: EB2018ACEMGEO0001 (EN/333)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	:		

Dates

Date Samples Received	: 09-Nov-2018 10:00	Issue Date	: 21-Dec-2018
Client Requested Due Date	: 10-Dec-2018	Scheduled Reporting Date	: **14-Jan-2019**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 23.2°C - Ice Bricks present
Receipt Detail	: MEDIUM ESKY	No. of samples received / analysed	: 12 / 12

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please be advised that the turnaround time has been extended, as the samples require Gamma Irradiation at Steritech prior to testing.**
- **21/12/18: SRN has been resent to acknowledge that date has been moved due to steritech and public holidays. For any further information regarding these adjustments please contact client services at ALSEnviro.Brisbane@alsglobal.com.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - AG-1 EB Only Agricultural Soil Suite 1 EB Only	SOIL - EA055-103 Moisture Content	SOIL - EA058 Emerson Aggregate Test	SOIL - EA150H/EA152 Particle Sizing with Hydrometer + Soil Particle	SOIL - EP004 Organic Matter in Soil (Walkley Black)	SOIL - S-05 TRH/BTEXN/8 Metals	SOIL - STERILISE-SOL Sterilisation via Gamma Irradiation
EB1827271-001	05-Nov-2018 00:00	TP1 S1	✓	✓	✓	✓	✓	✓	✓
EB1827271-002	05-Nov-2018 00:00	TP1 S2	✓	✓	✓	✓	✓	✓	✓
EB1827271-003	06-Nov-2018 00:00	TP2 S1	✓	✓	✓	✓	✓	✓	✓
EB1827271-004	06-Nov-2018 00:00	TP2 S2	✓	✓	✓	✓	✓	✓	✓
EB1827271-005	05-Nov-2018 00:00	TP3 S1	✓	✓	✓	✓	✓	✓	✓
EB1827271-006	05-Nov-2018 00:00	TP3 S2	✓	✓	✓	✓	✓	✓	✓
EB1827271-007	05-Nov-2018 00:00	TP4 S1	✓	✓	✓	✓	✓	✓	✓
EB1827271-008	05-Nov-2018 00:00	TP4 S2	✓	✓	✓	✓	✓	✓	✓
EB1827271-009	06-Nov-2018 00:00	TP5 S1	✓	✓	✓	✓	✓	✓	✓
EB1827271-010	06-Nov-2018 00:00	TP5 S2	✓	✓	✓	✓	✓	✓	✓
EB1827271-011	06-Nov-2018 00:00	TP6 S1	✓	✓	✓	✓	✓	✓	✓
EB1827271-012	06-Nov-2018 00:00	TP6 S2	✓	✓	✓	✓	✓	✓	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

IAN SMITH

- *AU Certificate of Analysis - NATA (COA)	Email	ianandedwina@hotmail.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	ianandedwina@hotmail.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	ianandedwina@hotmail.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	ianandedwina@hotmail.com
- A4 - AU Tax Invoice (INV)	Email	ianandedwina@hotmail.com
- Chain of Custody (CoC) (COC)	Email	ianandedwina@hotmail.com
- EDI Format - XTab (XTAB)	Email	ianandedwina@hotmail.com

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1827271**	Page	: 1 of 12
Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Contact	: Customer Services EB
Address	: P.O BOX 455 GORDONS PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +675 342 6121	Telephone	: +61-7-3243 7222
Project	: IWMP, Roku	Date Samples Received	: 09-Nov-2018 10:00
Order number	:	Date Analysis Commenced	: 20-Nov-2018
C-O-C number	: ----	Issue Date	: 14-Jan-2019 16:31
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 12		
No. of samples analysed	: 12		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP1 S1	TP1 S2	TP2 S1	TP2 S2	TP3 S1
			Client sampling date / time	05-Nov-2018 00:00	05-Nov-2018 00:00	06-Nov-2018 00:00	06-Nov-2018 00:00	05-Nov-2018 00:00
Compound	CAS Number	LOR	Unit	EB1827271-001	EB1827271-002	EB1827271-003	EB1827271-004	EB1827271-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.5	5.8	6.4	6.8	6.5
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	3	5	21	14	34
EA055: Moisture Content								
Moisture Content	----	1.0	%	11.1	14.6	7.4	10.2	8.0
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Strong Brown (7.5YR 4/6)	Brown (7.5YR 4/4)	Strong Brown (7.5YR 4/6)	Strong Brown (7.5YR 4/6)	Very Dark Brown (7.5YR 2.5/2)
Texture	----	-	-	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand	Sandy Loam
Emerson Class Number	EC/TC	-	-	8	8	8	8	3
EA150: Particle Sizing								
+75µm	----	1	%	68	55	57	64	34
+150µm	----	1	%	64	50	50	60	25
+300µm	----	1	%	61	47	44	56	20
+425µm	----	1	%	60	46	41	54	18
+600µm	----	1	%	58	44	38	52	15
+1180µm	----	1	%	50	39	30	45	12
+2.36mm	----	1	%	36	30	21	33	8
+4.75mm	----	1	%	17	17	12	20	4
+9.5mm	----	1	%	<1	5	4	10	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	11	15	16	18	22
Silt (2-60 µm)	----	1	%	19	29	24	16	41
Sand (0.06-2.00 mm)	----	1	%	30	24	36	29	28
Gravel (>2mm)	----	1	%	40	32	24	37	9
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.31	2.24	2.29	2.33	2.18
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	0.4	<0.1	----	----	----
ø Exchangeable Aluminium	----	0.1	meq/100g	0.2	<0.1	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP1 S1	TP1 S2	TP2 S1	TP2 S2	TP3 S1
				Client sampling date / time	05-Nov-2018 00:00	05-Nov-2018 00:00	06-Nov-2018 00:00	06-Nov-2018 00:00	05-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1827271-001	EB1827271-002	EB1827271-003	EB1827271-004	EB1827271-005
					Result	Result	Result	Result	Result
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		2.7	3.4	7.9	8.6	9.9
Exchangeable Magnesium	----	0.1	meq/100g		5.0	3.5	2.4	2.0	3.0
Exchangeable Potassium	----	0.1	meq/100g		0.3	0.4	0.2	0.2	0.8
Exchangeable Sodium	----	0.1	meq/100g		0.4	0.3	0.5	0.6	0.1
Cation Exchange Capacity	----	0.1	meq/100g		8.8	7.6	11.1	11.4	13.8
Exchangeable Sodium Percent	----	0.1	%		5.3	3.9	4.2	5.5	0.9
Calcium/Magnesium Ratio	----	0.1	-		0.5	1.0	3.3	4.3	3.3
Magnesium/Potassium Ratio	----	0.1	-		17.2	9.2	9.9	11.4	3.7
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg		<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg		11	9	27	24	21
Copper	7440-50-8	5	mg/kg		30	20	38	37	25
Lead	7439-92-1	5	mg/kg		8	7	18	13	15
Nickel	7440-02-0	2	mg/kg		7	8	11	9	23
Zinc	7440-66-6	5	mg/kg		18	5	15	9	7
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EP004: Organic Matter									
Organic Matter	----	0.5	%		0.5	0.9	2.0	1.2	4.9
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	10	mg/kg		<10	<10	<10	<10	<10
C10 - C14 Fraction	----	50	mg/kg		<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
C29 - C36 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
^ C10 - C36 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	10	mg/kg		<10	<10	<10	<10	<10
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg		<10	<10	<10	<10	<10
>C10 - C16 Fraction	----	50	mg/kg		<50	<50	<50	<50	<50
>C16 - C34 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	<50

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP1 S1	TP1 S2	TP2 S1	TP2 S2	TP3 S1
				Client sampling date / time	05-Nov-2018 00:00	05-Nov-2018 00:00	06-Nov-2018 00:00	06-Nov-2018 00:00	05-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1827271-001	EB1827271-002	EB1827271-003	EB1827271-004	EB1827271-005
					Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	50	mg/kg		<50	<50	<50	<50	<50
EP080: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	100-41-4	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
ortho-Xylene	95-47-6	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
^ **Sum of BTEX**	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ **Total Xylenes**	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Naphthalene	91-20-3	1	mg/kg		<1	<1	<1	<1	<1
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.2	%		**86.5**	**82.1**	**90.6**	**88.6**	**90.2**
Toluene-D8	2037-26-5	0.2	%		**81.9**	**106**	**84.6**	**82.0**	**80.9**
4-Bromofluorobenzene	460-00-4	0.2	%		**93.0**	**107**	**93.3**	**92.6**	**89.0**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP3 S2	TP4 S1	TP4 S2	TP5 S1	TP5 S2
			Client sampling date / time	05-Nov-2018 00:00	05-Nov-2018 00:00	05-Nov-2018 00:00	06-Nov-2018 00:00	06-Nov-2018 00:00
Compound	CAS Number	LOR	Unit	EB1827271-006	EB1827271-007	EB1827271-008	EB1827271-009	EB1827271-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	5.2	5.4	6.3	6.3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	16	6	6	10	11
EA055: Moisture Content								
Moisture Content	----	1.0	%	7.4	11.3	13.2	8.3	17.2
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown (7.5YR 3/4)	Reddish Yellow (7.5YR 5/6)	Brown (7.5YR 5/4)	Red (2.5YR 4/8)	Yellowish Red (5YR 5/8)
Texture	----	-	-	Sandy Loam	Gravelly Sand	Gravelly Sand	Gravelly Sand	Sandy Loam
Emerson Class Number	EC/TC	-	-	4	8	8	8	3
EA150: Particle Sizing								
+75µm	----	1	%	42	66	52	67	61
+150µm	----	1	%	35	62	47	64	58
+300µm	----	1	%	31	58	44	62	56
+425µm	----	1	%	29	55	42	60	54
+600µm	----	1	%	27	52	41	58	52
+1180µm	----	1	%	22	43	35	50	46
+2.36mm	----	1	%	18	30	27	37	36
+4.75mm	----	1	%	10	15	15	21	25
+9.5mm	----	1	%	4	4	2	8	8
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	19	15	22	17	18
Silt (2-60 µm)	----	1	%	35	16	24	14	17
Sand (0.06-2.00 mm)	----	1	%	27	35	25	28	26
Gravel (>2mm)	----	1	%	19	34	29	41	39
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.49	2.21	2.28	2.33	2.51
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	----	2.1	0.8	----	----
ø Exchangeable Aluminium	----	0.1	meq/100g	----	1.7	0.6	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP3 S2	TP4 S1	TP4 S2	TP5 S1	TP5 S2
				Client sampling date / time	05-Nov-2018 00:00	05-Nov-2018 00:00	05-Nov-2018 00:00	06-Nov-2018 00:00	06-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1827271-006	EB1827271-007	EB1827271-008	EB1827271-009	EB1827271-010
					Result	Result	Result	Result	Result
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		5.5	2.6	2.3	4.9	4.0
Exchangeable Magnesium	----	0.1	meq/100g		2.0	5.8	3.3	5.5	5.0
Exchangeable Potassium	----	0.1	meq/100g		0.4	0.3	0.2	0.4	0.3
Exchangeable Sodium	----	0.1	meq/100g		<0.1	0.5	0.3	0.4	0.4
Cation Exchange Capacity	----	0.1	meq/100g		8.0	11.3	6.9	11.1	9.7
Exchangeable Sodium Percent	----	0.1	%		1.1	5.1	5.4	3.2	3.7
Calcium/Magnesium Ratio	----	0.1	-		2.8	0.4	0.7	0.9	0.8
Magnesium/Potassium Ratio	----	0.1	-		4.8	20.0	13.6	14.5	16.7
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		<5	<5	<5	49	24
Cadmium	7440-43-9	1	mg/kg		<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg		29	8	30	55	26
Copper	7440-50-8	5	mg/kg		27	42	29	72	40
Lead	7439-92-1	5	mg/kg		18	10	10	68	6
Nickel	7440-02-0	2	mg/kg		20	7	8	24	7
Zinc	7440-66-6	5	mg/kg		7	8	6	11	7
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.6	<0.5	0.6	<0.5	0.8
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	10	mg/kg		<10	<10	<10	<10	<10
C10 - C14 Fraction	----	50	mg/kg		<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
C29 - C36 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
^ C10 - C36 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	10	mg/kg		<10	<10	<10	<10	<10
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg		<10	<10	<10	<10	<10
>C10 - C16 Fraction	----	50	mg/kg		<50	<50	<50	<50	<50
>C16 - C34 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	mg/kg		<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	50	mg/kg		<50	<50	<50	<50	<50

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP3 S2	TP4 S1	TP4 S2	TP5 S1	TP5 S2
				Client sampling date / time	05-Nov-2018 00:00	05-Nov-2018 00:00	05-Nov-2018 00:00	06-Nov-2018 00:00	06-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1827271-006	EB1827271-007	EB1827271-008	EB1827271-009	EB1827271-010
					Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	50	mg/kg		<50	<50	<50	<50	<50
EP080: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	100-41-4	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
ortho-Xylene	95-47-6	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
^ **Sum of BTEX**	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ **Total Xylenes**	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
Naphthalene	91-20-3	1	mg/kg		<1	<1	<1	<1	<1
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.2	%		**89.0**	**87.3**	**86.0**	**85.6**	**80.5**
Toluene-D8	2037-26-5	0.2	%		**83.7**	**79.6**	**79.6**	**77.9**	**70.2**
4-Bromofluorobenzene	460-00-4	0.2	%		**92.8**	**90.3**	**88.4**	**87.8**	**83.6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP6 S1	TP6 S2	----	----	----
			Client sampling date / time	06-Nov-2018 00:00	06-Nov-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1827271-011	EB1827271-012	--------	--------	--------
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.3	5.6	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	32	7	----	----	----
EA055: Moisture Content								
Moisture Content	----	1.0	%	4.0	11.3	----	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Brown (7.5YR 2.5/2)	Strong Brown (7.5YR 5/6)	----	----	----
Texture	----	-	-	Gravelly Sand	Gravelly Sand	----	----	----
Emerson Class Number	EC/TC	-	-	8	8	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	43	48	----	----	----
+150µm	----	1	%	34	40	----	----	----
+300µm	----	1	%	31	37	----	----	----
+425µm	----	1	%	30	36	----	----	----
+600µm	----	1	%	29	35	----	----	----
+1180µm	----	1	%	26	30	----	----	----
+2.36mm	----	1	%	20	20	----	----	----
+4.75mm	----	1	%	11	10	----	----	----
+9.5mm	----	1	%	<1	<1	----	----	----
+19.0mm	----	1	%	<1	<1	----	----	----
+37.5mm	----	1	%	<1	<1	----	----	----
+75.0mm	----	1	%	<1	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	13	19	----	----	----
Silt (2-60 µm)	----	1	%	42	30	----	----	----
Sand (0.06-2.00 mm)	----	1	%	23	28	----	----	----
Gravel (>2mm)	----	1	%	22	23	----	----	----
Cobbles (>6cm)	----	1	%	<1	<1	----	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.28	2.29	----	----	----
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	----	1.0	----	----	----
ø Exchangeable Aluminium	----	0.1	meq/100g	----	0.8	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP6 S1	TP6 S2	----	----	----
				Client sampling date / time	06-Nov-2018 00:00	06-Nov-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1827271-011	EB1827271-012	--------	--------	--------
					Result	Result	----	----	----
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		6.3	2.8	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		3.1	2.8	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		0.5	0.4	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		0.2	0.6	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		10.1	7.6	----	----	----
Exchangeable Sodium Percent	----	0.1	%		2.1	8.4	----	----	----
Calcium/Magnesium Ratio	----	0.1	-		2.0	1.0	----	----	----
Magnesium/Potassium Ratio	----	0.1	-		5.6	7.5	----	----	----
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		<5	<5	----	----	----
Cadmium	7440-43-9	1	mg/kg		<1	<1	----	----	----
Chromium	7440-47-3	2	mg/kg		4	6	----	----	----
Copper	7440-50-8	5	mg/kg		11	26	----	----	----
Lead	7439-92-1	5	mg/kg		<5	5	----	----	----
Nickel	7440-02-0	2	mg/kg		4	5	----	----	----
Zinc	7440-66-6	5	mg/kg		6	7	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	----	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		2.3	0.6	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	10	mg/kg		<10	<10	----	----	----
C10 - C14 Fraction	----	50	mg/kg		<50	<50	----	----	----
C15 - C28 Fraction	----	100	mg/kg		<100	<100	----	----	----
C29 - C36 Fraction	----	100	mg/kg		<100	<100	----	----	----
^ C10 - C36 Fraction (sum)	----	50	mg/kg		<50	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	10	mg/kg		<10	<10	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg		<10	<10	----	----	----
>C10 - C16 Fraction	----	50	mg/kg		<50	<50	----	----	----
>C16 - C34 Fraction	----	100	mg/kg		<100	<100	----	----	----
>C34 - C40 Fraction	----	100	mg/kg		<100	<100	----	----	----
^ >C10 - C40 Fraction (sum)	----	50	mg/kg		<50	<50	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP6 S1	TP6 S2	----	----	----
				Client sampling date / time	06-Nov-2018 00:00	06-Nov-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1827271-011	EB1827271-012	--------	--------	--------
					Result	Result	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	50	mg/kg		<50	<50	----	----	----
EP080: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	----	----	----
Toluene	108-88-3	0.5	mg/kg		<0.5	<0.5	----	----	----
Ethylbenzene	100-41-4	0.5	mg/kg		<0.5	<0.5	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg		<0.5	<0.5	----	----	----
ortho-Xylene	95-47-6	0.5	mg/kg		<0.5	<0.5	----	----	----
^ **Sum of BTEX**	----	0.2	mg/kg		<0.2	<0.2	----	----	----
^ **Total Xylenes**	----	0.5	mg/kg		<0.5	<0.5	----	----	----
Naphthalene	91-20-3	1	mg/kg		<1	<1	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.2	%		**90.4**	**83.8**	----	----	----
Toluene-D8	2037-26-5	0.2	%		**81.3**	**76.5**	----	----	----
4-Bromofluorobenzene	460-00-4	0.2	%		**90.1**	**86.6**	----	----	----

Surrogate Control Limits

Sub-Matrix: **SOIL**

Compound	CAS Number	Recovery Limits (%) Low	High
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	53	134
Toluene-D8	2037-26-5	60	131
4-Bromofluorobenzene	460-00-4	59	127

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EB1827271**	Page	: 1 of 7
Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Contact	: Customer Services EB
Address	: P.O BOX 455 GORDONS PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +675 342 6121	Telephone	: +61-7-3243 7222
Project	: IWMP, Roku	Date Samples Received	: 09-Nov-2018
Order number	:	Date Analysis Commenced	: 20-Nov-2018
C-O-C number	: ----	Issue Date	: 14-Jan-2019
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 12		
No. of samples analysed	: 12		

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

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

This Quality Control Report contains the following information:

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

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

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA002: pH 1:5 (Soils) (QC Lot: 2047909)									
EB1827271-001	TP1 S1	EA002: pH Value	----	0.1	pH Unit	5.5	5.5	0.00	0% - 20%
EB1827271-011	TP6 S1	EA002: pH Value	----	0.1	pH Unit	6.3	6.4	0.00	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2047908)									
EB1827271-001	TP1 S1	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	3	3	0.00	No Limit
EB1827271-011	TP6 S1	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	32	28	14.0	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2047910)									
EB1827271-001	TP1 S1	EA055: Moisture Content	----	0.1	%	11.1	12.1	8.95	0% - 50%
EB1827271-011	TP6 S1	EA055: Moisture Content	----	0.1	%	4.0	3.8	5.67	No Limit
ED005: Exchange Acidity (QC Lot: 2084026)									
EB1827271-001	TP1 S1	ED005: Exchange Acidity	----	0.1	meq/100g	0.4	0.3	0.00	No Limit
		ED005: Exchangeable Aluminium	----	0.1	meq/100g	0.2	0.2	0.00	No Limit
ED007: Exchangeable Cations (QC Lot: 2084025)									
EB1827271-001	TP1 S1	ED007: Exchangeable Calcium	----	0.1	meq/100g	2.7	2.6	0.00	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	5.0	4.9	0.00	0% - 20%
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.3	0.3	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	0.4	0.5	0.00	No Limit
ED007: Exchangeable Cations (QC Lot: 2084029)									
EB1827271-003	TP2 S1	ED007: Exchangeable Calcium	----	0.1	meq/100g	7.9	8.3	5.14	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	2.4	2.6	4.66	0% - 20%
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	0.5	0.5	0.00	No Limit
EG005T: Total Metals by ICP-AES (QC Lot: 2047905)									
EB1827271-001	TP1 S1	EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	11	10	9.93	No Limit

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG005T: Total Metals by ICP-AES (QC Lot: 2047905) - continued									
EB1827271-001	TP1 S1	EG005T: Nickel	7440-02-0	2	mg/kg	7	7	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	30	26	12.6	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	8	8	0.00	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	18	16	8.39	No Limit
EB1827271-011	TP6 S1	EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.00	No Limit
		EG005T: Chromium	7440-47-3	2	mg/kg	4	6	37.0	No Limit
		EG005T: Nickel	7440-02-0	2	mg/kg	4	5	0.00	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Copper	7440-50-8	5	mg/kg	11	11	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	<5	6	18.7	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	6	6	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2047904)									
EB1827271-001	TP1 S1	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EB1827271-011	TP6 S1	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EP004: Organic Matter (QC Lot: 2047714)									
EB1827271-001	TP1 S1	EP004: Organic Matter	----	0.5	%	0.5	0.6	0.00	No Limit
EB1827271-010	TP5 S2	EP004: Organic Matter	----	0.5	%	0.8	0.6	23.1	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2047906)									
EB1827271-001	TP1 S1	EP080: C6 - C9 Fraction	----	10	mg/kg	<10	<10	0.00	No Limit
EB1827271-011	TP6 S1	EP080: C6 - C9 Fraction	----	10	mg/kg	<10	<10	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2047907)									
EB1827271-001	TP1 S1	EP071: C15 - C28 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C29 - C36 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C10 - C14 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EB1827271-011	TP6 S1	EP071: C15 - C28 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C29 - C36 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: C10 - C14 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2047906)									
EB1827271-001	TP1 S1	EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	0.00	No Limit
EB1827271-011	TP6 S1	EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2047907)									
EB1827271-001	TP1 S1	EP071: >C16 - C34 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C34 - C40 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C10 - C16 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EB1827271-011	TP6 S1	EP071: >C16 - C34 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C34 - C40 Fraction	----	100	mg/kg	<100	<100	0.00	No Limit
		EP071: >C10 - C16 Fraction	----	50	mg/kg	<50	<50	0.00	No Limit
EP080: BTEXN (QC Lot: 2047906)									

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP080: BTEXN (QC Lot: 2047906) - continued									
EB1827271-001	TP1 S1	EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Naphthalene	91-20-3	1	mg/kg	<1	<1	0.00	No Limit
EB1827271-011	TP6 S1	EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Naphthalene	91-20-3	1	mg/kg	<1	<1	0.00	No Limit

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

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

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA002: pH 1:5 (Soils) (QCLot: 2047909)								
EA002: pH Value	----	----	pH Unit	----	4 pH Unit	100	98	102
				----	7 pH Unit	100	98	102
EA010: Conductivity (1:5) (QCLot: 2047908)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	99.3	97	103
ED005: Exchange Acidity (QCLot: 2084026)								
ED005: Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----
ED005: Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
ED007: Exchangeable Cations (QCLot: 2084025)								
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.54 meq/100g	92.1	79	113
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.15 meq/100g	93.1	85	115
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.635 meq/100g	100.0	70	122
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.382 meq/100g	82.8	76	112
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	5.707 meq/100g	93.6	82	112
ED007: Exchangeable Cations (QCLot: 2084029)								
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	3.54 meq/100g	94.8	79	113
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.15 meq/100g	97.6	85	115
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.635 meq/100g	104	70	122
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.382 meq/100g	85.5	76	112
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	5.707 meq/100g	96.9	82	112
EG005T: Total Metals by ICP-AES (QCLot: 2047905)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	106 mg/kg	110	84	123
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
EG005T: Chromium	7440-47-3	2	mg/kg	<2	16.5 mg/kg	120	83	125
EG005T: Copper	7440-50-8	5	mg/kg	<5	50.6 mg/kg	109	86	122
EG005T: Lead	7439-92-1	5	mg/kg	<5	64.4 mg/kg	91.1	84	119
EG005T: Nickel	7440-02-0	2	mg/kg	<2	13.3 mg/kg	110	89	126
EG005T: Zinc	7440-66-6	5	mg/kg	<5	118 mg/kg	105	87	127
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2047904)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	0.0847 mg/kg	92.7	70	130
EP004: Organic Matter (QCLot: 2047714)								
EP004: Organic Matter	----	0.5	%	<0.5	80 %	94.1	83	115
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2047906)								
EP080: C6 - C9 Fraction	----	10	mg/kg	<10	16 mg/kg	111	72	120

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2047907)								
EP071: C10 - C14 Fraction	----	50	mg/kg	<50	310 mg/kg	101	79	123
EP071: C15 - C28 Fraction	----	100	mg/kg	<100	490 mg/kg	106	77	123
EP071: C29 - C36 Fraction	----	100	mg/kg	<100	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2047906)								
EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	18.5 mg/kg	104	70	119
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2047907)								
EP071: >C10 - C16 Fraction	----	50	mg/kg	<50	450 mg/kg	102	81	122
EP071: >C16 - C34 Fraction	----	100	mg/kg	<100	320 mg/kg	105	74	122
EP071: >C34 - C40 Fraction	----	100	mg/kg	<100	----	----	----	----
EP080: BTEXN (QCLot: 2047906)								
EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	1 mg/kg	97.6	69	118
EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	1 mg/kg	99.6	73	123
EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	1 mg/kg	99.4	73	115
EP080: meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	2 mg/kg	101	75	115
EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	1 mg/kg	102	75	115
EP080: Naphthalene	91-20-3	1	mg/kg	<1	1 mg/kg	95.5	71	113

Matrix Spike (MS) Report

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

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
EG005T: Total Metals by ICP-AES (QCLot: 2047905)							
EB1827271-002	TP1 S2	EG005T: Arsenic	7440-38-2	50 mg/kg	94.0	70	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	86.2	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	88.9	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	86.6	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	94.2	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	83.8	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	88.5	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2047904)							
EB1827271-002	TP1 S2	EG035T: Mercury	7439-97-6	5 mg/kg	104	70	130
EP004: Organic Matter (QCLot: 2047714)							
EB1827271-002	TP1 S2	EP004: Organic Matter	----	2.667 %	73.5	70	130

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2047906)							
EB1827271-002	TP1 S2	EP080: C6 - C9 Fraction	----	8 mg/kg	72.0	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2047907)							
EB1827271-002	TP1 S2	EP071: C10 - C14 Fraction	----	310 mg/kg	91.9	70	130
		EP071: C15 - C28 Fraction	----	490 mg/kg	97.7	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2047906)							
EB1827271-002	TP1 S2	EP080: C6 - C10 Fraction	C6_C10	8 mg/kg	70.6	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2047907)							
EB1827271-002	TP1 S2	EP071: >C10 - C16 Fraction	----	450 mg/kg	94.0	70	130
		EP071: >C16 - C34 Fraction	----	320 mg/kg	97.5	70	130
EP080: BTEXN (QCLot: 2047906)							
EB1827271-002	TP1 S2	EP080: Benzene	71-43-2	2 mg/kg	85.5	70	130
		EP080: Toluene	108-88-3	2 mg/kg	86.3	70	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1827271**	Page	: 1 of 12
Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Telephone	: +61-7-3243 7222
Project	: IWMP, Roku	Date Samples Received	: 09-Nov-2018
Site	: ----	Issue Date	: 14-Jan-2019
Sampler	: ----	No. of samples received	: 12
Order number	:	No. of samples analysed	: 12

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

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

Summary of Outliers

Outliers : Quality Control Samples

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

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002: pH 1:5 (Soils)						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	05-Dec-2018	12-Nov-2018	**23**	----	----	----
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	05-Dec-2018	13-Nov-2018	**22**	----	----	----
EA010: Conductivity (1:5)						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	05-Dec-2018	12-Nov-2018	**23**	----	----	----
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	05-Dec-2018	13-Nov-2018	**22**	----	----	----
EA055: Moisture Content						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	----	----	----	21-Nov-2018	19-Nov-2018	**2**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	----	----	----	21-Nov-2018	20-Nov-2018	**1**
ED005: Exchange Acidity						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	13-Dec-2018	03-Dec-2018	**10**	13-Dec-2018	03-Dec-2018	**10**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	13-Dec-2018	04-Dec-2018	**9**	13-Dec-2018	04-Dec-2018	**9**
ED006: Exchangeable Cations on Alkaline Soils						

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation: Date extracted	Extraction / Preparation: Due for extraction	Extraction / Preparation: Days overdue	Analysis: Date analysed	Analysis: Due for analysis	Analysis: Days overdue
ED006: Exchangeable Cations on Alkaline Soils - Analysis Holding Time Compliance						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	13-Dec-2018	03-Dec-2018	**10**	13-Dec-2018	03-Dec-2018	**10**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	13-Dec-2018	04-Dec-2018	**9**	13-Dec-2018	04-Dec-2018	**9**
ED007: Exchangeable Cations						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	13-Dec-2018	03-Dec-2018	**10**	13-Dec-2018	03-Dec-2018	**10**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	13-Dec-2018	04-Dec-2018	**9**	13-Dec-2018	04-Dec-2018	**9**
ED008: Exchangeable Cations						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	13-Dec-2018	03-Dec-2018	**10**	13-Dec-2018	03-Dec-2018	**10**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	13-Dec-2018	04-Dec-2018	**9**	13-Dec-2018	04-Dec-2018	**9**
EG035T: Total Recoverable Mercury by FIMS						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	04-Dec-2018	03-Dec-2018	**1**	07-Dec-2018	03-Dec-2018	**4**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	----	----	----	07-Dec-2018	04-Dec-2018	**3**
EP004: Organic Matter						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	13-Dec-2018	03-Dec-2018	**10**	13-Dec-2018	03-Dec-2018	**10**

Matrix: **SOIL**

Method / Container / Client Sample ID(s)	Extraction / Preparation: Date extracted	Extraction / Preparation: Due for extraction	Extraction / Preparation: Days overdue	Analysis: Date analysed	Analysis: Due for analysis	Analysis: Days overdue
EP004: Organic Matter - Analysis Holding Time Compliance						
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	13-Dec-2018	04-Dec-2018	**9**	13-Dec-2018	04-Dec-2018	**9**
EP080/071: Total Petroleum Hydrocarbons						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	23-Nov-2018	19-Nov-2018	**4**	26-Nov-2018	19-Nov-2018	**7**
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	27-Nov-2018	19-Nov-2018	**8**	----	----	----
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	23-Nov-2018	20-Nov-2018	**3**	26-Nov-2018	20-Nov-2018	**6**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	27-Nov-2018	20-Nov-2018	**7**	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions						
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	23-Nov-2018	19-Nov-2018	**4**	26-Nov-2018	19-Nov-2018	**7**
Soil Glass Jar - Unpreserved						
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	27-Nov-2018	19-Nov-2018	**8**	----	----	----
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	23-Nov-2018	20-Nov-2018	**3**	26-Nov-2018	20-Nov-2018	**6**
Soil Glass Jar - Unpreserved						
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	27-Nov-2018	20-Nov-2018	**7**	----	----	----
EP080: BTEXN						

Matrix: **SOIL**

Method / Container / Client Sample ID(s)		Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EP080: BTEXN - Analysis Holding Time Compliance							
Soil Glass Jar - Unpreserved							
TP1 S1,	TP1 S2,	23-Nov-2018	19-Nov-2018	**4**	26-Nov-2018	19-Nov-2018	**7**
TP3 S1,	TP3 S2,						
TP4 S1,	TP4 S2						
Soil Glass Jar - Unpreserved							
TP2 S1,	TP2 S2,	23-Nov-2018	20-Nov-2018	**3**	26-Nov-2018	20-Nov-2018	**6**
TP5 S1,	TP5 S2,						
TP6 S1,	TP6 S2						

Analysis Holding Time Compliance

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

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

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

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

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1:5 (Soils)								
Soil Glass Jar - Unpreserved (EA002)								
TP1 S1,	TP1 S2,	**05-Nov-2018**	**05-Dec-2018**	12-Nov-2018	×	**05-Dec-2018**	05-Dec-2018	✓
TP3 S1,	TP3 S2,							
TP4 S1,	TP4 S2							
Soil Glass Jar - Unpreserved (EA002)								
TP2 S1,	TP2 S2,	**06-Nov-2018**	**05-Dec-2018**	13-Nov-2018	×	**05-Dec-2018**	05-Dec-2018	✓
TP5 S1,	TP5 S2,							
TP6 S1,	TP6 S2							
EA010: Conductivity (1:5)								
Soil Glass Jar - Unpreserved (EA010)								
TP1 S1,	TP1 S2,	**05-Nov-2018**	**05-Dec-2018**	12-Nov-2018	×	**05-Dec-2018**	02-Jan-2019	✓
TP3 S1,	TP3 S2,							
TP4 S1,	TP4 S2							
Soil Glass Jar - Unpreserved (EA010)								
TP2 S1,	TP2 S2,	**06-Nov-2018**	**05-Dec-2018**	13-Nov-2018	×	**05-Dec-2018**	02-Jan-2019	✓
TP5 S1,	TP5 S2,							
TP6 S1,	TP6 S2							

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA055: Moisture Content							
Soil Glass Jar - Unpreserved (EA055)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**----**	----	----	**21-Nov-2018**	19-Nov-2018	×
Soil Glass Jar - Unpreserved (EA055)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**----**	----	----	**21-Nov-2018**	20-Nov-2018	×
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**----**	----	----	**22-Dec-2018**	04-May-2019	✓
Snap Lock Bag (EA058)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**----**	----	----	**22-Dec-2018**	05-May-2019	✓
EA150: Particle Sizing							
Snap Lock Bag (EA150H)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**----**	----	----	**14-Jan-2019**	04-May-2019	✓
Snap Lock Bag (EA150H)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**----**	----	----	**14-Jan-2019**	05-May-2019	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag (EA150H)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**----**	----	----	**14-Jan-2019**	04-May-2019	✓
Snap Lock Bag (EA150H)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**----**	----	----	**14-Jan-2019**	05-May-2019	✓

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**----**	----	----	**14-Jan-2019**	04-May-2019	✓
Snap Lock Bag (EA152)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**----**	----	----	**14-Jan-2019**	05-May-2019	✓
ED005: Exchange Acidity							
Soil Glass Jar - Unpreserved (ED005)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**13-Dec-2018**	03-Dec-2018	×	**13-Dec-2018**	03-Dec-2018	×
Soil Glass Jar - Unpreserved (ED005)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**13-Dec-2018**	04-Dec-2018	×	**13-Dec-2018**	04-Dec-2018	×
ED006: Exchangeable Cations on Alkaline Soils							
Soil Glass Jar - Unpreserved (ED006)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**13-Dec-2018**	03-Dec-2018	×	**13-Dec-2018**	03-Dec-2018	×
Soil Glass Jar - Unpreserved (ED006)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**13-Dec-2018**	04-Dec-2018	×	**13-Dec-2018**	04-Dec-2018	×
ED007: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED007)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**13-Dec-2018**	03-Dec-2018	×	**13-Dec-2018**	03-Dec-2018	×
Soil Glass Jar - Unpreserved (ED007)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**13-Dec-2018**	04-Dec-2018	×	**13-Dec-2018**	04-Dec-2018	×

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED008: Exchangeable Cations							
Soil Glass Jar - Unpreserved (ED008)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**13-Dec-2018**	03-Dec-2018	×	**13-Dec-2018**	03-Dec-2018	×
Soil Glass Jar - Unpreserved (ED008)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**13-Dec-2018**	04-Dec-2018	×	**13-Dec-2018**	04-Dec-2018	×
EG005T: Total Metals by ICP-AES							
Soil Glass Jar - Unpreserved (EG005T)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**04-Dec-2018**	04-May-2019	✓	**06-Dec-2018**	04-May-2019	✓
Soil Glass Jar - Unpreserved (EG005T)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**04-Dec-2018**	05-May-2019	✓	**06-Dec-2018**	05-May-2019	✓
EG035T: Total Recoverable Mercury by FIMS							
Soil Glass Jar - Unpreserved (EG035T)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**04-Dec-2018**	03-Dec-2018	×	**07-Dec-2018**	03-Dec-2018	×
Soil Glass Jar - Unpreserved (EG035T)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**04-Dec-2018**	04-Dec-2018	✓	**07-Dec-2018**	04-Dec-2018	×
EP004: Organic Matter							
Soil Glass Jar - Unpreserved (EP004)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**13-Dec-2018**	03-Dec-2018	×	**13-Dec-2018**	03-Dec-2018	×
Soil Glass Jar - Unpreserved (EP004)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**13-Dec-2018**	04-Dec-2018	×	**13-Dec-2018**	04-Dec-2018	×

Matrix: **SOIL**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080/071: Total Petroleum Hydrocarbons							
Soil Glass Jar - Unpreserved (EP080)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**23-Nov-2018**	19-Nov-2018	×	**26-Nov-2018**	19-Nov-2018	×
Soil Glass Jar - Unpreserved (EP071)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**27-Nov-2018**	19-Nov-2018	×	**27-Nov-2018**	06-Jan-2019	✓
Soil Glass Jar - Unpreserved (EP080)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**23-Nov-2018**	20-Nov-2018	×	**26-Nov-2018**	20-Nov-2018	×
Soil Glass Jar - Unpreserved (EP071)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**27-Nov-2018**	20-Nov-2018	×	**27-Nov-2018**	06-Jan-2019	✓
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions							
Soil Glass Jar - Unpreserved (EP080)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**23-Nov-2018**	19-Nov-2018	×	**26-Nov-2018**	19-Nov-2018	×
Soil Glass Jar - Unpreserved (EP071)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**27-Nov-2018**	19-Nov-2018	×	**27-Nov-2018**	06-Jan-2019	✓
Soil Glass Jar - Unpreserved (EP080)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**23-Nov-2018**	20-Nov-2018	×	**26-Nov-2018**	20-Nov-2018	×
Soil Glass Jar - Unpreserved (EP071)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**27-Nov-2018**	20-Nov-2018	×	**27-Nov-2018**	06-Jan-2019	✓
EP080: BTEXN							
Soil Glass Jar - Unpreserved (EP080)							
TP1 S1, TP1 S2, TP3 S1, TP3 S2, TP4 S1, TP4 S2	**05-Nov-2018**	**23-Nov-2018**	19-Nov-2018	×	**26-Nov-2018**	19-Nov-2018	×
Soil Glass Jar - Unpreserved (EP080)							
TP2 S1, TP2 S2, TP5 S1, TP5 S2, TP6 S1, TP6 S2	**06-Nov-2018**	**23-Nov-2018**	20-Nov-2018	×	**26-Nov-2018**	20-Nov-2018	×

Quality Control Parameter Frequency Compliance

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

Matrix: **SOIL**

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

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Electrical Conductivity (1:5)	EA010	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchange Acidity by 1M Potassium Chloride	ED005	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Electrical Conductivity (1:5)	EA010	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	2	12	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Electrical Conductivity (1:5)	EA010	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchange Acidity by 1M Potassium Chloride	ED005	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	2	12	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Organic Matter	EP004	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

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

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons, (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2) (Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).
TRH - Semivolatile Fraction	EP071	SOIL	In house: Referenced to USEPA SW 846 - 8015A Sample extracts are analysed by Capillary GC/FID and quantified against alkane standards over the range C10 - C40. Compliant with NEPM amended 2013.

Analytical Methods	Method	Matrix	Method Descriptions
TRH Volatiles/BTEX	EP080	SOIL	In house: Referenced to USEPA SW 846 - 8260B. Extracts are analysed by Purge and Trap, Capillary GC/MS. Quantification is by comparison against an established 5 point calibration curve. Compliant with NEPM amended 2013.

Preparation Methods	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)
Methanolic Extraction of Soils for Purge and Trap	ORG16	SOIL	In house: Referenced to USEPA SW 846 - 5030A. 5g of solid is shaken with surrogate and 10mL methanol prior to analysis by Purge and Trap - GC/MS.
Tumbler Extraction of Solids	ORG17	SOIL	In house: Mechanical agitation (tumbler). 10g of sample, Na2SO4 and surrogate are extracted with 30mL 1:1 DCM/Acetone by end over end tumble. The solvent is decanted, dehydrated and concentrated (by KD) to the desired volume for analysis.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

CLIENT: ACEM GEOTECHNIQUES	TURNAROUND REQUIREMENTS: ☐ Standard TAT (List due date): (Standard TAT may be longer for some tests e.g., Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):	FOR LABORATORY USE ONLY (Circle)	
OFFICE: PORT MORESBY		Custody Seal Intact?	Yes No N/A
PROJECT: IWMP, Roku PROJECT NO.:	ALS QUOTE NO.:	Free ice / frozen ice bricks present upon receipt?	Yes No N/A
ORDER NUMBER: PURCHASE ORDER NO.:	COUNTRY OF ORIGIN:	Random Sample Temperature on Receipt:	°C
PROJECT MANAGER: Ian Smith CONTACT PH: 33713584	COC SEQUENCE NUMBER (Circle) COC: 1 2 3 4 5 6 7 OF: 1 2 3 4 5 6 7	Other comment:	
SAMPLER: SAMPLER MOBILE:	RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY: / RECEIVED BY:
COC Emailed to ALS? (YES) NO) EDD FORMAT (or default):			
Email Reports to (will default to PM if no other addresses are listed): ianandedwina@hotmail.com	DATE/TIME:	DATE/TIME:	DATE/TIME: / DATE/TIME:
Email Invoice to (will default to PM if no other addresses are listed): ditto			

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
		WATER												Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES									
1	BH1 S1	14/11/18 – 10:15 AM			5	As ALS Quote				11/9				WATER TABLE AT DEPTH 7.2 m
2	BH1 S2	14/11/18 – 11:45 AM			5			ditto						DEPTH 7.2 m
3	BH2 S1	DRY – –		—	5			ditto						DRY / NO WATER
4	BH2 S2	DRY – –		—	5			ditto						DRY
				TOTAL										

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

Environmental Division
Brisbane
Work Order Reference
EB1829292

KC

Telephone : + 61-7-3243 7222

Glass;

Form Page 1 of 1

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1829292**

Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Contact	: Customer Services EB
Address	: P.O BOX 455 GORDONS PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: ianandedwina@hotmail.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +675 342 6121	Telephone	: +61-7-3243 7222
Facsimile	: +675 343 0711	Facsimile	: +61-7-3243 7218
Project	: IWMP, Roku	Page	: 1 of 3
Order number	:	Quote number	: EB2018ACEMGEO0001 (EN/333)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	:		

Dates

Date Samples Received	: 29-Nov-2018 15:36	Issue Date	: 30-Nov-2018
Client Requested Due Date	: 06-Dec-2018	Scheduled Reporting Date	: **06-Dec-2018**

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 1	Temperature	: 29.3°C - Ice Bricks present
Receipt Detail	: SMALL ESKY	No. of samples received / analysed	: 2 / 2

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method / Client sample ID	Sample Container Received	Preferred Sample Container for Analysis
Dissolved Mercury by FIMS : EG035F		
BH1 S1	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
BH1 S2	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite A : EG020A-F		
BH1 S1	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
BH1 S2	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	Client sampling date / time	Client sample ID	WATER - EA005P pH (PCT)	WATER - IN-1 EC plus TDS Calculated	WATER - NT-01 & 02 Ca, Mg, Na, K, Cl, SO4, Alkalinity	WATER - W-05 TRH/BTEXN/8 Metals
EB1829292-001	14-Nov-2018 10:15	BH1 S1	✓	✓	✓	✓
EB1829292-002	14-Nov-2018 11:45	BH1 S2	✓	✓	✓	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

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

Method / Client Sample ID(s)	Container	Due for extraction	Due for analysis	Samples Received Date	Samples Received Evaluation	Instructions Received Date	Instructions Received Evaluation
EA005-P: pH by PC Titrator							
BH1 S1	Clear Plastic Bottle - Natural	----	14-Nov-2018	29-Nov-2018	×	----	----
BH1 S2	Clear Plastic Bottle - Natural	----	14-Nov-2018	29-Nov-2018	×	----	----
ED037-P: Alkalinity by PC Titrator							
BH1 S1	Clear Plastic Bottle - Natural	----	28-Nov-2018	29-Nov-2018	×	----	----
BH1 S2	Clear Plastic Bottle - Natural	----	28-Nov-2018	29-Nov-2018	×	----	----
ED093F: Major Cations - Dissolved							
BH1 S1	Clear Plastic Bottle - Natural	----	21-Nov-2018	29-Nov-2018	×	----	----
BH1 S2	Clear Plastic Bottle - Natural	----	21-Nov-2018	29-Nov-2018	×	----	----
EP071: TRH - Semivolatile Fraction							
BH1 S1	Amber Glass Bottle - Unpreserv	21-Nov-2018	31-Dec-2018	29-Nov-2018	×	----	----
BH1 S2	Amber Glass Bottle - Unpreserv	21-Nov-2018	31-Dec-2018	29-Nov-2018	×	----	----
EP080: TRH Volatiles/BTEX							
BH1 S1	Amber VOC Vial - Sulfuric Acid	28-Nov-2018	28-Nov-2018	29-Nov-2018	×	----	----
BH1 S2	Amber VOC Vial - Sulfuric Acid	28-Nov-2018	28-Nov-2018	29-Nov-2018	×	----	----

Requested Deliverables

IAN SMITH

- *AU Certificate of Analysis - NATA (COA)	Email	ianandedwina@hotmail.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	ianandedwina@hotmail.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	ianandedwina@hotmail.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	ianandedwina@hotmail.com
- A4 - AU Tax Invoice (INV)	Email	ianandedwina@hotmail.com
- Chain of Custody (CoC) (COC)	Email	ianandedwina@hotmail.com
- EDI Format - XTab (XTAB)	Email	ianandedwina@hotmail.com

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1829292**	Page	: 1 of 5
Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Contact	: Customer Services EB
Address	: P.O BOX 455 GORDONS PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +675 342 6121	Telephone	: +61-7-3243 7222
Project	: IWMP, Roku	Date Samples Received	: 29-Nov-2018 15:36
Order number	:	Date Analysis Commenced	: 30-Nov-2018
C-O-C number	: ----	Issue Date	: 05-Dec-2018 09:36
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 2		
No. of samples analysed	: 2		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BH1 S1	BH1 S2	----	----	----
			Client sampling date / time	14-Nov-2018 10:15	14-Nov-2018 11:45	----	----	----
Compound	CAS Number	LOR	Unit	EB1829292-001	EB1829292-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**5.24**	**6.38**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**589**	**616**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**383**	**400**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**6**	**45**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**6**	**45**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**145**	**117**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**68**	**84**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**41**	**44**	----	----	----
Magnesium	7439-95-4	1	mg/L	**11**	**14**	----	----	----
Sodium	7440-23-5	1	mg/L	**40**	**44**	----	----	----
Potassium	7440-09-7	1	mg/L	**3**	**4**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.002**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0002**	**0.0002**	----	----	----
Chromium	7440-47-3	0.001	mg/L	**0.001**	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.034**	**0.031**	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.016**	**0.013**	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.002**	**0.003**	----	----	----
Zinc	7440-66-6	0.005	mg/L	**1.42**	**2.61**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**5.06**	**5.70**	----	----	----
Total Cations	----	0.01	meq/L	**4.77**	**5.36**	----	----	----
Ionic Balance	----	0.01	%	**2.94**	**3.08**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	BH1 S1	BH1 S2	----	----	----
				Client sampling date / time	14-Nov-2018 10:15	14-Nov-2018 11:45	----	----	----
Compound	CAS Number	LOR	Unit		EB1829292-001	EB1829292-002	--------	--------	--------
					Result	Result	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		**360**	**230**	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	**200**	----	----	----
C29 - C36 Fraction	----	50	µg/L		**80**	**270**	----	----	----
^ **C10 - C36 Fraction (sum)**	----	50	µg/L		**80**	**470**	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		**350**	**220**	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L		**350**	**220**	----	----	----
>C10 - C16 Fraction	----	100	µg/L		<100	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L		**120**	**380**	----	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	**170**	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L		**120**	**550**	----	----	----
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L		<100	<100	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	<1	----	----	----
Toluene	108-88-3	2	µg/L		<2	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	<2	----	----	----
^ **Total Xylenes**	----	2	µg/L		<2	<2	----	----	----
^ **Sum of BTEX**	----	1	µg/L		<1	<1	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	<5	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	2	%		**93.5**	**91.7**	----	----	----
Toluene-D8	2037-26-5	2	%		**100**	**99.2**	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		**110**	**109**	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EB1829292**	Page	: 1 of 6
Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Contact	: Customer Services EB
Address	: P.O BOX 455 GORDONS PNG	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +675 342 6121	Telephone	: +61-7-3243 7222
Project	: IWMP, Roku	Date Samples Received	: 29-Nov-2018
Order number	:	Date Analysis Commenced	: 30-Nov-2018
C-O-C number	: ----	Issue Date	: 05-Dec-2018
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 2		
No. of samples analysed	: 2		

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

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

This Quality Control Report contains the following information:

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

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

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005P: pH by PC Titrator (QC Lot: 2067958)									
EB1829231-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.93	8.00	0.879	0% - 20%
EB1829251-006	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	4.15	4.14	0.241	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 2067959)									
EB1829231-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	441	438	0.684	0% - 20%
EB1829251-006	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	3080	3070	0.320	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 2067960)									
EB1829231-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	82	83	1.58	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	82	83	1.58	0% - 20%
EB1829251-006	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.00	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 2068419)									
EB1829288-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	8	8	0.00	No Limit
EB1829377-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1840	1860	1.16	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 2068420)									
EB1829288-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	4	4	0.00	No Limit
EB1829377-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	13500	13400	0.596	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2069397)									
EB1829329-003	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	219	230	4.77	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	52	55	5.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	9	10	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 2069397) - continued									
EB1829329-003	Anonymous	ED093F: Potassium	7440-09-7	1	mg/L	4	5	0.00	No Limit
EB1829292-001	BH1 S1	ED093F: Calcium	7440-70-2	1	mg/L	41	42	0.00	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	11	11	0.00	0% - 50%
		ED093F: Sodium	7440-23-5	1	mg/L	40	40	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	3	4	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2069398)									
EB1829329-003	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0002	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.009	0.009	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.011	0.012	0.00	0% - 50%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.076	0.079	4.13	0% - 50%
EB1829292-001	BH1 S1	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0002	0.0002	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.001	0.002	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.034	0.035	0.00	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.016	0.017	0.00	0% - 50%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	1.42	1.45	2.01	0% - 20%
EG035F: Dissolved Mercury by FIMS (QC Lot: 2069399)									
EB1829329-009	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1829292-001	BH1 S1	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2067807)									
EB1829316-001	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2067807)									
EB1829316-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 2067807)									
EB1829316-001	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit

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

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

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA005P: pH by PC Titrator (QCLot: 2067958)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98	102
				----	7 pH Unit	100	98	102
EA010P: Conductivity by PC Titrator (QCLot: 2067959)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	220 µS/cm	# 108	91	107
				<1	12890 µS/cm	101	91	107
ED037P: Alkalinity by PC Titrator (QCLot: 2067960)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	50 mg/L	106	80	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2068419)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	107	85	118
				<1	100 mg/L	93.0	85	118
ED045G: Chloride by Discrete Analyser (QCLot: 2068420)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	101	90	115
				<1	1000 mg/L	104	90	115
ED093F: Dissolved Major Cations (QCLot: 2069397)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 2069398)								
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	98.1	88	116
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	93.7	88	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	95.4	87	113
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	93.4	88	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	102	89	110
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	96.7	89	113
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	94.2	87	113
EG035F: Dissolved Mercury by FIMS (QCLot: 2069399)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	100	84	118
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2067807)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	160 µg/L	81.6	76	122
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2068042)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	1070 µg/L	67.3	65	135
EP071: C15 - C28 Fraction	----	100	µg/L	<100	1770 µg/L	78.6	62	138

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2068042) - continued								
EP071: C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2067807)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	185 µg/L	77.2	75	123
EP080: C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2068042)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	1560 µg/L	73.2	66	134
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	1190 µg/L	77.3	61	139
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN (QCLot: 2067807)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	86.1	77	119
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	91.3	78	122
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	88.6	78	119
EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	20 µg/L	92.2	77	121
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	94.0	76	121
EP080: Total Xylenes	----	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	96.7	75	120

Matrix Spike (MS) Report

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

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%): MS	Recovery Limits (%): Low	Recovery Limits (%): High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 2068419)							
EB1829288-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	120	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 2068420)							
EB1829288-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	99.1	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2069398)							
EB1829292-002	BH1 S2	EG020A-F: Arsenic	7440-38-2	0.1 mg/L	101	70	130
		EG020A-F: Cadmium	7440-43-9	0.1 mg/L	106	70	130
		EG020A-F: Chromium	7440-47-3	0.1 mg/L	100.0	70	130
		EG020A-F: Copper	7440-50-8	0.2 mg/L	103	70	130
		EG020A-F: Lead	7439-92-1	0.1 mg/L	98.2	70	130
		EG020A-F: Nickel	7440-02-0	0.1 mg/L	104	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG020F: Dissolved Metals by ICP-MS (QCLot: 2069398) - continued							
EB1829292-002	BH1 S2	EG020A-F: Zinc	7440-66-6	0.2 mg/L	# Not Determined	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 2069399)							
EB1829329-001	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	93.0	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2067807)							
EB1829316-001	Anonymous	EP080: C6 - C9 Fraction	----	40 µg/L	99.8	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2067807)							
EB1829316-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	40 µg/L	94.8	70	130
EP080: BTEXN (QCLot: 2067807)							
EB1829316-001	Anonymous	EP080: Benzene	71-43-2	10 µg/L	98.5	70	130
		EP080: Toluene	108-88-3	10 µg/L	97.2	70	130

ALS Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1829292**	Page	: 1 of 7
Client	: **ACEM GEOTECHNIQUES**	Laboratory	: Environmental Division Brisbane
Contact	: IAN SMITH	Telephone	: +61-7-3243 7222
Project	: IWMP, Roku	Date Samples Received	: 29-Nov-2018
Site	: ----	Issue Date	: 05-Dec-2018
Sampler	: ----	No. of samples received	: 2
Order number	:	No. of samples analysed	: 2

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

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

Summary of Outliers

Outliers : Quality Control Samples

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

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

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

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

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Laboratory Control Spike (LCS) Recoveries							
EA010P: Conductivity by PC Titrator	QC-2067959-004	----	**Electrical Conductivity @ 25°C**	----	108 %	91-107%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
EG020F: Dissolved Metals by ICP-MS	EB1829292--002	BH1 S2	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method / Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural						
BH1 S1, BH1 S2	----	----	----	30-Nov-2018	14-Nov-2018	**16**
ED037P: Alkalinity by PC Titrator						
Clear Plastic Bottle - Natural						
BH1 S1, BH1 S2	----	----	----	30-Nov-2018	28-Nov-2018	**2**
ED093F: Dissolved Major Cations						
Clear Plastic Bottle - Natural						
BH1 S1, BH1 S2	----	----	----	03-Dec-2018	21-Nov-2018	**12**
EP080/071: Total Petroleum Hydrocarbons						
Amber Glass Bottle - Unpreserved						
BH1 S1, BH1 S2	30-Nov-2018	21-Nov-2018	**9**	----	----	----
Amber VOC Vial - Sulfuric Acid						
BH1 S1, BH1 S2	30-Nov-2018	28-Nov-2018	**2**	30-Nov-2018	28-Nov-2018	**2**
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions						
Amber Glass Bottle - Unpreserved						
BH1 S1, BH1 S2	30-Nov-2018	21-Nov-2018	**9**	----	----	----
Amber VOC Vial - Sulfuric Acid						
BH1 S1, BH1 S2	30-Nov-2018	28-Nov-2018	**2**	30-Nov-2018	28-Nov-2018	**2**
EP080: BTEXN						
Amber VOC Vial - Sulfuric Acid						
BH1 S1, BH1 S2	30-Nov-2018	28-Nov-2018	**2**	30-Nov-2018	28-Nov-2018	**2**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type / Method	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP) - Continued					
TRH - Semivolatile Fraction	0	3	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
TRH - Semivolatile Fraction	0	3	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

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

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

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

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

Matrix: **WATER**

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

Method / *Container* / Client Sample ID(s)	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**30-Nov-2018**	14-Nov-2018	×
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**30-Nov-2018**	12-Dec-2018	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**30-Nov-2018**	28-Nov-2018	×
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**30-Nov-2018**	12-Dec-2018	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**30-Nov-2018**	12-Dec-2018	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**03-Dec-2018**	21-Nov-2018	×
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Natural (EG020A-F)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**03-Dec-2018**	13-May-2019	✓
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Natural (EG035F)							
BH1 S1, BH1 S2	**14-Nov-2018**	**----**	----	----	**03-Dec-2018**	12-Dec-2018	✓

Matrix: **WATER**

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

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080/071: Total Petroleum Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP071)							
BH1 S1, BH1 S2	**14-Nov-2018**	**30-Nov-2018**	21-Nov-2018	×	**30-Nov-2018**	09-Jan-2019	✓
Amber VOC Vial - Sulfuric Acid (EP080)							
BH1 S1, BH1 S2	**14-Nov-2018**	**30-Nov-2018**	28-Nov-2018	×	**30-Nov-2018**	28-Nov-2018	×
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions							
Amber Glass Bottle - Unpreserved (EP071)							
BH1 S1, BH1 S2	**14-Nov-2018**	**30-Nov-2018**	21-Nov-2018	×	**30-Nov-2018**	09-Jan-2019	✓
Amber VOC Vial - Sulfuric Acid (EP080)							
BH1 S1, BH1 S2	**14-Nov-2018**	**30-Nov-2018**	28-Nov-2018	×	**30-Nov-2018**	28-Nov-2018	×
EP080: BTEXN							
Amber VOC Vial - Sulfuric Acid (EP080)							
BH1 S1, BH1 S2	**14-Nov-2018**	**30-Nov-2018**	28-Nov-2018	×	**30-Nov-2018**	28-Nov-2018	×

Quality Control Parameter Frequency Compliance

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

Matrix: **WATER**

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

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	3	**0.00**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	3	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

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

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Calculated TDS (from Electrical Conductivity)	EA016	WATER	In house: Calculation from Electrical Conductivity (APHA 2510 B) using a conversion factor specified in the analytical report. This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

APPENDIX E:

ACEM SELECTFILL SPECIFICATION

ACEM SPECIFICATION SELECT FILL

This specification covers the selection of Select Fill on which to found concrete raft foundations or for use in replacing soft material for the purpose of creating building foundations and fills for RE walls. 10 kg samples of the sample shall be submitted to ACEM for testing and approval, with additional samples submitted, as requested by ACEM, should the initial tests prove marginal or uncertain. The requirements for RE walls are the same AS 4678.

Select Fill Grades

This Specification is divided into requirement for three grades, Grade 1, 2, 3, with Grade 1 being the highest and Grade 3 the lowest. For most buildings or sub-rafts Grade 1 is required, but other grades can also be used if the design criteria are suitable adjusted.

Grading

The material shall lie within the curves A-B and C-D on Figure 1 (also shown in Table 1) and shall be well graded. Gradings that lie within the extended zone may also be considered on merit and after samples have been submitted for testing. Gradings outside line C-D may also be considered but need to be treated as special cases probably accompanied by field trials.

An example of a typical well graded material within the curves A,B,C,D is shown in Table 1 and represents top quality Select Fill for Foundations and with an expected Qa=200kPa. The highest strength select fill will typically be rockfill within gradings C-D-E-F-G. Indicative Qa values are shown below but these will be confirmed by ACEM after consideration of the full range of all test results.

Table 1 SELECT FILL OVERALL GRADING	
Sieve Size	**% Passing**
530 mm	100
190 mm	100-75
75 mm	100-50
37.5 mm	100-30
19 mm	100-10
9.5 mm	100-0
1.18 mm	48-25
75 microns	15-0

Table 2 TYPICAL TOP QUALITY WELL GRADED SELECT FILL	
Sieve Size	**% Passing**
530 mm	100
190 mm	100-90
75 mm	100-75
37.5 mm	86-56
19 mm	75-40
9.5 mm	66-35
1.18 mm	40-20
75 microns	10-0

Other Requirements

Table 2—Material Properties (Max USO)				
Property	**Class 1**	**Class 2**	**Class 3**	**Test Method**
Liquid Limit (LL)	25%	28%	35%	Q104A/AS1289.3.1.1
Plasticity Index PI	2-6%	2-8%	12%	Q105/AS1289.3.3.1
Linear Shrinkage LS	4%	5%	6.5%	Q106/AS1289.3.4.1

PI x % pass 0.425	150	200	360	
%0.075/%0.425	0.3-0.55	0.3-0.65	0.3-0.65	
Soaked CBR 98%MDD,(5.2.1)	Min 80	Min 45	Min 15	Q113C/AS1289.6.1.1
10% fines value (wet)	Min 105kN	Min 105kN	Min 105kN	Q205B/AS1141.22
Wet/Dry Strength Variation	35%	40%	none	Q205C/AS1141.22
ACV Aggregate Crushing*				Q113C/AS1141.22
Los Angeles Abrasion				
Indicative Qa kPa to be confirmed by ACEM	200-350	180-200	150	*only if requested

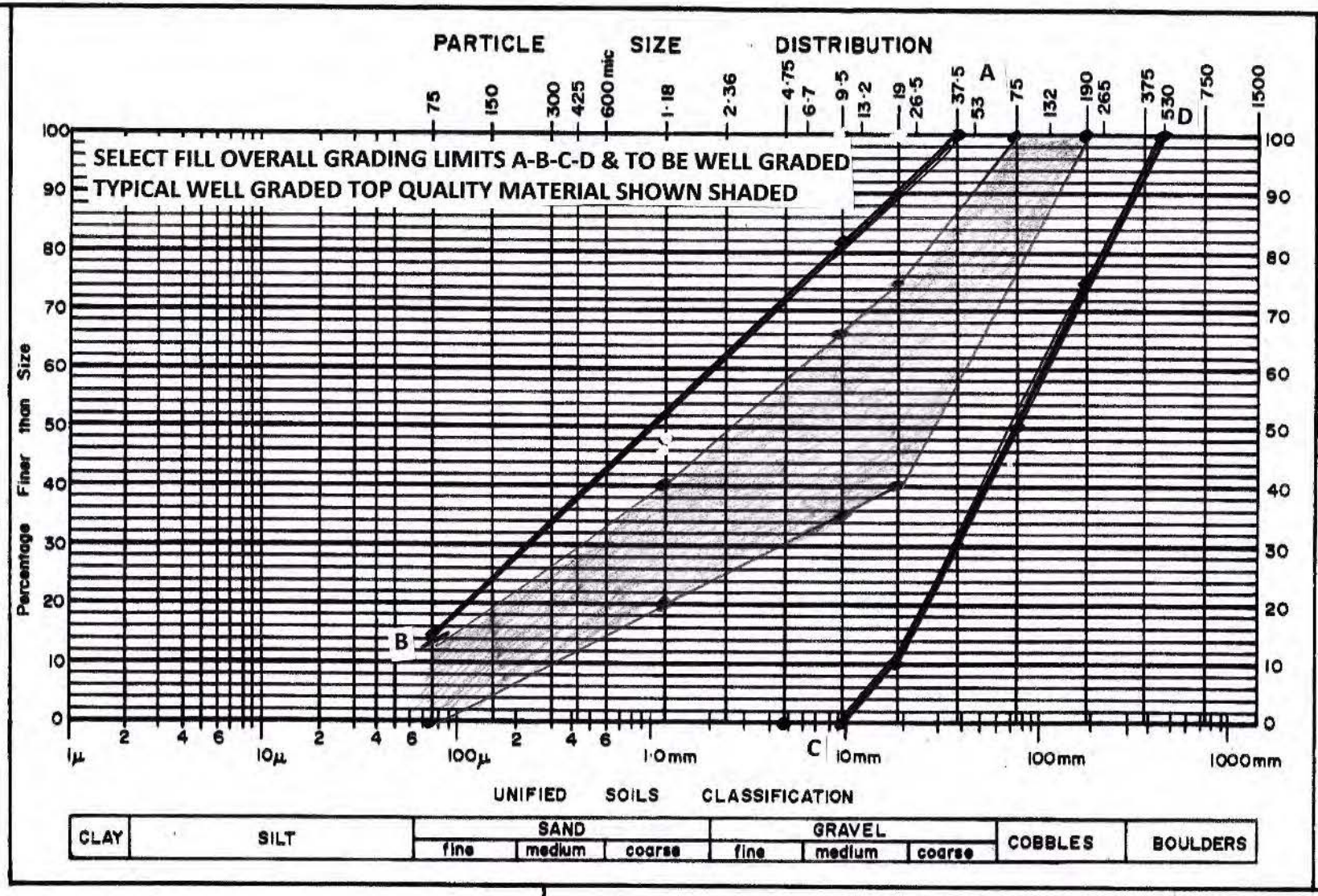
Qa values will be assigned by ACEM after considering all test results.

RE Walls

Table 3 Particle Grading for Select Fill For RE Reinforced Earth Structures	
Sieve Size	**% Passing**
150 mm	100
9.5 mm	100-25
2.36 mm	100-15
600 micron	100-10
75 micron	15-0

Table 4 Other Properties for RE Wall Select Fill—(Maximum USO)	
Coefficient Uniformity D_{60}/D_{10}	2
Plasticity Index PI	12
Resistivity (ohm, cm)	1,000
pH (min)	5
pH (polyester steel only)	10
Chlorides (mg/kg)	200
Sulfates (mg/kg)	1,000

Rev2-20/4/15



ACEM

GEOTECHNIQUES

ACEM SPECIFICATION

DRAWN	**SELECT FILL UNDER BUILDINGS OR RAFTS**
CHECKED	
DATE	
JOB NUMBER	

Figure 1

APPENDIX F:

ASK REPORT ON AIR & NOISE MONITORING

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Napa Napa Road, Papua New Guinea

Air Quality and Noise Baseline Monitoring

Report: 9769R01V01

Prepared for:

ACEM Geotechniques

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Document Approval	
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1. Introduction

ASK Consulting Engineers Pty Ltd (ASK) has been commissioned by ACEM Geotechniques to provide air quality and acoustics consultancy services for the Integrated Waste Management Facility (IWMF) proposed by Total Waste Management (TWM) on a site on Napa Napa Road, north-west of Roku, Papua New Guinea.

This report presents the baseline air quality and noise monitoring data.

The scope of this report includes the following:

- Outline the relevant air quality and noise criteria.
- Present the methodology and results of monitoring.
- Discuss the results of the monitoring.

To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

2. Study Area Description

The site is located on Napa Napa Road, north-west of Roku, Papua New Guinea as shown in **Figures 2.1** and **2.2**.



Figure 2.1 Location of Site (Image from Google Earth Pro)



Figure 2.2 Aerial Photo of Site (Image from Google Earth Pro)

The site has been used for a quarry and a timber mill. It is near other industrial uses to the north and north-east across Napa Napa Road, light industry to the north-west, and forested land in other directions. There is a major port facility to the north-east, which has an unsealed access road branching off Napa Napa Road. During the site visit, substantial suspended particulate was observed arising from vehicle traffic on the unsealed access road.

3. Proposed Development

TWM proposes to construct and operate an IWMF consisting of the following:

- composting plant
- incineration plant
- waste oil processing unit
- fixation plant
- wastewater treatment plant
- quarrying activities
- engineered landfill
- hazardous waste storage.

The Conservation and Environment Protection Authority (CEPA) has issued an environment permit (EP). Two of the requirements are as follows:

- *Undertake an ambient air quality baseline assessment to describe the current air quality in terms of the environmental values identified in the EP, considering the industrial activities on neighbouring properties and to provide information to develop an air quality monitoring program for regular sampling at key boundary locations.*
- *Undertake a noise level baseline assessment to report measurements of ambient noise levels and determine the background noise levels at the boundaries of the site with specific focus on the existing industrial noise particularly during the night time period.*

4. Criteria

4.1 Overview

The EP includes the following relevant sections:

(41) *Conduct monitoring of baseline ambient air quality during the first year of operation and prior to the majority of the plant and infrastructure becoming operational to inform the determination of appropriate site-specific external ambient air quality standards ..... set out in Table 1 below.* [Table 1 lists standards for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, sulphur dioxide, lead, particles as PM_{10}, particles as $PM_{2.5}$.]

(45) *Comply with the performance criteria, management controls, monitoring, reporting and corrective actions set out in the Noise Management Sub-Plan presented in the EMP in order to comply with the noise criteria set out in Table 2 below*:

Environment Permit Table 2 Noise Criteria Guidelines

Receptor	***One hour equivalent continuous sound pressure level***	
	Day (07:00 – 22:00)	*Night (22:00 – 07:00)*
Residential	*55 dBA*	*45 dBA*
Industrial and Commercial	*70 dBA*	*70 dBA*

In relation to the air quality standards in Table 1 of the EP, ASK notes that these are generic standards designed to be applied in urban areas and are not specific to this development. Of those, CO, ozone and lead are not relevant to the IWMF project and have not been included for the following reasons:

- Carbon monoxide is associated with fuel combustion and is rarely an issue except in close proximity to emission sources such as vehicles.
- Ozone is a component of photochemical smog in large urban areas such as Sydney and Brisbane where emissions of nitrogen oxides and volatile organic compounds undergo complex reactions over the airshed. This is not likely to occur in an airshed with the population of Port Moresby.
- Lead is mostly associated with emissions from vehicles with leaded petrol.

4.2 Air Quality

4.2.1 WHO Guidelines

The World Health Organisation (WHO) had set air quality guidelines (WHO, 2006) for the relevant pollutants as shown in **Table 4.1**.

Table 4.1 WHO Air Quality Guidelines

Pollutant	Averaging Period	WHO Guidelines (µg/m^3)
PM_{10}	24 hours	50
	1 year	20
$PM_{2.5}$	24 hours	25
	1 year	10
SO_2	10 minutes	500

Pollutant	Averaging Period	WHO Guidelines (µg/m^3)
	24 hours	20
NO_2	1 hour	200
	1 year	40

4.2.2 Total Suspended Particulates (TSP)

The TSP criterion for Queensland [EPP(Air), 2008] and New South Wales (NSW EPA, 2016), Australia, which is 90 µg/m^3 for annual average concentration, has been adopted in this assessment.

5. Monitoring

5.1 Air Quality

5.1.1 Monitoring Location

Air quality monitoring was undertaken at the Total Waste Management site from the 5th to 10th of November 2018.

The position of the external monitoring location is shown in **Figure 5.1**.



Figure 5.1 Air Quality Monitoring Location

5.1.2 Monitoring Methodology

5.1.2.1 TSI DustTrak II Aerosol Monitor 8530

A TSI DustTrak II Aerosol Monitor 8530 (serial number 8530114502), calibrated on 23 March 2018 was used for particulate measurement within the site. It is a light scattering photometer measuring aerosol concentrations in the range from 0.001 to 400 µg/m^3. The air sample passes through a laser beam in a photometer and then through a filter to remove the aerosols before reaching the pump. The light is scattered by the individual particles of dust. A significant portion of the scattered light is captured by a gold coated spherical mirror which focuses the light on to a photo detector where light is converted into an electrical pulse which is proportional to the mass concentration of the aerosol.

The monitor was setup to log particulate concentrations with a one minute sampling time-step. The inlet was configured for sampling of TSP.

5.1.2.2 MultiRAE Gas Monitor

A MultiRAE Lite PGM6208 monitor (serial number MBA30018N8), calibrated on 31 October 2018 was used to measure SO_2 gas continuously. The SO_2 gas was measured using an electrochemical sensor that measures a concentration range of 0 to 20 ppm with a resolution of 0.1 ppm.

The monitor was setup to log SO_2 concentrations with a one minute sampling time-step.

5.1.2.3 GrayWolf Gas Monitor

The GrayWolf Probe TG501 (serial number 03-1620), calibrated on 17 July 2018 was used to measure NO_X gases. Up to five gas sensors and a temperature sensor can be installed in one probe. All gas sensors are electrochemical. In addition to NO_X components [nitric oxide (NO) and nitrogen dioxide (NO_2)], the probe used had other gas sensors including for oxygen (O_2), ozone (O_3) and hydrogen sulphide (H_2S), which have not been included in this report.

The monitor was setup to log concentrations with a one minute sampling time-step.

5.1.3 Monitoring Results – Particulate Monitoring

Particulate monitoring was undertaken from 5 November 2018, 5:59pm to 10 November 2018, 1:30pm, with a gap of approximately one hour from 6 November, 12:16pm to 1:08pm. A summary of the 24-hour average particulate monitoring results is shown in **Table 5.1**. Data on 5 and 10 November were not included as they were insufficient to determine the 24-hour average concentrations.

To estimate the PM_{10} concentrations, the TSP concentrations were multiplied by 0.39 which is the typical ratio of PM_{10} to TSP around Australian mines (ACARP, 1999). An assumed $PM_{2.5}$ to TSP ratio of 0.1 was used to estimate the $PM_{2.5}$ concentrations.

Table 5.1 24-Hour Average Particulate Concentrations

Date	Measured TSP Concentration (µg/m^3)	Calculated PM_{10} Concentration (µg/m^3)	Calculated $PM_{2.5}$ Concentration (µg/m^3)
6/11/2018	56	22	6
7/11/2018	100	39	10
8/11/2018	74	29	7
9/11/2018	71	28	7
Average	**75**	**29**	**8**
Maximum	**100**	**39**	**10**

5.1.4 Monitoring Results – Gaseous Monitoring

The SO_2 monitoring was undertaken from 5 November 2018, 5:49pm to 10 November 2018, 1:36pm, with a short break from 6 November, 12:28pm to 1:02pm.

The NO_X monitoring was undertaken from 5 November 2018, 5:52pm to 10 November 2018, 1:37pm, continuously.

The SO_2, NO and NO_2 concentrations recorded were 0.0 ppm (<0.05ppm) at all times during the monitoring period.

5.2 Noise Monitoring

5.2.1 Overview and Locations

Acoustic measurements consisted of attended noise measurements and noise logging. The noise measurement locations are shown in **Figure 5.2**.

The noise monitoring was undertaken in general accordance with Australian Standard AS1055 Acoustics – Description and measurement of environmental noise.



Figure 5.2 Noise Monitoring Locations A to E

5.2.2 Attended Noise Measurements

Attended noise measurements were undertaken at Locations A to E. The measurements were undertaken between 9:00am and 2:00pm on 6/11/2018 over a 15 minute periods using a field and laboratory calibrated Norsonic NOR140 sound level meter. The microphone height was approximately 1.3m above natural ground level and was located in the free field. Weather during the time of monitoring was overcast and warm with 3/4 cloud cover and a slight breeze from the south.

The measured noise levels are summarised in **Table 5.2**.

Table 5.2 Attended Noise Measurement Results

Location	Date & Time	Period (Minutes)	Results & Notes
A	9:21am 06/11/18	15	Statistical noise levels: L_{10} 56 dBA, L_{eq} 52 dBA, L_{90} 44 dBA Noise from crane working on TWM site 44 to 57 dBA Noise from AES site and Harbour 43 to 47 dBA Trucks on local road 45 to 56 dBA Airbrakes from trucks stopping at AES gate 45 to 57 dBA Crows nearby 50 t0 52 dBA
B	9:49am 06/11/18	15	Statistical noise levels: L_{10} 44 dBA, L_{eq} 44 dBA, L_{90} 37 dBA Birds nearby 37 to 47 dBA Trucks on local road 50 to 61 dBA Cars on local road 46 to 49 dBA Distant noise from AES site and Harbour audible but difficult to measure. Estimated 37 to 40 dBA Wind in grass and trees 35 to 36 dBA
C	10:55am 06/11/18	15	Statistical noise levels: L_{10} 44 dBA, L_{eq} 44 dBA, L_{90} 37 dBA Distant machinery noise 33 to 34 dBA Noise from insects nearby 36 to 40 dBA Wind rustling grass and trees 34 to 37 dBA Birds nearby 35 to 44 dBA Impact noises from surrounding sites 35 to 42 dBA
D	11:21am 06/11/2018	30sec	Statistical noise levels: L_{10} 58 dBA, L_{eq} 58 dBA, L_{90} 58 dBA Measurement dominated by noise coming from communications tower.
E	11:45am 06/11/18	15	Statistical noise levels: L_{10} 48 dBA, L_{eq} 45 dBA, L_{90} 40 dBA Forklift operating on TWM site 45 to 51 dBA Impact noises from neighbouring site to the northwest 39 to 44 dBA Grinder used on neighbouring site to the northwest 45 to 47 dBA Wind rustling trees and grass 38 to 42 dBA Reverse beepers on TWM site 43 to 45 dBA

Location	Date & Time	Period (Minutes)	Results & Notes
A	1:34pm 06/11/18	15	Statistical noise levels: L_{10} 52 dBA, L_{eq} 49 dBA, L_{90} 43 dBA Trucks on local road 47 to 57 dBA Airbrakes from trucks stopping at AES gate 44 to 48 dBA Trucks on AES and harbour road 44 to 55 dBA Impact noises from AES site 44 to 52 dBA Noise from Harbour audible but difficult to measure. Birds nearby 47 to 52 dBA

Note: * The reported noise levels, excluding the statistical noise levels, are the instantaneous levels read from the sound level meter, and generally represent the range in noise levels or maximum noise levels for a particular noise source.

5.2.3 Noise Logging

Noise logging was undertaken at Location A in the free field. Logging was undertaken from 5/11/2018 to 10/11/2018 using a field and laboratory calibrated ARL NGARA environmental noise logger. The serial numbers of the equipment used are as follows:

- Instrument Serial Number: 87816D
- Microphone Serial Number: 322320
- Pre-amplifier Serial Number: 28460

The measured noise levels are shown in **Figure 5.3**.

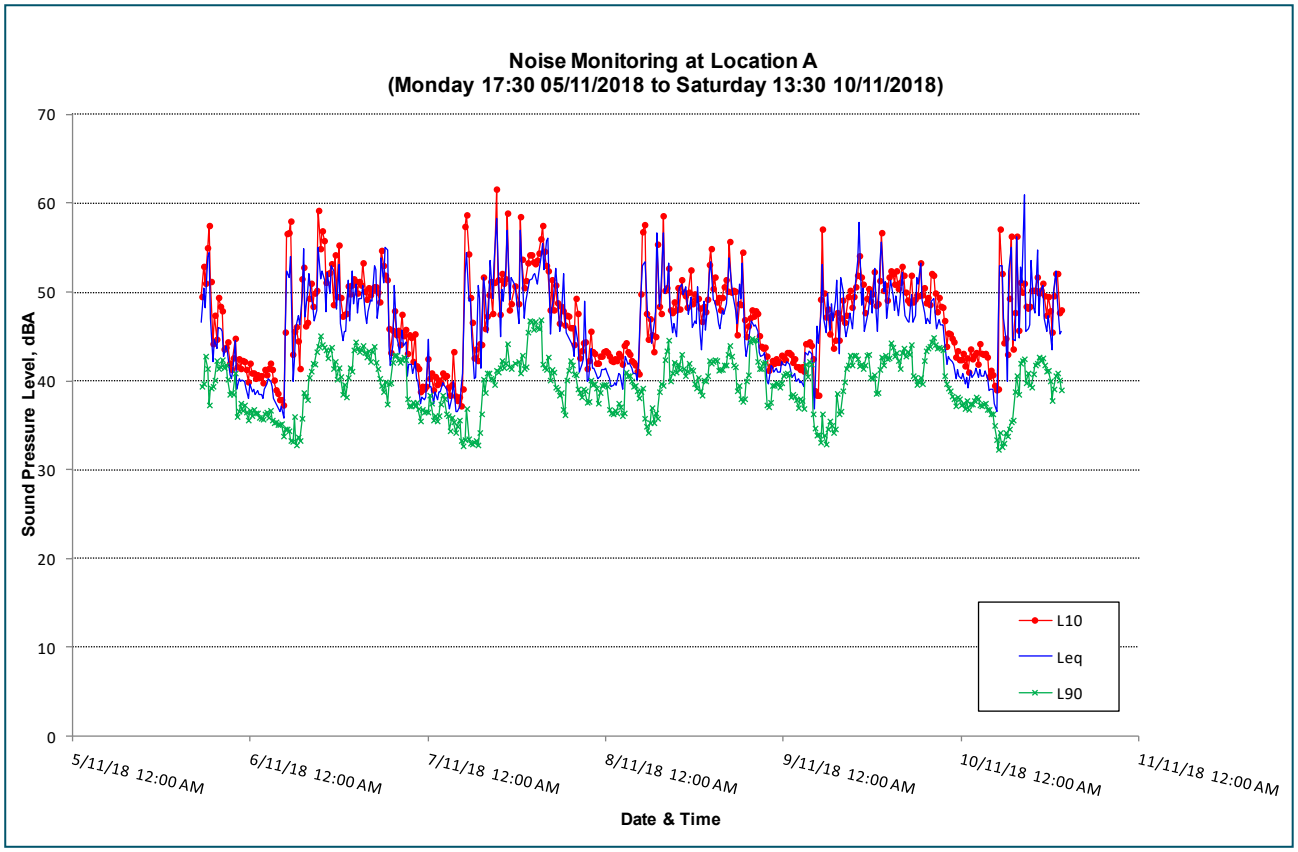


Figure 5.3 Graph of Noise Logging Results at Location A

From the noise logging the statistical results have been summarised in **Table 5.3**.

Table 5.3 Statistical Noise Levels at Location A

Parameter	Noise Levels dBA [Maximum-Top 10%-(Average)-Bottom 10%-Minimum]		
	Day	Evening	Night
L_{max}	87-74-(69)-60-55	84-73-(60)-51-47	74-69-(54)-46-41
L_1	71-67-(60)-53-50	69-65-(53)-45-43	68-62-(49)-42-40
L_{10}	62-54-(50)-48-44	58-51-(47)-43-41	59-48-(43)-39-37
L_{eq}	61-54-(50)-46-41	55-51-(46)-42-40	55-49-(42)-38-36

The background noise levels calculated using the lowest 10th percentile method are shown in **Table 5.4**.

Table 5.4 Background Noise Levels at Location A

Period	Background Noise Level L_{90} dBA
Day (7am to 6pm)	39
Evening (6pm to 10pm)	38
Night (10pm to 7am)	34

6. Summary

6.1 Air Quality

A summary of the air pollutant concentrations is provided in **Table 6.1** with the relevant WHO criteria except for TSP. As shown, the average PM_{10} concentration exceeded the annual average criterion. The other particulate concentrations were high, approaching the relevant criteria.

The measured gas concentrations were below the instrument detection limit. Although the instruments used did not have sufficient sensitivity to compare to the long-term averages, the low short-term average concentrations indicate that long-term averages are also likely to be low.

Table 6.1 Summary of Air Pollutant Concentrations

Pollutant	Averaging Period	Concentrations (µg/m^3)	WHO Criterion (µg/m^3)
TSP	1 year	75	90 [1]
PM_{10}	24 hours	39	50
	1 year	**29**	20
$PM_{2.5}$	24 hours	10	25
	1 year	8	10
SO_2	10 minutes	< 131	500
	24 hours	< 131	20
NO_2	1 hour	< 94	200
	1 year	< 94	40

Note:

1. *Based on Queensland and New South Wales regulations.*
2. *The average measured concentrations for the monitoring period were used for the one-year averaging period.*
3. *The maximum concentrations were reported for averaging periods of less than a year.*

Overall, the background air quality during the monitoring period had high concentrations of particulates and low concentrations of combustion gases. Site observations suggest that a major source of particulates was vehicle traffic on the access road to the port, north of the site.

6.2 Noise

The subject site is located in an industrial area and noise levels on the site especially on the northern boundary close to the local road and AES site, are dominated by car and truck movements as well as industrial noise. Moving away from the local road, AES site and harbour the noise levels reduce and insects, birds and wind rustling the grass and trees are the dominant noise sources.

References

ACARP (1999), Fine Dust and the Implications for the Coal Industry, Report C7009.

Environmental Protection Agency (2008), Environmental Protection (Air) Policy, Queensland EPA.

NSW EPA (2016), Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, New South Wales Environment Protection Authority.

WHO (2005), Air Quality Guidelines: Global Update 2005: Particulate matter, ozone, nitrogen dioxide and sulphur dioxide, World Health Organisation.

Appendix A Glossary

Parameter or Term	Description
General	
ASK	ASK Consulting Engineers Pty Ltd
Air Quality	
CO	Carbon monoxide
EPA	Queensland Environmental Protection Act 1994
EPP (Air)	Queensland Environmental Protection (Air) Policy 2008
H_2S	Hydrogen sulphide
NSW EPA	New South Wales Environment Protection Authority
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen including nitric oxide and nitrogen dioxide
$PM_{2.5}$	Particulates suspended in air with aerodynamic diameter less than 2.5 microns
PM_{10}	Particulates suspended in air with aerodynamic diameter less than 10 microns
ppm	Parts per million by volume
SO_2	Sulphur dioxide
TSP	Total particulates suspended in air
$\mu g/m^3$	Micrograms per cubic metre
WHO	World Health Organisation
Noise	
dB	The decibel (dB) is the unit measure of sound. Most noises occur in a range of 20 dB (quiet rural area at night) to 120 dB (nightclub dance floor or concert).
dBA	Noise levels are most commonly expressed in terms of the 'A' weighted decibel scale, dBA. This scale closely approximates the response of the human ear, thus providing a measure of the subjective loudness of noise and enabling the intensity of noises with different frequency characteristics (e.g. pitch and tone) to be compared.
Day	The period between 7am and 6pm.
Evening	The period between 6pm and 10pm.
Night	The period between 10pm and 7am.
Free-field	The description of a noise receiver or source location which is away from any significantly reflective objects (e.g. buildings, walls).
L_1	The noise level exceeded for 1% of the measurement period.
L_{10}	The noise level exceeded for 10% of the measurement period. It is sometimes referred to as the average maximum noise level.
L_{90}	The noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.

Parameter or Term	Description
L_{eq}	The equivalent continuous sound level, which is the constant sound level over a given time period, which is equivalent in total sound energy to the time-varying sound level, measured over the same time period.
$L_{eq,1hour}$	As for L_{eq} except the measurement intervals are defined as 1 hour duration.
L_{max}	Maximum A-weighted sound pressure level.

APPENDIX G:

GENERAL NOTES

ASFE PUBLICATION-IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT

GENERAL NOTES

GENERAL

August, 1999

This report comprises the results of an investigation carried out for a specific purpose and client as define in the introduction section(s) of the document. The report should not be used by other parties or for other purposes as it may not contain adequate or appropriate information.

TEST HOLE LOGGING

The information on the Test hole Logs (Boreholes, Backhoe Pits, Exposures etc.) has been based on a visual and tactile assessment expect at the discrete locations where test information is available (filed and/or laboratory results).

References should be made to our standard sheets for the definition of our logging procedures (Soils and Rock Description).

GROUNDWATER

Unless otherwise indicated the water levels given on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ form this record level depending on material permeabilities. Further variations of this level could occur with time due to such effects as seasonal and tidal fluctuations or construction activities. Final confirmation of levels can only be made by appropriate instrumentation techniques and programmes.

INTERPRETATION OF RESULTS

The discussions and recommendations contained within this report are normally based on a site evaluation form discrete test hole data. Generalized or idealized subsurface conditions (including any cross-sections contained in the report) have been assumed or prepared by interpolation/extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalized ground conditions used for this report can occur, particularly between discrete test hole locations. Furthermore, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behavior of the site.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed in this report should be referred to this firm for appropriate assessment and comment.

FOUNDATION DEPTH

Where referred to in the report, the recommended depth of any foundation (piles, caissons, footings, etc) is engineering estimated of the depth to which they should be constructed, the estimate is influenced and perhaps limited by the fieldwork method and testing carried out on connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an estimate and therefore liable variation. Foundation drawings, designs and specifications based upon this report should provide for variations in the final depth depending upon the ground conditions at each point of support.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in this report for the inclusion in the contract documents or engineering specification of the subject development, such reproduction should include at least all of the contract relevant test holes and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

This report is the subject of copyright and shall not be reproduced either totally or in part without the express permission of this firm.

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsur–face conditions than any other factor as troublesome as subsurface problems can be their frequency and extent have been lessened considerably in recent years due in large measure to programs and publications of ASFE The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include the general nature of the structure involved, its size and configuration, the location of the structure on the site and its orientation, physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise *your geotechnical engineer report should not be used*

- When the nature of the proposed structures is changed, for example, if an office building will be erected instead of a parking garage or if a refrigerated warehouse will be built instead of an unrefrigerated one.
- When the size or configuration of the proposed structure is altered.
- When the location or orientation of the proposed structure is modified.
- When there is a change of ownership or for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered on their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geotechnical Engineers who then render an opinion about overall subsurface conditions their likely reaction to proposed construction activity and appropriate foundation design.

Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified and no subsurface exploration program, no matte how comprehensive can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage,* to identify variances conduct additional tests which may be needed and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions which exited at the time of subsurface exploration, *construction decisions should be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events and should be consulted to determine of additional tests are necessary.

GEOTECNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineer reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor or even some other consulting civil engineer. Unless indicate otherwise this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose or by the client for a different purpose may result in problems. *No individual other than the client should apply this report for its intended purposed without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than originally contemplated first conferring with the geotechnical engineer.*

ACEM Geotechniques

Appendix 4
(IWMF Groundwater Investigation)

Mineral Resources Authority

Geoscience for Mining, Energy and Humanity
Geological Survey Division

GROUNDWATER SURVEY AT TOTAL WASTE MANAGEMENT SITE, ROKU, CENTRAL PROVINCE, PAPUA NEW GUINEA

REPORT 2018/07

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REFERENCE

The recommended reference for this publication is:

Fabila D, 2018, Groundwater survey at Total Waste Management Site, Roku, Central Province, Papua New Guinea: Mineral Resources Authority, Papua New Guinea, Report 2018/??, 24p.

Disclaimer

The Mineral Resources Authority through the Geological Survey Division is committed to providing qualitative geoscientific information and technical services to its clients and stakeholders for enlarging the database concerning Papua New Guinea's earth resources through advanced knowledge of PNG geology and mineral resources. The Authority seeks to ensure accuracy, currency and reliability of information provided in reports or via the Authority's website; however no guarantee can be given in this regard. The information disseminated is correct to the best of our knowledge, but no warranty as to accuracy or completeness is given and each person or organization without seeking proper independent advice should not act on the basis of its content.

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Acronyms

TWM	Total Waste Management
VES	Vertical Electrical Sounding
SWL	Static Water Level
PWL	Pumping Water Level
bgl	below ground level
asl	above sea level

Executive Summary

A groundwater investigation was carried out in September 2018 at the Total Waste Management site in Roku, Central Province. The investigation was done with the main objective to assess the general groundwater conditions and to identify any potential water bearing layers (aquifer) within the site. Any freshwater aquifers identified would be drilled to provide water for Total Waste Management site, and may also be used for water level monitoring for the purpose of landfill operations.

The groundwater investigation identified two aquifers; a shallow perched aquifer and a deep aquifer. The deep aquifer occurs in coarse sand and gravel. From the resistivity survey, the deep aquifer was encountered at shallower depths of 7-9 m at the lower lying areas, and at deeper depths of 16-28 m at higher elevated areas. The thickness of the deep aquifer ranges between 12-33 m. From previous investigations in the nearby area, this aquifer is expected to have good groundwater yield, therefore, further investigation of the aquifer using borehole drilling is recommended for this site in order to confirm the depth and thickness of the deep aquifer.

1.0 INTRODUCTION

Upon request by the Soil Engineers Ltd, the Hydrogeology and Geophysics teams from the Geological Survey Division of the Mineral Resources Authority (MRA) carried out a groundwater survey at the Total Waste Management (TWM) Site. The TWM site is located within the Central Province in the Hiri Sub-District, Roku. The survey was carried out on the 27th of September, 2018.

The main aim of the investigation was to assess the general groundwater conditions within the TWM premise and to identify if there is any freshwater aquifer at depth which can aid in the supply of water to the TWM site for industrial purposes. Since TWM is a waste management site which may be interested in using landfill methods for disposal of chemical wastes, it is necessary to investigate the possible depth of the groundwater table, in order to avoid leachate leakage and contamination into the aquifer.

Field work consisted of hydrogeological field traverses over the site and geophysical investigation method, primarily using ground resistivity probing.

2.0 SITE DESCRIPTION

TWM is located approximately 9km east of Port Moresby within the Hiri Sub-District near Roku Village. It is situated along the Napa Napa Road and is approximately 1km northwest of the Roku Village and 1km southwest of the Fairfax Harbour. The site is accessible through the Napa Napa Road via the Baruni Road from Port Moresby (Figure 1). Travel distance along the Napa Napa Road would cover at least 6.7km west, then 2.3km south, and eventually 1.8km southeast to arrive at the site. The TWM premise is bounded within the coordinates 509037 – 509503mE and 8954804 – 8955370mS. Another company known as the Avennel Engineering Systems (AES) is also located in the nearby area; the main premises of the AES are located just opposite the road from the TWM grounds, while another branch of AES known as AGL Builders are located adjacent to TWM to the west (Figure 2).

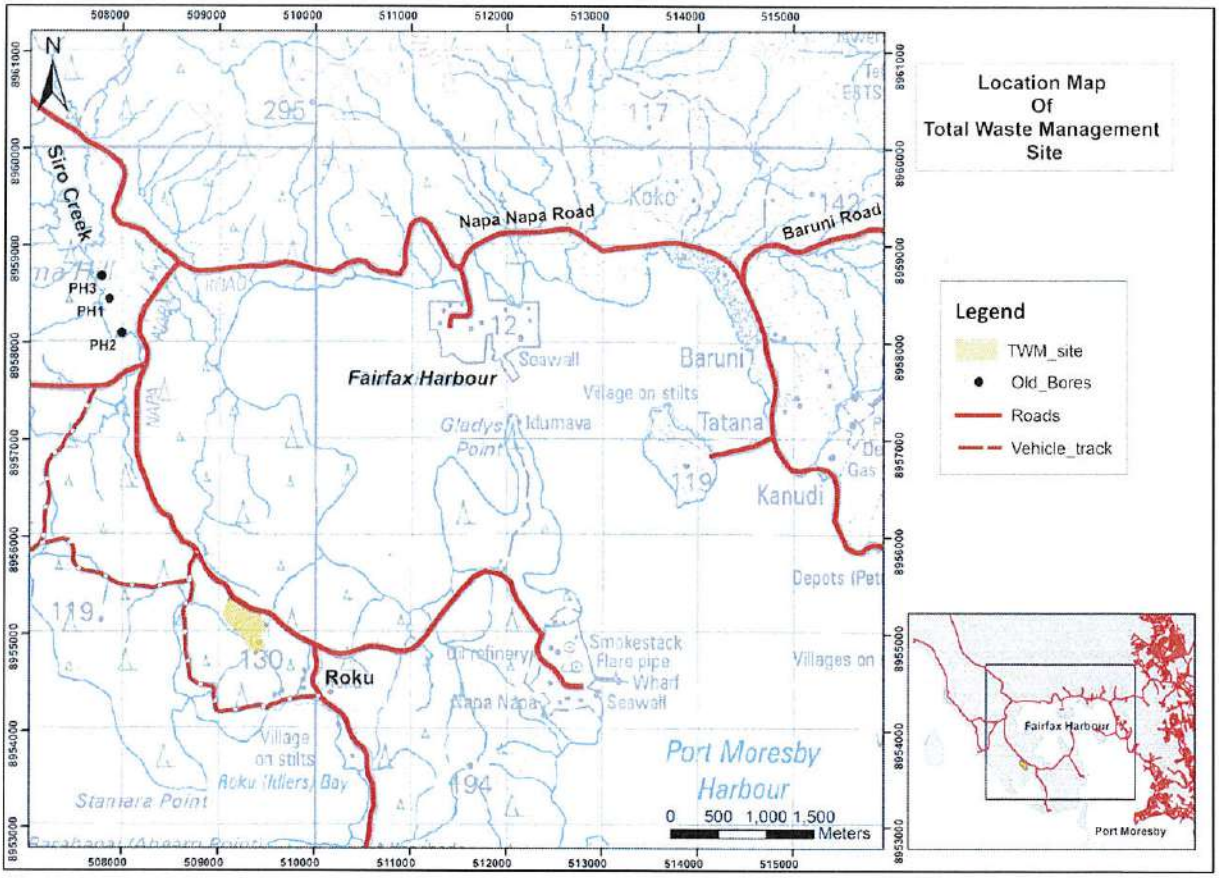


Figure 1: Topographic map showing general location of Total Waste Management Site with main access roads.

3.0 TOPOGRAPHY AND DRAINAGE

Two hills trending in an ENE-WSW direction are visible within the area occupied by the TWM, AGL and AES industrial grounds (Figure 2). TWM is located on the northern side of the higher elevated hill; the highest point within the TWM grounds is at the hilltop which is approximately 117m above sea level (asl), and it gently slopes towards the northwest to about 52m asl. The lower hill occurs nearby the AES industrial site with the highest point being 78m asl. Vegetation cover was of savanna grassland and numerous scattered eucalyptus trees.

No distinct drainage network was noticeable within the area, however, seasonal drainages occur just outside the boundaries of the TWM site, and a seasonal intermittent stream occurs west of the AES premises. The seasonal drainages near the TWM site which drain south toward Roku Village eventually terminate at the base of the hill. The seasonal drainages that drain the area west of the TWM grounds drain the area in a westerly direction, and eventually drain into the marsh lands towards Idlers Bay in the south (Figure 2). The seasonal intermittent stream near the AES premises flows toward the north and eventually drains into the sea at the Fairfax Harbour.

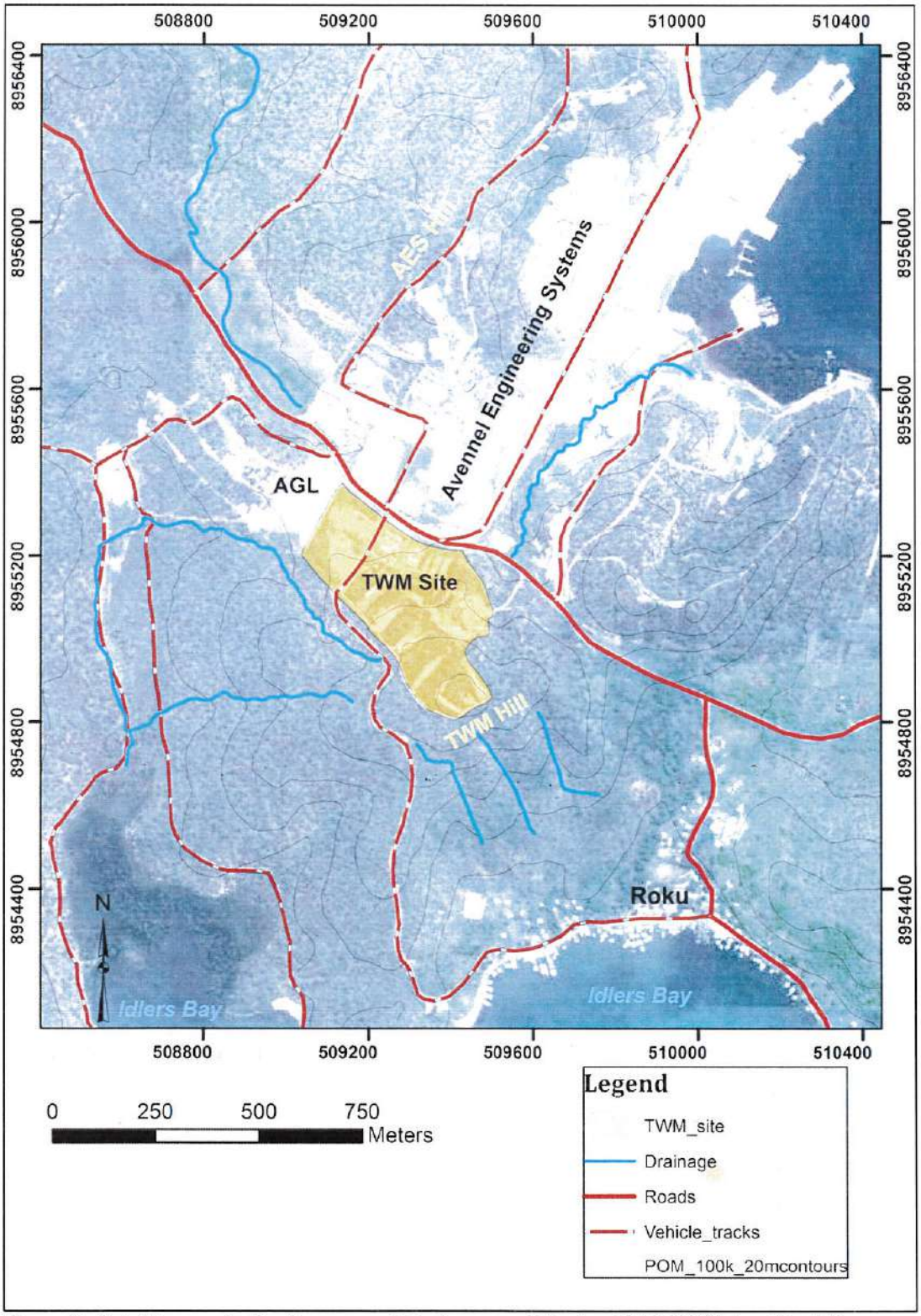


Figure 2: Satellite map indicating seasonal drainages and the two ENE-WSW trending hills.

4.0 CLIMATE AND RAINFALL

The climate of the Roku area is more or less similar to the tropical climate of Port Moresby, resulting in a vegetation cover of grassland and scattered trees. Rainfall patterns vary seasonally which are controlled by two wind systems; the northwest monsoons prevail between the months of December and April creating a season of high rainfall between these months, while the southeast trade winds prevailing between May and October bring drier, cooler winds, creating a dry season within these months (McAlpine et al, 1983).

According to McAlpine et al (1983), mean maximum temperatures for Roku are between 30-32°C, while the mean minimum temperatures are between 28-30°C. Roku and Port Moresby fall within the zone of lowest rainfall within Papua New Guinea (PNG) within the range of 0-2000mm of rainfall per year.

Based on mean monthly rainfall data from a gauging station in Port Moresby (National Weather Services) for a 10 year period of 2005-2014, the wet monsoon season occurred between the months of November-April, while the dry trade winds season prevailed between May-October (Table 1). July was recorded as the month with lowest rainfall, while the month of March had most rainfall, followed by January. Typical weather experienced during the time of visit was mostly sunny with clear skies.

Table 1: Rainfall data for Port Moresby from 2005-2014.

VrMax55006 PAPUA NEW GUINEA NATIONAL WEATHER SERVICE

STATION NAME: PORT MORESBY W LATITUDE: 9.45 South LONGITUDE: 147.20 East
STATION ID: 55006 ELEVATION: 42 Metres
Obs Time: 10 AM

Mean Monthly Rainfall Units: mm

Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
2005	290.4	93.8	271.6	309.8	57.8	11.2	4.0	1.2	29.0	1.0	24.0	177.2	1271.0
2006	296.0	181.6	231.6	220.6	88.6	23.8	5.6	1.2	68.6	0.0	45.6	12.2	1173.4
2007	135.4	209.4	365.0	80.0	20.2	127.2	0.0	14.0	81.0	15.2	433.2	39.2	1519.8
2008	117.0	69.0	131.2	238.8	10.0	9.0	80.2	20.8	27.6	40.2	73.8	163.8	981.4
2009	236.0	182.8	414.0	243.8	73.6	51.8	51.8	99.2	8.2	14.2	141.4	43.8	1560.6
2010	241.4	93.0	206.8	83.6	49.8	6.8	6.6	12.8	75.6	40.8	96.6	157.2	1128.0
2011	226.2	220.0	276.2	110.0	31.0	286.4	0.2	0.6	18.2	3.4	22.2	359.0	1579.4
2012	309.0	170.2	310.8	107.0	126.6	131.4	36.8	38.8	10.6	169.0	3.6	18.2	1432.4
2013	307.4	117.0	303.0	190.8	17.2	51.8	4.2	4.8	44.4	25.4	120.6	133.6	1320.2
2014	269.0	134.2	220.2	144.2	0.0	16.2	7.0	38.4	92.4	6.0	64.8	36.6	1023.6
SUMMARY													
Mean	242.2	147.1	273.0	172.9	47.5	77.1	19.7	23.2	45.2	34.3	102.6	114.1	1298.8
Highest	309.0	220.0	414.0	309.8	126.6	286.4	80.2	99.2	92.4	169.0	433.2	359.0	1579.4
Lowest	117.0	69.0	131.2	80.0	0.0	9.0	0.0	0.6	8.2	0.0	3.6	12.2	981.4

5.0 GEOLOGY

The geology of Roku and the surrounding area lies within the boundary of the Port Moresby Beds. This unit is of early to middle Eocene age and comprises mostly of argillites, siliceous argillites, calcilutite, shale, and minor chert and calcarenite (Pieters, 1978). These rocks are

overlain by Quaternary Alluvial deposits of unconsolidated material consisting mainly of gravel, sand, silt, and clay.

The sedimentary formations within the area generally strike in a northwest-southeast alignment, and dip toward the northeast. Towards the north, just west of the Fairfax Harbour, a valley lies along the axis of a NNW-SSE trending syncline, known as the Fairfax Syncline (Figure 3).

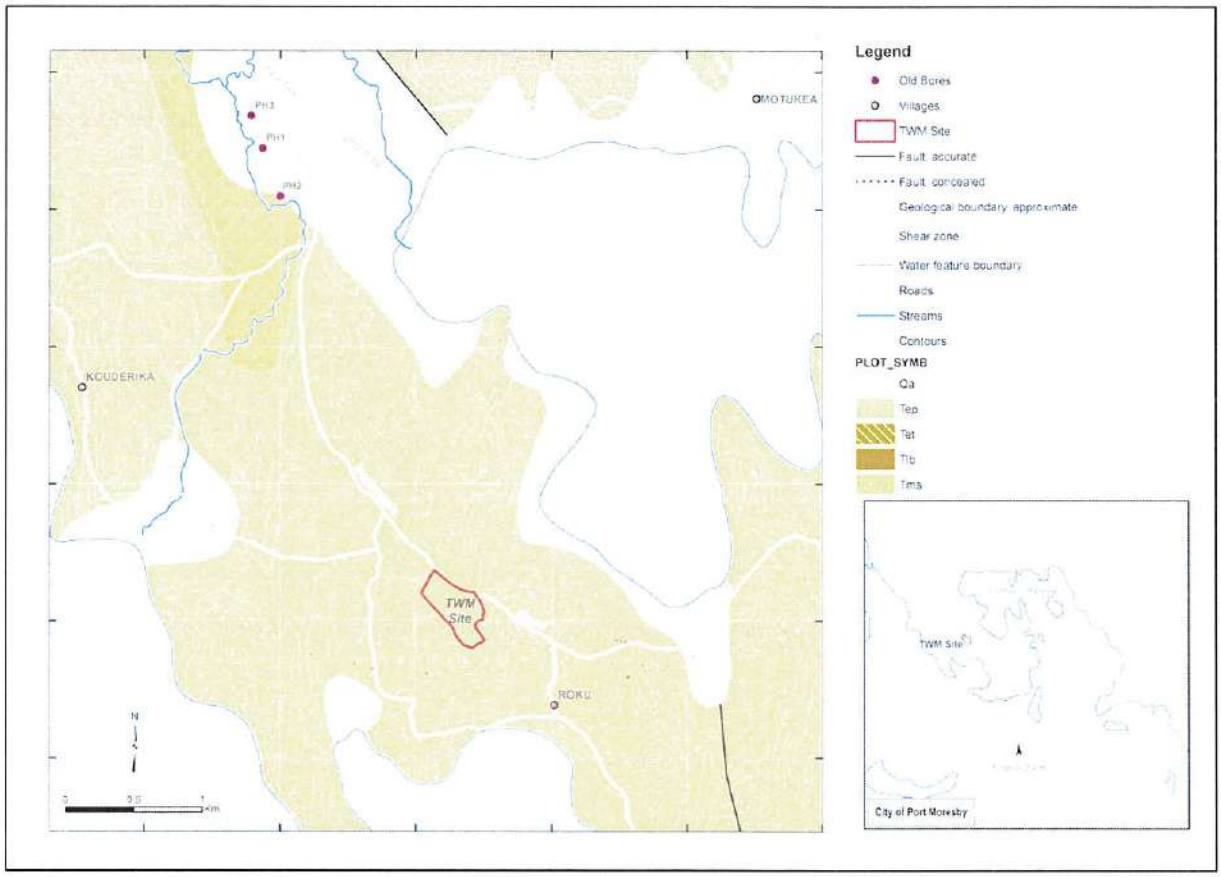


Figure 3: Simplified and modified geology map of the Roku area (Pieters, 1978).

6.0 METHODOLOGY

The hydrogeological investigation for groundwater potential at the TWM site was carried out in two parts:

- A desktop review of the evidence on groundwater availability within the study area was made followed by a hydrogeological assessment and;
- Geophysical surveys were conducted using the Vertical Electrical Sounding (VES) profiling method to define the location and thickness of the potential water bearing layer or the aquifer.

6.1 PREVIOUS INVESTIGATIONS

Previous boreholes drilled within the nearby area are sited at the AGL Builders premises. Further details of the bores are lacking, however, the initial resistivity survey results of the bores were

reported by Ken et al (2017). From the 7 vertical electrical sounding profiles conducted, 2 interpretive profiles were done in a north-south and northwest-southeast direction (Figure 4).

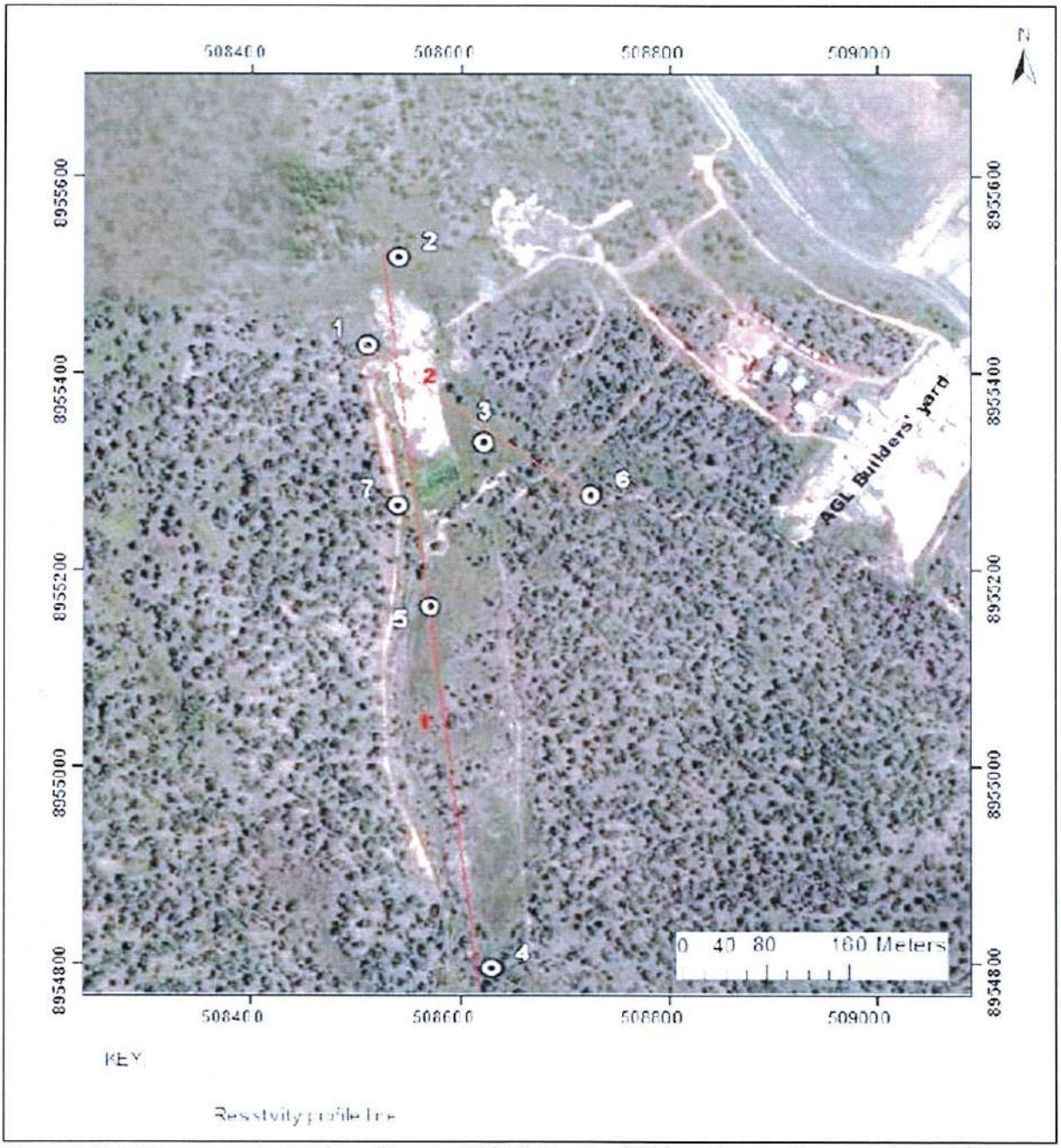


Figure 4: Satellite map extracted from Ken et al (2017) showing VES locations and interpretive resistivity profile lines.

Basically, 4 layers were encountered from the resistivity survey, except for VES7 which encountered a fifth layer of brackish water. From both of the interpretive resistivity profiles, the topsoil layer ranged in thickness from 0.1-1m. The second layer consisting of dry gravelly, sandy clay and gravel was encountered at a depth range of 0.3-2.1m; this layer was not encountered in

VES1 and 2. The third layer consisting of wet clay was encountered in all 7 VES profiles, within a depth range of 2.6-12.1m, with the thinnest layer found in VES6 (2.6m) and the thickest layer in VES5 (12.1m). The fourth layer which was interpreted as the potential aquifer was encountered in all 7 VES profiles, except for VES6 where dry aquifer material was intersected. Thickness of the aquifer could not be confirmed, however, only VES7 showed a thickness of 22.6m, followed by brackish water beneath.

Records of older boreholes sited within the vicinity of the Roku and Fairfax Harbour area are located near the junction of the Porebada/ Roku road (Rooke, 1988) which is approximately 3-3.7km north of the TWM site. The three boreholes, PH1, PH2 and PH3 were drilled within a depression zone known as the Fairfax Syncline (Figure 3). They were drilled adjacent to a southerly flowing creek, represented on the map as Siro Creek. (Figure 1).

Borehole PH1 and PH3 were drilled to a depth of 24m, while borehole PH2 was drilled to 22m (Table 2). Water was encountered in all three bores within a depth range of 8-9m; water was also encountered at 18m in PH2. The static water level (SWL) for these bores ranged between 3-3.6m, indicating confined aquifer conditions. However, upon pumping of PH3, the top of the aquifer became de-watered (i.e. pumping water level (PWL) reduced below the confining boundary), hence allowing unconfined aquifer conditions to prevail. It was concluded that the onset of unconfined aquifer conditions may be encountered in other boreholes tapping into this aquifer, which will limit the yield per borehole. Generally, all three bores showed a uniform aquifer thickness of ~16m; the aquifer consisted of coarse sand and fine-coarse gravel, commonly with intercalations of clay (Appendix 1). The aquifer was located between a depth range of 8-24m below ground level (bgl) which was overlain by an 8m thick confining layer of impermeable clay, and underlain by bedrock.

Table 2: Generalised details of previous bores sited at Porebada/Roku Road junction, extracted from report by Rooke (1988) and Central Drillers data.

Registered No / Well ID	Location	Total Depth (m)	Groundwater Level (m)	S.W.L (m)	Supply (L/min)	Lab Test	Pump Test	Year	Remarks
PH1	Porebada Roku Junction	24	8.8	3	0.7 L/sec	Yes	Yes	1986	
PH2	Porebada Roku Junction	22	9 & 18	3.6		Yes For Standing water samples	No	1986	Used only for SWL monitoring
PH3	Porebada Roku Junction	24	9	3.32	1.3 L/sec	Yes	Yes	1987	

Water samples chemically analysed from all three bores (Appendix 2 and 3) indicated brackish water from PH1 and PH2; PH3 encountered freshwater for the total depth of the water bearing formation, which bordered onto brackish water below, however, only the uppermost layer around 9m was more saline. Results of PH3 samples also indicated slightly corrosive waters, with a Reizner Stability Index of 7.2, therefore, inert material was recommended for construction of

PH3. The overall chemical results were marginally acceptable and water softening was recommended for water sourced from PH1 and PH3.

6.2 FIELD OBSERVATIONS

No evidence of streams or seepages were observable within the study site, hence, no stream profiles were encountered. The only outcrops observed were of cherty mudstones/ argillites which belong to the Port Moresby Beds. This formation has poor groundwater potential, hence will not be discussed further.

6.2.1 PRESENT WATER SUPPLY

At present, TWM pays a certain fee to the AES management for water to be reticulated from the AES water supply system over to the TWM buildings. Initially, AES sourced water from boreholes drilled about 2.5km northwest from the AES premises, however, to date, AES depends largely on water sourced from the sea.

The water from the sea is transferred into 6 large 9000L tuffa tanks, which are sent into the desalinisation plant; the water goes through a process called reverse osmosis in order to remove the salt from the sea water, which is then sent into two 9000L tanks. The water from the two tanks is sent up to another two tanks at the top of the hill (Figure 4) where it goes through a second cleansing process before been sent into two large storage tanks with capacities of 264,000L. From the two large tanks, water is gravity fed back to the AES buildings and camp, and also reticulated to the TWM site.

The initial constant discharge pumping test data of the two bores drilled for AES by Central Drillers in 2012 and 2013 are presented in Table 3. The first bore was drilled to a depth of 15m with an SWL of 1.4m. The bore was pump tested at a discharge rate of 40 L/min with the pump positioned at 12m bgl. The borehole reached equilibrium after 5 minutes of pumping (Appendix 4), and after 3 hours, the pump was stopped and the bore fully recovered within eight (8) minutes. Based on the time taken for full recharge, it was concluded that the bore can produce up to 57,600 litres of water per day, with a pumping rate of 40 L/min.

The second borehole was drilled to a depth of 19.5m with an SWL of 1.85m. The bore was pump tested at 60 L/min with the pump positioned at 15m bgl. The bore reached equilibrium after 2 hours of pumping, and after 4 hours, the pump was stopped and the bore fully recovered within 14 minutes. From the recovery time, it was concluded that the bore could sustain a continual pumping rate of 60 L/min which would give a daily yield of 86,400 litres.

Table 3: Constant discharge pumping test data from AES bores, Central Drillers, 2012 and 2013.

Well I.D	Pumping Rate	Duration (hrs)	Drawdown (m)	Full Recovery Time	Daily Yield (L)
AES Bore No.1	40 L/min	3	5.85	8 minutes	57,600
AES Bore No.2	60 L/min	4	6.55	14 minutes	86,400

To date, bacterial analysis of one of the bores still operating shows very high number of faecal coliforms and E.coli (TNTC-too numerous to count), therefore, AES do not rely on this source of water, but depend largely on desalinised water.

6.3. RESISTIVITY SURVEY-VERTICAL ELECTRICAL SOUNDINGS

A total of 6 Vertical Electrical Soundings (VES) were carried out on site, recorded as TWM_VES1 to TWM_VES6 (Figure 5). TWM_VES1 was conducted near the fence at the main entrance to the TWM premise while TMW_VES2 was conducted near the fence toward the western boundary of the TWM site. TWM_VES3 was conducted along the main entrance road within the TWM site, while TWM_VES4 was conducted at the hilltop where the quarry is located, towards the eastern side of the site. TWM_VES5 was conducted just behind the timber yard, while TWM_VES6 was conducted approximately 53m outside the TWM boundary to the west.

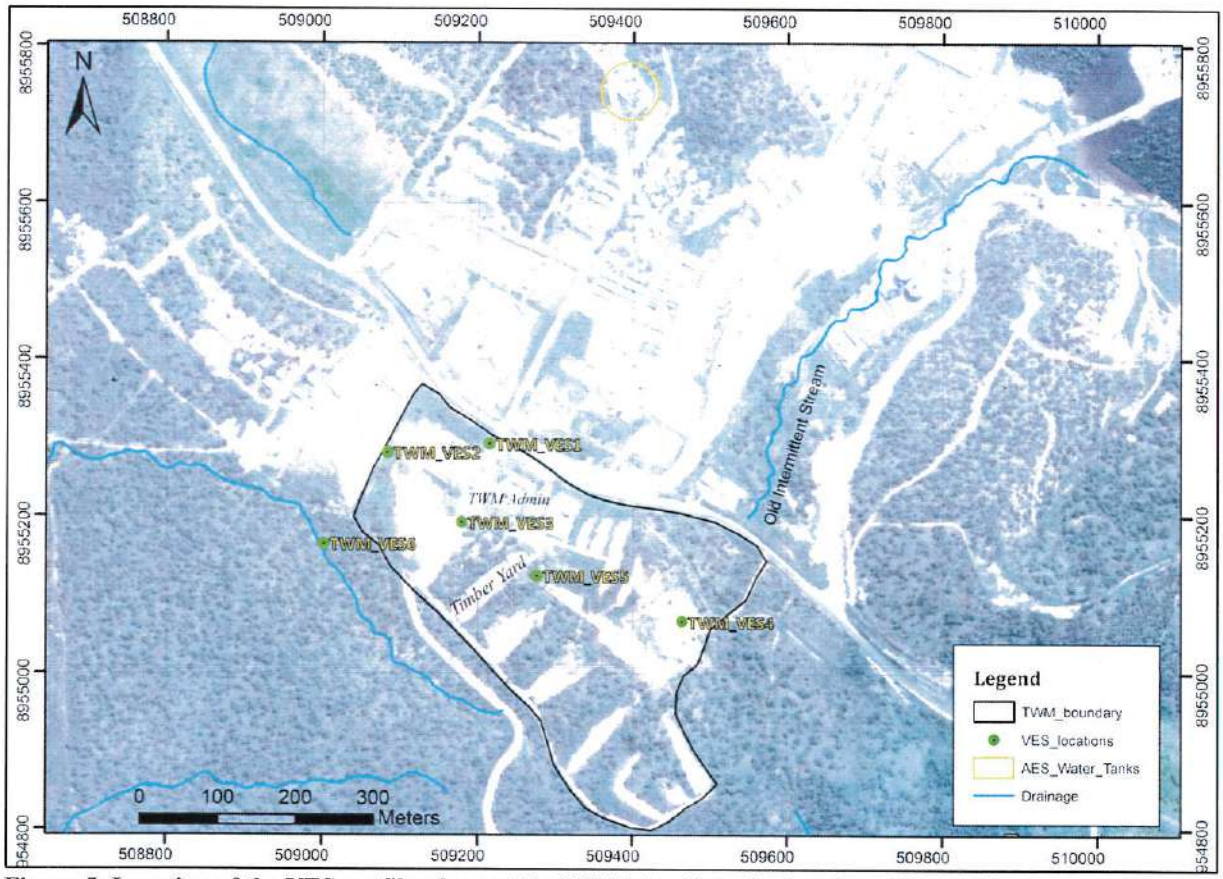


Figure 5: Location of the VES profiles done at the TWM site. Note the location of the AES water storage tanks where TWM currently is supplied water from.

The results of the VES profiles generally showed five (5) different resistive layers, except for TWM_VES2 and TWM_VES6 which showed 4 and 6 resistive layers respectively. It is evident that there are slight lateral variations in the lithological composition and the corresponding

thickness of the subsurface layers. The general descriptions of these resistive layers are given below.

Dry top soil was encountered in three VES profiles, specifically TWM_VES1, 5 and 6. This layer was quite thin, ranging from 0.2-0.4 m with an apparent resistivity range of 259-710 Ωm. Dry landfill materials were encountered in TWM_VES2 and 3, with apparent resistivities of 198 and 74 Ωm and thickness of 1.3 and 1.2 m respectively.

The next layer consisting of dry gravel, sand and clay was encountered in all VES profiles, ranging in thickness of 1.1-2.7 m with an apparent resistivity range of 37-251 Ωm. This layer was thickest at TWM_VES5 and the thinnest at TWM_VES6.

A third layer consisting of dry clay, sand and gravel was encountered in all VES profiles, giving a thickness range of 3.5-18 m, with an apparent resistivity range of 40-131 Ωm. This layer was thickest at TWM_VES4 and the thinnest at TWM_VES2. In TWM_VES3, 4 and 6, a potential shallow aquifer occurs just above the dry clay, sand and gravel layer. This potential shallow aquifer is thinnest at TWM_VES6 with a thickness of 2m, and is thickest at TWM_VES3 (9.3m).

Occurring just below the dry clay, sand and gravel layer is a layer assumed to be mostly of coarse sand and gravel regolith from the basement rock. This layer was encountered in all VES profiles, except for TWM_VES2. Apparent resistivity of this layer is between 5-21 Ωm, with a thickness ranging from 12-33 m. This layer is the thickest at TWM_VES5 and the thinnest at TWM_VES6; thickness of this layer was not confirmed for TWM_VES3. TWM_VES2 did not encounter this layer, however, wet clay, gravel and sand was intersected, giving an apparent resistivity of 47 Ωm with unknown thickness.

A last layer of weathered bedrock was encountered in TWM_VES1, 4, 5 and 6. This layer consists of mudstone and cherty mudstone from the Port Moresby Beds. Thickness of this layer was unknown; however, resistivity range was between 109-222 Ωm. Further details of the resistivity survey are provided in Appendix 5.

7.0 GROUNDWATER CONDITIONS

From this groundwater investigation, it is evident that two (2) potential freshwater aquifers exist within the TWM site. The potential shallow aquifers were identified in TWM_VES3, 4 and 6, indicated by layer 2 in TWM_VES4 and layer 3 in TWM_VES3 and 6. The potential deep aquifer was encountered in all VES profiles except TWM_VES2. It is represented as layer 4 in TMW_VES1, 4 and 5, and as layer 5 in TWM_VES3 and 6.

The shallow aquifers most likely consist of gravel, sand and clay. This is an unconfined aquifer; therefore recharge to the aquifer would be through direct rainfall infiltration from the surface. Although this may be a potential aquifer, this layer was not encountered in all VES profiles, therefore, it is concluded that this is a perched aquifer. The underlying clay layer acts as a temporary trap where water is stored during high rainfall periods, therefore, giving perched aquifer conditions.

The potential deep aquifer occurs at shallower depths at the lower lying areas (TWM_VES1 and TWM_VES6), but is encountered at deeper depths at the higher elevated areas. The shallowest depth of the deep aquifer encountered was at 7.4m bgl at TWM_VES6 and was the deepest at TWM_VES3 at a depth of 27.5m bgl. An indication of the thickness of the deep aquifer was given in TWM_VES1, 4, 5 and 6. The deep aquifer was thickest at TWM_VES5 (33m), followed by TWM_VES1 and 4 (23 and 22m respectively), and was thinnest at TWM_VES6 (12m). From previous investigations in nearby areas and from the current resistivity results, this aquifer proves to be a confined aquifer which consist mostly of coarse sand and gravel regoltih from the bedrock. Recharge to the aquifer may be through the seasonal drainages during periods of high rainfall.

Water samples from previous bores drilled within the Fairfax Harbour area indicated fresh water overlying brackish water. This was also confirmed from resistivity surveys carried out in the nearby AGL Builders premises. Therefore, there is possibility of intersecting brackish water below the fresh water zone within the aquifer at the TWM site.

This investigation shows a number of sites where freshwater may be intersected. However, higher elevated areas which are located on a sloped surface will have a similar sloped water table at the subsurface which will eventually cause groundwater to flow downslope to the lower lying areas. Therefore, the most preferred sites for test drilling should target the northern end of TWM_VES3 and the lower lying area towards TWM_VES1.

8.0 BOREHOLE DRILLING AND WELL DEVELOPMENT

The most commonly used drilling method in and around Port Moresby is the rotary drilling method. Hence, this method of drilling is recommended for test drilling within the TWM site. The boreholes will be drilled using a truck-mounted drill rig.

The most suitable sites for drilling (Figure 6) would be at coordinates 509190mE and 8955308mS (Site_1), and 509189mE and 8955266mS (Site_2). This recommended site for drilling is at TWM_VES1 just west of the main entrance, and at TWM_VES3 along the main entrance road of TWM. Both areas recommended are easily accessible for mobilizing the drill rig and for drilling operation.

The boreholes should target depths of at least 33m at Site_1 and 35m at Site_2 in order to intersect the deep aquifer. PVC casing and slotted screen is recommended for drilling and developing the wells as PVC is not prone to rusting and lasts longer than steel casings and screens. Length and size of the slotted screen will be decided once the borehole(s) is completed and tested.

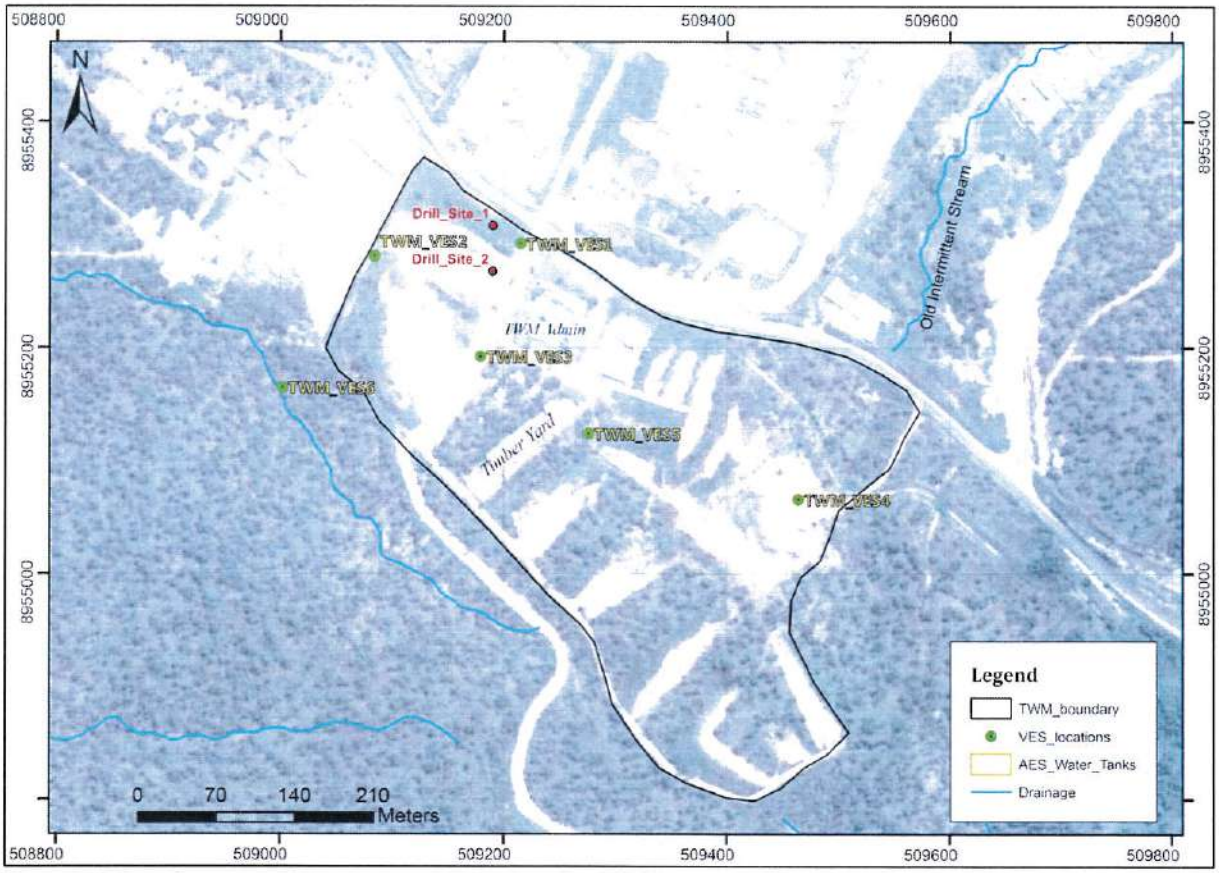


Figure 6: Location map of the proposed drill sites for TWM.

8.1 PUMPING TEST

Pumping tests should be carried out once drilling has been completed. These tests will help determine aquifer characteristics which can be used to determine production yield and pumping rate. Three common pumping tests are the step test, constant-rate test and recovery test. Recovery test is usually carried out after a step test or constant-rate test.

Step Test is designed to establish the short-term relationship between yield and draw-dawn for the borehole being tested. It consists of pumping the borehole in a series of steps each at a different discharge rate, usually with rate increasing with each step. The final step should approach the maximum yield of the borehole.

Constant-rate Test is carried out by pumping at a constant rate for a much longer period of time than the step test and primarily designed to provide information on the hydraulic characteristics of the aquifer.

Recovery Test is carried out by monitoring the recovery of the water levels on the cessation of pumping at the end of a constant-rate test (sometimes after a step test). This tests can be carried out singly or in combination.

9.0 CONCLUSIONS

From this investigation, the following conclusions were established;

1. Two potential aquifers were identified at the TWM premises; a shallow perched aquifer and a deep coarse sand and gravel aquifer.
2. The deep aquifer was encountered in all VES profiles except for TWM_VES2. Most preferred site for drilling would be at TWM_VES1 and TWM_VES3 site.
3. The deep aquifer has a good thickness of 23m at TWM_VES1 and is at a shallower depth, therefore may be more economical to drill at this site.
4. Although the deep aquifer was encountered in other VES locations, these areas are situated at highly elevated and slope areas, which will eventually lose water to the lower lying areas.

10.0 RECOMMENDATIONS

The following are recommended;

1. The most suitable site recommended for drilling investigation is at Site_1, located just west of the main entrance to TWM site. This location is represented by coordinates 509190mE and 8955308mS. Drilling is recommended for this area as the aquifer is at a shallow depth and will cut down the cost of drilling to deeper depths. Drilling should target depths as far as 33m bgl to confirm the extent of the deep aquifer.

2. The next alternative site for drilling is at Site_2, located along the main entrance road of TWM represented by coordinates 509189mE and 8955266mS. Target depth of drilling should be below 28m to 35m total depth.

3. Drilling and well construction should be supervised by a qualified and trained personnel or a Hydrogeologist. Once drilling is initiated, water samples must be collected for lab analysis to obtain groundwater quality data.

REFERENCES

McAlpine, J, R, Keig, G, and Falls, R, 1983, Climate of Papua New Guinea, CSIRO, Australian National University Press, Canberra.

Pieters, P, E, 1978, Port Moresby-Kalo-Aroa 1:250 000 Geological series – Explanatory notes, Bureau of Mineral Resources, Geology and Geophysics, Geological Survey of Papua New Guinea, Australian Government Publishing Service, Canberra 1978.

Rooke, E, R, Groundwater supply to Hiri villages – Porebada, Roku and Kouderika, Technical Note TN 4-88, 1988, Geological Survey of Papua New Guinea.

Ken, M, Irarue, P, Klink, J, 2017, Resistivity soundings for groundwater investigation, Roku, Central Province, Papua New Guinea, Technical Note 2017/05, Geological Survey of Papua New Guinea.

APPENDIX

Appendix 1: Lithological logs of historical bores located at Porebada/ Roku Road junction.

Registered No / Well ID	Location	Total Depth (m)	Lithology	Remarks
PH1	Porebada Roku Junction	24	0-4m – Black sticky CLAY – top soil. 3-4m, soft brownish, sandy silty CLAY and minor angular gravel. 3-4m becomes more sandy. 4-5m – Greyish clean coarse SAND and minor gravel. 5-7m – Greyish sandy silty CLAY. Minor gravel. 7-11m – Grey clayey gravelly SAND becoming coarse and clean below 8m. 11.5m become silty and clayey. 11-18m – Grey sandy silty CLAY. Sand and silt proportion increasing below. 16m, as above with minor gravel. Becoming more silty. 18-24m – Brownish, freshly fragmented MW-SW GRAVEL with occasional coarse sand. Average size of gravel 10-40mm.	Water encountered at 8.8m. SWL at 3m.
PH2	Porebada Roku Junction	22	0-1m – Dark sticky CLAY. 1-3m – Dark gravelly CLAY with some coarse sand. 3-4m – Gravelly coarse SAND. 4-9m – Greyish white gravelly, sandy, silty CLAY with occasional angular cobbles. 8m, percentage of sand and gravel increasing. 9-13m – Coarse gravelly SAND becoming finer downwards. Minor cobbles. 13-15m – Blackish fine to coarse SAND. 15-16m – Grey sandy silty CLAY. 16-22m – Gravelly medium-coarse SAND with occasional angular-sub angular cobbles. 20m, percentage of fine sand increasing below.	Water encountered at 9m and 18m. SWL at 3.6m.
PH3	Porebada Roku Junction	24	0-2m – Soft greyish brown plastic CLAY and a little subangular sand and gravel. 1m, as above but more sandy and gravelly and brown only. 2-4m – Brown, white, red, light grey slightly clayey sandy medium GRAVEL becoming sandier below 3m. 4-8m – Very soft light brown sandy gravelly plastic CLAY. 6m, as above but silty and bluish streaks. 7m, as above but coarser gravel. 8-24m – Red, brown, white, black coarse sandy GRAVEL with small balls of soft white clay, grading to fine gravelly angular medium to coarse sand at 10m. 11m, Light brown, red, dark grey soft clayey sandy medium GRAVEL. 13m, as above but finer GRAVEL, occasional pockets of cream clay. 14m, as above but less sandy. 15m, as above but more sandy and clayey. 15.5m, less sandy and clayey. 16.5m, Coarse GRAVEL. 17.5m, more clayey. 18m, less clayey more sandy coarse GRAVEL. 20m as above but finer GRAVEL and a little clay and silt. 22m, as above, finer GRAVEL.	Water encountered at 9m. SWL at 3.9 initially, but rose to 3.32

Appendix 2: Table of chemical analysis results of PH1.

	PH1 - Sample 5733 (7-8m)	PH1 - Sample 5731 (19-20m)	PH1 - Sample 5732 (21-22m)	PH1 - After 3 minutes pumping	PH1 - After 10 minutes pumping	PH1 - After 30 minutes pumping	PH1 - After 45 minutes pumping
Colour (Hazen Unit)	5	5	5				
Turbidity (J.T.Unit)	200	15	35	50 N.T.Unit	28 N.T.Unit	20 N.T.Unit	14 N.T.Unit
pH (mol/L)	7.3	7.8	7.8	7.1	7.2	6.8	6.8
Conductance (µmho/cm)	1850	2500	2600	1530	1530	1520	1520
Total Dissolved Solids (ppm)				1137	1151	1234	1237
Total Hardness (mg/L CaCO3)	271	367	411	262	264	293	270
Total Alkalinity (mg/L CaCO3)	244	192	209	286	283	281	279
Iron (Fe) ppm				<0.2	<0.2	<0.2	<0.2
Calcium (Ca) ppm	60	59	77	52	53	63	52
Magnesium (Mg) ppm	30	53	53	32	32	33	34
Sodium (Na) ppm	294	375	429	175	163	158	156
Potassium (K) ppm	7	3	4	<1	<1	<1	<1
Bicarbonate (HCO3) ppm	298	234	255		345	343	340
Carbonate (CO3) ppm	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chlorine (Cl) ppm	250	500	520	398	426	501	467
Sulphate (SO4) ppm	160	170	190	58	31	30	30
Flourine (Fl) ppm	0.1	0.5	0.5	0.1	0.1	0.2	0.2
Silicates (SiO2) ppm	60	45	52	130	130	128	125

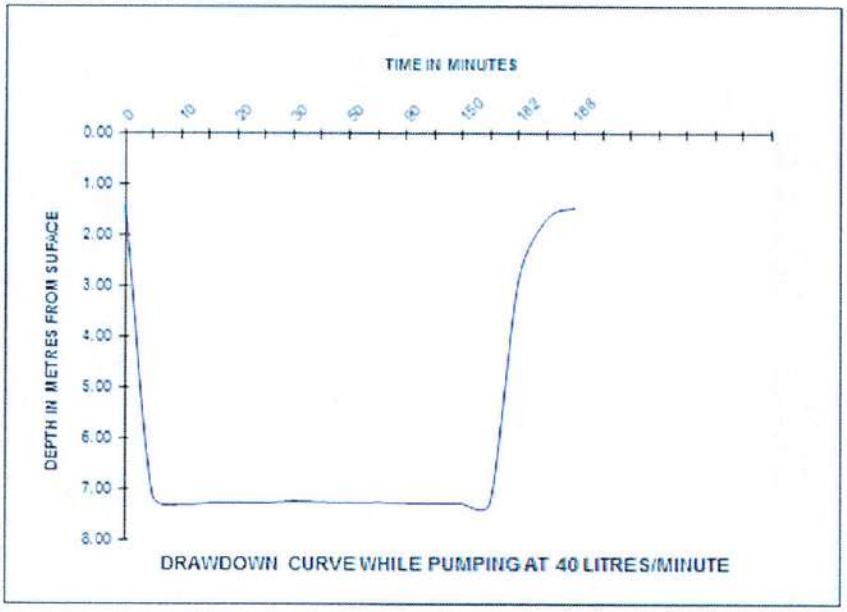
Appendix 3: Table of chemical analysis results of PH2 and PH3.

	PH2 - Sample 5758 (14-15m)	PH2 - Sample 5759 (16-17m)	PH2 - Sample 5760 (18-19m)	PH2 - Sample 5761 (20-21m)	PH3 - After 1hr pumping
Colour (Hazen Unit)	5	5	5	5	5
Turbidity (J.T.Unit)	50	70	250	300	8 N.T.Unit
pH (mol/L)	7.9	8	7.9	7.8	7.2
Conductance (µmho/cm)	5800	5000	5000	4600	
Total Dissolved Solids (ppm)					1017
Total Hardness (mg/L CaCO3)	350	331	308	319	356
Total Alkalinity (mg/L CaCO3)	223	227	234	245	290
Iron (Fe) ppm					0.08
Carbon dioxide (CO2) ppm					35
Calcium (Ca) ppm	60	54	69	56	92
Magnesium (Mg) ppm	49	48	45	44	264
Sodium (Na) ppm	1053	1036	966	869	
Potassium (K) ppm	7	7	7	7	
Bicarbonate (HCO3) ppm	272	277	285	298	290
Carbonate (CO3) ppm	Nil	Nil	Nil	Nil	Nil
Chlorine (Cl) ppm	1699	1634	1549	1384	304
Sulphate (SO4) ppm	32	27	25	26	
Flourine (Fl) ppm	0.4	0.3	0.3	0.3	0.5
Silicates (SiO2) ppm	12	12	12	11	

Appendix 4: Initial constant discharge pump test drawdown data and drawdown graphs of the two AES bores.

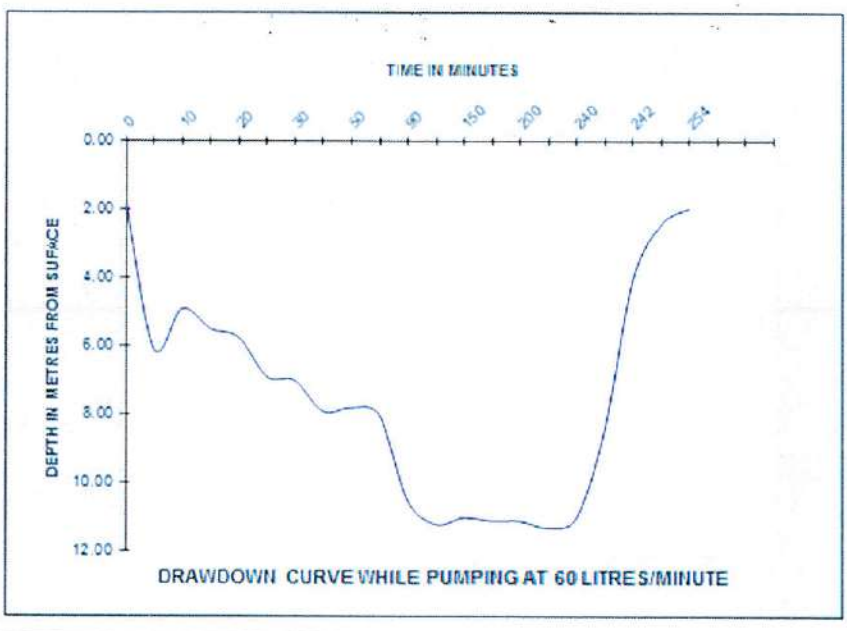
AES Bore No.1 WATER LEVEL DRAWDOWN DATA AND GRAPH

TIME	WATER DEPTH
0.00	1.40
5.00	7.10
10.00	7.27
15.00	7.25
20.00	7.24
25.00	7.25
30.00	7.21
40.00	7.23
50.00	7.24
60.00	7.23
90.00	7.24
120.00	7.25
150.00	7.25
180.00	7.25
182.00	2.85
186.00	1.65
188.00	1.44



AES Bore No.2 WATER LEVEL DRAWDOWN DATA AND GRAPH

TIME	WATER DEPTH
0.00	1.85
5.00	6.10
10.00	4.90
15.00	5.50
20.00	5.75
25.00	6.90
30.00	7.00
40.00	7.90
50.00	7.80
60.00	8.00
90.00	10.50
120.00	11.20
150.00	11.00
180.00	11.10
200.00	11.10
220.00	11.30
240.00	11.00
240.50	8.40
242.00	4.00
246.00	2.40
254.00	1.95



Appendix 5:
Geophysical investigation report for Total Waste Management Site

RESISTIVITY SURVEY

Six (6) vertical electrical soundings (TWMVES_1, 2, 3, 4, 5 & 6, Fig. 1) were carried out using the Schlumberger array method. The data was processed using the Interpex 1xD inversion program. The 1D models showing geo-electric layers, depth and thickness are presented.



Figure 2: Location map of vertical electrical soundings (VES).

Vertical Electrical Sounding 1 (TWMVES_1)

TWM_VES1 was conducted near the entrance beside the lower pad. It was centred at approximate GPS location of 509215 mE and 8955292 mN and elevation of 62 m. The survey line was oriented at an azimuth of 165° and had a maximum current electrode spacing of 200 m (AB/2=100 m).

Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Interpretation
1	259	0.2	0 – 0.2	Dry topsoil
2	98	1.5	0.2 – 1.7	Dry gravel, sand, clay
3	42	7	1.7 – 8.7	Dry clay, gravel, sand
4	21	23	8.7 – 31.7	Potential aquifer
5	168	?	31.7 – ?	Weathered bedrock

Table 1: Modelled and interpreted results of TWMVES_1.

TWMVES_1 results were modelled using a five-layer model (Table 1). Layer 1 had a high resistivity of 259 Ωm that was attributed to dry topsoil. Layer 2 shows a lower resistivity of 98 Ωm, is 1.5 m thick and was interpreted as dry gravel, sand and clay. Layer 3 has an even lower resistivity of 42 Ωm and is 7 m thick. This layer was interpreted to represent clay, gravel and sand that may be wet. A fourth layer (Layer 4) exists at 8.7 m depth, has a low resistivity of 21 Ωm and is 23 m thick. This layer was interpreted as the potential aquifer. Layer 5 shows a high resistivity (168 Ωm), exists at a depth of 31.7 m and was interpreted as weathered bedrock.

Vertical Electrical Sounding 2 (TWMVES_2)

TWMVES_2 was carried out at the western end of main pad. It was sited at approximate GPS location of 509084 mE and 8955281 mN and elevation of 65 m. The line was oriented at an azimuth of 30° and had a maximum current electrode spacing of 200 m (AB/2=100 m).

Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Interpretation
1	198	1.3	0 – 1.3	Dry landfill materials
2	90	2	1.3 – 3.3	Dry gravel, sand, clay
3	131	3.5	3.3 – 6.8	Dry clay, sand, gravel
4	47	?	6.8 – ?	Wet clay, gravel, sand

Table 2: Modelled and interpreted results of TWMVES_2.

A four-layer model was applied to the results of TWMVES_2 (Table 2). Layer 1 shows a high resistivity of 198 Ωm and has a thickness of 1.3 m. This layer was ascribed to dry

compacted landfill earth materials. Layer 2 has a resistivity of 90 Ωm, is 2 m thick and was interpreted as dry gravel, sand and clay. Layer 3 shows a high resistivity (131 Ωm) and is 3.5 m thick. This layer was interpreted to be representative of dry clay, sand and gravel. These are underlain by a fourth layer (Layer 4), bearing a low resistivity (47 Ωm) and exists at 6.8 m depth. This layer was interpreted as wet clay, gravel and sand.

Vertical Electrical Sounding 3 (TWMVES_3)

TWMVES_3 was conducted along the main access road beside the upper pad. It was centred at approximate GPS location of 509179 mE and 8955192 mN and elevation of 67 m. The survey line was oriented at an azimuth of 30° and had a maximum current electrode spacing of 200 m (AB/2=100 m).

Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Interpretation
1	74	1.2	0 – 1.2	Dry landfill materials
2	108	2.3	1.2 – 3.5	Dry gravel, sand, clay
3	25	9.3	3.5 – 12.8	Top (shallow) potential aquifer
4	67	14.7	12.8 – 27.5	Dry clay, sand, gravel
5	21	?	27.5 – ?	Bottom (deep) potential aquifer

Table 3: Modelled and interpreted results of TWMVES_3.

The results of TWMVES_3 (Table 3) were modelled using five layers. Layer 1 shows a resistivity of 74 Ωm and is 1.2 m thick. This layer was attributed to dry landfill materials. Layer 2 has a high resistivity of 108 Ωm and shows a thickness of 2.3 m. This layer was interpreted as dry gravel, sand and clay. A third layer (Layer 3) bears a low resistivity of 25 Ωm and is 9.3 m thick. This layer exists at 3.5 m depth and was interpreted as the potential top (shallow) aquifer. The fourth layer (Layer 4) bears a high resistivity (67 Ωm), lies at 12.8 m depth and is 14.7 m thick. This layer was interpreted as dry clay, sand and gravel. Layer 5 shows a low resistivity of 21 Ωm. This layer exists at a depth of 25.7 m and was interpreted as the potential bottom (main) aquifer. The thickness of deep aquifer could not be determined.

Vertical Electrical Sounding 4 (TWMVES_4)

TWMVES_4 was conducted up on the quarry site. It was sited at approximate GPS location of 509464 mE and 8955066 mN and elevation of 83 m. The survey line was orientated at an azimuth of 90° and had a maximum current electrode spacing of 200 m (AB/2=100 m).

Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Interpretation
1	37	2.4	0 – 2.4	Dry gravel, sand, clay
2	16	5	2.4 – 7.4	Top (shallow) potential aquifer
3	40	18	7.4 – 25.4	Dry clay, sand, gravel
4	5	22	25.4 – 47.4	Bottom (deep) potential aquifer
5	109	?	47.4 – ?	Weathered bedrock

Table 4: Modelled and interpreted results of TWMVES_4.

The results of TWMVES_4 were modelled using a five-layer model (Table 4). Layer 1 shows a high resistivity (37 Ωm), is 2.4 m thick, and was interpreted as a mixture of dry gravel, sand and clay. Layer 2 has a low resistivity of 16 Ωm, exists at 2.4 m depth and is 5 m thick. This layer was interpreted as the potential top (shallow) aquifer. Layer 3 shows a high resistivity of 40 Ωm and exists at 7.4 m depth. It shows a thickness of 18 m and was interpreted to represent dry clay, gravel and sand. A fourth layer (Layer 4) shows a very low resistivity of 5 Ωm and has a thickness of 22 m. This layer lies at 25.4 m depth and was interpreted as the potential bottom (deep) aquifer. Layer 5 bears a high resistivity of 109 Ωm. This layer exists at 47.4 m depth and was interpreted to represent weathered bedrock.

Vertical Electrical Sounding 5 (TWMVES_5)

TWMVES_5 was carried out on the hillside where the timber yard is located. It was sited at approximate GPS location of 509276 mE and 8955124 mN and elevation of 80 m. The survey line was oriented at an azimuth of 45° and had a maximum current electrode spacing of 200 m (AB/2=100 m).

Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Interpretation
1	351	0.4	0 – 0.4	Dry topsoil
2	251	2.7	0.4 – 3.1	Dry gravel, sand, clay
3	69	13	3.1 – 16.1	Dry clay, sand, gravel
4	14	33	16.1 – 49.1	Potential aquifer
5	123	?	49.1 – ?	Weathered bedrock

Table 5: Modelled and interpreted results of TWMVES_5.

A five-layer model was applied to the results of TWMVES_5 (Table 5). Layer 1 shows a very high resistivity (351 Ωm) that was attributed to dry topsoil. Layer 2 has a high resistivity of 251 Ωm, is 2.7 m thick and was interpreted to represent dry gravel, sand and clay. Layer 3 bears a resistivity of 69 Ωm and has a thickness of 13 m. This layer exists at 3.1 m depth and was interpreted as dry clay, sand and gravel. A fourth layer (Layer 4) shows a low resistivity (14 Ωm), begins at 16.1 m depth and is 33 m thick. This layer was interpreted as the potential aquifer. Layer 6 bears a high resistivity of 123 Ωm, exists at 49.1 m depth and was interpreted as weathered bedrock.

Vertical Electrical Sounding 6 (TWMVES_6)

TWMVES_6 was carried out at approximate GPS location of 509002 mE and 8955165 mN and elevation of 45 m. The survey line was orientated at an azimuth of 135° and had a maximum current electrode spacing of 150 m (AB/2=75 m).

Layer	Apparent resistivity (Ωm)	Thickness (m)	Depth (m)	Interpretation
1	710	0.3	0 – 0.3	Dry topsoil, rock fragments
2	92	1.1	0.3 – 1.4	Dry gravel, sand, clay
3	18	2	1.4 – 3.4	Top (shallow) potential aquifer
4	68	4	3.4 – 7.4	Dry clay, sand, gravel
5	16	12	7.4 – 19.4	Bottom (deep) potential aquifer
6	222	?	19.4 – ?	Bedrock

Table 6: Modelled and interpreted results of TWMVES_6.

The results of TWMVES_6 were modelled using a six-layer model (Table 6). Layer 1 shows a very high resistivity of 710 Ωm that was attributed to dry topsoil and rock fragments. Layer

2 has a high resistivity (92 Ωm), is 1.1 m thick and was interpreted as dry gravel, sand and clay. A third layer (Layer 3) bears a low resistivity of 18 Ωm and exists at 1.4 m depth. This layer is 2 m thick and was interpreted as the potential top (shallow) aquifer. Layer 4 shows a high resistivity (68 Ωm), is 4 m thick and was interpreted to represent dry clay, sand and gravel. The fifth layer (Layer 5) has a low resistivity of 16 Ωm and begins at 7.4 m depth. Layer 5 is 12 m thick and was interpreted as the bottom (main) potential aquifer. Layer 6 bears a high resistivity of 222 Ωm and was interpreted to represent bedrock.

DISCUSSION

The results of vertical electrical soundings 3, 4 and 6 revealed two potential aquifers (a shallow and a deep aquifer) separated by a resistive layer. The deeper aquifer is preferred as the potential ground water source.

The resistive layer has a resistivity of 40-69 Ωm and was interpreted as dry clay, sand and gravel. It exists at varying depths across the sites and may act as a protective seal concealing the deep aquifer. This layer has a thickness of 4-7 m under TWMVES_1, 2 and 6. It is thicker under TWMVES_3 (14.7 m), TWMVES_4 (18 m) and TWMVES_5 (13 m).

The resistivity of the deep aquifer ranges from 5 Ωm at the quarry to 21 Ωm around the pad area. It exists deeper (25-28 m depth) at the quarry and upper pad site. Shallower depths were encountered at TWMVES_5 (16 m), TWMVES_1 (9 m) and TWMVES_6 (7 m).

The thickness of the deep aquifer ranges from 12 m at TWMVES_6 to 33 m TWMVES_5. TWMVES_1 and TWMVES_4 registered thicknesses of 23 and 22 m respectively. The thickness under TMWVES_3 was undefined. The resistivity profile (Figure 2) infers deepening of the bedrock and increasing aquifer thickness downslope. Hence the aquifer may thicken under TMWVES_3.

It is therefore recommended that test drilling be focused at TWMVES_3 and at low lying areas towards TWMVES_1 Drilling should attempt to penetrate through the resistive layer.

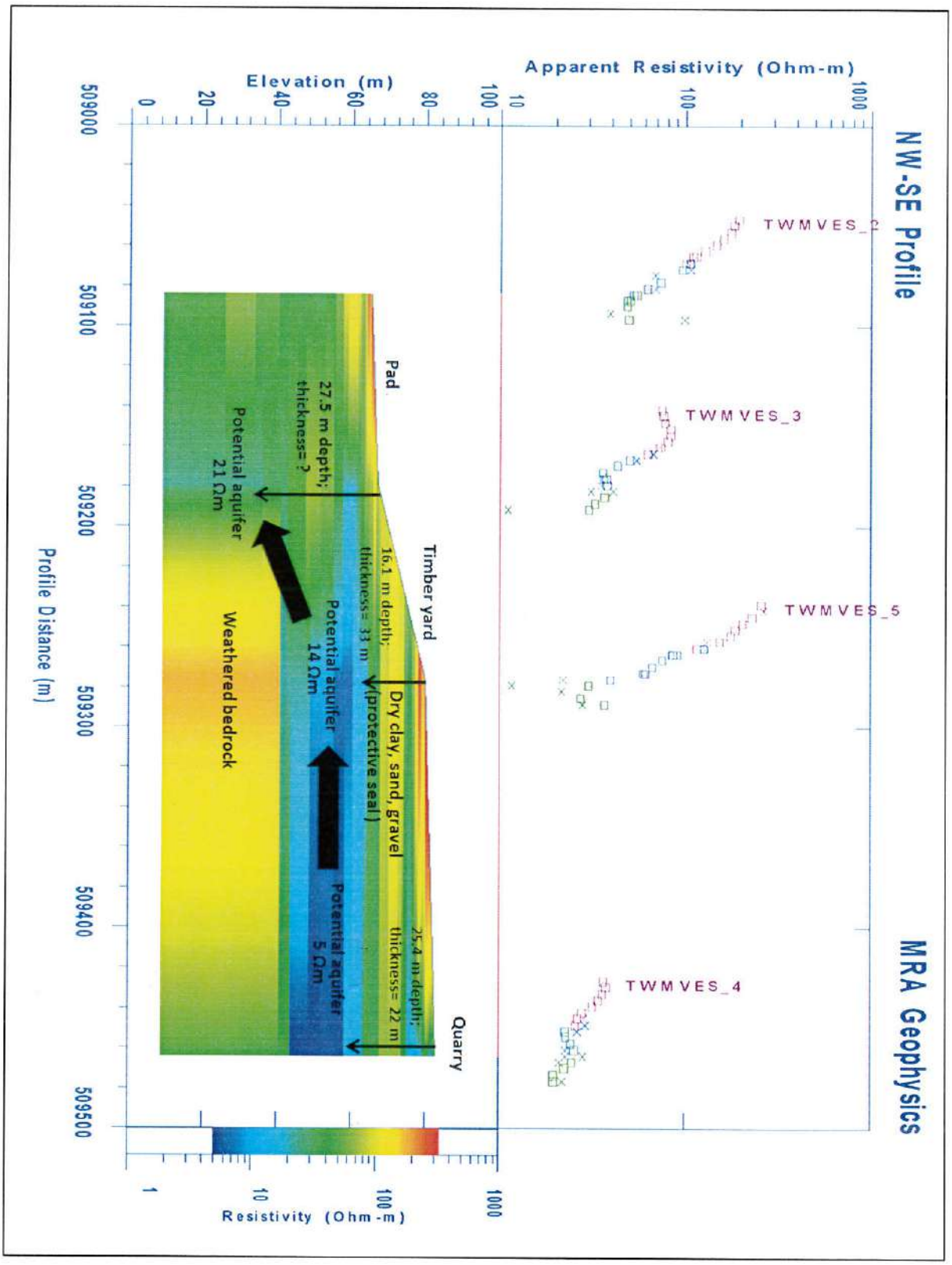


Figure 2: Resistivity cross-section linking TWMVES_2, 3, 4 and 5.

CONCLUSION AND RECOMMENDATION

The resistivity survey revealed the existence of a potential shallow and deep aquifer. The deep aquifer was deemed the potential groundwater source and is to be targeted.

The deep aquifer had a resistivity of 5-21 Ωm. It exists at 25-28 m depth at the quarry and upper pad site. Shallower depths were encountered at TWMVES_5 (16 m), TWMVES_1 (9 m) and TWMVES_6 (7 m). It is concealed on top by a thick resistive layer of varying thickness. This layer conceals the deep aquifer and is thickest under TWMVES_4 (18 m), TWMVES_3 (14.7 m) and TWMVES_5 (13 m).

The thickness of the deep aquifer ranges from 12 m at TWMVES_6 to 33 m at TWMVES_5. TWMVES_1 and TWMVES_4 registered thicknesses of 23 and 22 m respectively. The NW_SE resistivity cross-section infers thickening of the aquifer under TMWVES_3.

It is therefore recommended that test drilling be focused at TWMVES_3 and at low lying areas towards TWMVES_1 Drilling should attempt to penetrate through the resistive layer (protective seal).

Appendix 5
(Air Quality Assessment Report)

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Roku Integrated Waste Management Facility

Site Portion 2703, Napa Napa Road, Porebada, Central Province, Papua New Guinea

Air Quality Assessment

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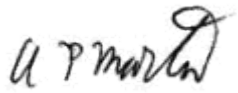
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1. Introduction

1.1 Overview

ASK Consulting Engineers (ASK) has been commissioned by Total Waste Management (TWM) to provide air quality consultancy services for the proposed integrated waste management facility (IWMF) to be located at Site Portion 2703, Napa Napa Road, Porebada, Central Province, Papua New Guinea (PNG) to the north-west of the village of Roku.

1.2 Scope

This report presents an assessment of the air quality impacts associated with the IWMF for an Environmental Permit Level 3 (EP L3) application. It is based on the following tasks:

- Review the project and the associated potential air emissions.
- Use Google Earth Pro to observe the site and land uses.
- Review existing air quality monitoring data applicable to the project site.
- Undertake meteorological modelling in the region and vicinity using TAPM and Calmet with assimilation of available representative data.
- Develop an emission inventory based on existing operations, stack testing, and published emission factors in literature. Air pollutants to be included are particulates less than 2.5 microns ($PM_{2.5}$), particulates less than 10 microns (PM_{10}), total suspended particulates (TSP), hydrogen chloride (HCl), cadmium, lead, mercury, arsenic, nickel, dioxins and furans, polycyclic aromatic hydrocarbon (PAH) and hexachlorobenzene (HCB).
- Model the dispersion of expected air pollutants based on proposed activities using Calpuff to estimate levels of the emissions reaching sensitive receptors and develop contours over the modelling domain.
- Analyse the results of meteorological and pollutant dispersion modelling and compare modelling results with the relevant air quality criteria.
- Provide recommendations on control measures.

Nuisance odour is not included in the scope of this assessment. To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

1.3 Method Overview

In order to predict what happens to the pollutants after they are emitted to air, a mathematical model is used to simulate their dispersion and deposition. It is accepted by regulatory agencies that this type of modelling has associated uncertainties. These are normally addressed by using statistics over long simulation times, and deriving emission rates based on published emission factors or data representing high emission conditions.

With sources close to ground level, the critical wind conditions tend to be near-calm i.e. low wind speeds. Gaussian plume models such as Ausplume and Aermod cannot model near-calm conditions and have low accuracy in light winds, especially in valleys where katabatic flows are present and where drainage flows turn to follow the valley. Calpuff, being a non-steady-state Lagrangian puff model, is able to simulate stagnation over time, which is critical in near-calm conditions. Its meteorological pre-processor Calmet performs diagnostic simulation of terrain effects on the wind field. It has a specific slope flow algorithm that predicts katabatic flows(Scire and Robe, 1997).

In near-calm conditions there is little turbulent mixing and less dilution by incoming wind. Windy conditions cause more emission of dust from some sources, but much greater mixing and dispersion of the dust before its travels far.

Thus Calpuff (Version 7.2.1) was chosen as the most appropriate model. The predictions undertaken for this assessment are based on the following method:

- The activity scenario selected for modelling was based on the highest potential to cause impact to nearby sensitive receivers.
- Dust emission estimates were based on accepted methods and data consolidated by the National Pollutant Inventory (NPI) and the United States Environmental Protection Agency (USEPA). The main emission calculation methods utilised are included in **Appendix B**.
- Prediction of input meteorology was completed using TAPM developed by the CSIRO Division of Atmospheric Research. TAPM has a prognostic 3 dimensional meteorological component which can be used to generate hourly meteorological data for input into dispersion models. TAPM was run over a full representative year (2018) to include all seasons. For areas outside Australia, it uses gridded terrain data at approximately 1 kilometre grid spacing to shape the windfields.
- TAPM input meteorology was enhanced using Calmet, the meteorological pre-processor for Calpuff. This fits the windfields to the terrain based on gridded terrain data at approximately 30 metre grid spacing.
- Dust and gas concentrations were predicted using Calpuff.

2. Study Area Description

2.1 Zoning of Site and Surrounds

The site is located on Site Portion 2703, Napa Napa Road, Porebada, Central Province, Papua New Guinea (PNG) as shown in **Figure 2.1** and **Figure 2.2.**



Figure 2.1 Location of Site (Image from Google Earth Pro)



Figure 2.2 Aerial Photo of Site (Image from Google Earth Pro)

The site is near other industrial uses to the north and north-east across Napa Napa Road, light industry to the north-west, and forested land in other directions. There is a major port facility to the north-east, which has an unsealed access road branching off Napa Napa Road. During a site visit undertaken on 5 to 10 November, 2018, substantial suspended particulate was observed arising from vehicle traffic on the unsealed access road.

2.2 Identification of Existing Sensitive Receptors

In the absence of a definition of a sensitive place in PNG, the definition was adopted from Queensland Department of Environment and Science (DES 2019). This definition is a place that could include but is not limited to:

- a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises
- a motel, hotel or hostel
- a kindergarten, school, university or other educational institution
- a medical centre or hospital
- a natural area protected under legislation or a World Heritage Area
- a public park or garden
- a place used as a workplace including an office for business or commercial purposes.

Ambient air criteria for health and wellbeing and amenity are derived to allow for sensitive populations exposed for most of their lives, which is applicable to some but not all of the above places. Where appropriate an exposure assessment may be required to derive appropriate criteria.

Receptors representative of sensitive places are summarised in **Table 2.1** including their northing and easting locations and are shown in **Figure 2.3**. The closest receptor to the site is Tuhava Town accommodation. The receptors listed in **Table 2.1** are residences. Staff accommodation within the site and adjacent industries to the west and north are not considered sensitive for the purposes of this assessment, although predicted impacts onto these places are shown in pollution contour plots in **Section 11**.

The modelled sensitive receptors have been modelled with a flagpole height of 1.5 metres which is the approximate breathing zone height, except for receptor A which has been modelled with a flagpole height of 4.5 metres to take into account the high-set building. The ground level elevation at receptor A is lower than at the subject site. The receptors have also been modelled with zero height for dust deposition prediction.

Table 2.1 List of Sensitive Receptors with UTM Coordinates (WGS84 Z55)

ID	Name / Description	Approximate Distance and Direction from Site Boundary	Easting (m)	Northing (m)
A	Tuhava Town	160 m west	508942	8955380
B	Avenell Engineering Systems	230 m north	509356	8955472
C	Roku Village	360 m south-east	509837	8954647
D	Roku Village	500 m south-east	509885	8954475
E	Roku Village	580 m south-east	509838	8954345
F	Roku Village	480 m south-east	509640	8954354
G	Roku Village	430 m south-east	509492	8954354



Figure 2.3 Location of Site and Sensitive Receptors (Image from Google Earth Pro)

3. Proposed Development

3.1 Overview

This section includes information provided to ASK that is relevant to the air quality assessment.

The site is located on Portion 2703, Napa Napa Road, Porebada, Central Province, PNG. TWM are broadly seeking to extend its operations from the current EP L2 to EP L3. This is to include the safe handling, recycling, storage, treatment and disposal of a broad range of solid, liquid and intractable wastes, including quarantine wastes, that may be defined as hazardous contaminants under provisions contained within Section 133 of the Environment (Amendment) Act 2014.

The EP L2-(485) was issued on 15 January 2016 and commenced on 12 February 2016 and has been amended twice since. The latest amendment was on 31 March 2020 to extend the permit to 25 years to 11 February 2041 and granted permission for the treatment and disposal of quarantine and COVID-19 health care facility wastes. As the IWMF already has an EP L2, construction of the site is underway at the time of writing this report, and the incinerator is already operating. The site will be under development for the period to end 2021. The proposed layout of the site is presented in **Figure 3.1.** The following plant and infrastructure will collectively form the IWMF:

- A receiving hall is for the segregation of recoverable materials from the incoming waste stream utilising both mechanical and manual methodologies.
- Recycling includes baling, shredding, containerising and crushing activities for glass, metals, paper/cardboard, plastics and organic materials. While these activities are approved under the current EP L2 for a capacity greater than 100 tonnes per year, the L3 permit application seeks to extend the type and complexity of recycling with inclusion of e-waste dismantling and plastics reprocessing.
- Composting of organic materials is an activity approved under the current EP L2-(485).
- Incineration plant using high temperature, pollution control system technology is capable of meeting USEPA and EU emission standard for the thermal destruction of medical waste, quarantine wastes, hazardous waste contaminants, contaminated soils and liquid wastes. While this activity is approved under the current EP L2-(485) for a capacity greater than 10 tonnes per year, the L3 permit application will seek to extend the type and complexity of hazardous contaminants able to be thermally destructed through this process.
- Waste oil processing unit (WOPU) for the recycling of waste oils is an activity approved under the current EP L2-(485).
- Industrial services for the cleaning of tanks and wastewater treatment systems is for beneficial reuse and closed loop applications.
- Fixation bays are used for the stabilisation of selected materials prior to landfilling.
- Waste water treatment plant is an activity approved under the current EP L2-(485); however, given the extension of hazardous and industrial liquid waste types to be received and processed at the IWMF, the L3 permit application will seek to operate an industrial waste water treatment plant.
- Quarrying activities in an existing quarry. This is an approved activity under the current EP L2-(485) for extraction of more than 100,000 tonnes per year.
- Engineered industrial landfill activities are for the disposal of stabilised hazardous contaminants, quarantine wastes, asbestos, construction and demolition materials and other wastes unsuitable for recycling and reuse. While the construction and operation of a landfill for the disposal of municipal wastes is an approved activity under the current EP L2-(485), the L3 permit application will seek to construct and operate a hazardous waste landfill to USEPA standard.

Hazardous waste storage is for the safe consolidation and storage of hazardous contaminants for onsite treatment or export to approved disposal facilities. Temporary storage of waste is approved under the

current EP L2-(485). The L3 permit application seeks to extend the type and complexity of hazardous contaminants that can be stored and treated and disposed at the site.

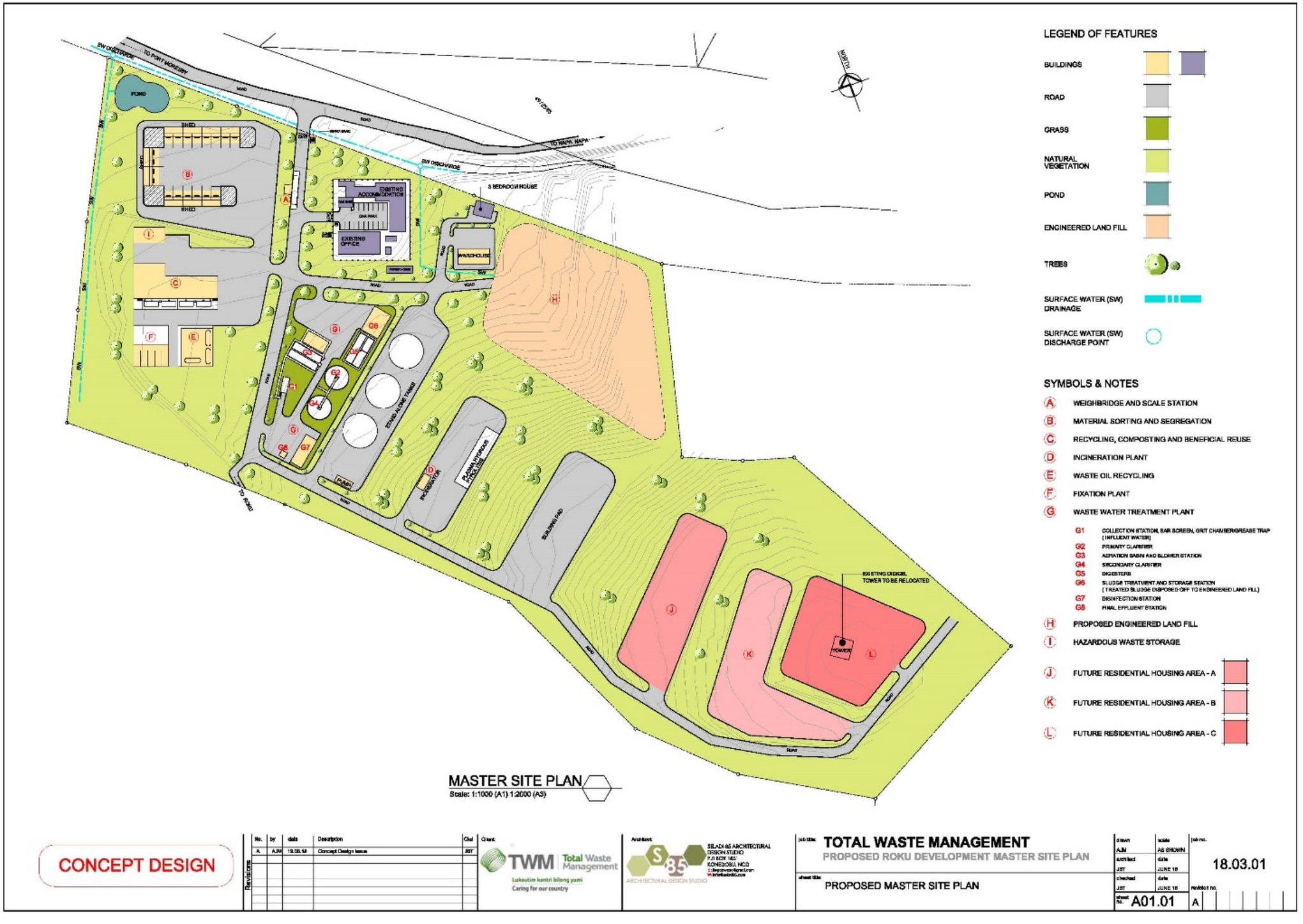
The IWMF is expected to receive up to 150,000 tonnes of commercial and industrial waste materials annually. These volumes may vary over time in line with TWM client operating and expansion program requirements. Waste materials will be delivered by TWM vehicles to the site. **Table 3.1** presents the estimated amount of materials to be received on-site.

Table 3.1 Estimated Amount of Materials To Be Received

Material	Amount of Materials	Treatment
General Wastes		
Recyclables including end of life tyres	35,000 tonnes per year	Baled for export, crushed for on-site use
Non-hazardous C&I	25,000 tonnes per year	Recovery/recycling/incineration/landfill disposal
Putrescible organic wastes	25,000 tonnes per year	Composting
Restricted Wastes		
Clinical and medical wastes	3,000 tonnes per year [1]	Incineration
Contaminated soils	2,500 tonnes per year [1]	Incineration/landfill disposal
Industrial wastewater	15,000,000 litres per year	Wastewater treatment
Soils and sludge	10,000 tonnes per year	Composting
Hazardous Waste Exports		
Acids	50,000 litres per year	Physico-chemical treatment / landfill disposal
Alkalis	50,000 litres per year	Physico-chemical treatment / landfill disposal
Biocides	50,000 litres per year	Physico-chemical treatment / stabilised for landfilling. Higher toxicity materials batch blended as a fuel source
Non halogenated solvents	100,000 litres per year	Physico-chemical treatment / stabilised for landfilling and batch blended as a fuel source
Oxidisers	10,000 litres per year	Physico-chemical treatment / landfill disposal
Waste oils	1,000,000 litres per year	Physico-chemical treatment / used as fuel to generate energy

Notes: 1. The volume of material estimated for incineration are approximate only and will be limited by the actual capacity of the incinerator (500 kg/hour)

All incoming vehicles will pass over the weighbridge where waste tracking documents are received and a visual assessment undertaken to verify compliance with site and environmental permit acceptance criteria. Loads passing through the weighbridge will be directed to the adjacent waste receival hall or to specific processing points on site as determined by the load material type and characteristics.


SW DISCHARGE
TO PORT MORESBY
ROAD
POND
SHED
SHED
TO HAPA HAPA
SW DISCHARGE
3 BEDROOM HOUSE
EXISTING ACCOMMODATION
EXISTING OFFICE
WAREHOUSE
ROAD
ROAD
SW
SW
SW
SW
SW
SW
ROAD
ROAD
ROAD

3.2 Sorting and Segregation Facility

Commercial and industrial (C&I), and construction and demolition (C&D) wastes are unloaded in the sorting and segregation facility for further inspection. The sorting and segregation facility is contained, vented and bunded to prevent release of pollutants to the environment. Loads will be mechanically separated and materials suitable for recycling and/or beneficial reuse will be recovered and stored temporarily in segregated bunkers and directed to specific site areas for storage, treatment or disposal.

The construction and operation of the waste segregation and sorting facility is approved under EP-L2 (485); however, the Project includes the extension of the type and complexity of waste sorting, storage and recycling, and will include dismantling of e-waste and plastics reprocessing which requires a Level 3 permit.

3.3 Recycling, Composting and Beneficial Re-Use Centre

The following recycling activities will be conducted to maximise the supply of recyclables to the international market, or the reprocessing and value adding of materials for use on site or distribution to domestic markets:

- Baling and containerising of recyclables.
- Crushing of glass.
- Shredding and composting of green waste.

These activities will be undertaken at the recycling, compositing and beneficial re-use centre. Materials that will undergo recycling, compositing and beneficial re-use activities will include glass, metals, paper and cardboard, plastics, and organic materials. Crushed glass will be used as an aggregate for on-site construction, road construction and maintenance, and as a component in the daily landfill cover.

The composting facility will receive a mixed feedstock of green wastes, biosolids, waste oil sludge and paper and cardboard.

3.4 Incineration

Combustible waste streams including oily rags, health care and hazardous wastes, contaminated soils, quarantine and liquid wastes are fed into the incinerator. The incinerator has a burn rate of approximately 500 kilograms per hour. Diesel fuel is used in the burners with a consumption rate of approximately 40 to 50 litres per hour. The incinerator has a dual combustion chamber operating at more than 850°C. The minimum retention time in the secondary combustion chamber is two seconds. The secondary chamber is to prevent dioxins from cracking into smaller more reactive molecules. Micro-particulates are forced through a flame curtain which combusts harmful emissions. A particulate filter and an air-cooled heat exchanger are used to cool the flue gas. Combustion efficiency is more than 99% and approximately 3 to 5% of ash residue is generated. The ash generated is disposed of to the landfill.

Incinerators burning hazardous wastes (other than health care waste and oily rags) shall meet the emissions limits contained in the US EPA 40 CFR Part 60 Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units).

3.5 WOPU

The WOPU is used for processing and treating feedstock, including hydrocarbon based oils (i.e., waste oils), fuels, sludge's and contaminated waters, to a quality sufficient for re-use. The WOPU has a processing capacity of 1,000 to 2,000 litres per hour of oil. TWM does not require further Level 3 approvals for the operation of the WOPU.

3.6 Fixation

Fixation bays have been constructed and will operate in the western corner of the IWMF, as shown in **Figure 3.1**, for the stabilisation, neutralisation and fixation of selected hazardous materials prior to landfilling. Stabilisation of these materials will occur through mixing and fixation within cementing material. Waste streams that will undergo fixation prior to disposal in the landfill will include hazardous wastes such as acids, alkalis, and biocides, and the ash of regulated wastes that have undergone incineration, including oil filters and rags, paints (oil and water based), health care wastes, and contaminated soils. The construction and operation of these fixation bays for treating some hazardous wastes is currently approved under EP-L2 (485). However, fixation bays will be operated for the purposes of neutralising and fixating the proposed additional hazardous waste streams, and as such this activity requires assessment in this EIS.

Six fixation bays have been constructed so as to enable mixing to be carried out using excavator, or similar. Fixation and stabilisation media will be added using a mechanical feed system of fixation media stored in a silo adjacent to the pit, in a pre-determined proportion to the material being fixated. Stabilisation material is usually cement based, and will occasionally utilise proprietary products such as cement/clay/polymer mixes dependent of the materials to be stabilised or inert solid chemical material. Following successful stabilisation and fixation of waste in fixation bays, residual materials will be transported and disposed to the industrial landfill.

3.7 Domestic Wastewater Treatment Plant

The domestic wastewater treatment plant will compose of anoxic tank, aeration tank, membrane bioreactor unit, sludge dewater unit, oxygen dissolving tank and treated water tank. The majority of treated water will be used for beneficial reuse. Sludge from the wastewater treatment plant are composted on-site.

3.8 Industrial Wastewater Treatment Plant

Raw water is transferred from a collection sump into the raw water storage tank and then transferred to the flocculation system where pH correction, coagulation and flocculation chemicals are dosed and mixed into the water. The chemically dosed water then enters the dissolved air flotation (DAF) system where water saturated with air is introduced into the bottom of the vessel and the dissolved air floats to the surface as small air bubbles carrying with it suspended matter such as oil, grease and particulates. The frothy sludge is then scraped into a sludge hopper and then transferred to a sludge storage tank where it is periodically removed. The treated water from the DAF unit overflows into the treated water distribution/collection storage.

3.9 Quarrying

The site has an existing quarry. Previous quarrying works have excavated an area suitable for the construction of the initial cell of the landfill. The quarry may produce blocks suitable for coastal and river flood defence or retaining walls. Other products may be used in construction projects including the on-site road network.

The materials excavated will undergo various processes. They will be fed into a vibrator chute for scalping and primary crushing. Some of the materials from the primary crusher will be stockpiled, while the rest will go to a secondary cone crusher. The materials will either be screened and stockpiled or go through a tertiary cone crusher after which they will again be screened before going through the quaternary cone crusher. They will then be screened again before being stockpiled.

3.10 Industrial Landfill

The landfill is anticipated to receive up to approximately 70 tonnes of commercial and industrial non-restricted waste materials per day. Separate cells are to be constructed in sequence and as required. A layer of cover material will be applied daily which will consist of an earthen mix with low clay content combined with inert materials processed on-site including crushed glass, brick and concrete. Once the cell reaches capacity, a layer of predominantly clay/earthen mix will be placed as interim cover. The final covering of a completed landfill cell will consist of a gas distribution layer composed of porous materials and a network of pipes connecting the landfill gas trenches to vent the landfill gases, a second layer of compacted soil and geo-synthetic clay liner, and a surface or cap layer of topsoil which will then be planted with shallow rooted vegetation.

The materials received at the landfill will predominantly be inert and are expected to generate relatively low levels of leachate. The leachate generated will be pumped from the leachate sump to a central collection well before being pumped to a leachate holding pond or to the on-site wastewater treatment system.

As the landfill will receive mainly inert materials, minimal gases are expected to be generated. A gas capture system will be installed upon closure of the cells. The landfill gases will be vented to the environment. Monitoring of the gas extraction wells be undertaken monthly to ensure compliance with regulatory standards. If the gas generation levels change over time, installation of a gas flare system to burn off the gas will be considered.

3.11 Hazardous Waste Storage

The hazardous waste storage facility is constructed with impervious concrete bunds and blind sumps with at least 110% of the chemical storage capacity. Industrial steel racking and secondary bunded floor areas will separate chemicals in accordance with dangerous goods classifications for storage. Decanting areas, vents and gauges are all located within a bunded area.

Dust control devices are to be located at all openings to prevent visible emissions from the buildings during operating or maintenance activities or when staff or vehicles enter the storage building.

A decontamination area located within the building is to be used to ensure waste is not tracked outside of the building. Wastes and associated cleaning liquids through the decontamination process are collected for appropriate management.

Specific regulated wastes are transferred to approved consignees in Australia for environmentally sound treatment and disposal.

4. Air Quality Values and Criteria

4.1 Relevant Pollutants

This section identifies the pollutants anticipated from the sources being assessed. Quantitative details of these emissions are provided in **Section 9**.

The focus of this assessment will be on potential impacts due to emissions of particulate matter, CO, HCl, cadmium, lead, mercury and dioxins and furans.

Particulates will include the following fractions:

- TSP is the total suspended particulate matter (TSP).
- PM_{10} is the fraction of particulate matter with equivalent aerodynamic diameters of 10 µm or less.
- $PM_{2.5}$ is the fraction of particulate matter with equivalent aerodynamic diameters of 2.5 µm and less.

4.2 TWM PNG Ltd Environment Permit

The ambient air quality standards specified in the Environment Permit EP L2-(485) are presented in **Table 4.1**. These are based on the Australian Department of Environment National Environment Protection (Ambient Air Quality) Measure, February 2016, and the World Health Organisation 2006 Ambient Air Quality Standards for particulate matter.

Carbon monoxide (CO), sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) emissions on-site would come from combustion of diesel fuel for the mobile plant and fixed plant equipment and incineration of wastes. The emissions of these pollutants within the site would be relatively minimal and are not likely to cause an exceedance of the criteria. In addition, the proposed extension of the current environmental permit to level 3 would have very minimal impact on the CO, SO_2 and NO_x emissions on-site from fuel combustion. Incineration of hazardous wastes are not likely to increase the emissions of these pollutants in comparison to incineration of general wastes.

EEA (2019) has documented emission factors of various waste streams. Emission factors of these compounds from incineration of industrial wastes including hazardous wastes are at least an order of magnitude lower than the emission factors for incineration of clinical wastes and at least three orders of magnitude lower than emission factors for incineration of municipal wastes. The stack testing results for these compounds from the incinerator on-site are higher than all of those presented by EEA (2019).

Ozone is formed in the atmosphere by photochemical reactions involving NO_x and VOC concentrations, which are emitted by a wide range of regional sources, and so has not been included in this assessment.

Table 4.1 EP L2-(485) Ambient Air Quality Standards

Pollutant	Averaging Period	Maximum Concentration	Maximum Allowable Exceedences
CO	8 hours	9.0 ppm	1 day per year
NO_2	1 hour	0.12 ppm	1 day per year
	1 year	0.03 ppm	None
Ozone	1 hour	0.10 ppm	1 day per year
	4 hours	0.08 ppm	1 day per year
SO_2	1 hour	0.20 ppm	1 day per year
	1 day	0.08 ppm	1 day per year
	1 year	0.02 ppm	None
Lead	1 year	0.50 µg/m^3	None
PM_{10}	24 hours	150 µg/m^3	None
	1 year	70 µg/m^3	None
$PM_{2.5}$	24 hours	75 µg/m^3	None
	1 year	35 µg/m^3	None

4.3 Other Criteria

In the absence of PNG and WHO guidelines for ambient concentration of the other assessed pollutants, the criteria found in the Queensland Environmental Protection (Air) Policy (EPP (Air)) 2019, the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA, 2016), and the Texas Commission on Environmental Quality (2016) have been considered. The relevant criteria are presented in **Table 4.2**.

Table 4.2 Other Relevant Criteria

Pollutant	Averaging Period	Maximum Concentration (µg/m^3)	Maximum Allowable Exceedences	Source
Cadmium and compounds (measured as the total metal content in PM_{10})	1 year	0.005	None	Qld EPP (Air) 2019
Cadmium and compounds	1 hour	0.018	99.9th percentile	NSW EPA (2016)
Inorganic mercury vapour	1 year	1.1	None	Qld EPP (Air) 2019
Inorganic mercury	1 hour	1.8	99.9th percentile	NSW EPA (2016)
Organic mercury	1 hour	0.18	99.9th percentile	NSW EPA (2016)
Dioxins and furans	1 hour	2.0E-6 TEQ	99.9th percentile	NSW EPA (2016)
Hydrogen chloride	1 hour	140	99.9th percentile	NSW EPA (2016)

Pollutant	Averaging Period	Maximum Concentration (µg/m^3)	Maximum Allowable Exceedences	Source
Arsenic and compounds	1 hour	0.09	99.9th percentile	NSW EPA (2016)
	1 year	0.006	None	Qld EPP (Air) 2019
Nickel and compounds	1 hour	0.18	99.9th percentile	NSW EPA (2016)
	1 year	0.022	None	Qld EPP (Air) 2019
PAH as benzo(a)pyrene	1 hour	0.4	99.9th percentile	NSW EPA (2016)
	1 year	0.0003	None	Qld EPP (Air) 2019
HCB	1 hour	0.25	None	Texas Commission on Environmental Quality Effects Screening Levels (ESL)
	1 year	0.025	None	
Deposited dust	1 month	120 mg/m^2/day	None	DES (2019)
		2 g/m^2/month (incremental)	None	NSW EPA (2016)
		4 g/m^2/month (cumulative)	None	NSW EPA (2016)

5. Greenhouse Gas Regulatory Requirements

As PNG does not have greenhouse gas assessment or reporting guidelines, the Australian legislative framework has been used.

5.1 National Greenhouse and Energy Reporting (NGER)

The legislative framework for a national greenhouse and energy reporting system is established via:

- the National Greenhouse and Energy Reporting Act 2007 (NGER Act)
- the National Greenhouse and Energy Reporting Regulations 2008 (NGER Regulations) as amended 1 July 2020
- the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Determination) as amended 1 July 2020.

The NGER Technical Guidelines (Department of the Environment and Energy, 2017) provide additional guidance and commentary to assist in estimating greenhouse gas emissions for reporting under the NGER system. The emission factors used in these guidelines are consistent with those specified in the National Greenhouse Accounts Factors (Department of the Environment and Energy, 2019). The National Greenhouse Account Factors have no standing in relation to reporting under the NGER legislation; however, they are generally referred to as the current values to use.

The NGER Act makes reporting mandatory for corporations whose energy production, energy use, or greenhouse gas emissions meet certain specified thresholds. These thresholds are detailed in the NGER Regulations. **Section 5.2** summarises the reporting thresholds.

The NGER Determination provides methods for the estimation and measurement of:

(1) greenhouse gas emissions

(2) the production of energy

(3) the consumption of energy.

Greenhouse gas emissions are defined in Section 2.23 of the NGER Regulation as follows:

(2) Emissions of greenhouse gas, in relation to a facility, means the release of greenhouse gas into the atmosphere as a direct result of one of:

(a) an activity, or series of activities (including ancillary activities) that constitute the facility (scope 1 emissions)

(b) one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility (scope 2 emissions).

Coverage of scope 1 emission sources is given in Section 1.3 (4) of the NGER Determination by:

(a) fuel combustion, which deals with emissions released from fuel combustion

(b) fugitive emissions from fuels, which deal with emissions mainly released from the extraction, production, processing and distribution of fossil fuels

(c) industrial processes emissions, which deal with emissions released from the consumption of carbonates and the use of fuels as feedstock or as carbon reductants, and the emission of synthetic gases in particular cases

(d) waste emissions, which deal with emissions mainly released from the decomposition of organic material in landfill or wastewater handling facilities.

Scope 2 emissions are generally emissions that result from activities that generate power offsite for consumption onsite. The largest contributor to scope 2 emissions is consumption of electricity or steam.

Scope 3 emissions are indirect emissions other than scope 2 from sources not owned or controlled by the facility. These are not reported under the NGER scheme. Scope 3 emissions have not been included in this assessment.

5.2 Reporting Thresholds

Section 13 of the NGER Act sets reporting thresholds for the operation of a facility or corporations, as per the following excerpts:

(1) A controlling corporation's group meets a threshold for a financial year if in that year:

(e) the total amount of greenhouse gases emitted from the operation of facilities under the operational control of entities that are members of the group has a carbon dioxide equivalence of: ....

(iii) 50 kilotonnes or more; or

....

(c) the total amount of energy consumed from the operation of facilities under the operational control of entities that are members of the group is:

....

(iii) 200 terajoules or more; or

(d) an entity that is a member of the group has operational control of a facility the operation of which during the year causes:

i) emission of greenhouse gases that have a carbon dioxide equivalence of 25 kilotonnes or more; or

ii) production of energy of 100 terajoules or more; or

iii) consumption of energy of 100 terajoules or more

Note that within a corporation, incidental facilities may be reported as percentages of the total or otherwise estimated as per the NGER Regulations as updated by the National Greenhouse and Energy Reporting Amendment (Streamlining Reporting) Regulation 2013.

5.3 Greenhouse Gases

Gases addressed by the NGER Regulations (Department of Industry, Science, Energy and Resources, 2020c), are the six key greenhouse gases consistent with the Kyoto Protocol. These gases differ in their capacity to trap heat and contribute to the greenhouse effect. The capacity of each gas to contribute to global warming is referred to as its Global Warming Potential (GWP) relative to that of carbon dioxide. The GWP's of the six Kyoto greenhouse gases are provided in **Table 5.1.**

Table 5.1 Global Warming Potential of Greenhouse Gases

Greenhouse Gas	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
Hydrofluorocarbons (HFC's)	92 – 14,800
Perfluorocarbons (PFC's)	7,390 – 12,200
Sulphur hexafluoride (SF_6)	22,800

Note: Source is Department of Industry, Science, Energy and Resources (2020c).

Because of the variation in GWP between different gases, the emission factors used to calculate greenhouse gas emissions from the project are stated in terms of carbon dioxide equivalents (CO_2-e) and consider the various GWP's of the different greenhouse gases.

6. Greenhouse Gas Emissions

6.1 Methodology for Impact Assessment

The following data and assumptions were used in emission calculations:

- Fugitive gas emissions from the use of liquid fuels for the mobile and fixed plant equipment, and from composting and wastewater have been determined using Method 1 from the NGER Technical Guidelines (Department of the Environment and Energy, 2017).
- Emissions from incineration have also been calculated using stack testing results (Assured Environmental, 2019).
- It is understood that there are no areas of vegetation to be cleared that have crown cover greater than 20%.
- It has been assumed that there are no CH_4 or CO_2 emissions from the working and breathing losses of tanks containing waste oil (API, 2009).
- Emissions from the landfill are assumed to be minimal, considering organic putrescible wastes will be composted, and hence have not been included in this assessment. Non-organic putrescible waste will be incinerated with the ash fixated for disposal at the landfill.
- Emissions from industrial wastewater are also assumed to be minimal, considering the process only involves physical separation of impurities.
- The electricity consumption of the facility has been calculated.

The mobile and fixed equipment anticipated to utilise diesel fuel are summarised in **Table 6.1.**

Table 6.1 Mobile and Fixed Plant

Equipment Description	Make/Model/Description	Quantity
Landfill		
Dozer	D9 with rippers CAT	1
Excavator	2016 CAT 325 FCR 20-45T	1
Front end loader	CAT 950H 2011 18.5T	1
Screen	2014 McCloskey s130 double deck wheeled screener 4200x1524 screen box; CAT C4.4 engine on 17.5 tyres	1
Crusher	2014 Mcloskey J50CT Jaw Crusher	1
Haulage truck	2007 Western Star 4800 FX Stratosphere	2
Dump truck	2012 CAT 740B 6x4 articulated	2
Remainder site		
Forklift	1.5T	2
Forklift	5T	1
Front end loader	12T	1
Trucks		
Truck	6x4 articulated	3
Truck	3 tonne	1
Truck	4x2 articulated light	2
Vehicles		
Vehicle	Utilities	2
Vehicle	SUVs	2
Vehicle	Hiace bus	1

Equipment Description	Make/Model/Description	Quantity
Vehicle	Coaster bus	1
Other Fixed plants		
Incinerator	Inciner8 I8-700	1
Generators	250 kVA	2

Fuel usage from the mobile and fixed plants listed in **Table 6.1** is approximately 1,500 litres per week of diesel.

6.2 Emissions from Vegetation Clearing

It is understood that there are no areas of vegetation to be cleared that have crown cover greater than 20%. Thus, vegetation removal is not included in the inventory.

6.3 Liquid Fuel Combustion Emissions

Diesel fuel will be used primarily by mobile equipment, fixed plant, and light vehicles. Power will also be supplied by diesel generators during mains power outage.

Greenhouse emission factors for liquid fuel consumption are shown in **Table 6.2**. Note that the emission factors are per kilolitre of fuel. The greenhouse gas emissions for the combustion of diesel oil for stationary engine and general transport are slightly different. As the mobile equipment will be the main consumer of the diesel oil, the emission factors for general transport have been used to calculate the diesel combustion emissions.

Table 6.2 Liquid Fuel Greenhouse Gas Emission Factors

Fuel Type	Energy Content (GJ/kL) [1]	Scope 1 Emission Factor (kg CO_2-e/GJ) [1, 2]	GHG Emission Factor (tonnes CO_2-e/ kL) [3]
Diesel oil (stationary engine)	38.6	70.2	2.71
Diesel oil (general transport)	38.6	70.5	2.72

Notes: 1. Energy content of fuel is sourced from Table 2 to Table 4 of Department of the Environment and Energy (2019).
2. Emission factors include contributions from CO_2, CH_4 and N_2O.
3. GHG Emission Factor is the Energy Content multiplied by Scope 1 Emission Factor.

The annual diesel consumption was calculated to be 78 kL (1,500 L per week x 52 weeks per year).

The greenhouse gas emission from fuel usage is calculated by multiplying the fuel consumption by the emission factor from the last column in **Table 6.2**. **Table 6.3** below present the total fuel consumption and the resultant emissions, with a total greenhouse gas emission of 255 kt CO_2-e from fuel combustion.

Table 6.3 Fuel Combustion Emission Summary

Activity	Total Fuel Consumed (kL)	Emission Factor (t CO_2-e/kL) [1]	Total Emissions (kt CO_2-e)
Diesel combustion	78	2.72	0.21

Note: 1. Emission factors from **Table 6.2**.

6.4 Composting Emissions

Greenhouse gas emissions from composting have been calculated as summarised in **Table 6.4**.

Table 6.4 Composting Emission Summary

Activity	Total Putrescible Waste (tonnes)	Emission Factor (t CO_2-e/t) [1, 2]	Total Emissions (kt CO_2-e)
Composting	35,000	0.048	1.7

Notes: 1. Emission factor is sourced from Department of the Environment and Energy (2017).
2. Emission factors include contributions from CH_4 and N_2O.

6.5 Domestic Wastewater Emissions

The calculation of greenhouse gas emissions from anaerobic treatment of wastewater is summarised in **Table 6.5**. Due to limited information, the total calculated COD in the raw wastewater has been conservatively assumed to be emitted as methane during anaerobic digestion. In reality, some of the CODs would be removed with the sludge and the rest would remain in the effluent.

The amount of COD from the wastewater has been calculated based on the assumed number of people served of 5,000 (as the minimum limit of the approved Level 2B Subcategory 11.1). In reality, there will be substantially less people (approximately 20 based on the domestic wastewater produced of 1.39 ML per year, assuming 200 litres per day per person) serviced by the domestic wastewater treatment plant. The domestic wastewater from on-site accommodation and administrative facilities that will treated by the domestic wastewater treatment plant will only be 10% of the total wastewater processed by the plant. Approximately 90% will be commercial feedstock. Due to lack of information about the nature of the commercial wastewater feedstock, it is not possible to assess the greenhouse gas emissions from its treatment. It has been assumed that the over-conservative number of people serviced will be sufficient substitute for the commercial wastewater treatment emissions.

Table 6.5 Domestic Wastewater Emission Summary

Activity	Population Served	Quantity of COD (tonnes per person) [1]	Methane Correction Factor [1]	Methane Emission Factor (t CO_2-e/t COD) [1]	Total Emissions (kt CO_2-e)
Anaerobic digestion	5,000 [2]	0.0585	0.8	6.3	1.5

Notes: 1. Emission factor is sourced from Department of the Environment and Energy (2017).
2. Based on activities for Level 2B Subcategory 11.1.

6.6 Incinerator Waste Emissions

Stack emissions testing of the incinerator has been undertaken for waste streams classified as general waste, medical waste and contaminated soils. The incinerating of the general waste stream was found to emit the most CO_2 among the waste streams tested. A CO_2 emission rate of 3,666 g/min has been measured. Assuming the incinerator is operating all the time during facility's operating hours, and is constantly emitting 3,666 g/min of CO_2, the annual CO_2 emissions from the incinerator has been calculated to be 0.63 kt. This

includes the emissions from the combustion of wastes and the diesel fuel. The fuel consumption would be 143 kL per annum (500 L per day x 365 day per year x 5.5 working days per week / 7 days per week). This is higher than the total diesel fuel consumed on-site as presented in **Table 6.2**, which means that the incinerator will not be operating all the time during operating hours. The greenhouse gas emissions from incinerator waste emissions have therefore been conservatively calculated to be 0.63 kt CO_2 per year (3,666 g/min x 60 min/hour x 10 hours/day x 5.5 days per week x 365 days per year / 7 days per week x 1 kt / 10^9 g).

6.7 Scope 2 Emissions

Emission factors associated with consumption of purchased electricity are shown in **Table 6.6.** The latest electricity consumption on-site from January 2020 to August 2020 is 2,000 kWh. Extrapolating the electricity consumption to December 2020, the annual electricity consumption would be 3,000 kWh. Currently, not all of the approved activities are in operation on-site and construction work is still undergoing. Hence, it is likely that the electricity consumed will increase into the future.

Two 250 kVA diesel generators will be kept on standby as a backup power source in the event of a power failure. Based on this, the power required on-site will likely be approximately 500 kW. The electrical power required on-site has been calculated to be 1,433,929 kWh (500kW x 10 hours per day x 5.5 days per week x 365 days per year / 7 days per week). As there is uncertainty regarding the number of hours the generators would typically operate and the amount of diesel the generators consume, it has been conservatively assumed that the backup generators use approximately 1,500 litres per week. As a 250 kVA generator typically uses 53 litres per hour (Able Sales Australia, 2020 & Connor Generators, 2020), the approximate number of hours of mains power outage is 14 hours per week (1,500 litres per week / (2 x 53 litres per hour)). The actual electrical power consumed is estimated to be 1,064,993 kWh (500kW x (10 hours per day x 5.5 days per week - 1,500 litres per week / (2 x 53 litres per hour)) x 365 days per year / 7 days per week).

Table 6.6 Purchased Electricity (Scope 2) Emission Summary

Total Electricity Consumed (kWh)	Emission factor (kg CO_2-e / kWh)	Total Emissions (kt CO_2-e)
1,064,993	0.63 [1]	0.67

Note: 1. Source is Table 5 of Department of the Environment and Energy (2019). As the electricity grid is not listed in the table, the emission factor for the Northern Territory is used as recommended by Department of the Environment and Energy (2019).

6.8 Summary of Greenhouse Gas Emissions

Based on the emission calculations, the major source of greenhouse gas emissions is the anaerobic wastewater treatment. The annual scope 1 emissions from the Project are estimated to be 4.7 kilotonnes CO_2-e. A summary of the emissions breakdown is presented in **Table 6.7**.

Table 6.7 Greenhouse Gas Emissions

Activity	Total Annual Emissions (kt CO_2-e)
Scope 1 Equipment and power generation fuel combustion	0.21
Scope 1 Vegetation cleared	0
Scope 1 Composting	1.7
Scope 1 Wastewater treatment	1.5
Scope 1 Waste incineration	0.63
Scope 2 Grid electricity consumption	0.67
Total	**4.7**

The greenhouse gas emissions presented in this section has been estimated for the proposed level 3 operations. As most of the activities in the approved base case level 2 scenario will remain the same for the proposed level 3 scenario, the difference in greenhouse gas emissions between the two scenarios is likely to be minimal. It is likely that scopes 1 and 2 greenhouse gas emissions for the proposed level 3 scenario would be slightly higher as there will be slightly more wastes expected to be coming into site with the expansion of the types of wastes to be received and expansion of activities (e.g. treatment of hazardous wastes). However, the proposed level 3 activities would also likely result in scope 3 greenhouse gas savings as industries would find it more cost-effective to dispose of their hazardous waste closer to their facilities, and the hazardous wastes received can be treated and disposed on-site instead of being exported, reducing greenhouse gas emissions from waste transportation.

6.9 Recommendations for Mitigation Measures

6.9.1 Best Practice

Best practice measures for reducing greenhouse gas emissions from mining have been published by Environment Australia (2002) and include the following:

- Energy audits are to provide a breakdown of energy use by activity, profiles of energy load across key plant items, analysis of energy efficiency initiatives, trending of energy usage over time and addressing energy usage in procedures.
- Training should be provided to all staff in energy management specific to their roles.
- Less greenhouse intensive fuels for vehicles should be considered.
- Reducing haulage emissions by using conveyors or in-pit crushing.
- Appropriate design of water management systems to minimise consumption and pumping can have substantial savings in energy consumption as can use of variable speed drives on large pumps.
- Appropriate choice of crushing method is critical. It is recommended that optimising feed size into mills be a priority in the design and purchasing of the primary and secondary crushers.
- Air leaks account for most of the energy loss in compressed air systems.

Other measures considered are:

- Use large haul trucks where practical, provided they will be taking full loads. This has potential for substantial reductions in diesel consumption.

The recommended measures to minimise greenhouse gas emissions from the project are in the following subsections.

6.9.2 Equipment and Energy Efficiency

(1) Include energy efficiency as a criterion when selecting diesel and electric powered motors and other equipment for purchase, for example variable speed drive pumps. This has potential for substantial reductions in electricity demand.

(2) Where practical use biodiesel for mobile plant. This has potential for substantial reductions in net greenhouse gas emissions.

(3) Install light sensitive switches and motion sensors to switch on lighting throughout the project site where practical and safe. This has potential for small reductions in electricity demand.

(4) Large haul trucks are to be used where practical, as these decrease diesel consumption by reducing the number of trips.

6.9.3 Quarry/Landfill Planning

(5) Design pit and dump haul roads and ramps to limit the travel time and duty cycle for trucks especially when fully loaded.

(6) Where practical reuse vegetation that has to be cleared as timber product or mulch for rehabilitation. This has potential for small reductions in emissions due to decay of vegetation.

(7) Vegetation buffers could be established in the direction of the nearest sensitive receptor and the highway, using mulch from cleared vegetation.

(8) Rehabilitate the land as soon as practical. The subsequent growth of vegetation would provide an offset sink for CO_2.

6.9.4 Operations

(9) Use production monitoring systems and payload management to maximise the loads of each bucket dug by excavators and each load carried by trucks. This will eliminate unnecessary bucket pass and truck hauls.

(10) Use production monitoring systems to minimise fuel burn rates and reduce the time when trucks are idling.

(11) Maintain equipment to retain energy efficiency. This has potential for reductions in electricity demand.

(12) Compact haul roads to minimise rolling resistance. This has potential for reductions in diesel consumption.

(13) Recycle water in the processing operations to reduce off site pumping requirements.

(14) Undertake regular checking of compressed air tubing to reduce leaks. This has potential for substantial reductions in electricity demand.

(15) Provide training for operators of mobile plant in how to minimise fuel consumption, including no unnecessary idling.

(16) Where suitable, use local personnel to reduce transport emissions. This has potential for reductions in transport fuel consumption.

(17) As far as practical, obtain construction materials and ongoing consumables from local suppliers to reduce fuel consumption.

6.9.5 New Technology

(18) Consider use of solar energy and other clean energy sources.

6.9.6 Management Systems

(19) Following completion of annual reporting, undertake an internal energy audit and energy mass balance to ensure that the activities are using best practice for minimisation of energy consumption.

(20) Complete an Energy Management System for the site.

7. Meteorological Modelling

7.1 TAPM Meteorological Modelling

7.1.1 TAPM Fundamentals

The meteorological component of The Air Pollution Model (TAPM) was used to provide wind fields over the region. Wind speed and direction data from the nearest continuous monitoring station were assimilated into the model as described in **Section 7.1.3**.

The databases required to run TAPM are provided by CSIRO and include global and Australian terrain height data, vegetation and soil type datasets, sea surface temperature datasets and synoptic scale meteorological datasets.

The global terrain data and land cover data are in the form of 30-second grid spacing (approximately 1 kilometre) and are based on data available from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC). The global soil types data and 5-year monthly mean Leaf Area Index (LAI) data are in the form of 2-degree grid spacing (approximately 4 kilometres) and are based on FAO/UNESCO soil classes dataset and Boston University LAI datasets (derived from MODIS products), respectively. The Rand's global 10-year monthly mean sea surface temperatures data is in the form of 1-degree grid spacing (approximately 100 kilometres) and is based on data available from the US National Centre for Atmospheric Research (NCAR).

The synoptic scale meteorology dataset used is a six-hourly synoptic scale analysis on a longitude/latitude grid at 0.75 or 1.0-degree grid spacing (approximately 75 kilometres or 100 kilometres). The database is derived from US NCEP reanalysis synoptic product.

TAPM dynamically fits the gridded data for the selected region to finer grids including the influences of terrain, surface type and surface moisture conditions. It produces detailed fields of hourly estimated temperature, winds, pressure, turbulence, cloud cover and humidity at various levels in the atmosphere as well as surface solar radiation and rainfall.

7.1.2 TAPM Configuration

The year 2018 has been used as discussed in **Section 7.1.3**.

Due to numerical instability and flatlining of the results, the TAPM was setup to have smaller than ideal outermost domain. TAPM was successfully run using three nested 25 x 25 grids centred on latitude 9°27.5' south, longitude 147°6.5' east. The three nested grids are as follows:

- 250 km x 250 km with 10 km resolution
- 75 km x 75 km with 3 km resolution
- 25 km x 25 km with 1 km resolution

Thirty (30) vertical levels were used with lower level steps at 10, 25, 50, 75 and 100 metres up to 8 kilometres in altitude. This is a greater than normal number of vertical layers in order to provide better resolution of vertical layers. Boundary conditions on the outer grid were derived from the synoptic analysis.

TAPM land use data was updated using the latest aerial photography available being July 2020 from Google Earth Pro.

7.1.3 Observational Data Assimilation

Meteorological data from the Jacksons Airport station, located approximately 16 kilometres north-east from the site, were available for assimilation into the model run.

Windroses for the years 2007 to 2019 at Jackson Airport Station from WindAlert data (WindAlert, 2020) were compared. Monthly daytime windroses for each year from 2015 to 2019 have been compared against the monthly daytime windroses averaged over all years 2007 to 2019. These windroses are presented in **Appendix B**. Based on the comparison of windroses, the year 2018 was deemed most representative and was chosen for modelling.

The distribution of wind speeds and directions is shown in **Table 7.1.** The frequency of calm to light winds up to 1.5 m/s is 15%. A windrose of this data is shown in **Figure 7.1**. TAPM was initially run without assimilation of this data and the windrose for the same period is shown in **Figure 7.2**. The two wind roses show a similar pattern including similar proportion of calm and light wind conditions. Higher wind speeds at the Jacksons Airport station are not apparent in the TAPM results which is typical. The observational data was included into the TAPM model for generating data for the project. The radius of influence set to 17 kilometres and data quality was set to 0.4, which recognises the good observational data, but allows smooth integration with the model data as distance from the observational site increases.

Table 7.1 Frequency Distribution of Wind Speed (m/s) and Direction from Observational Data

Direction	0.0 to 0.5	0.5 - 1.5	1.5 – 3.0	3 - 5	5.0 - 7.5	7.5 - 10.5	10.5 – 14.0	>14.0	Total %
Calm	2.2	-	-	-	-	-	-	-	**2**
N	-	1.9	5.4	1.9	0.3	0	0	0	**10**
NNE	-	1.3	1.4	1.0	0.1	0	0	0	**4**
NE	-	0.7	0.3	0.1	0	0	0	0	**1**
ENE	-	0.7	0.2	0	0	0	0	0	**1**
E	-	0.5	0.3	0	0	0	0	0	**1**
ESE	-	0.7	0.9	0	0	0	0	0	**2**
SE	-	0.6	3.1	3.5	0.5	0	0	0	**8**
SSE	-	0.7	4.1	9.4	13.7	8.8	0.4	0	**37**
S	-	0.8	2.3	2.0	1.2	0.4	0	0	**7**
SSW	-	0.3	1.0	1.2	0	0	0	0	**3**
SW	-	0.4	1.2	0.6	0	0	0	0	**2**
WSW	-	0.4	1.0	1.0	0	0	0	0	**2**
W	-	0.3	0.7	0.6	0.2	0	0	0	**2**
WNW	-	0.6	0.6	0.5	0.4	0.1	0	0	**2**
NW	-	1.0	2.3	0.7	0.7	0.2	0	0	**5**
NNW	-	1.8	6.3	2.6	1.4	0.1	0	0	**12**
Total %	**2**	**13**	**31**	**25**	**19**	**10**	**0**	**0**	**100**

Note. Any slight discrepancy between the totals and the sum of the value is due to rounding off.

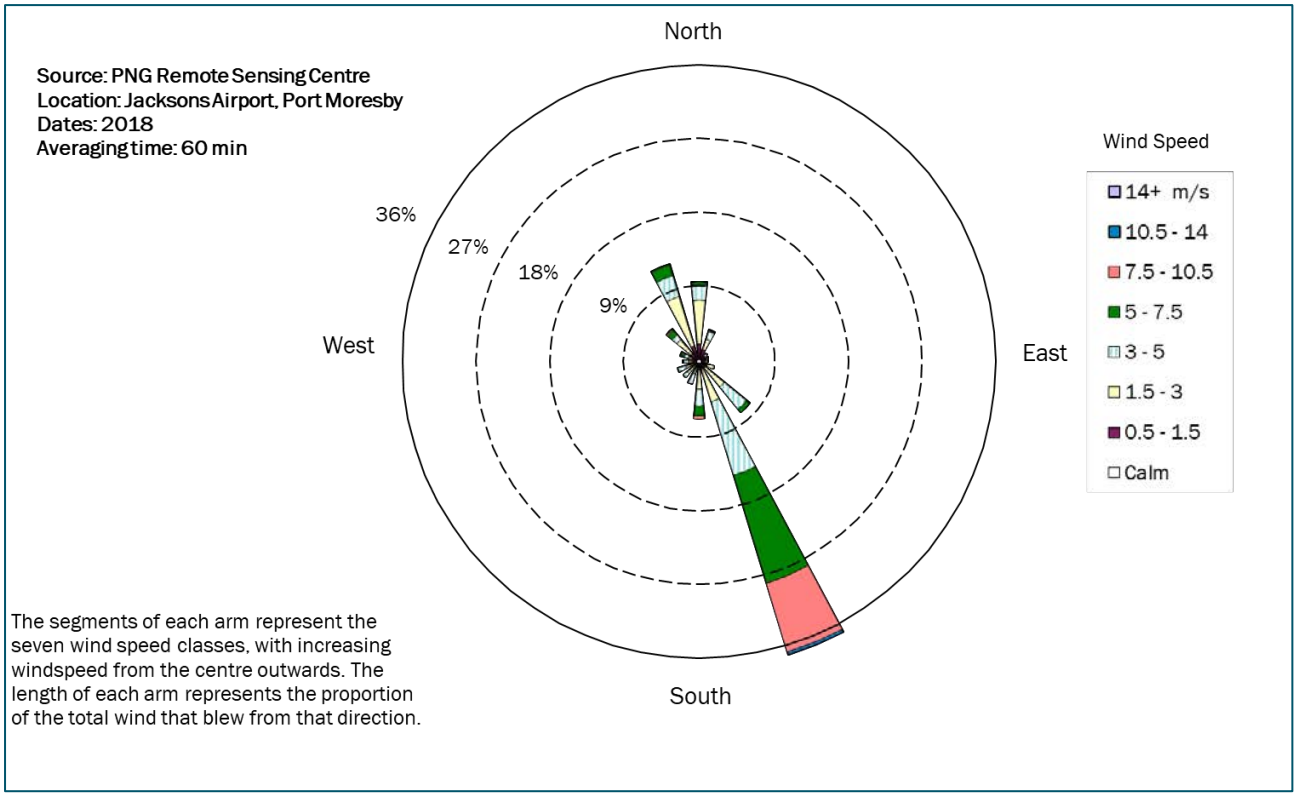


Figure 7.1 Wind Rose of Jacksons Airport Weather Station Data

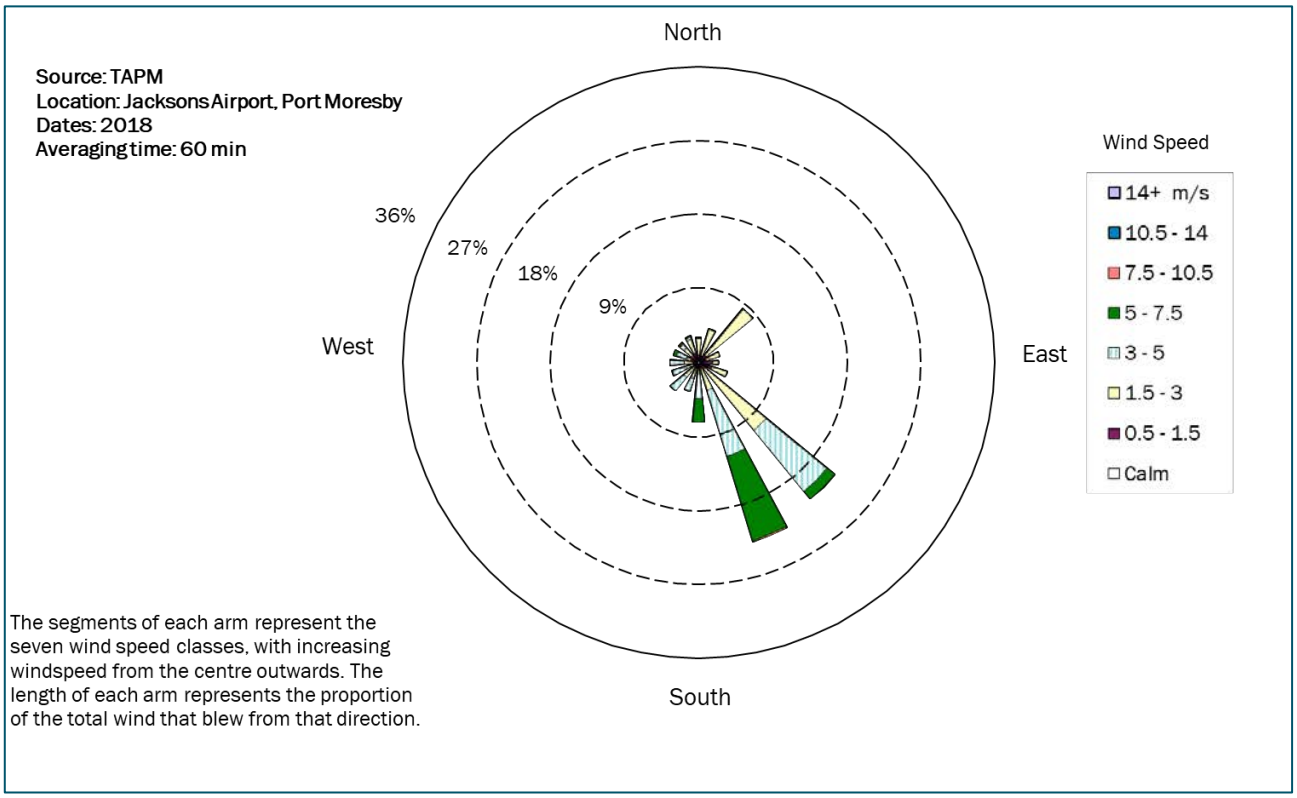


Figure 7.2 Wind Rose from TAPM for Same Period as Jacksons Airport Weather Station Data

7.1.4 TAPM Validation

The TAPM GIS visualisation tool was used to examine the final windfields generated by the model. The last few hours of the year were reviewed to ensure the model completed the run correctly. The windfields in the inner grid throughout the month of June were examined in detail to understand the local wind patterns, influence of topography, and to ensure that the data assimilation had progressed smoothly. The following patterns were observed:

- Wind speeds over the water were consistently and substantially higher than those over the land, as expected.
- Wind in the vicinity of the observational station was consistent with the remainder of the inner grid.
- Winds are consistently from the south-east quarter.
- Morning winds were mostly moderate.
- Afternoon winds were mostly strong.
- Night winds were mostly light.

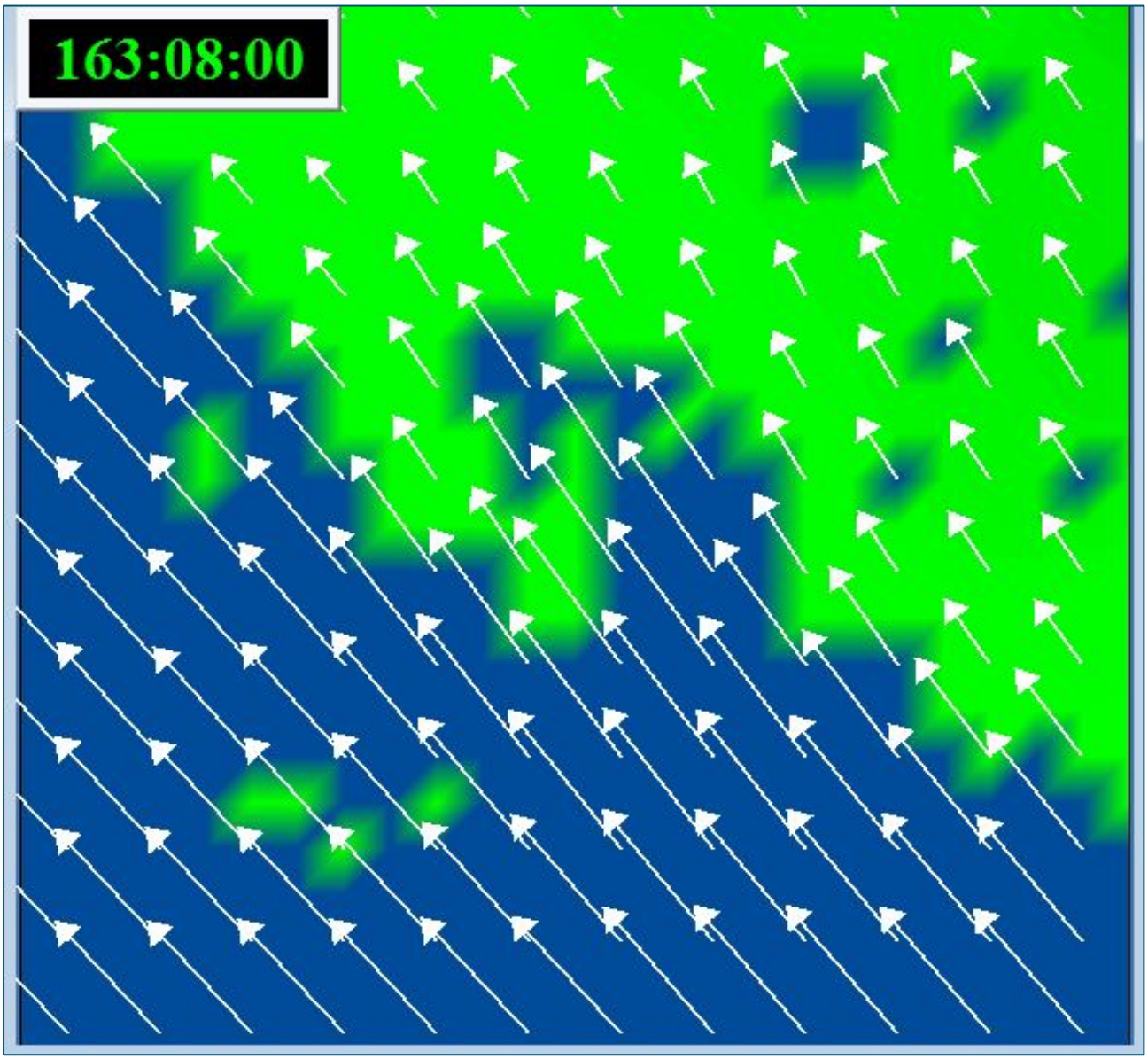


Figure 7.3 Example of TAPM Predicted Wind Flows for 12 June 2018 8am

7.2 Topography and Land Use

For the purpose of providing topographic data for the detailed modelling, the coordinates of a rectangular grid representative of the area around the proposed site were derived using WGS84 coordinates from Google Earth Professional. Calmet was run using two nested domains. The outer domain's south-west corner coordinates were (504186, 8947384), north-east corner coordinates were (519186, 8962384) and the grid interval was 200 metres. The inner domain's south-west corner coordinates were (507430, 8953395), north-east corner coordinates were (510930, 8956895) and the grid interval was 50 metres.

The WGS84 and GDA94 grids are identical to an accuracy of less than one metre. All coordinates in this report are rounded off to the nearest metre and are valid for both coordinate grids.

Gridded topographic data for Calmet was created using Global Mapper to process the Shuttle Radar Topography Mission (SRTM) elevations on a 1-second grid (approximately 30 metre spacing) and Open Street Map terrain file with approximately 25 metre spacing, both in GDB database file format, using the Kriging method. The gridded file was overlayed onto an SRTM3 (approximately 90 metre spacing) before exporting for input into Calmet to fill out missing terrain data from the gridded file.

The land use and topography in the two nested Calmet domains are shown in **Figure 7.4** and **Figure 7.7**.

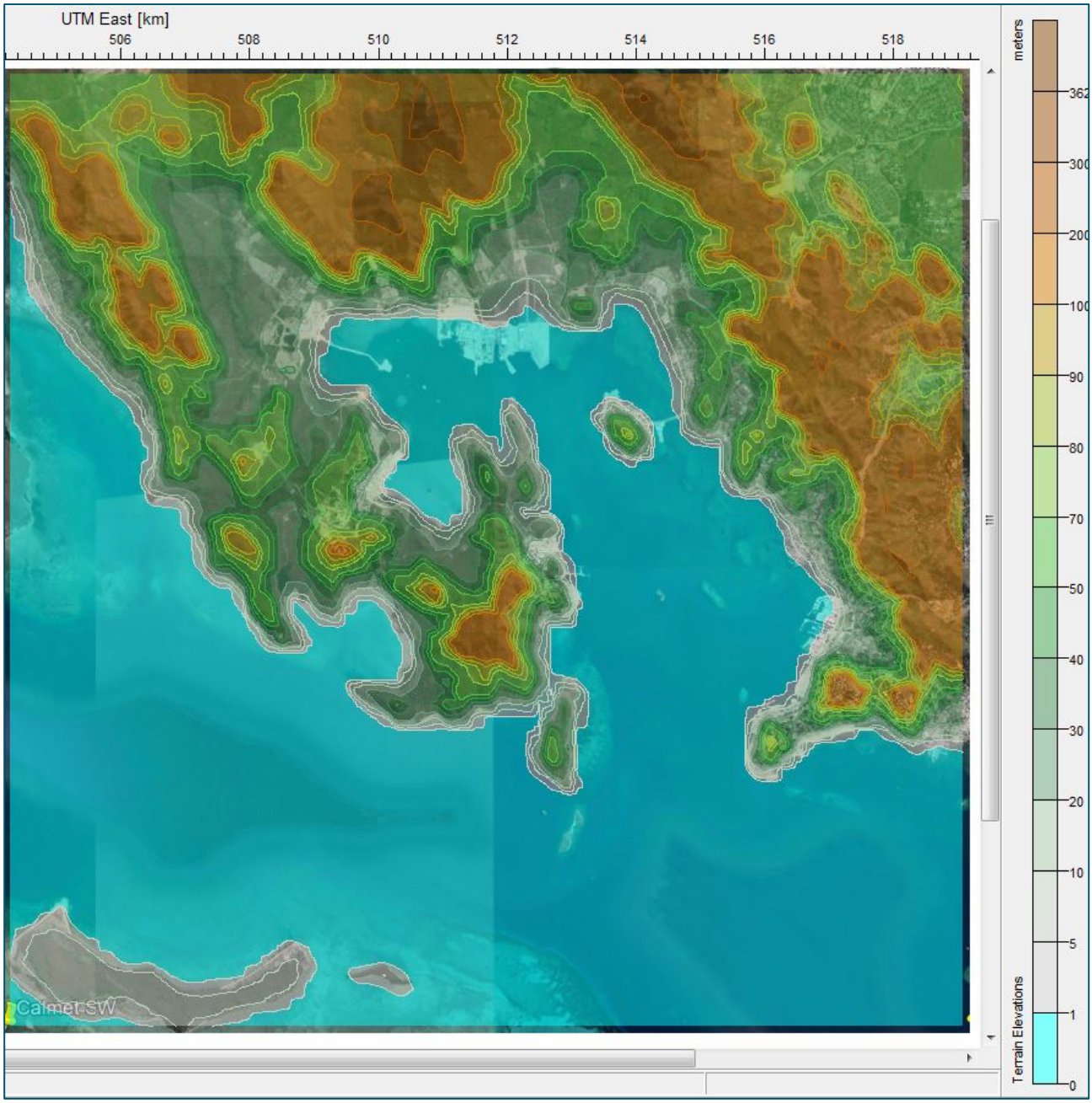


Figure 7.4 Terrain in the Outer Calmet Model

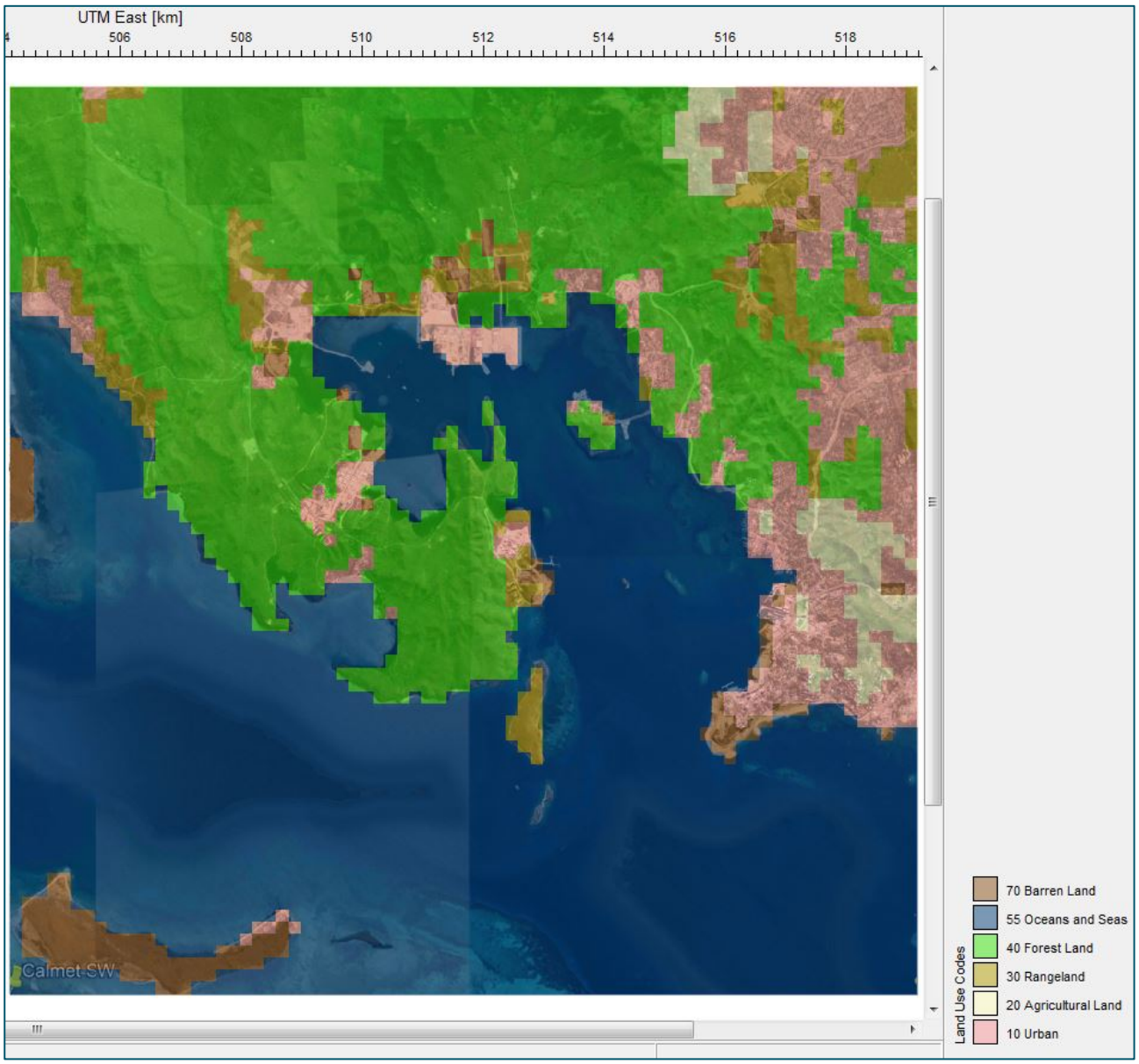


Figure 7.5 Land Use in the Outer Calmet Model

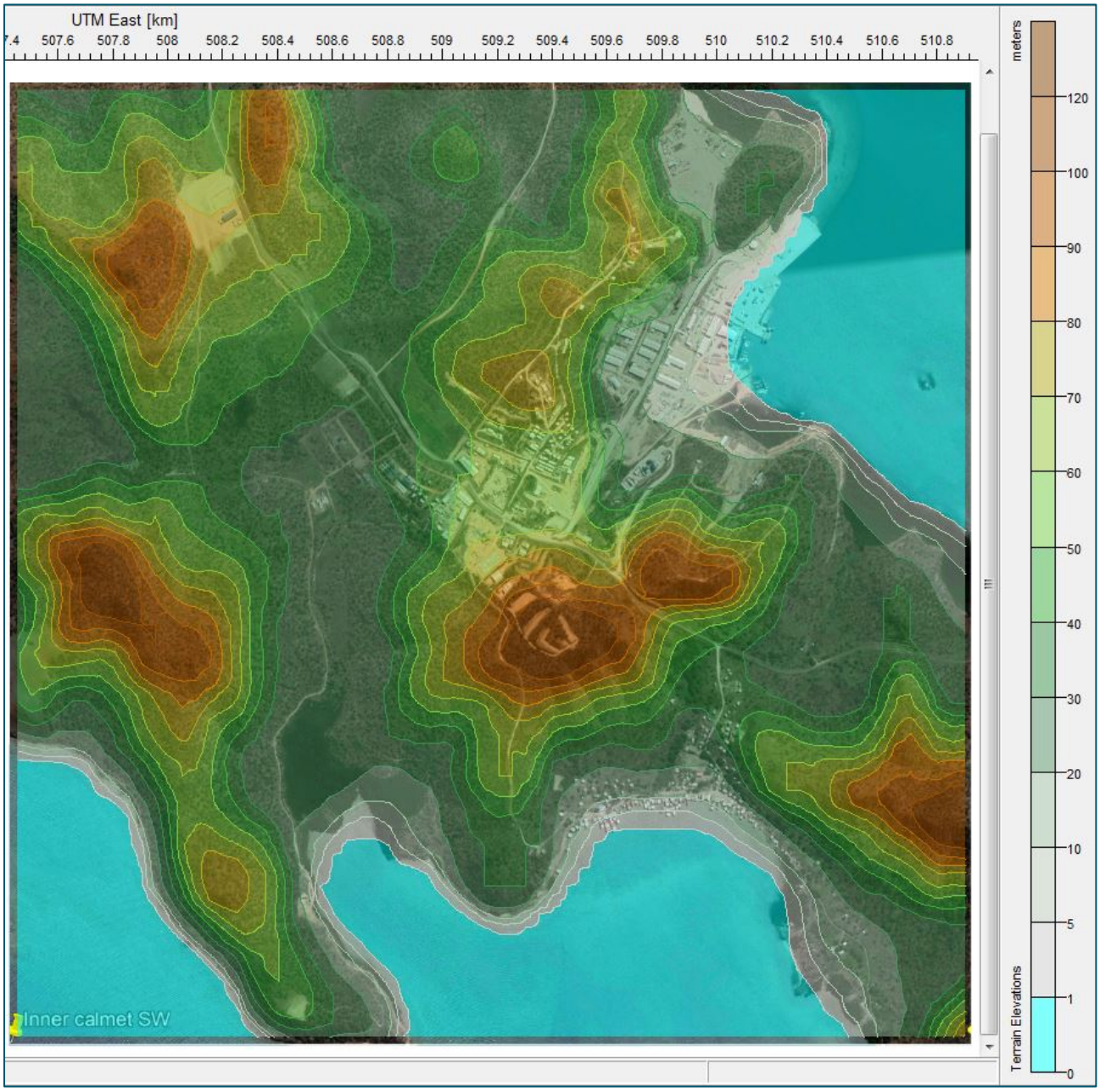


Figure 7.6 Terrain in the Inner Calmet Model

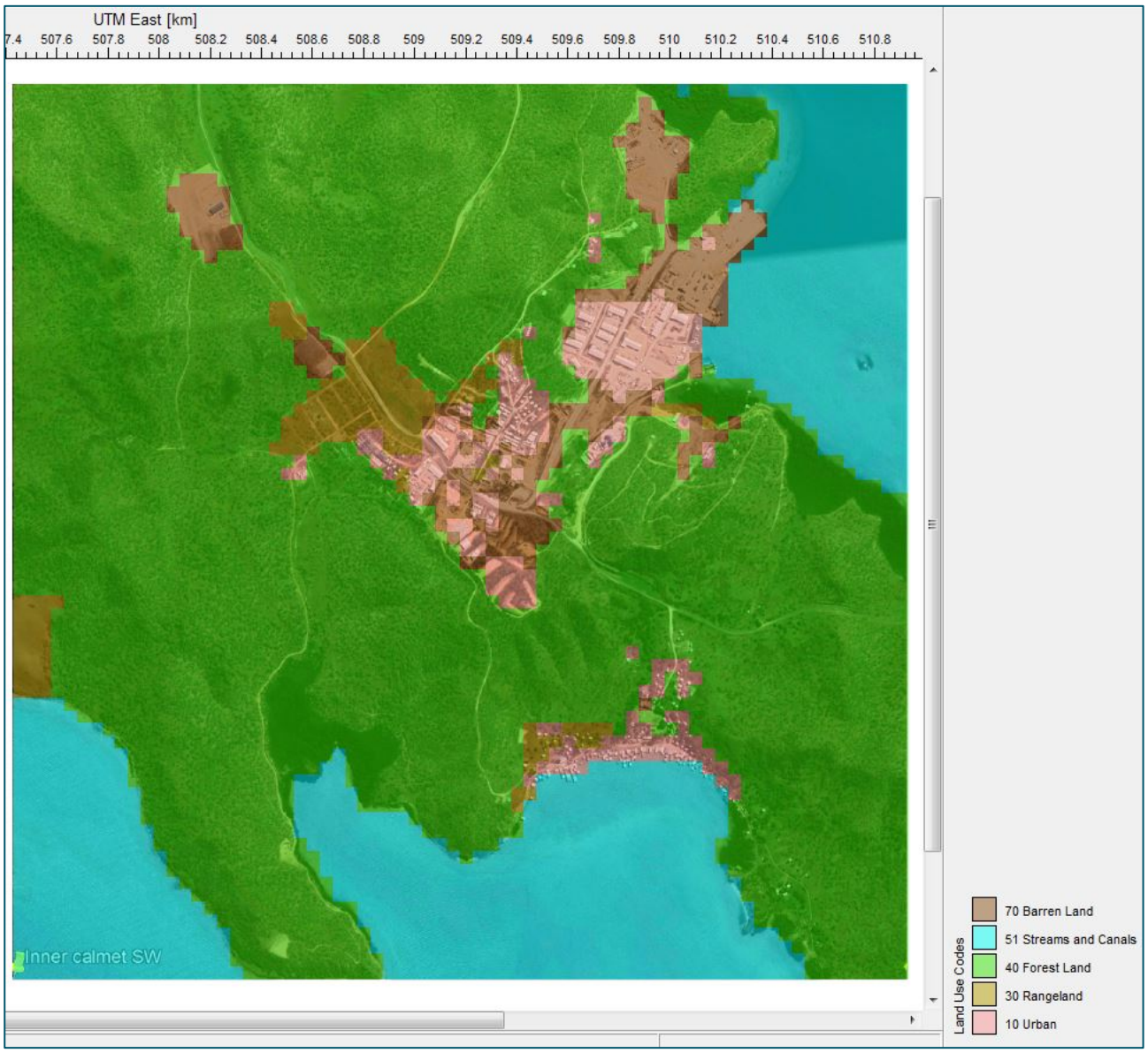


Figure 7.7 Land Use in the Inner Calmet Model

7.3 Calmet Modelling Configuration.

The Calmet configuration used is consistent with NSW OEH guidance (TRC 2011).

To include the effects of both regional and local complex terrain and varying surface features, Calmet was run over two nested domains. The model was run over the full year of 2018 based on a 3-dimensional grid produced using the Caltapm utility program to convert TAPM data to MM5 format suitable for Calmet to read. The first Calmet domain was set to grid spacing of 200 metres and 75 by 75 grid points. The output of the first Calmet domain, along with TAPM extracted surface and upper air input files, was used as input into the second Calmet domain. The second Calmet run was undertaken to refine the initial Calmet domain with higher resolution.

Twelve vertical layers were modelled with cell face heights of 0, 20, 40, 80, 160, 300, 450, 650, 900, 1200, 1700, 2300, and 3200 metres. This is greater than normal number of vertical layers in order to provide better resolution of vertical layers.

Mixing height calculation parameters were set to default values except the Coriolis parameter which was set to 2.39×10^{-5} as calculated from the Coriolis parameter equation, $f = 2\Omega \sin(\phi)$ where f is the Coriolis parameter, Ω is the Earth's rotation rate ($2\pi/86400$ or 7.29×10^{-5} rad·s^{-1}) and φ is the latitude which in this case is -9.45°.

Temperature prediction parameters were set to default.

Divergence minimisation was used. Slope flow effects were included. The radius of influence of terrain features was set to 2 kilometres for the outer Calmet run and 1 kilometre for the inner Calmet run. As surface and upper air input files are required as input to run a second Calmet nest, surface and upper air files were extracted at a point on the western flatter side of the inner Calmet. The maximum radius of influence for wind field interpolation (RMAX1, RMAX2 and RMAX3) was set to 1 kilometre and the relative weighting of step 1 field vs. observations was set to 0.5 kilometres (R1 and R2), such that the influence of these datafiles is limited to a small portion of the domain at the south-west corner.

The output from the inner Calmet run was a three dimensional grid of wind-field data for incorporation into Calpuff.

7.4 Calmet Results

7.4.1 Wind Speed and Direction

The frequency distributions of occurrences of winds for each direction sector and for each wind speed class as predicted by Calmet are shown in **Table 7.2** and illustrated as wind roses in **Figure 7.8**. The frequency of calm to light winds up to 1.5 m/s is 19%. The wind roses show predominant winds from the south-east quarter.

Table 7.2 Frequency Distribution of Wind Speed (m/s) and Direction Predicted by Calmet

Direction	0.0 to 0.5	0.5 - 1.5	1.5 – 3.0	3 - 5	5.0 - 7.5	7.5 - 10.5	10.5 – 14.0	>14.0	Total %
Calm	2.3	-	-	-	-	-	-	-	**2**
N	-	0.9	1.6	0.1	0	0	0	0	**3**
NNE	-	0.7	0.6	0.1	0	0	0	0	**1**
NE	-	0.4	0.2	0	0	0	0	0	**1**
ENE	-	0.2	0.1	0	0	0	0	0	**0**
E	-	0.3	0.0	0.0	0	0	0	0	**0**
ESE	-	0.6	0.4	0	0	0	0	0	**1**

Direction	0.0 to 0.5	0.5 - 1.5	1.5 – 3.0	3 - 5	5.0 - 7.5	7.5 - 10.5	10.5 – 14.0	>14.0	Total %
SE	-	1.1	4.1	6.8	0.2	0	0	0	**12**
SSE	-	1.4	6.2	21.8	11.2	0	0	0	**41**
S	-	1.1	2.0	1.9	0.3	0	0	0	**5**
SSW	-	0.7	1.4	0.2	0	0	0	0	**2**
SW	-	0.7	2.1	0	0	0	0	0	**3**
WSW	-	0.9	2.1	0.1	0	0	0	0	**3**
W	-	1.1	2.0	0.8	0	0	0	0	**4**
WNW	-	1.5	1.8	1.0	0	0	0	0	**4**
NW	-	2.7	4.2	1.4	0.1	0	0	0	**8**
NNW	-	2.6	4.8	1.3	0	0	0	0	**9**
Total %	**2**	**17**	**34**	**36**	**12**	**0**	**0**	**0**	**100**

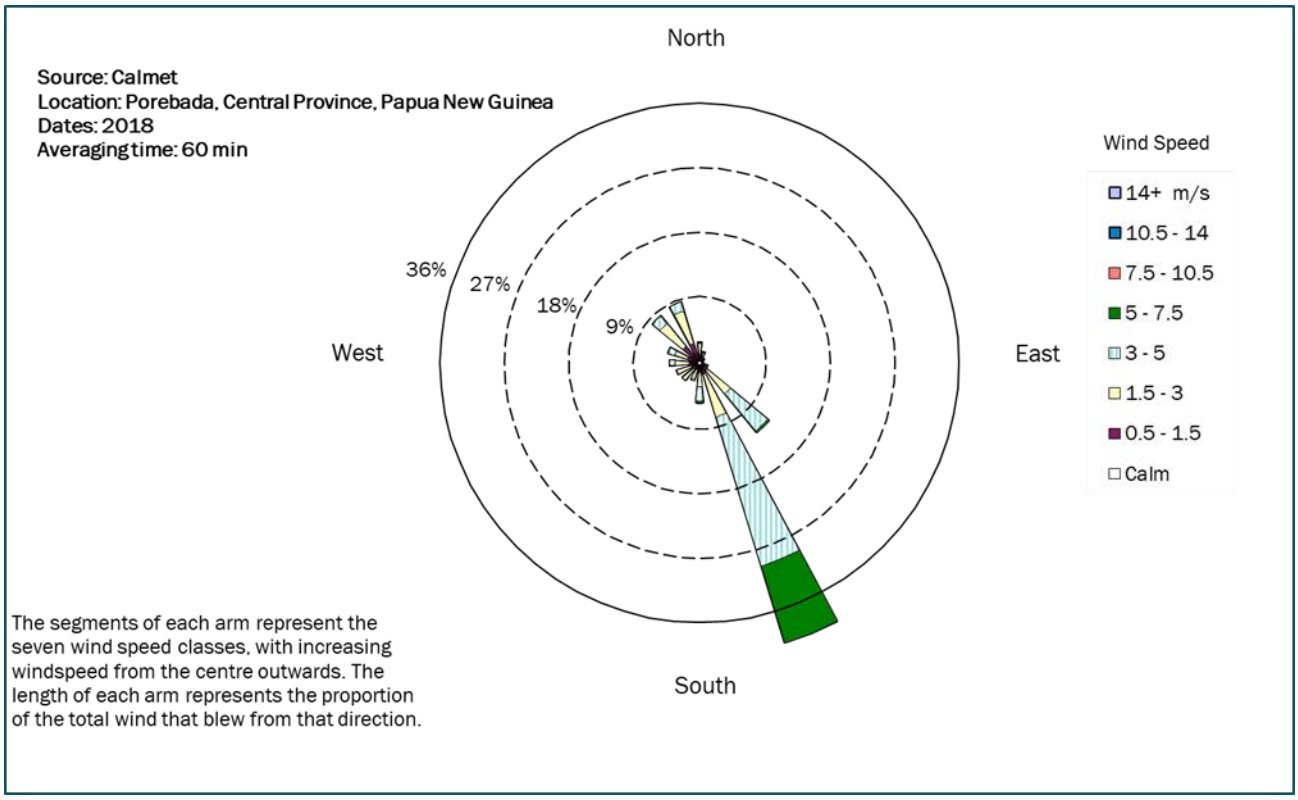


Figure 7.8 Wind Rose from Calmet Data

7.4.2 Stability Class

Figure 7.9 shows the frequency of stability classes throughout the day.

Day time conditions are either neutral or unstable, whilst night time conditions are stable. Modelling of emissions will therefore consider this high proportion of stable conditions, which may lead to lesser dispersion of ground level or downwashed emissions, whilst maintaining height on elevated emissions not subject to downwash. Structural downwash will therefore be important in the dispersion modelling.

The breakup of the night-time stable conditions is rapid at dawn and the reformation in the evening is slow compared to typical Australian conditions.

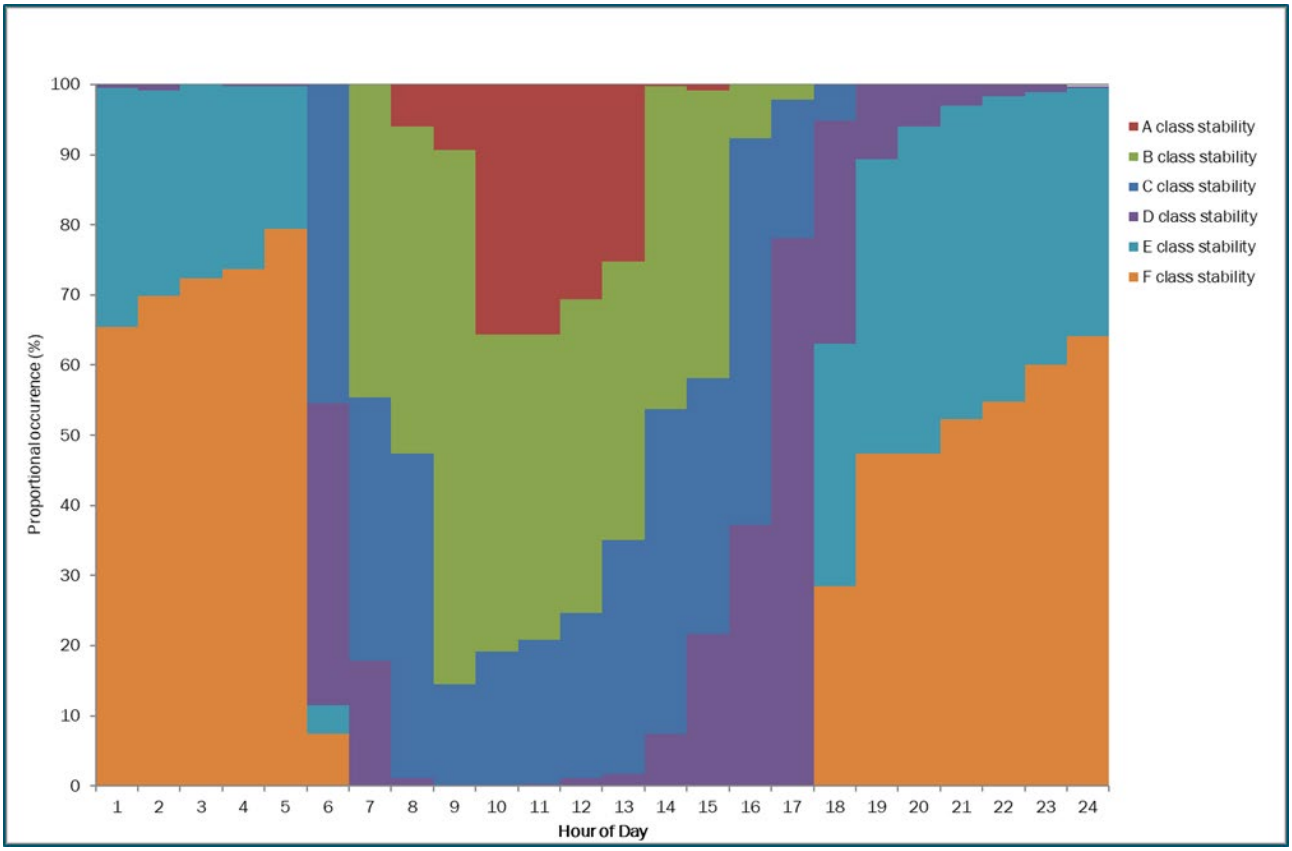


Figure 7.9 Diurnal Frequency of Stability Classes

7.4.3 Mixing Height

Figure 7.10 shows the variation of mixing height throughout the day.

In the morning the mixing height rises up gradually reaching an average of approximately 1.9 kilometres by the afternoon, then reforming near ground level again at nightfall.

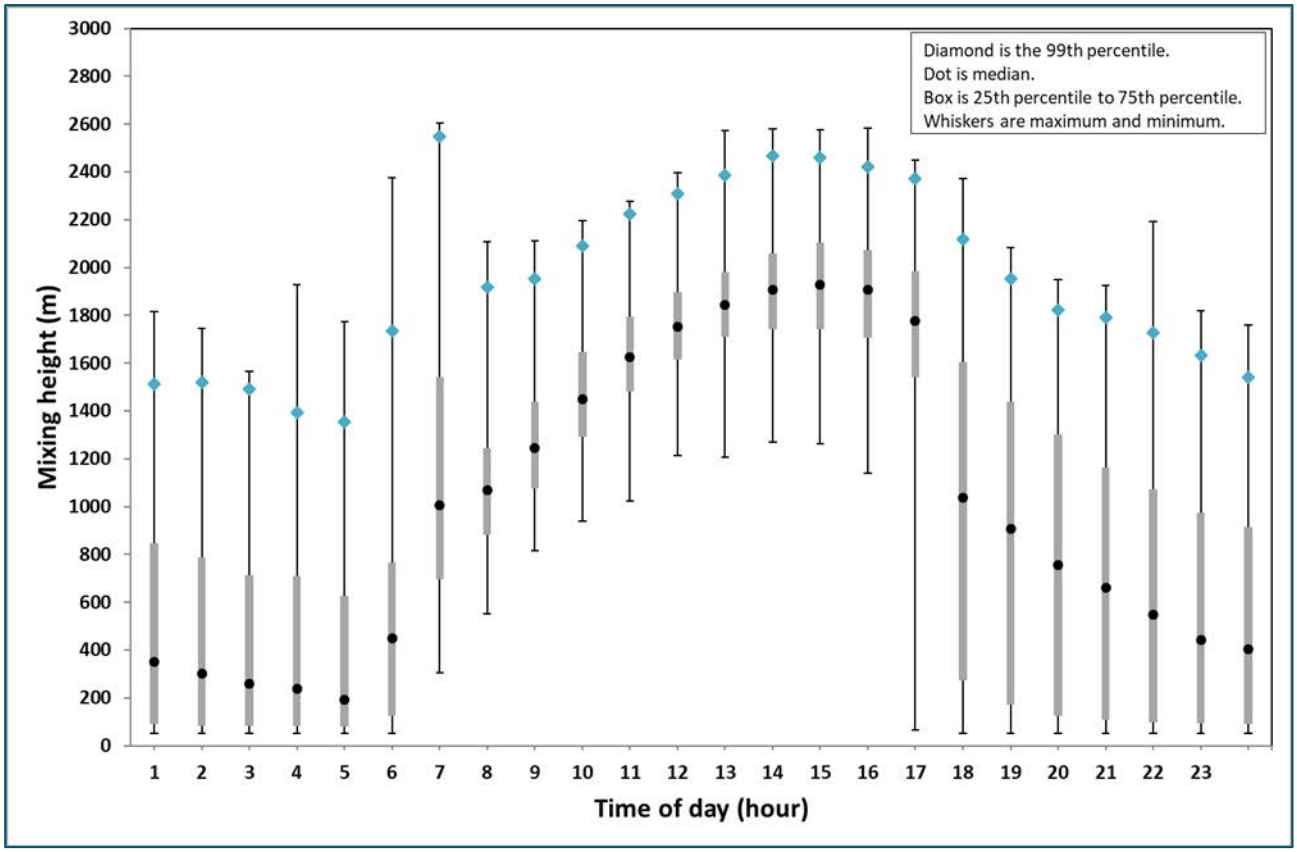


Figure 7.10 Prediction of Mixing Height from Calmet Model

It shows mixing layer heights are commonly 100 to 800 metres above ground during the hour ending 6am, and 700 to 1,500 metres above ground in the hour ending 7am. Night time inversion heights are commonly higher than in Australia.

8. Background Air Quality

8.1 Monitoring

Air quality monitoring was undertaken at the TWM site from the 5th to 10th of November 2018.

The position of the external monitoring location is shown in **Figure 8.1**.



Figure 8.1 Air Quality Monitoring Location

8.1.1 Monitoring Methodology

A TSI DustTrak II Aerosol Monitor 8530 (serial number 8530114502), calibrated on 23 March 2018 was used for particulate measurement within the site. It is a light scattering photometer measuring aerosol concentrations in the range from 0.001 to 400 µg/m^3. The air sample passes through a laser beam in a photometer and then through a filter to remove the aerosols before reaching the pump. The light is scattered by the individual particles of dust. A significant portion of the scattered light is captured by a gold coated

spherical mirror which focuses the light on to a photo detector where light is converted into an electrical pulse which is proportional to the mass concentration of the aerosol.

The monitor was setup to log particulate concentrations with a one minute sampling time-step. The inlet was configured for sampling of TSP.

8.1.2 Monitoring Results – Particulate Monitoring

Particulate monitoring was undertaken from 5 November 2018, 5:59pm to 10 November 2018, 1:30pm, with a gap of approximately one hour from 6 November, 12:16pm to 1:08pm. A summary of the 24-hour average particulate monitoring results is shown in **Table 8.1**. Data on 5 and 10 November were not included as they were insufficient to determine the 24-hour average concentrations.

To estimate the PM_{10} concentrations, the TSP concentrations were multiplied by 0.39 which is the typical ratio of PM_{10} to TSP around Australian mines (ACARP, 1999). An assumed $PM_{2.5}$ to TSP ratio of 0.1 was used to estimate the $PM_{2.5}$ concentrations.

Table 8.1 24-Hour Average Particulate Concentrations

Date	Measured TSP Concentration (µg/m³)	Calculated PM_{10} Concentration (µg/m³)	Calculated $PM_{2.5}$ Concentration (µg/m³)
6/11/2018	56	22	6
7/11/2018	100	39	10
8/11/2018	74	29	7
9/11/2018	71	28	7
Average	**75**	**29**	**8**
Maximum	**100**	**39**	**10**

8.1.3 Monitoring Summary

A summary of the air pollutant concentrations is provided in **Table 8.2** with the relevant EP-L2(485) criteria except for TSP. As shown, all pollutants are well below their criteria except for TSP. The TSP concentration approach the relevant criterion, however there is no TSP criterion in the EP-L2(485).

Table 8.2 Summary of Air Pollutant Concentrations

Pollutant	Averaging Period	Concentrations (µg/m³)	TWM EP L2 Criteria (µg/m³)
TSP	1 year [2]	75	90 [1]
PM_{10}	24 hours [3]	39	150
	1 year [2]	29	70
$PM_{2.5}$	24 hours [3]	10	75
	1 year [2]	8	35

Note:

1. *Based on Queensland and New South Wales regulations.*
2. *The average measured concentrations for the monitoring period were used for the one-year averaging period.*
3. *The maximum concentrations were reported for averaging periods of less than a year.*

Overall, the background air quality during the monitoring period had relatively high concentrations of particulates. Site observations suggest that a major source of particulates was vehicle traffic on the access road to the port, north of the site.

Although monitoring should ideally be undertaken in accordance to recognised standard methods and for a period of at least one year to determine background levels, the levels in **Table 8.2** have been used as background due to the absence of more complete data. Comparison of the data to those measured by the DES Gladstone air quality monitoring network, the data appears reasonable as they are higher than typically measured by monitoring stations classified as neighbourhood, even relatively near industrial facilities, and similar to levels measured by monitoring station at an industrial facility classified as peak.

8.2 Dust Deposition

Dust deposition varies substantially depending on local sources. Any dust deposition data for the local area is not publicly available.

Background dust deposition levels vary according to local sources. In rural agricultural or industrial areas, they are typically 50 mg/m^2/day. In urban areas they are typically 40 mg/m^2/day, and in rural forested areas typically 30 mg/m^2/day or less.

For this assessment, a background level of 50 mg/m^2/day has been adopted.

8.3 Dioxins

Typical Australian background concentrations of dioxins and furans have been published by Department of the Environment & Heritage (Gras *et al* 2004). The average TEQ dioxin and furan concentration over a year was 0.0089 pg/m^3 at Eagle Farm and 0.0015 pg/m^3 at Mutdapilly. Eagle Farm is in an industrial area of Brisbane, whilst Mutdapilly is in a rural area to the west of Brisbane. The adopted background level for this study is 0.01 pg/m^3, which provides a conservative over-estimate of expected concentrations.

8.4 Polycyclic Aromatic Hydrocarbons

Brisbane background concentrations of benzo(a)pyrene have been reported in five studies and provide an indication of typical urban background:

- Kumar (2008) found an average of 0.1 ng/m^3 in 56 PM_{10} samples at Rocklea in 2003 and 2004.
- Yang (1991) found an average of 0.89 ng/ m^3 in TSP samples at a roadside location in Brisbane.
- Muller (1998) found an average of 0.32 ng/ m^3 in TSP samples at a roadside location in Brisbane.
- Lim et al (2005) found that benzo(a)pyrene in TSP samples were below detection limits (0.001 ng/ m^3) at ANZ stadium in Robertson in 2002. Lim et al (2005) also measured other PAHs.
- Martin & Mejia (2010) reported that in 10 samples analysed for PAHs at Willawong in 2010, all benzo(a)pyrene measurements were below the limit of reporting 0.4 ng/ m^3.

The Kumar study appears to be a robust measure of background as the Yang and Muller studies are more likely affected by vehicle engine emissions, the Lim et al study is less conservative, and the Martin & Meija measurement is below the limit of reporting. The average measured concentration by Kumar (2008) was therefore used in this assessment.

8.5 Other Pollutants

Background concentrations of the other assessed pollutants including lead, mercury, hydrogen chloride, arsenic, nickel and HCB are not routinely monitored and are expected to be negligible.

9. Emission Inventory

9.1 Modelling Scenarios

There were two scenarios modelled: the base case scenario which includes activities approved under TWM's current EP L2-(485), and the proposed scenario which extends the approved activities with storage, treatment, reprocessing, incineration or disposal of hazardous contaminants. The emissions were modelled to be occurring during the proposed hours of operation: Monday to Friday 7am to 5pm and Saturday 7am to 12pm, except for activities that were scaled based on wind speeds: wind erosion and material handling, loading and unloading. Wind erosion could occur outside operating hours when wind conditions are met. Material handling and loading and unloading would only occur within operating hours.

9.2 Fugitive Dust Emissions

Dust emission sources at the proposed waste transfer station would be as follows:

- Screening
- Crushing
- Material handling
- Truck loading and unloading
- Dozing
- Vehicle movements
- Wind erosion from exposed areas

The emission rates entered into the dispersion modelling are based on the activity and source information discussed in **Section 3**. **Appendix C** provides the calculations methods for the modelled emission sources.

Note that the typically-used equations from the Australian NPI manual are designed for estimating total annual emissions. Some of the equations are based on annual averages of wind speed and rainfall. Using annual averages is not appropriate for dispersion modelling where maximum concentration may occur during dry and windy conditions. Therefore, in this project, rain has been removed from the emission calculations and, emission rates are variable dependent on wind speed category.

The proposed IWMF is expected to receive up to 150,000 tonnes of commercial and industrial waste materials annually. These volumes may vary over time depending on TWM client operating and expansion program requirements. There is no indication of the future volume increase. Hence, this assessment is mainly based on the amount of materials presented in **Table 3.1**.

9.2.1 Emission Inventory Calculations

The emission rates entered into the dispersion modelling are based on the activity and source information provided by TWM as presented in **Section 3**.

Dust emission rates were estimated using the base equation:

$$ER = A\ x\ EF\ x\ (1 - CF)$$

where:

ER = emission rate (typically in g/s)

A = activity or operations data

EF = emission factor based on AP-42 or NPI

CF = emissions reduction after implementation of dust control measures.

Table 9.1 presents the activities and corresponding amount of materials modelled.

Table 9.1 Activities Modelled

Activities	Amount of Materials (tonnes per annum)		Comment
	Base Case (EP L2)	**Proposed (EP L3)**	
Receival Area • Truck unloading • Material handling • Truck loading • Wind erosion	95,000	95,260	The additional 260 tonnes per annum for the proposed scenario are for the additional hazardous wastes listed in **Table 3.1** other than waste oils. Other additional wastes, including e-waste, plastics in recycling, and asbestos are assumed to be minimal in comparison to the total amount of materials received and would make indiscernible difference to air quality. In addition, these wastes have very minimal dust emissions except for asbestos which will be packed to prevent asbestos dust from being released.
Recycling Area • Truck unloading • Material handling • Truck loading • Wind erosion	70,000	70,000	-
• Glass crushing	23,333	23,333	Without available information, the amount of glass received was assumed to be one-third of the recyclables received.
• Glass and compost screening	46,667	46,667	Without available information, the amount of compost produced was also assumed to be one-third of the recyclables received.
• Material handling for composting (x4) ○ Pre-mixing compost feed ○ Feeding to in-vessel ○ Transfer to aerated windrows ○ Physical turning of the compost pile	23,333	23,333	
Incineration • Ash loading to trucks • Truck unloading wastes • Stack emission	1,434	1,434	Although the total amount to be incinerated based on **Table 3.1** is 5,500 tonnes per year, this is well above the incinerator capacity of 500 kg of

Activities	Amount of Materials (tonnes per annum)		Comment
Fixation • Unloading of incineration ash	1,434	1,434	wastes per hour. The emissions modelled were based on the incinerator capacity. Without a breakdown of feed materials, and as some of the incinerator feed is contaminated soil which will likely have a high proportion of incombustible materials, the amount of ash produced was conservatively assumed to be equal to the wastes received. It was also further assumed conservatively that all wastes unloaded would generate dust upon unloading as with soil. In reality, the amount of ash would generally be substantially less than the wastes incinerated, and not all wastes would be dusty.
• Cement unloading to silo • Mixer loading	615	1,127	According to a study by Suryawan et al (2019) and Lam et al (2010), stabilisation using a bottom and fly ash to cement ratio of 75:25 can meet the quality standards discharge to landfill. Rozumova et al (2015) has found that 30% cement addition and 28 days solidification period is ideal among the combinations they tested. For this assessment, the stabilisation mixture was assumed to consist of 30% cement. The additional cement for L3 is for the stabilisation of the additional hazardous wastes particularly biocides and non halogenated solvents. The proportion is based on 256 kg cement and cement supplement to 75 litres of water (USEPA, 2011).
• Aggregate and sand transfer	-	2,988	The aggregate and sand addition was assumed based on concrete material ratio of 1,494 kg aggregate and sand to 75 litres of water (USEPA, 2011).
Quarry • Feeding to vibrating chute • Truck loading • Wind erosion	100,000	100,000	-

Activities	Amount of Materials (tonnes per annum)		Comment
• Material handling ○ Scalping fines to stockpile ○ Primary stockpile ○ Blinding stockpile ○ Final screening stockpile	25,000 each	25,000 each	It has been assumed that the amount of materials quarried will be evenly distributed to each stockpile of varying sizes
• Primary crushing	75,000	75,000	-
• Secondary crushing	50,000	50,000	-
• Tertiary crushing	25,000	25,000	-
• Quaternary crushing	25,000	25,000	-
• Screening (x3) ○ Screening after primary crushing ○ Screening after secondary crushing ○ Screening after quaternary crushing	25,000	25,000	-
Landfill Operations • Truck unloading • Material handling • Dozing • Wind erosion	25,000	25,000	Although there will be additional materials to be landfilled from the fixation bay and received asbestos, these materials will be not be generating dust with the way they are treated (stabilised and solidified) and packaged, and hence have not been included in the modelled dust-emitting activities in the landfill. There will be a slight increase in traffic from fixation bay to landfill due to the additional landfilled materials, but the increase is only minimal.
Truck traffic	Modelled hourly frequency of movement		It has been assumed than 10% of materials in the recycling area will go to landfill and the rest will be taken off-site. Truck traffic for other haul routes has not been included as these have very minimal traffic movements and are already compensated by the over-estimation of traffic movements on some of the haul routes modelled. The total number of trips calculated is 11 per hour, whereas 15 trips have been modelled per hour. The increase in number of trips for the proposed scenario was calculated to be 0.3 per hour or up to 3 trips per day and mainly
• Off-site to receival area	3	3	
• Receival area to recycling area	2	2	
• Quarry to off-site	1	1	
• Recycling to landfill	1	1	
• Recycling to offsite	2	2	
• Incinerator to fixation	1	1	
• Off-site to industrial wastewater	1	1	
• Fixation to landfill	1	1	

Activities	Amount of Materials (tonnes per annum)		Comment
• Within quarry/landfill	3	3	using forklifts on road. This increase in the number of trips is not likely to cause discernible changes to the air quality.

The parameters used to calculate the fugitive dust emissions are presented in **Table 9.2**.

Table 9.2 Emission Inventory Parameters

Parameter	Value	Comment
Moisture content (quarry materials)	9.4%	ACEM Geotechniques (2018)
Moisture content (other materials)	4.1%	PEL (2015)
Moisture content (ash)	10%	Based on the ideal water percentage of 10-12% for wet sorting of bottom ash (ISWA, 2015)
Silt content (landfill materials)	4%	PEL (2015) Used for dozing emission
Silt content (road with bentonite dust suppressant)	4.8%	Utah DAQ (2015)
Average truck weight (haul trucks for quarry materials)	54 tonnes	Based on average payload of 55 tonnes and gross combined mass (GCM) of 82 tonnes for haulage truck 2007 Western Star 4800 FX stratosphere and dump truck 2012 CAT 740B 6x4 articulated (Truck Sales, 2020a & RichieSpecs, 2020)
Average truck weight (haul trucks for other materials)	14 tonnes	Based on average payload of 11 tonnes and GCM of 20 tonnes for three 6x4 articulated trucks, one 3 tonne truck and two 4x2 articulated light trucks (Alibaba, 2020, Isuzu, 2020 and Fuso, 2020)
Average forklift weight	1.8 tonnes	Assumed to be used for hauling materials from incinerator to fixation and fixation to landfill. Based on a lift weight of 1.5 tonnes and service weight of 2.55 tonnes (Toyota, 2020)
Average truck weight (wastewater tanker)	30 tonnes	Based on a payload of 7 tonnes and GCM of 33 tonnes (Truck Sales, 2020b)

9.2.2 Dust Control Measures

Emission controls to reduce particulate emissions that have been included in the dispersion modelling are presented in **Table 9.3**.

Table 9.3 Dust Emission Controls

Emission Source	Control Efficiency Applied (%)	Reference
Wind erosion in receival and recycling shed	30	DSEWPC (2012)
Unpaved road with bentonite suppression and watering	85	Utah DAQ (2015)

In addition to the controls listed in **Table 9.3**, pit retention factors of 50% for TSP and 5% for PM_{10} were utilised for activities located within the quarry/landfill pit. These factors are specified by Environment Australia (2012).

Table 9.4 and **Table 9.6** present the modelled fugitive sources. These activities are modelled to occur Monday to Friday 7am to 5pm and Saturday 7am to 12pm, except for sources which are scaled based on wind speeds. Material handling sources are scaled based wind speeds as shown in **Table 9.5**. The emission rates that are different for the proposed scenario in comparison to the base scenario are in bold in **Table 9.4**. Wind erosion emissions are the same for both scenarios.

Table 9.4 Modelled Emission Rates for Volume Sources

Location	Activities	Model Source ID	TSP Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	$PM_{2.5}$ Emission Rate (g/s)	TSP Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	$PM_{2.5}$ Emission Rate (g/s)
			Base Case Scenario			Proposed Scenario		
Receival Area	Truck Unloading [1]	RHTU	1.02E-3	4.82E-4	7.23E-5	1.02E-3	**4.83E-4**	**7.25E-5**
	Material Handling [1]	RHMH	1.02E-3	4.82E-4	7.23E-5	1.02E-3	**4.83E-4**	**7.25E-5**
	Truck Loading [1]	RHTL	1.02E-3	4.82E-4	7.23E-5	1.02E-3	**4.83E-4**	**7.25E-5**
Recycling Area	Truck Unloading [1]	RCTU	7.51E-4	3.55E-4	5.33E-5	7.51E-4	3.55E-4	5.33E-5
	Material Handling [1]	RCMHv01	7.51E-4	3.55E-4	5.33E-5	7.51E-4	3.55E-4	5.33E-5
	Truck loading [1]	RCTL	7.51E-4	3.55E-4	5.33E-5	7.51E-4	3.55E-4	5.33E-5
	Glass Crushing	RCGC	6.10E-3	2.71E-3	4.07E-4	6.10E-3	2.71E-3	4.07E-4
	Glass/compost Screening	RCGS	5.65E-2	1.94E-2	2.92E-3	5.65E-2	1.94E-2	2.92E-3
	Compost handling: [1] • Pre-mixing compost feed • Feeding to in-vessel • Transfer to aerated windrows • Physical turning of pile	RCMHv02	1.00E-3	4.73E-4	7.10E-5	1.00E-3	4.73E-4	7.10E-5
Incinerator	Ash loading to trucks [1]	IALT	4.41E-6	2.09E-6	3.13E-7	4.41E-6	2.09E-6	3.13E-7
	Truck unloading waste [1]	ITUCS	1.54E-5	7.27E-6	1.09E-6	1.54E-5	7.27E-6	1.09E-6
Fixation	Unloading of ash [1]	FUA	4.41E-6	2.09E-6	3.13E-7	4.41E-6	2.09E-6	3.13E-7
	Cement unloading to silo	FCU	3.07E-2	1.74E-2	2.81E-3	**5.63E-2**	**3.20E-2**	**5.15E-3**
	Mixer loading	FM	1.70E-2	4.64E-3	7.49E-4	**3.12E-2**	**8.51E-3**	**1.37E-3**
	Aggregate and sand transfer	FAS	-	-	-	**2.68E-4**	**1.29E-4**	**2.08E-5**
Quarry	Feeding to vibrator chute [1]	QF	1.67E-4	1.50E-4	2.37E-5	1.67E-4	1.50E-4	2.37E-5
	Truck loading [1]	QTL	1.67E-4	1.50E-4	2.37E-5	1.67E-4	1.50E-4	9.90E-5
	Scalping fines transfer to stockpile [1]	QMHv01	4.17E-5	3.75E-5	5.92E-6	4.17E-5	3.75E-5	5.92E-6
	Primary stockpile [1]	QMHv02	4.17E-5	3.75E-5	5.92E-6	4.17E-5	3.75E-5	5.92E-6

Location	Activities	Model Source ID	TSP Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	$PM_{2.5}$ Emission Rate (g/s)	TSP Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	$PM_{2.5}$ Emission Rate (g/s)
	Blinding stockpile [1]	QMHv03	4.17E-5	3.75E-5	5.92E-6	4.17E-5	3.75E-5	5.92E-6
	Final screening stockpile [1]	QMHv04	4.17E-5	3.75E-5	5.92E-6	4.17E-5	3.75E-5	5.92E-6
	Primary crushing and screening	QCv01	2.49E-2	1.82E-2	2.87E-3	2.49E-2	1.82E-2	2.87E-3
	Secondary crushing and screening	QCv02	2.17E-2	1.54E-2	2.43E-3	2.17E-2	1.54E-2	2.43E-3
	Tertiary and quaternary crushing and fines screening	QCv03	2.08E-1	1.03E-1	1.62E-2	2.08E-1	1.03E-1	1.62E-2
Landfill	Truck unloading [1]	LFTU	1.34E-4	1.20E-4	1.90E-5	1.34E-4	1.20E-4	1.90E-5
	Material handling [1]	LFMH	1.34E-4	1.20E-4	1.90E-5	1.34E-4	1.20E-4	1.90E-5
	Dozing	LFD	2.65	0.868	0.557	2.65	0.868	0.557
Haul Roads	Off-site to receival area	URv01	8.74E-2	2.23E-2	2.23E-03	8.74E-2	2.23E-2	2.23E-3
	Receival hall to recycling	URv02	4.52E-2	1.15E-2	1.15E-3	4.52E-2	1.15E-2	1.15E-3
	Quarry to off-site	URv08	4.95E-2	1.26E-2	1.26E-3	4.95E-2	1.26E-2	1.26E-3
	Recycling to landfill	URv09	2.56E-2	6.52E-3	6.52E-4	2.56E-2	6.52E-3	6.52E-4
	Recycling to off-site	URv10	4.31E-2	1.10E-2	1.10E-3	4.31E-2	1.10E-2	1.10E-3
	Incinerator to fixation	URv11	1.97E-2	5.03E-3	5.03E-4	1.97E-2	5.03E-3	5.03E-4
	Off-site to industrial wastewater	URv12	5.03E-2	1.28E-2	1.28E-3	5.03E-2	1.28E-2	1.28E-3
	Fixation to landfill	URv13	5.99E-3	1.53E-3	1.53E-4	5.99E-3	1.53E-3	1.53E-4
	Within quarry/landfill	URv14	3.89E-3	1.88E-3	1.98E-4	3.89E-3	1.88E-3	1.98E-4

*Notes: 1. Wind-dependent emissions are scaled with the scaling factors presented in **Table 9.6**.*

Table 9.5 Scaling for Wind-Dependent Volume Sources

Wind speed	Scaling Factor
0 – 1.54 m/s	1.0
1.54 – 3.09 m/s	4.2
3.09 – 5.14 m/s	8.8
5.14 – 8.23 m/s	16.6
8.23 – 10.8 m/s	26.3
>10.8 m/s	35.1

Table 9.6 Modelled Emission Rates for Area Sources for Both Base Case and Proposed Scenarios

Location	Wind speed	TSP Emission Rate (kg/ha/h)	PM_{10} Emission Rate (kg/ha/h)	$PM_{2.5}$ Emission Rate (kg/ha/h)
Receival Area (open) and Quarry and Landfill	5.14 – 8.23 m/s	1.85E-2	9.27E-3	6.95E-4
	8.23 – 10.8 m/s	4.85E-1	2.43E-1	1.82E-2
	>10.8 m/s	1.01	5.07E-1	3.80E-2

9.3 Incinerator Stack Emissions

9.3.1 Existing Stack Testing Data

Stack emissions testing of the incinerator has been undertaken with three different approved waste streams. **Table 9.7** presents the stack testing results undertaken by Assured Environmental (2019). As shown, the worst pollutant emissions were during the incineration of general waste and hence, the modelled parameters used were those from the incineration of general waste stream. The general waste stream incinerated during the testing included food, paper and cardboard, plastics and foam and wood material or organics.

Without particle size information, the TSP emission was conservatively assumed and modelled as $PM_{2.5}$.

Table 9.7 Stack Testing Results

Parameters	General Waste	Medical Waste	Contaminated Soil	Modelled Values
Exhaust velocity (m/s)	53.4	60.9	58.4	53.4
Stack temperature (°C)	251	243	241	251
Emission rates (g/s)				
TSP	<10.8	7.8	5.4	10.8
HCl	6.6	2.52	2.4	6.6
Cadmium	0.00414	0.000480	0.00078	0.00414
Lead	0.0138	0.00780	0.00456	0.0138
Mercury	0.00840	0.00156	0.00132	0.00840
Dioxins and furans	0.000192	0.0000138	0.000015	0.000192

Note: 1. Source is Assured Environmental (2019).

9.3.2 Published Emission Data

Literature review was undertaken to determine dioxin emission rates from the incineration of hazardous waste for the modelling of the proposed scenario. The reported emission factors vary from 0.18 to 310 µg I-TEQ/tonne waste burned (Commonwealth of Australia, 2002). The very large range of the emission factors is likely due to the variation of chlorine content in different incinerator feedstock.

Emission factors for incineration of municipal, clinical and industrial wastes including hazardous waste and sewage are documented by the EEA (2019) and are presented in **Table 9.8**. The base case scenario model used emissions from the stack testing results. Pollutants that were not tested were modelled using the greater of the emission factors between the municipal and clinical waste streams. It has been noted that the emission factor for dioxins and furans based on the stack testing results is very high when general wastes were incinerated. The emission factor calculated is slightly above the maximum range published in literatures for incineration of hazardous wastes. It has also been noted that the measured dioxins and furans emissions during general waste incineration exceed the TWM EP-L2 emission limit by four orders of magnitude and that the secondary chamber temperature during the time of testing ranged from 721°C to 920°C and has not been able to be maintained >850°C.

Table 9.8 Incineration Emission Factors

Pollutants	Municipal Waste (g/tonne of waste)	Clinical Waste (g/tonne of waste)	Industrial Waste Including Hazardous Waste (g/tonne of waste)	Modelled Base Case Emission Factor (g/tonne of waste)
TSP	3	17,000	10	21.6 [1]
PM_{10}	3	-	7	21.6 [2]
$PM_{2.5}$	3	-	4	21.6 [2]
Cadmium	0.0046	8	0.1	0.0083 [1]
Lead	0.058	62	1.3	0.028 [1]
Mercury	0.0188	43	0.056	0.017 [1]
Arsenic	0.0062	0.2	0.016	0.2
Nickel	0.0216	2	0.14	2
Dioxins and furans	5.25E-8	0.04	0.00035	0.00038 [1]
PAH	4.74E-5	4.0E-5	0.02	4.74E-5
HCB	4.52E-5	0.1	0.002 (industrial waste including hazardous waste) 0.01 (hazardous wastes including paint production wastes and chlorine-containing wastes)	0.1

Notes: 1. Emission factor is based on the stack testing results assuming 500 kg per hour of wastes being burnt.
2. TSP emission from stack testing was conservatively assumed to be 100% $PM_{2.5}$.
3. Source is EEA (2019)

9.3.3 Calculated Emission Rates

Table 9.9 presents the calculated emissions for the base case scenario and for the incineration of hazardous waste. The base case scenario emissions are based on the stack testing results, where available. The hazardous waste emissions and the pollutant emissions for the base case scenario that have not been measured during stack testing are based on emission factors from literature (see **Table 9.8**) multiplied by the incinerator capacity of 500 kg of waste per hour. As the proposed scenario will still include the waste streams incinerated in the base case, it is appropriate to use the higher of the base case emissions and the calculated incinerator emissions for hazardous waste as the emissions for the proposed scenario, which are in bold.

Table 9.9 Incineration Calculated Emissions

Pollutants	Base Case (g/s)	Hazardous Waste (g/s)	Proposed Scenario (g/s)
TSP	**0.003**	0.0014	0.003
PM_{10}	**0.003**	9.7E-4	0.003
$PM_{2.5}$	**0.003**	5.6E-4	0.003
HCl	**0.0018**	No data	0.0018
Cadmium	1.2E-6	**1.4E-5**	1.4E-5
Lead	3.8E-6	**1.8E-4**	1.8E-4
Mercury	2.3E-6	**7.8E-6**	7.8E-6
Arsenic	**5.3E-8**	2.2E-6	5.3E-8

Pollutants	Base Case (g/s)	Hazardous Waste (g/s)	Proposed Scenario (g/s)
Nickel	**2.8E-5**	1.9E-5	2.8E-5
Dioxins and furans	**2.8E-4**	4.9E-8	2.8E-4
PAH	6.6E-9	**2.8E-6**	2.8E-6
HCB	**1.4E-5**	2.8E-7	1.4E-5

10. Pollution Modelling Methodology

10.1 Calpuff Configuration

The three dimensional wind fields from Calmet were entered into Calpuff for the full year 2018. Calpuff was run over a smaller computational grid (1.65 kilometres x 1.85 kilometres) with spacing of 50 metres, and with receptors gridded over the smaller domain (1.15 kilometres x 1.25 kilometres) with a nesting factor of 1.

Dry deposition was modelled with vegetation state set to active and stressed.

Wind speed profile was set to the Industrial Source Complex (ISC) Rural exponents. Transitional plume rise and partial penetration of boundary layers were included. Briggs rise algorithm was used since the sources are not very hot.

The emissions were modelled as puffs (not slugs). Puff-splitting was turned off.

Dispersion coefficients were derived by the model using turbulence generated by micrometeorology. The partial plume height adjustment method was used to allow winds to approach hills as terrain increases.

The minimum turbulence velocity, sigma v, was set to 0.2 m/s.

For the purpose of calculating the influence of deposition, Calpuff only allows each particulate species to be characterised by a single mean diameter and standard deviation. Therefore suspended TSP concentrations were modelled as three separate components: $PM_{2.5}$, coarse (between 2.5 and 10 microns) and "large" (between 10 and 75 microns). Emission rates of the species "large" were calculated as the difference between TSP and PM_{10} emissions from the inventory. Emission rates of the species "coarse" were calculated as the difference between PM_{10} and $PM_{2.5}$ emissions from the inventory. The predicted TSP results were then calculated as the sum of the model outputs for each of the three components. Similarly dust deposition was predicted as the sum of the deposition of the deposition of each of the three components.

10.2 Other Source Parameters

Other source parameters used in modelling are provided in **Table 10.1** and **Table 10.2**. **Figure 10.1** shows the location of modelled sources.

Table 10.1 Fugitive Source Parameters

Location	Activities	Model Source ID	Easting (m) WGS84	Northing (m) WGS84	Horizontal spread (m)	Vertical spread (m)	Effective Height (m)
Receival Area	Truck Unloading	RHTU	509138	8955291	0.93	0.93	3
	Material Handling	RHMH	509154	8955299	0.93	0.93	3
	Truck Loading	RHTL	509154	8955282	0.93	0.93	3
Recycling Area	Truck Unloading	RCTU	509111	8955232	0.93	0.93	3
	Material Handling	RCMHv01	509098	8955243	0.93	0.93	3
	Truck loading	RCTL	509123	8955227	0.93	0.93	3
	Glass Crushing	RCGC	509096	8955233	0.93	0.93	3
	Glass/compost Screening	RCGS	509103	8955229	0.93	0.93	3

Location	Activities	Model Source ID	Easting (m) WGS84	Northing (m) WGS84	Horizontal spread (m)	Vertical spread (m)	Effective Height (m)
	Compost handling: • Pre-mixing compost feed • Feeding to in-vessel • Transfer to aerated windrows • Physical turning of pile	RCMHv02	509116	8955223	0.93	0.93	3
Incinerator	Ash loading to trucks	IALT	509236	8955054	0.93	0.93	3
	Truck unloading waste	ITUCS	509232	8955047	0.93	0.93	3
Fixation	Unloading of ash	FUA	509081	8955202	0.93	0.93	3
	Cement unloading to silo	FCU	509081	8955194	0.93	0.93	3
	Mixer loading	FM	509073	8955193	0.93	0.93	3
	Aggregate and sand transfer	FAS	509087	8955198	0.93	0.93	3
Quarry	Feeding to vibrator chute	QF	509326	8955135	0.93	0.93	3
	Truck loading	QTL	509338	8955167	0.93	0.93	3
	Scalping fines transfer to stockpile	QMHv01	509343	8955124	0.93	0.93	3
	Primary stockpile	QMHv02	509323	8955118	0.93	0.93	3
	Blinding stockpile	QMHv03	509306	8955127	0.93	0.93	3
	Final screening stockpile	QMHv04	509336	8955152	0.93	0.93	3
	Primary crushing and screening	QCv01	509326	8955126	0.93	0.93	3
	Secondary crushing and screening	QCv02	509316	8955132	0.93	0.93	3
	Tertiary and quaternary crushing and fines screening	QCv03	509331	8955144	0.93	0.93	3
Landfill	Truck unloading	LFTU	509363	8955094	0.93	0.93	3
	Material handling	LFMH	509355	8955086	0.93	0.93	3
	Dozing	LFD	509376	8955098	0.93	0.93	3
Haul Roads	Off-site to receival area	URv01	various	various	8.1	2.0	2.13
	Receival hall to recycling	URv02	various	various	8.1	2.0	2.13
	Quarry to off-site	URv08	various	various	8.1	2.0	2.13

Location	Activities	Model Source ID	Easting (m) WGS84	Northing (m) WGS84	Horizontal spread (m)	Vertical spread (m)	Effective Height (m)
	Recycling to landfill	URv09	various	various	8.1	2.0	2.13
	Recycling to off-site	URv10	various	various	8.1	2.0	2.13
	Incinerator to fixation	URv11	various	various	8.1	2.0	2.13
	Off-site to industrial wastewater	URv12	various	various	8.1	2.0	2.13
	Fixation to landfill	URv13	various	various	8.1	2.0	2.13
	Within quarry/landfill	URv14	various	various	8.1	2.0	2.13
Receival area, recycling area, quarry and landfill	Wind erosion	WE	various	various	-	1	0 (landfill) 2 (others)

Table 10.2 Incinerator Stack Parameters

Location	Model Source ID	Easting (m) WGS84	Northing (m) WGS84	Stack Height (m)	Exit Temperature (K)	Inside Diameter (m)	Exit Velocity (m/s)
Incinerator	INC	509239	8955057	7.0	524	0.18	53.4

Note: 1. The rain cap option was turned on.

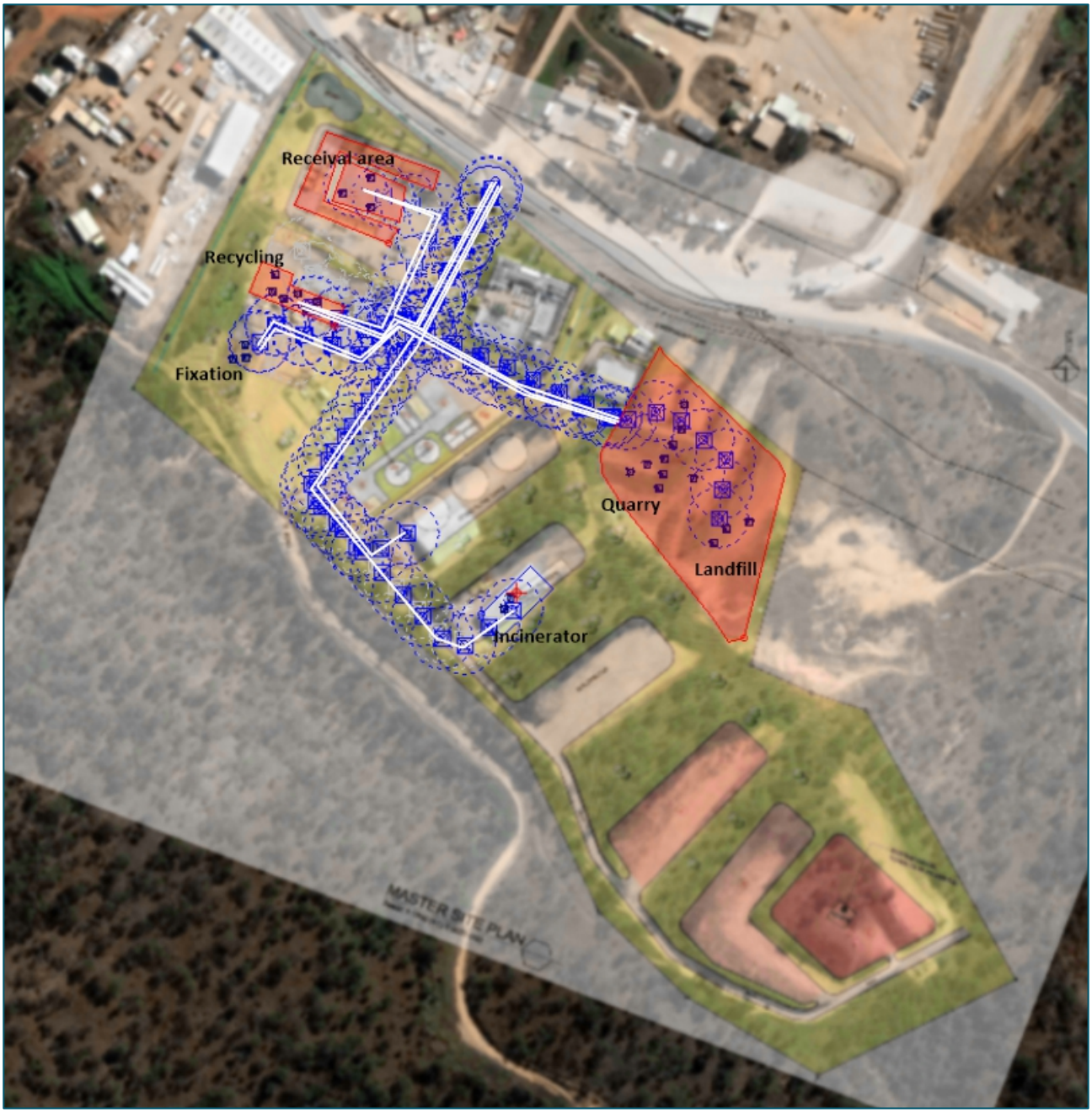


Figure 10.1 Modelled Sources

10.3 Building Downwash

Building downwash was modelled using the BPIP processor and the Prime algorithm since the length to width ratio of the buildings were less than 10. The incinerator building was modelled with a sloped roof with a height of 5.3 metres at the two sides and a peak of 7.5 metres in the middle.

10.4 Calpost Processing

Following dispersion modelling, contours of pollution concentrations were generated using the GIS software Surfer. Surfer was then used to overlay the model outputs onto a scan of a rectified aerial photograph of the area. Contours shown in this report were generated using the Kriging method and contours were created with smoothing set to high.

11. Dispersion Modelling Results

11.1 Limitations

The uncertainties associated with this type of assessment are normally only dealt with in a qualitative manner, but include:

- emission estimation techniques
- meteorological data variability
- inherent uncertainty in dispersion modelling.

Typically 95% confidence intervals are estimated to require a multiplicative factor of 2 or 3. In this case, the uncertainty is mostly due to assumptions regarding the details of emission sources and operating information. This has been addressed by conservative assumptions that will over-predict the ambient concentrations including the following:

- Emission rates were based on activities that are higher than typical including the quarry activities were based on the permit limit and incinerator emission rates were based on the maximum measured or maximum of emission factors of the various waste streams to be accepted.
- The emissions were based on the assumptions that materials will be dusty, whereas some of the wastes received will not be dusty.
- The activities were assumed to be undertaken at all times during the operating hours.

11.2 Suspended Particulate Results

The predicted concentrations at sensitive receptors are shown in **Table 11.1** and **Table 11.2** along with the criterion. The estimated background levels are shown in the tables separately but have not been added to the predicted concentrations shown.

There are very minor differences between the results of the base case scenario and the proposed scenario. The differences would not be discernible. All the assessed suspended particulate sizes are within their criteria. The TSP is the only size fraction that approaches the criterion, although this is mainly due to the relatively high background concentration used. It should also be noted that there is no criterion for TSP in TWM's current EP. The cumulative (including background) annual average TSP concentration at the most affected sensitive receptor is 79 $\mu g/m^3$, which is 88% of the criterion of 90 $\mu g/m^3$.

The results of the TSP modelling are illustrated in **Figure 11.1** by pollution contours overlayed onto an aerial photo. As shown, there is very little difference in the results between the two scenarios modelled.

Concentrations provided in tabular form are a prediction at a point in space and hence more accurate than the contours, which are graphical interpolations.

Table 11.1 Predicted Suspended Particulate Concentrations – Base Case Scenario

Receptor ID	Annual Average TSP ($\mu g/m^3$)	Maximum 24 h average PM_{10} ($\mu g/m^3$)	Annual average PM_{10} ($\mu g/m^3$)	Maximum 24 h Average $PM_{2.5}$ ($\mu g/m^3$)	Annual Average $PM_{2.5}$ ($\mu g/m^3$)
Criterion	90	150	70	75	35
Background	75	39	29	10	8
A	1	2	1	1	0
B	4	6	2	4	1
C	0	1	0	1	0

Receptor ID	Annual Average TSP (µg/m^3)	Maximum 24 h average PM_{10} (µg/m^3)	Annual average PM_{10} (µg/m^3)	Maximum 24 h Average $PM_{2.5}$ (µg/m^3)	Annual Average $PM_{2.5}$ (µg/m^3)
D	0	1	0	1	0
E	0	1	0	0	0
F	0	1	0	1	0
G	0	1	0	0	0

Table 11.2 Predicted Suspended Particulate Concentrations – Proposed Scenario

Receptor ID	Annual Average TSP (µg/m^3)	Maximum 24 h average PM_{10} (µg/m^3)	Annual average PM_{10} (µg/m^3)	Maximum 24 h Average $PM_{2.5}$ (µg/m^3)	Annual Average $PM_{2.5}$ (µg/m^3)
Criterion	90	150	70	75	35
Background	75	39	29	10	8
A	1	3	1	1	0
B	4	6	2	4	1
C	0	1	0	1	0
D	0	1	0	1	0
E	0	1	0	0	0
F	0	1	0	1	0
G	0	1	0	0	0

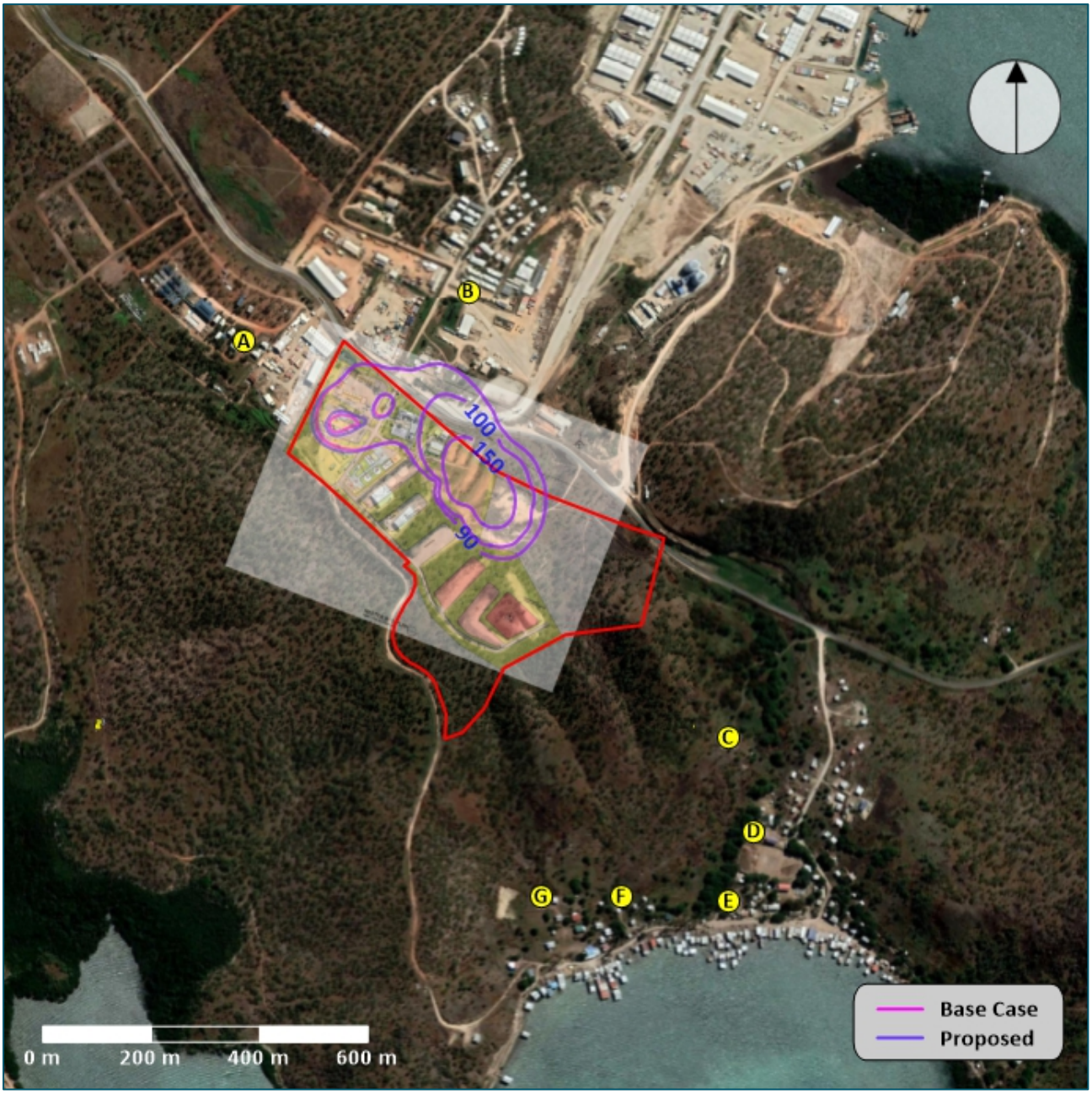


Figure 11.1 Predicted Annual Average TSP Concentrations (µg/m^3) Including Background

11.3 Incinerator Modelling Results

The predicted concentrations at sensitive receptors due to the incinerator emissions are presented in **Table 11.3** and **Table 11.4** along with the criterion. For the proposed scenario, only the pollutants with higher emissions than the base case have been presented. The estimated background levels are listed separately and not included in the predicted concentrations. All the pollutants assessed are well below the relevant criteria at the modelled sensitive receptors. The pollutant concentration closest to the criterion is dioxins and furans. The 99.9th percentile cumulative (including background) 1-hour average dioxins and furans concentration at the most affected receptor is 8.3E-7 µg/m^3, an order of magnitude within the criterion of 2.0E-6 µg/m^3. The results of the dioxins and furans modelling are illustrated in **Figure 11.2** by pollution contours overlayed onto an aerial photo. As shown, dioxins and furans concentrations are predicted to exceed the criterion level within the site and outside the site boundary where there are no sensitive receptors. This is based on the worst measured dioxins and furans emissions on-site for the base case scenario, which is slightly higher than the maximum range published in literatures for incineration of hazardous wastes. The proposed scenario will therefore not likely result in increase in the dioxins and furans.

Table 11.3 Predicted Concentrations from Incinerator Emissions – Base Case Scenario

Pollutant	Averaging Period	Criterion (µg/m^3)	Background (µg/m^3)	Predicted Concentrations (µg/m^3)						
Receptor ID				**A**	**B**	**C**	**D**	**E**	**F**	**G**
Lead	1 year	0.5	0	2.5E-6	1.4E-6	4.6E-7	3.1E-7	2.7E-7	3.3E-7	3.1E-7
Cadmium and compounds	1 hour	0.018	0	1.8E-5	1.1E-5	3.8E-6	3.2E-6	3.4E-6	4.5E-6	4.7E-6
	1 year	0.005	0	7.6E-7	4.3E-7	1.4E-7	9.4E-8	8.1E-8	9.8E-8	9.3E-8
Mercury	1 hour	0.18	0	3.6E-5	2.2E-5	7.7E-6	6.5E-6	6.8E-6	9.2E-6	9.5E-6
	1 year	1.1	0	1.5E-6	8.6E-7	2.8E-7	1.9E-7	1.6E-7	2.0E-7	1.9E-7
Dioxins and furans	1 hour	2.0E-6	1.0E-8	8.2E-7	5.1E-7	1.8E-7	1.5E-7	1.6E-7	2.1E-7	2.2E-7
Hydrogen chloride	1 hour	140	0	2.8E-2	1.8E-2	6.1E-3	5.1E-3	5.3E-3	7.2E-3	7.4E-3
Arsenic and compounds	1 hour	0.09	0	4.3E-4	2.7E-4	9.2E-5	7.7E-5	8.1E-5	1.1E-4	1.1E-4
	1 year	0.006	0	1.8E-5	1.0E-5	3.3E-6	2.3E-6	1.9E-6	2.4E-6	2.3E-6
Nickel and compounds	1 hour	0.18	0	4.3E-3	2.7E-3	9.2E-4	7.7E-4	8.1E-4	1.1E-3	1.1E-3
	1 year	0.022	0	1.8E-4	1.0E-4	3.3E-5	2.3E-5	1.9E-5	2.4E-5	2.3E-5
PAH as benzo(a)pyrene	1 hour	0.4	1.0E-4	1.0E-7	6.3E-8	2.2E-8	1.8E-8	1.9E-8	2.6E-8	2.7E-8
	1 year	3.0E-4	1.0E-4	4.4E-9	2.4E-9	7.8E-10	5.4E-10	4.6E-10	5.6E-10	5.3E-10
HCB	1 hour	0.25	0	2.1E-4	1.3E-4	4.6E-5	3.9E-5	4.0E-5	5.5E-5	5.6E-5
	1 year	0.025	0	9.2E-6	5.1E-6	1.7E-6	1.1E-6	9.7E-7	1.2E-6	1.1E-6

Table 11.4 Predicted Concentrations from Incinerator Emissions – Proposed Scenario

Pollutant	Averaging Period	Criterion (µg/m³)	Background (µg/m³)	Predicted Concentrations (µg/m³)						
Receptor ID				**A**	**B**	**C**	**D**	**E**	**F**	**G**
Lead	1 year	0.5	0	1.2E-4	6.7E-5	2.1E-5	1.5E-5	1.3E-5	1.5E-5	1.5E-5
Cadmium and compounds	1 hour	0.018	0	2.1E-4	1.3E-4	4.6E-5	3.9E-5	4.0E-5	5.5E-5	5.6E-5
	1 year	0.005	0	9.2E-6	5.1E-6	1.7E-6	1.1E-6	9.7E-7	1.2E-6	1.1E-6
Mercury	1 hour	0.18	0	1.2E-4	7.5E-5	2.6E-5	2.2E-5	2.3E-5	3.1E-5	3.2E-5
	1 year	1.1	0	5.2E-6	2.9E-6	9.3E-7	6.4E-7	5.5E-7	6.7E-7	6.3E-7
PAH as benzo(a)pyrene	1 hour	0.4	1.0E-4	4.3E-5	2.7E-5	9.2E-6	7.7E-6	8.1E-6	1.1E-5	1.1E-5
	1 year	3.0E-4	1.0E-4	1.8E-6	1.0E-6	3.3E-7	2.3E-7	1.9E-7	2.4E-7	2.3E-7

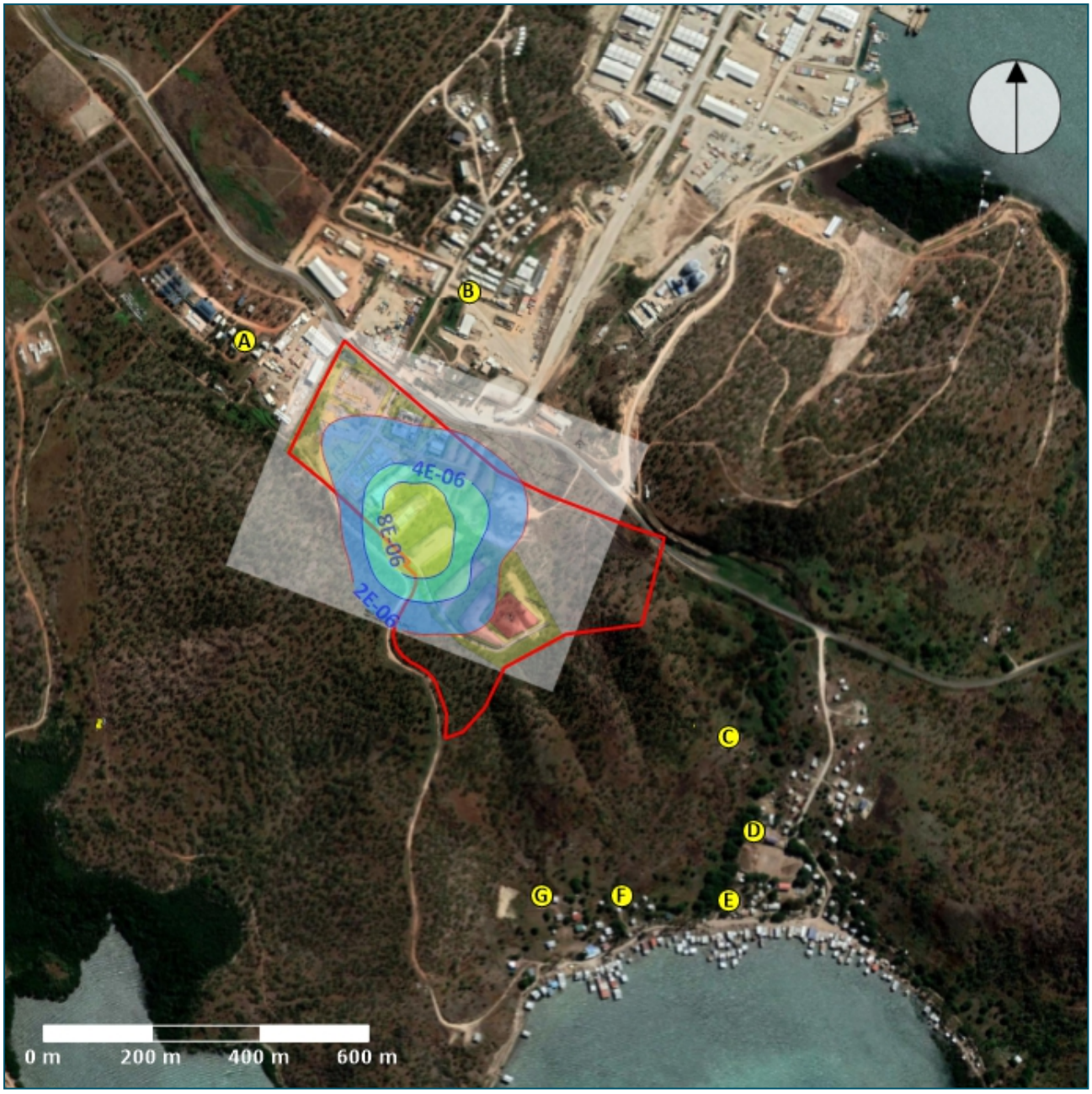


Figure 11.2 99.9th Percentile 1-Hour Dioxins and Furans Concentrations (µg/m³) Including Background

11.4 Dust Deposition Results

The predicted dust deposition levels at sensitive receptors are shown in **Table 11.5** and **Table 11.6** along with the criteria and estimated background levels. The dust deposition levels are within the criteria at the sensitive receptors. The closest indicator to the criteria/guideline is the cumulative maximum monthly deposition level including background which is 96 mg/m^2/day at Receptor B for the proposed scenario or 80% of the Queensland guideline of 120 mg/m^2/day. The results of the dust deposition modelling are illustrated in **Figure 11.3**. As with the predicted suspended particulates, the predicted dust deposition levels for the proposed scenario are only very slightly higher than those of the base case scenario. The difference in dust levels between the two scenarios would be indiscernible.

Table 11.5 Predicted Dust Deposition Levels – Base Case Scenario

Receptor ID	Annual Average Dust Deposition (g/m^2/month)	Maximum Monthly Deposition (mg/m^2/day)
Criteria	2 (incremental) 4 (cumulative)	120
Background	1.5	50
A	0.2	16
B	0.9	46
C	0.1	8
D	0.0	5
E	0.0	3
F	0.0	3
G	0.0	3

Table 11.6 Predicted Dust Deposition Levels – Proposed Scenario

Receptor ID	Annual Average Dust Deposition (g/m^2/month)	Maximum Monthly Deposition (mg/m^2/day)
Criteria	2 (incremental) 4 (cumulative)	120
Background	1.5	50
A	0.3	18
B	0.9	46
C	0.1	8
D	0.0	5
E	0.0	3
F	0.0	4
G	0.0	3

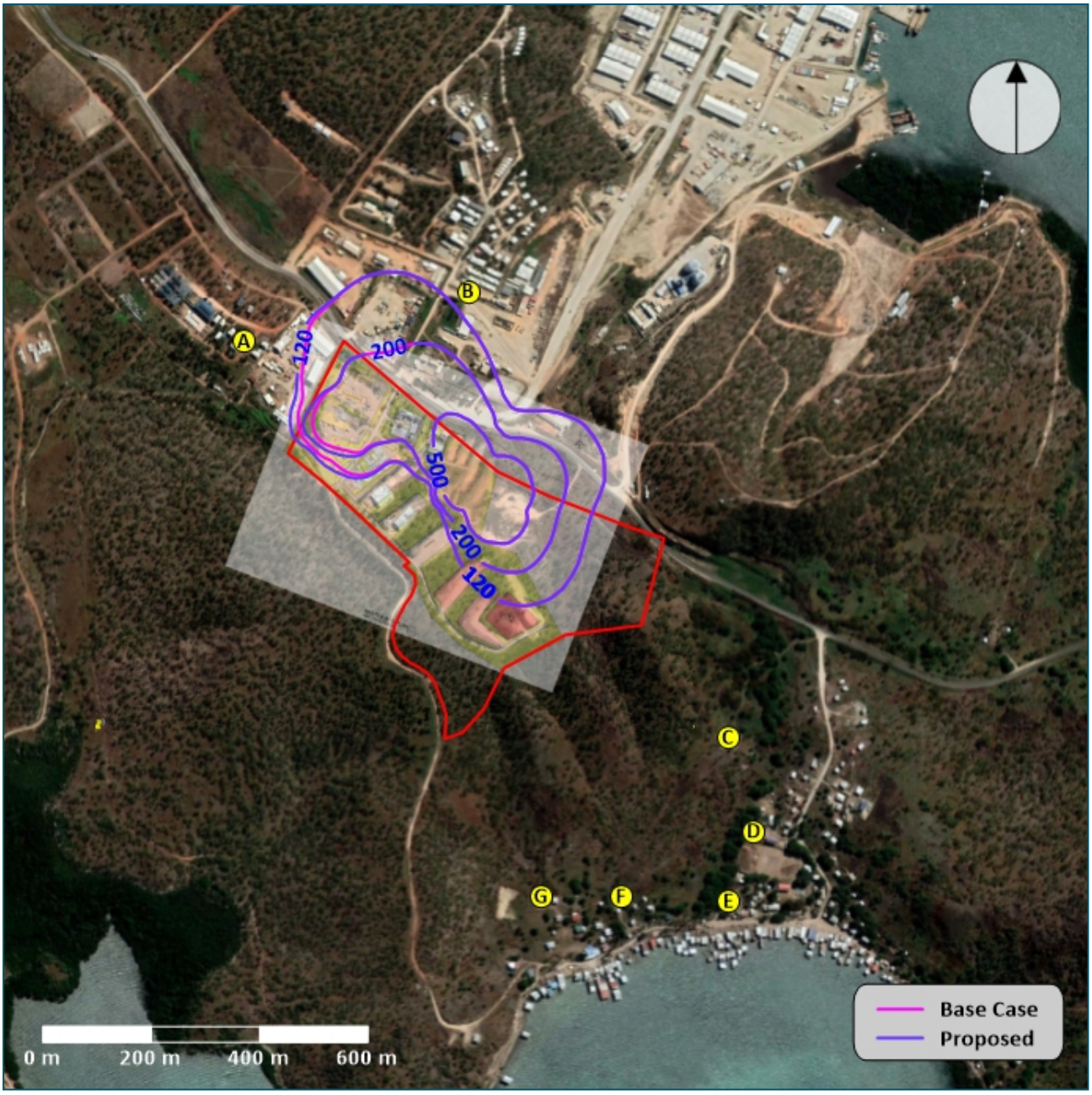


Figure 11.3 Maximum 30 Day Dust Deposition Levels (mg/m²/day) Including Background

12. Discussion

12.1 Summary of Results

Predicted concentrations and levels of all indicators are within the relevant criteria as summarised in **Table 12.1**. The worst-affected receptors are receptor B for dust and receptor A for incinerator emissions.

Table 12.1 Summary of Results

Indicator	Worst Affected Receptor	Prediction from Project (µg/m³)		Cumulative Prediction with Background (µg/m³)		Criterion (µg/m³)
Scenarios		**Base Case**	**Proposed**	**Base Case**	**Proposed**	
Annual average TSP	B	4	4	79	79	90
Maximum 24 h average PM_{10}	B	6	6	45	45	150
Annual average PM_{10}	B	2	2	31	31	70
Maximum 24 h average $PM_{2.5}$	B	4	4	14	14	75
Annual average $PM_{2.5}$	B	1	1	9	9	35
Annual average lead	A	2.5E-6	1.2E-4	2.5-6	1.2E-4	0.5
Maximum 1 h average cadmium	A	1.8E-5	2.1E-4	1.8E-5	2.2E-4	0.018
Annual average cadmium	A	7.6E-7	9.2E-6	7.6E-7	9.2E-6	0.005
Maximum 1 h average mercury	A	3.6E-5	1.2E-4	3.6E-5	1.2E-4	0.18
Annual average mercury	A	1.5E-6	5.2E-6	1.5E-6	5.2E-6	1.1
Maximum 1 h average dioxins and furans	A	8.2E-7	8.3E-7	8.4E-7	8.4E-7	2.0E-6
Maximum 1 h average hydrogen chloride	A	2.8E-2	2.8E-2	2.8E-2	2.8E-2	140
Maximum 1 h average arsenic	A	4.3E-4	4.3E-4	4.3E-4	4.3E-4	0.09
Annual average arsenic	A	1.8E-5	1.8E-5	1.8E-5	1.8E-5	0.006

Indicator	Worst Affected Receptor	Prediction from Project (µg/m³)		Cumulative Prediction with Background (µg/m³)		Criterion (µg/m³)
Maximum 1 h average nickel	A	4.3E-3	4.3E-3	4.3E-3	4.3E-3	0.18
Annual average nickel	A	1.8E-4	1.8E-4	1.8E-4	1.8E-4	0.022
Maximum 1 h average PAH	A	1.0E-7	4.3E-5	1.0E-4	1.4E-4	0.4
Annual average PAH	A	4.4E-9	1.8E-6	1.0E-4	1.0E-4	3.0E-4
Maximum 1 h average HCB	A	2.1E-4	2.2E-4	2.2E-4	2.2E-4	0.25
Annual average HCB	A	9.2E-6	9.2E-6	9.2E-6	9.2E-6	0.025
Maximum 30 day dust deposition	B	46 mg/m^2/day	46 mg/m^2/day	96 mg/m^2/day	96 mg/m^2/day	120 mg/m^2/day
Annual average dust deposition	B	0.9 g/m^2/month	0.9 g/m^2/month	2.4 g/m^2/month	2.4 g/m^2/month	4 g/m^2/month

12.2 Conclusion and Recommendation

An air quality assessment has been conducted for the IWMF at Site Portion 2703, Napa Napa Road, Porebada, Central Province, PNG for both the baseline approved activities and the proposed activities. The results of the assessment are summarised as follows:

- The predicted concentrations and levels of all indicators are within the relevant criteria.
- The scopes 1 and 2 greenhouse gas emissions were calculated to be 27 kilotonnes CO_2-e per year.
- For dust, the indicators predicted to be closest to the criteria at the sensitive receptors are the TSP and dust deposition, both of which are not included in the current TWM EP. The surrounding area is also industrial and relatively dusty which has been represented by the relatively high background levels assumed in this assessment. The background levels are higher contributors to the predicted cumulative impacts than the site's incremental impacts.
- The pollutant with the worst impacts due to the incinerator emissions is the dioxins and furans. Despite the very high dioxins and furans emissions measured during the stack testing of the general waste burning, the predicted concentrations at the sensitive receptors are still within the criterion.
- In summary, the predicted impacts from the IWMF are considered acceptable. There would be indiscernible difference to air quality if the IWMF shifts from EP L2 to EP L3 activities.

The recommendations of the assessment are as follows:

- The dust control measures assumed in this assessment should be implemented and maintained:
  - Use bentonite suppressant and water unpaved haul route within the landfill/quarry area.
  - Use wet handling of the ash from the incinerator. If not, handle the ash in fully enclosed systems or using vacuum trucks.
- Additional recommendations to minimise emissions from the site follow:
  - Ensure that the secondary combustion chamber of the incinerator maintains a temperature above 850°C to reduce dioxin and furan emissions.

References

Able Sales Australia (2020), *Diesel Generator Fuel Consumption Chart in Litres*, https://web.archive.org/web/20180609065950/https://www.ablesales.com.au/source/Diesel%20Generator%20Fuel%20Consumption%20Chart%20in%20Litres.pdf, access on 11 September 2020.

ACARP (1999), Fine Dust and the Implications for the Coal Industry, Report C7009.

ACEM Geotechniques (2018), Baseline Environmental & Geotechnical Study, Rev 0, Proposed Integrated Waste Management Plant at Roku, October 2018.

Alibaba (2020), Manufacturer's specifications for 6x4 articulated trucks, https://www.alibaba.com/product-detail/Sinotruk-HOWO-tipper-6x4-290hp-articulated_62298298214.htm, accessed on 7 September 2020.

API (2009), Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry, American Petroleum Institute, August 2009.

Ashcroft, J. (1994), The relationship between the gust ratio, terrain roughness, gust duration and the hourly mean wind speed, J. Wind Eng. Ind. Aerodyn. 53: 331-355.

Assured Environmental (2019), Source Emissions Monitoring – Napa Napa, Total Waste Management, Draft_1, 17 December 2019.

Commonwealth of Australia (2002), Sources of Dioxins and Furans in Australia: Air Emissions, Revised Edition, May 2002.

Connor Generators (2020), Perkins 1306CE87TAG4 specification, https://static1.squarespace.com/static/5e9a75aafea74979ec059753/t/5eabcd1afdf2d726c1913b3c/1588317468997/perkins-250kva.pdf, access on 11 September 2020.

Department of Climate Change (2007), National Greenhouse and Energy Reporting Act 2007. Office of Legislative Drafting and Publishing, Attorney-General's Department, Canberra.

Department of the Environment and Energy (2017), National Greenhouse and Energy Reporting Scheme Measurement, Technical Guidelines for the estimation of greenhouse gas emissions by facilities in Australia, October 2017.

Department of the Environment and Energy (2019), Australian National Greenhouse Account: National Greenhouse Accounts Factors, August 2019.

Department of Industry, Science, Energy and Resources (2020a), National Greenhouse and Energy Reporting Regulations 2008, as amended on 1 July 2020.

Department of Industry, Science, Energy and Resources (2020b), National Greenhouse and Energy Reporting (Measurement) Determination 2008, as amended on 1 July 2020.

Department of Industry, Science, Energy and Resources (2020c), National Greenhouse Gas inventory – Kyoto Protocol classifications, http://ageis.climatechange.gov.au/ , accessed on 11/09/2020.

DES (2019), Guideline: Application requirements for activities with impacts to air, version 4.03, Queensland Department of Environment and Science.

DSEWPC (2012), National Pollutant Inventory Emissions Estimation Technique Manual for Mining, Version 3.1, Department of Sustainability, Environment, Water, Population and Communities, January 2012.

EEA (2019), EMEP/EEA air pollutant emission inventory guidebook 2019, Technical guidance to prepare national emission inventories, European Environment Agency, 2019.

Environment Australia (2002), Best Practice Environmental Management in Mining: Energy Efficiency & Greenhouse Gas Reduction.

Environment Australia (2012), National Pollutant Inventory Emission Estimation Technique Manual for Mining Version 3.1.

Environmental Protection Agency (2019), Environmental Protection (Air) Policy, Queensland Government.

Fuso (2020), Manufacturer's specifications on 4x2 articulated light truck, **https://cdn.fuso.com.au/Docs/SpecSheets/Canter%20515%20City%20Cab%20S.pdf**, accessed on 1 September 2020.

Gras, J., Muller, J., Graham, B., Symons, R., Carras, J. and Cook, G. (2004), Dioxins in Ambient Air in Australia, National Dioxins Program, Technical Report No. 4, Australian Government Department of the Environment and Heritage, Canberra, ISBN 0-642-54996-6.

Graybeal, D. (2006), Relationships among Daily Mean and Maximum Wind Speeds, with Application to Data Quality Assurance, Int.J.Climatol. 26: 29-43.

ISWA (2015), Bottom Ash from WTE Plants Metal Recovery and Utilization, International Solid Waste Association.

Isuzu (2020), Manufacturer's specifications for a 3 tonne truck, **https://cdn.fuso.com.au/Docs/SpecSheets/Canter%20515%20City%20Cab%20S.pdf**, accessed on 1 September 2020.

Kumar, A. (2008), *Characterisation of Soluble Components and PAH in PM10 Atmospheric Particulate Matter in Brisbane*, Thesis submitted to the Faculty of Science, Queensland University of Technology, Brisbane.

Lam, C.H.K., Ip, A.W.M., Barford, J.P. & McKay, G. (2010), Use of Incineration MSW Ash: A Review, Sustainability 2010, 2, 1943-1968.

Lim M.C.H., Ayoko G.A. and Morawska L. (2005) *Characterization of elemental and polycyclic aromatic hydrocarbon compositions of urban air in Brisbane*, Atmospheric Environment, 39:463-476.

Martin & Mejia (2010), *Willawong Air Quality Health Risk Assessment*, Simtars Report oe102093f2b for Brisbane City Council 9 June 2011.

Muller, J., Hawker, D. and Connell, D. (1998), *Polycyclic Aromatic Hydrocarbons in the Atmospheric Environment of Brisbane, Australia*, Chemosphere, 37:1369-1383.

NEPM (2016), National Environment Protection (Ambient Air Quality) Measure, compilation prepared on 25 February, 2016 by Department of the Environment.

NSW EPA (2016), Approved Methods for the Modeling and Assessment of Air Pollutants in New South Wales, Department of Environment and Conservation.

Pacific Environment Limited (2015), *Development of Australia-Specific PM10 Emission Factors for Coal Mines*, ACARP Project C22027 Final Report.

Ritchie Specs (2020), Manufacturer's specifications for Caterpillar 740 articulated dump truck, **https://www.ritchiespecs.com/model/caterpillar-740-articulated-dump-truck**, accessed on 1 September 2020.

Scire J.S. & Robe F.R. (1997), Fine-Scale Application of the Calmet Meteorological Model to a Complex Terrain Site, Air and Waste Management Association's 90th Annual Meeting.

Suryawan, I.W.K., Prajati, G. & Afifah, A.S. (2019), Bottom and fly ash treatment of medical waste incinerator from community health centres with solidification/stabilization, AIP Conference Proceedings 2114, 050023 (2019).

Texas Commission on Environmental Quality (2016), Effects Screening Levels used by the TCEQ Toxicology Division, downloaded from https://www.tceq.texas.gov/toxicology/esl/list_main.html.

Toyota (2020), Manufacturer's specifications for a 1.5 tonne forklift, **https://qpsearch.bt-forklifts.com/PDFSearch/GetPDF.asp?artno=745562-040**, accessed on 11 September 2020.

TRC (2011), *Generic Guidance and Optimum Model Settings for the Calpuff Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessment of Air Pollutants in NSW, Australia',* prepared for NSW Office of Environment and Heritage.

Truck Sales (2020a), Manufacturer's specifications for Western Star trucks, **https://www.trucksales.com.au/items/western-star/**, access on 7 September 2020.

Truck Sales (2020b), Manufacturer's specifications for tanker, **https://www.trucksales.com.au/items/details/2007-hino-ranger-vacuum-tankers/SSE-AD-6430653/?Cr=6**, access on 7 September 2020.

United States Environmental Protection Agency (2004) AP42 Compilation of Air Pollution Emission Factors, 5th Edition, Volume 1, Chapter 11: Mineral Products Industry, Section 19.2 Crushed Stone Processing and Pulverized Mineral Processing.

United States Environmental Protection Agency (2006a) AP42 Compilation of Air Pollution Emission Factors, 5th Edition, Volume 1, Chapter 13: Miscellaneous Sources, Section 2.4 Aggregate Handling and Storage Piles.

United States Environmental Protection Agency (2006b) AP42 Compilation of Air Pollution Emission Factors, 5th Edition, Volume 1, Chapter 13: Miscellaneous Sources, Section 2.5 Industrial Wind Erosion.

United States Environmental Protection Agency (2011) AP42 Compilation of Air Pollution Emission Factors, 5th Edition, Volume 1, Chapter 11: Mineral Products Industry, Section 12 Concrete Batching, updated on August 2011.

Utah DAQ (2015), Memo Guidelines, Emission Factors for Paved and Unpaved Haul Roads, State of Utah Department of Environmental Quality, 12 January 2015.

WHO (2006), Air Quality Guidelines: Global Update 2005: Particulate matter, ozone, nitrogen dioxide and sulphur dioxide, World Health Organisation.

WindAlert (2020), Windroses for Port Moresby, **https://www.windalert.com/**, accessed on 17 July 2020.

Yang, S., Connell, D., Hawker, D. and Kayal, S. (1991), *Polycyclic Aromatic Hydrocarbons in Air, Soil and Vegetation in the Vicinity of an Urban Roadway*, The Science of the Total Environment, 102:229-240.

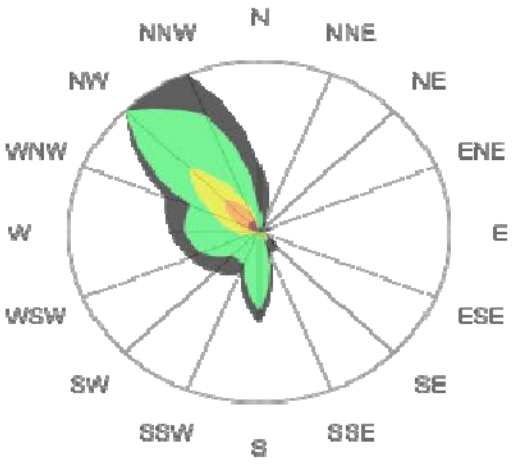
Appendix A Glossary

Parameter or Term	Description
ASK	ASK Consulting Engineers
C&D	Construction and demolition
C&I	Commercial and industrial
CO	Carbon monoxide
DAF	Dissolved air flotation
DES	Queensland Department of Environment and Science
EDC DAAC	Data Center Distributed Active Archive Center
EP L2	Environmental permit level 2
EP L2	Environmental permit level 3
EPP(Air)	Queensland Environmental Protection (Air) Policy 2019
EROS	Earth Resources Observation Systems
g/m^2/month	Grams per square metre per month
GWP	Global Warming Potential
HCB	Hexachlorobenzene
HCl	Hydrogen chloride
ISC	Industrial Source Complex
IWMF	Integrated Waste Management Facility
LAI	Leaf Area Index
m/s	Metres per second
mg/m^2/day	Milligrams per square metre per day
NCAR	US National Centre for Atmospheric Research
NO_x	Oxides of nitrogen including nitric oxide and nitrogen dioxide
NO_2	Nitrogen dioxide
NPI	National Pollutant Inventory
PAHs	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated benzene
$PM_{2.5}$	Particulates suspended in air with aerodynamic diameter less than 2.5 microns
PM_{10}	Particulates suspended in air with aerodynamic diameter less than 10 microns
PNG	Papua New Guinea
SO_2	Sulphur dioxide
SRTM	Shuttle Radar Topography Mission
TAPM	The Air Pollution Model developed by CSIRO and used by ASK for meteorological modelling
TEQ	Toxic Equivalent
TSP	Total particulates suspended in air

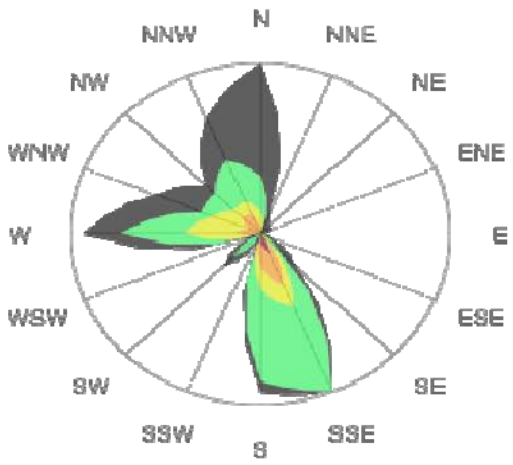
Parameter or Term	Description
TWM	Total Waste Management
µg/m^3	Micrograms per cubic metre
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator coordinate system
WHO	World Health Organisation
WOPU	Waste oil processing unit

Appendix B Historical Windroses at Jackson Airport Station

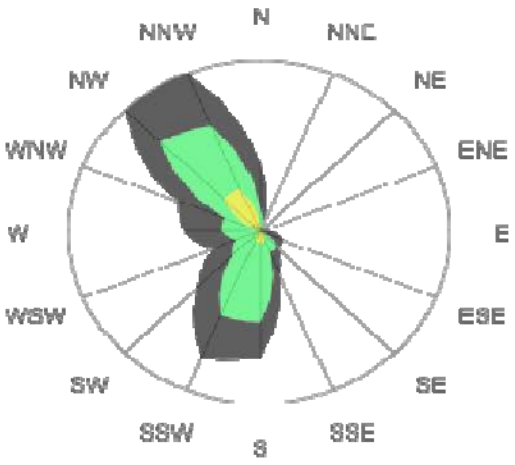
January - 2019 - Avg



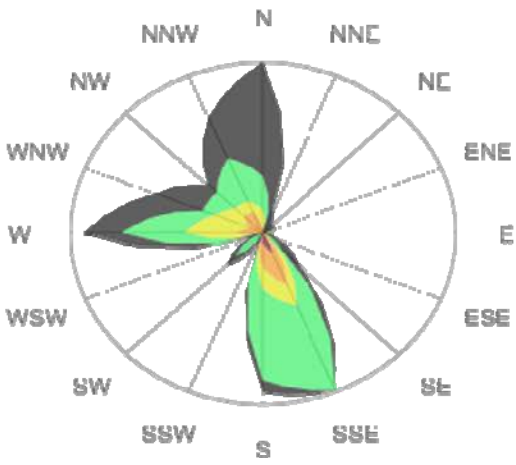
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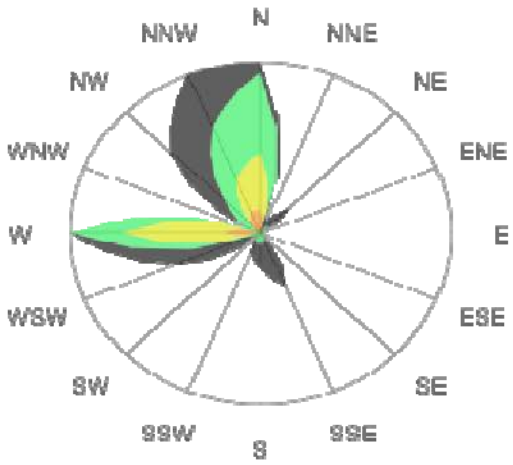
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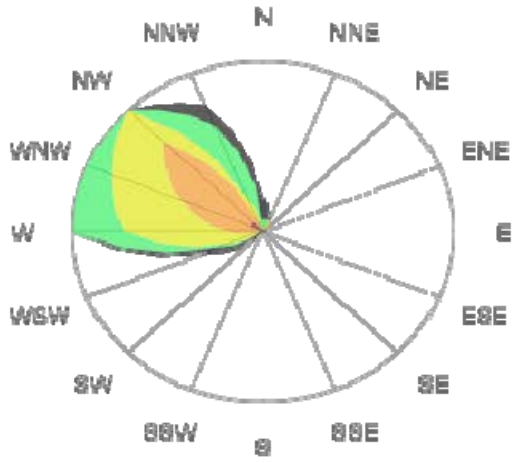
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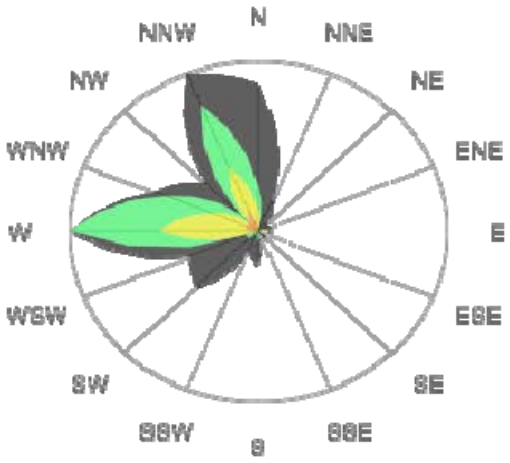
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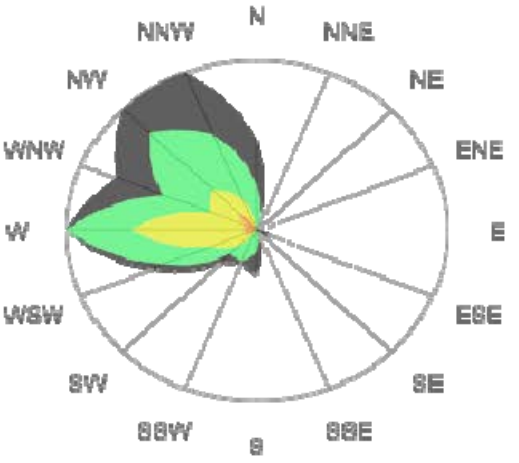
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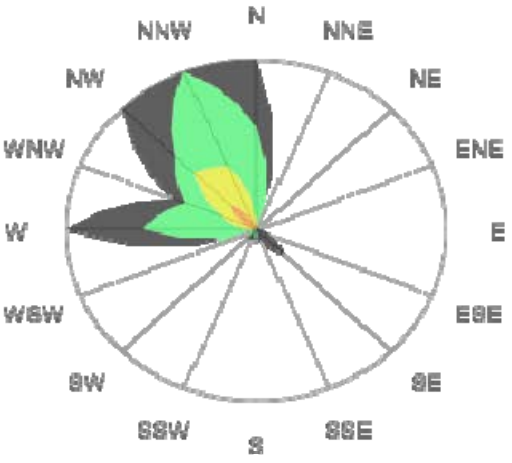
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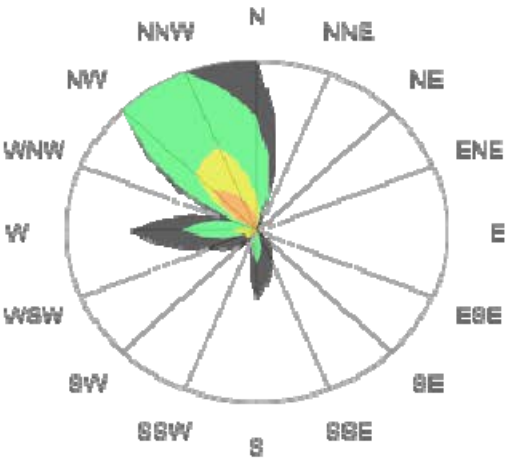
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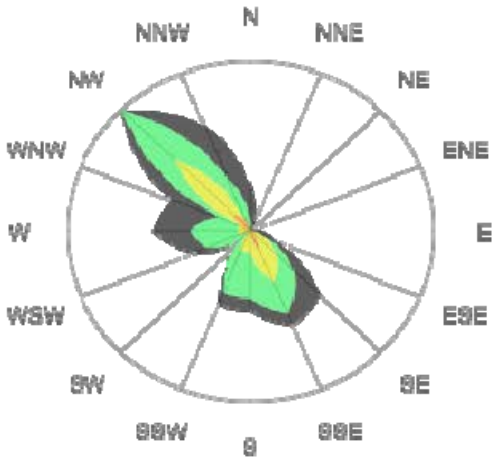
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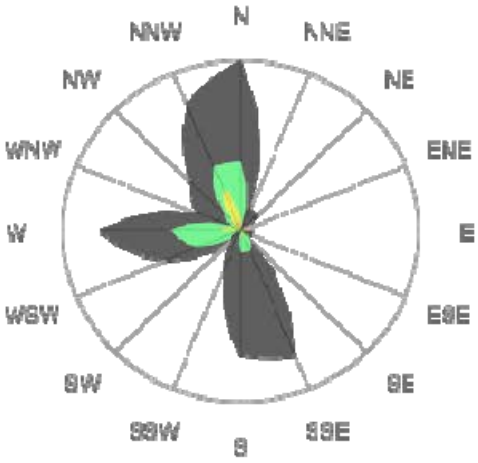
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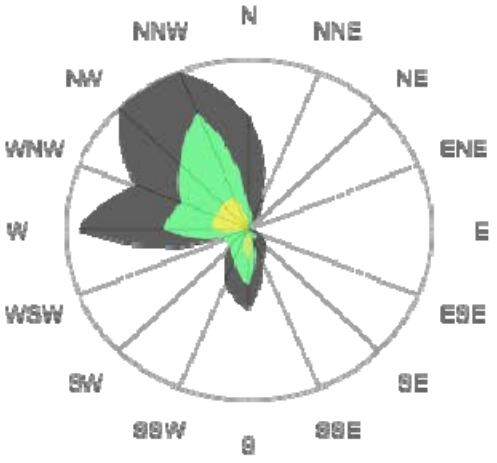
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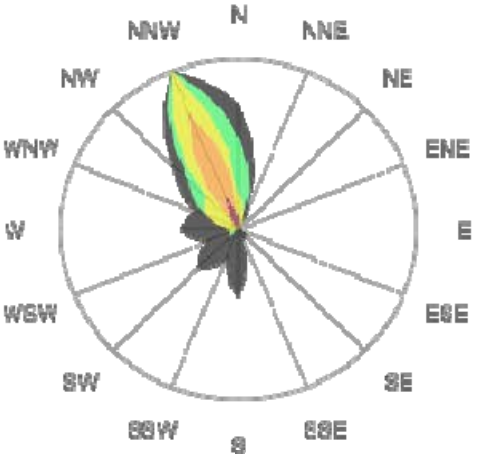
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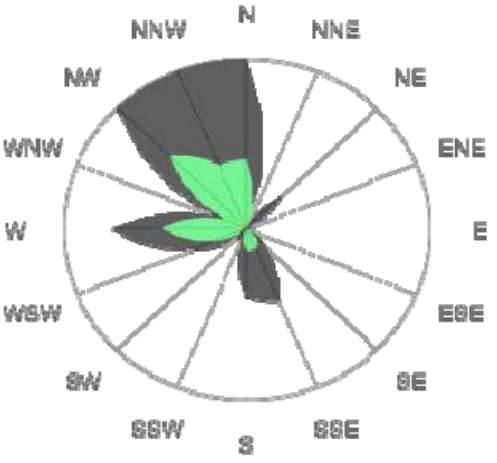
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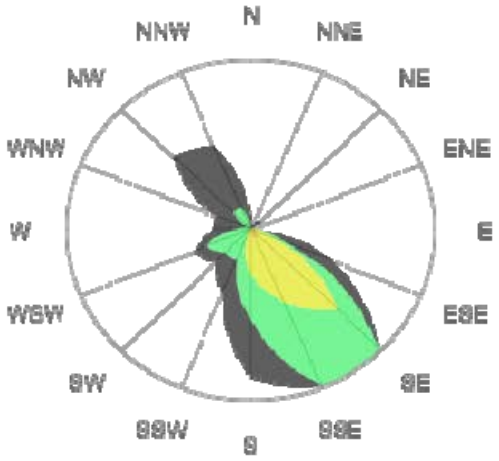
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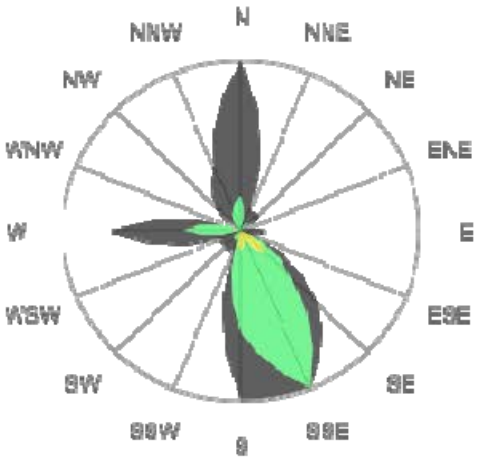
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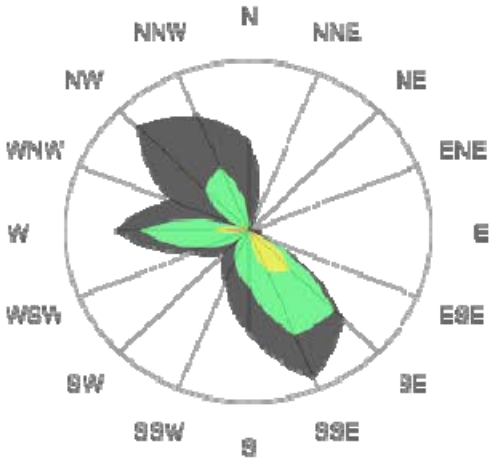
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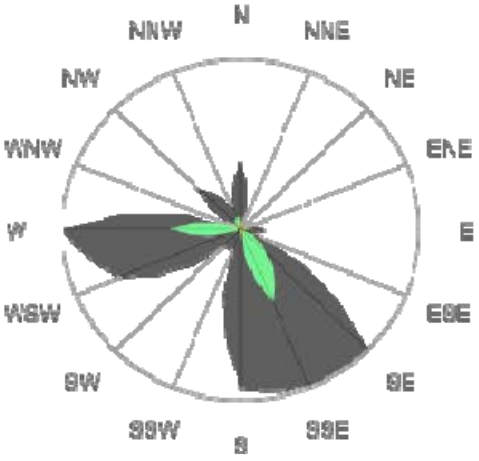
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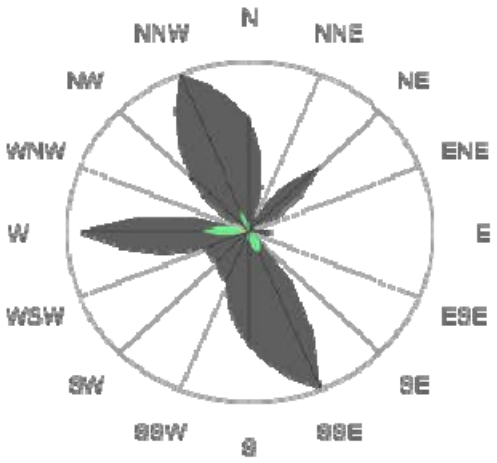
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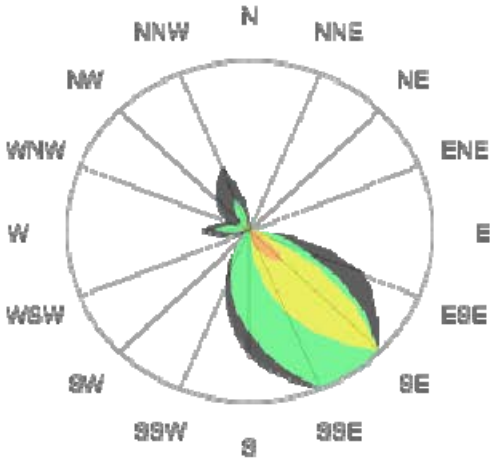
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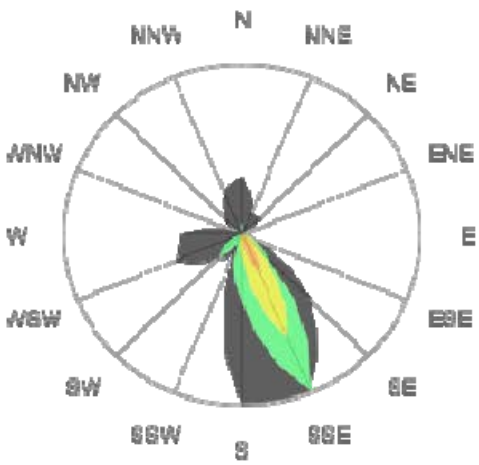
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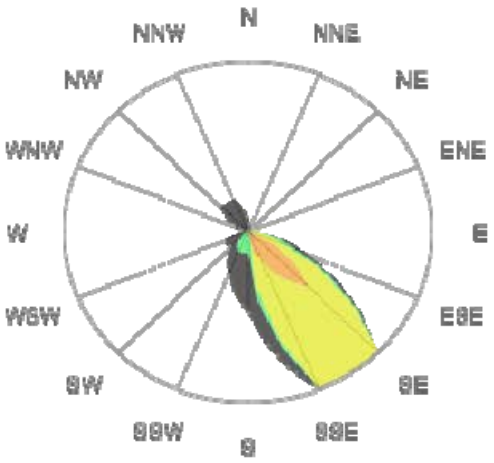
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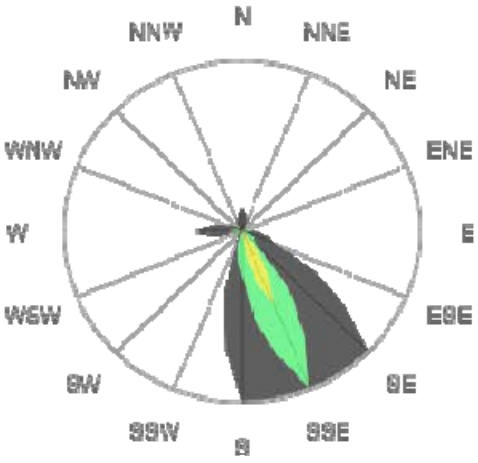
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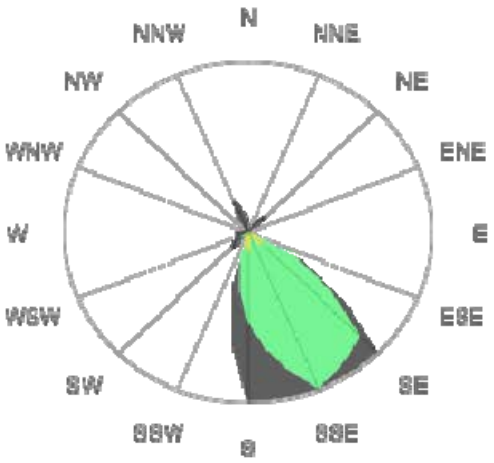
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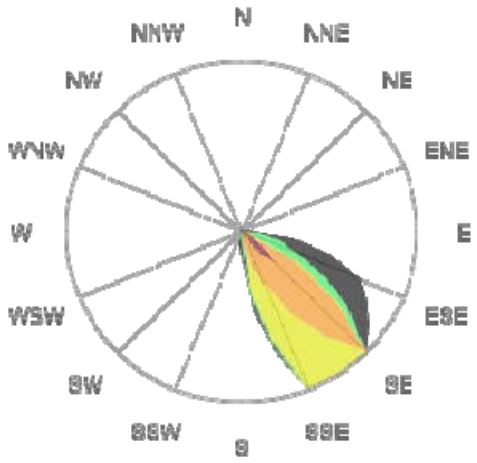
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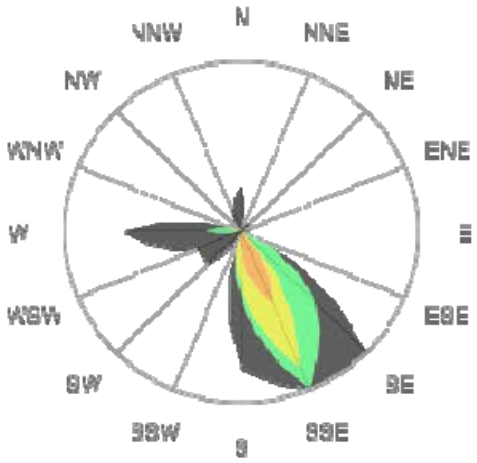
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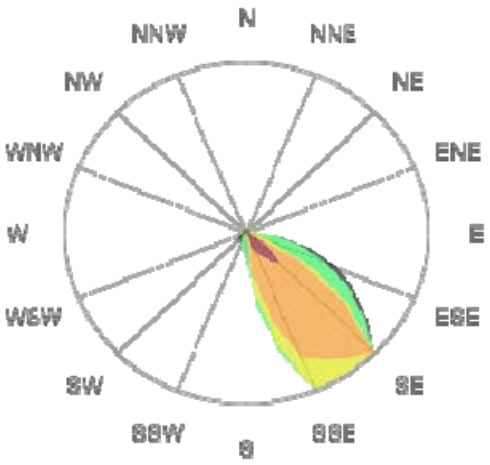
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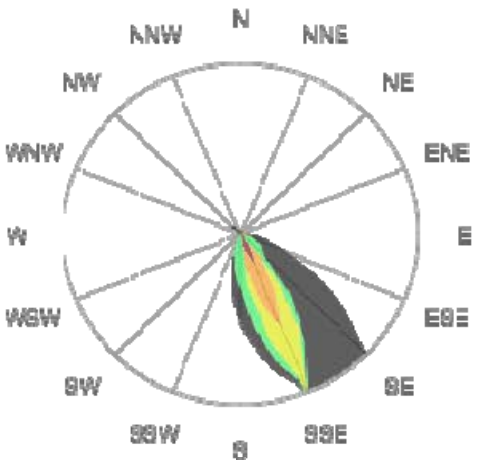
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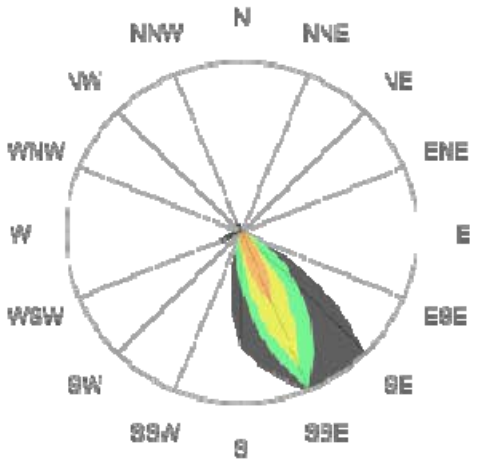
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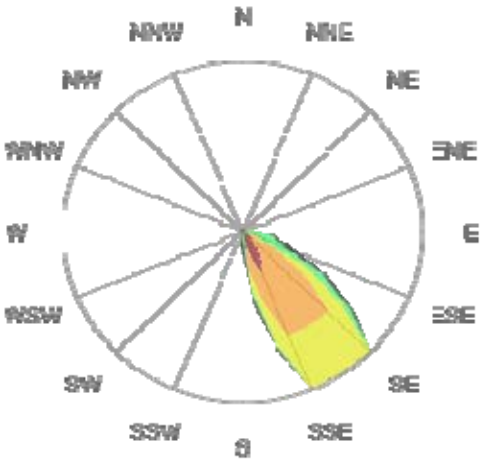
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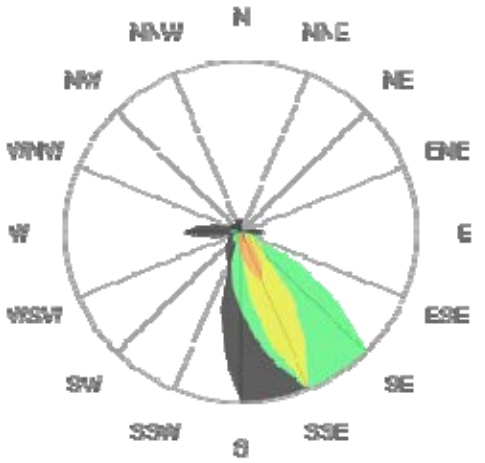
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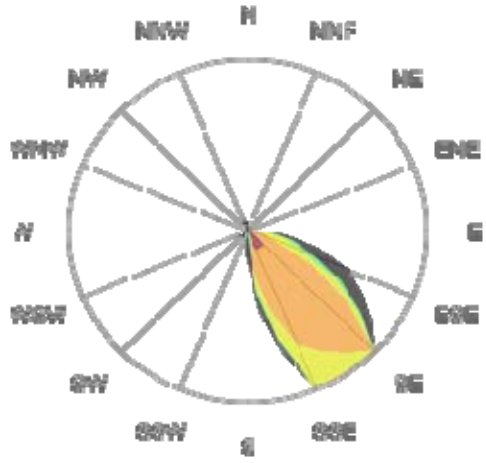
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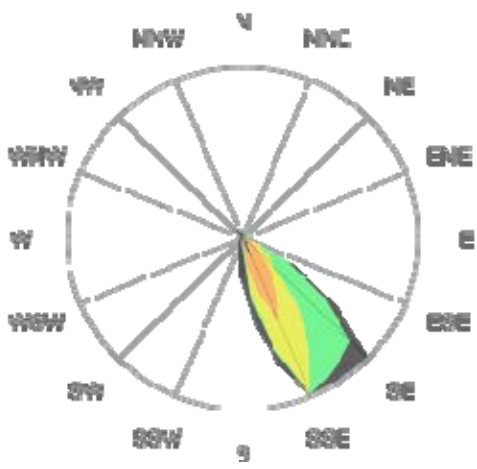
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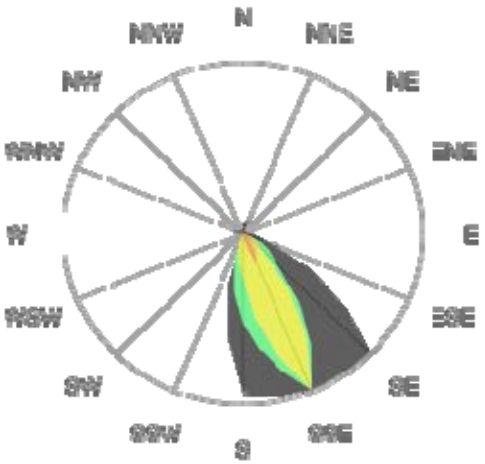
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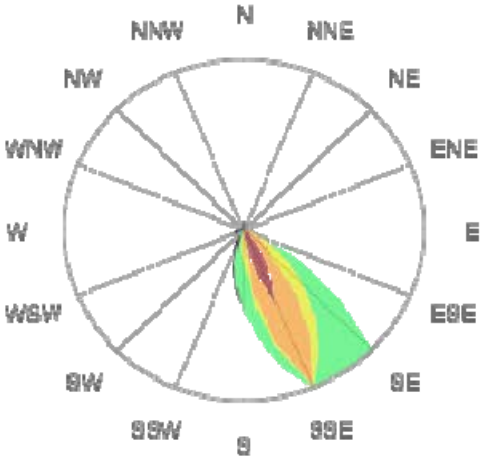
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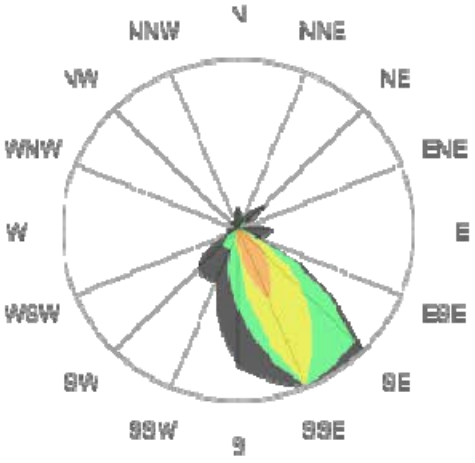
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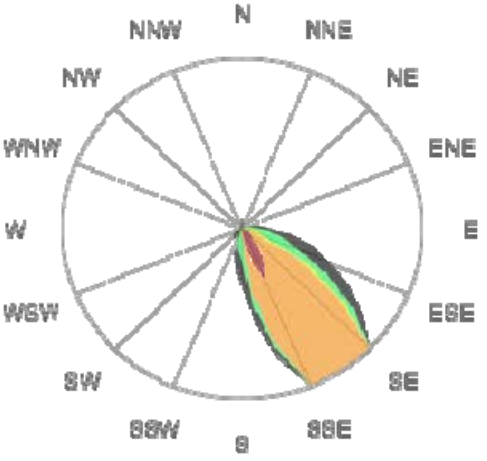
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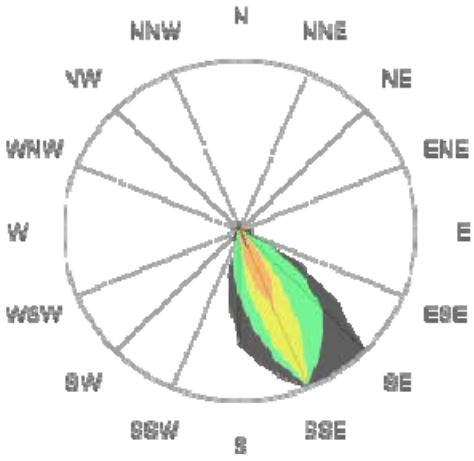
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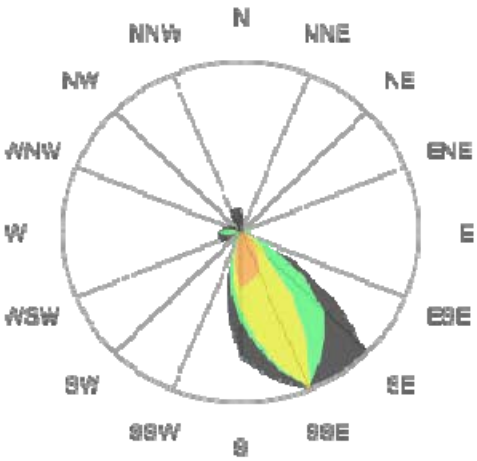
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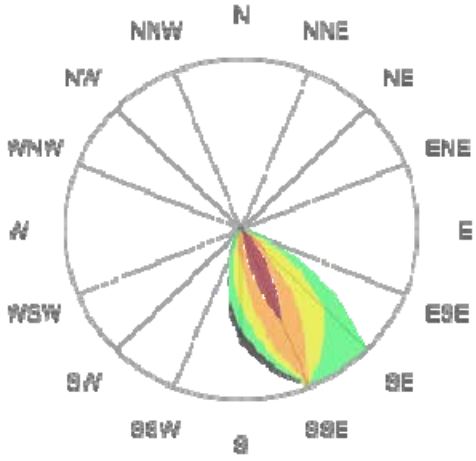
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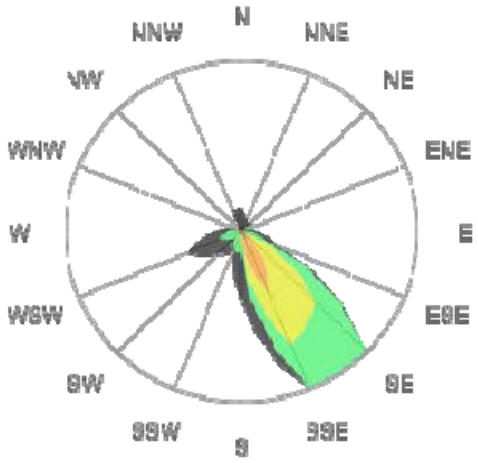
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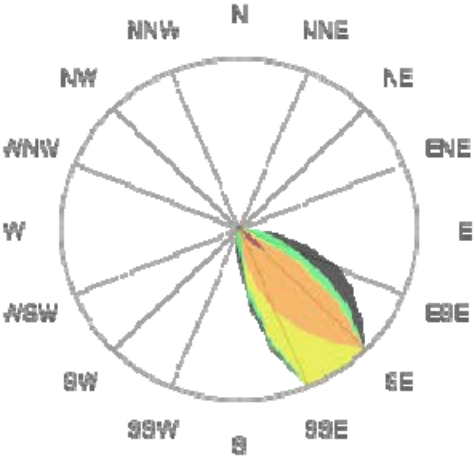
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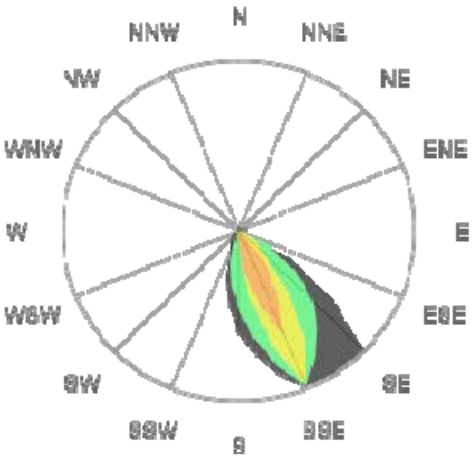
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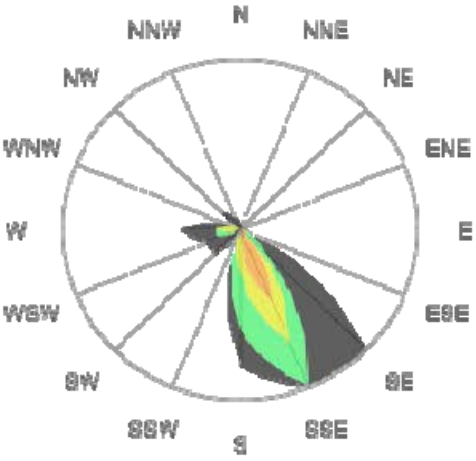
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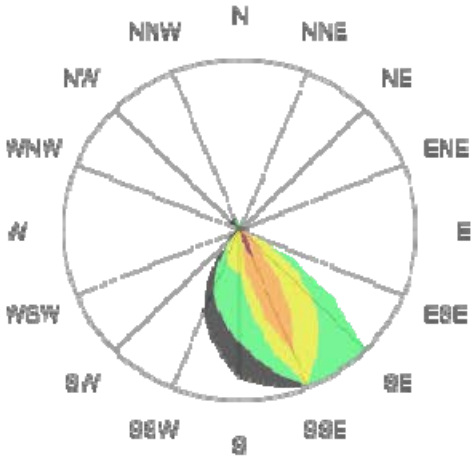
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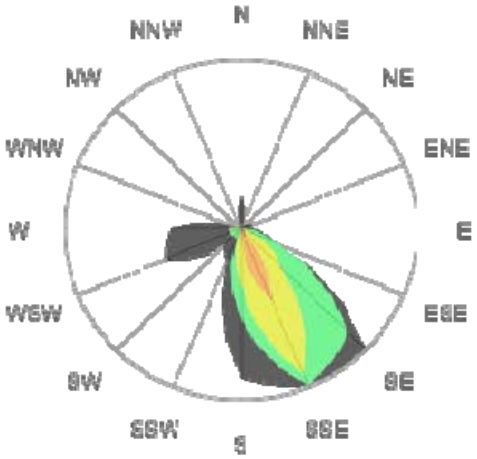
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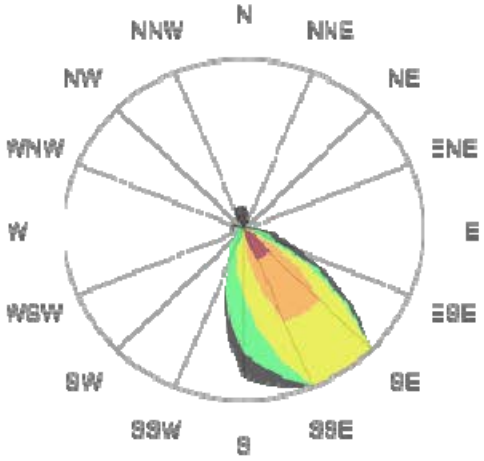
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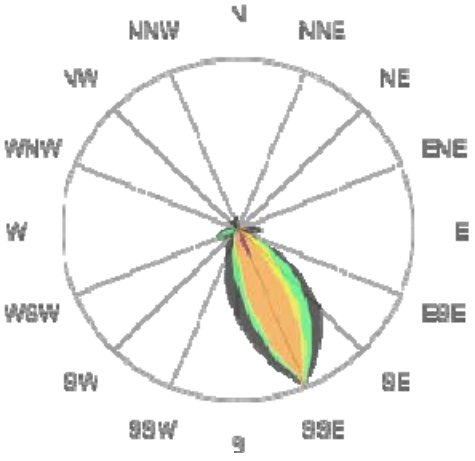
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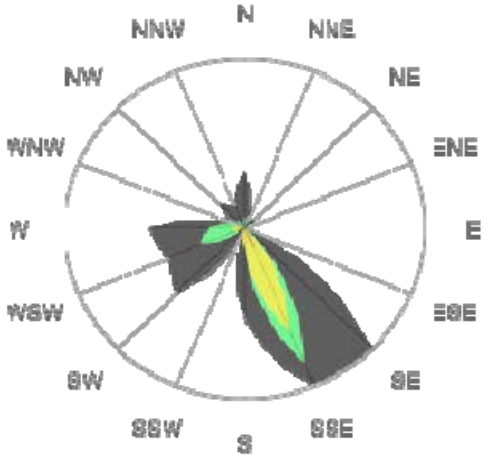
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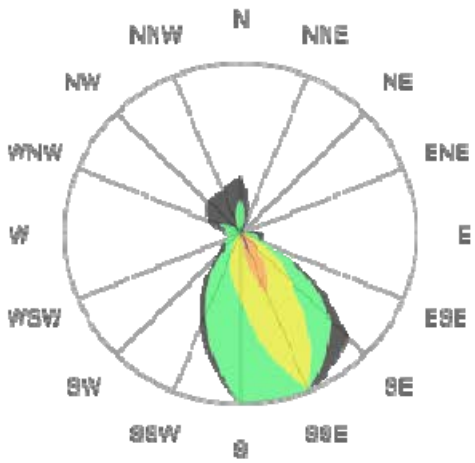
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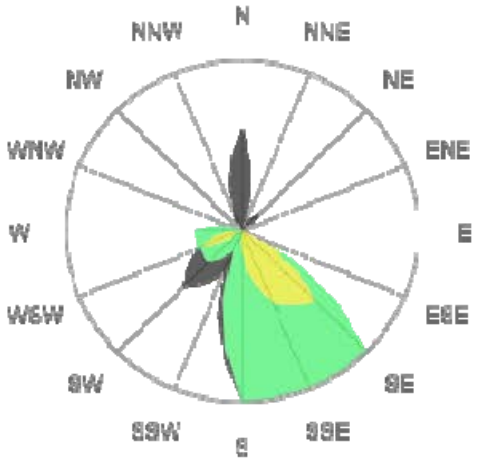
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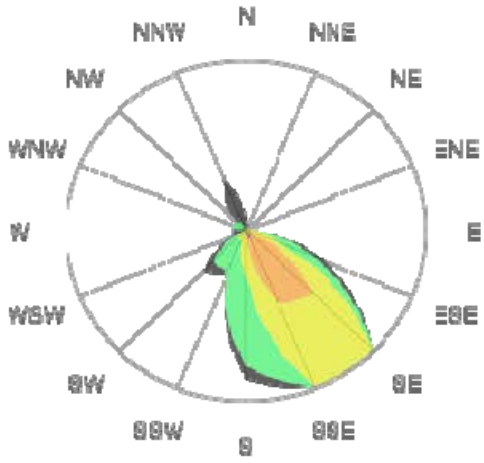
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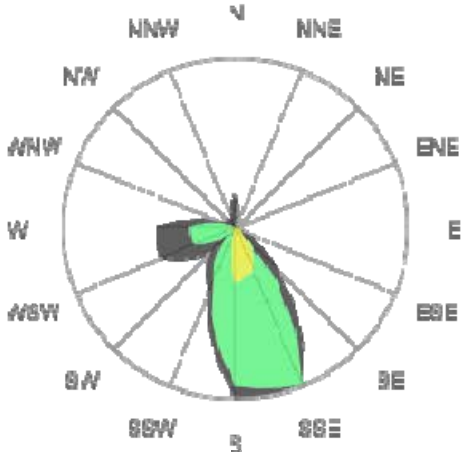
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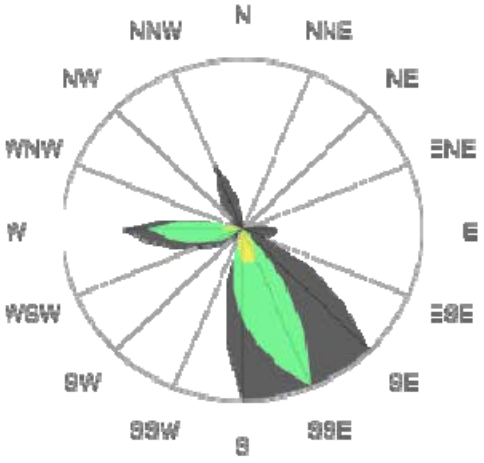
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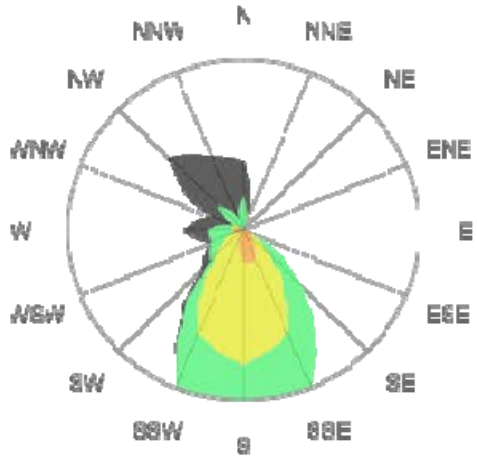
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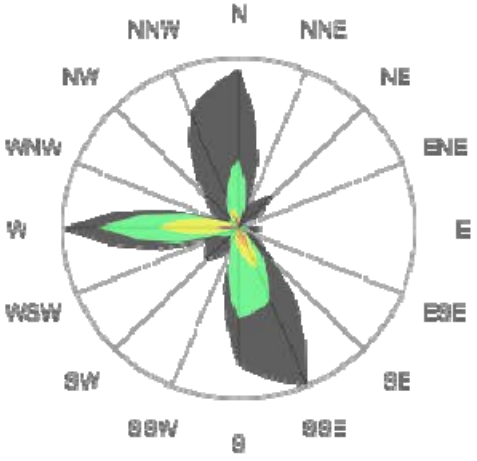
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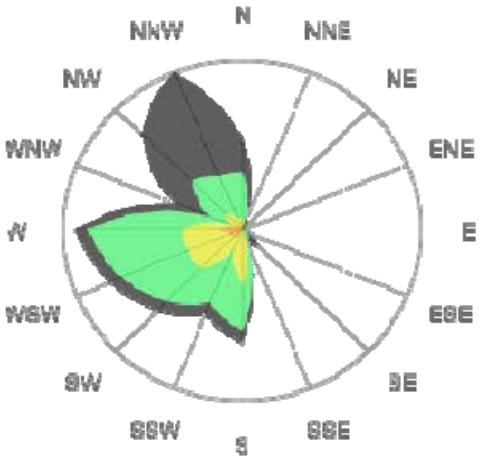
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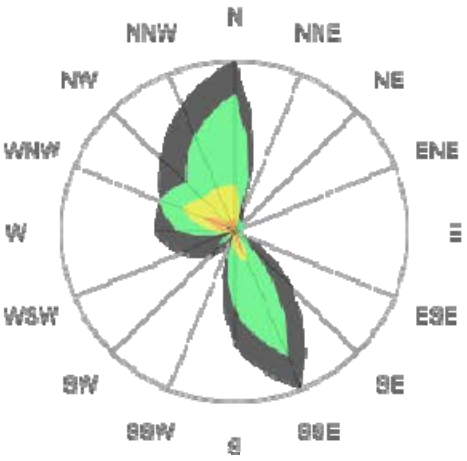
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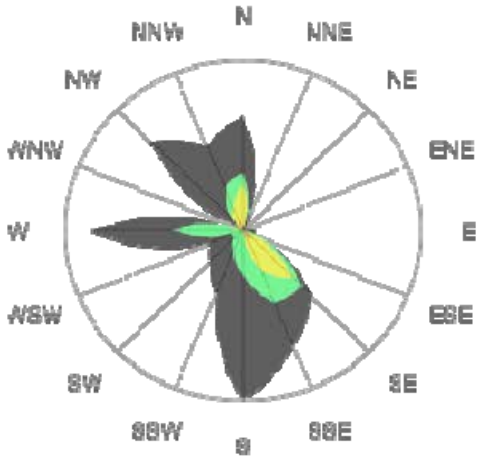
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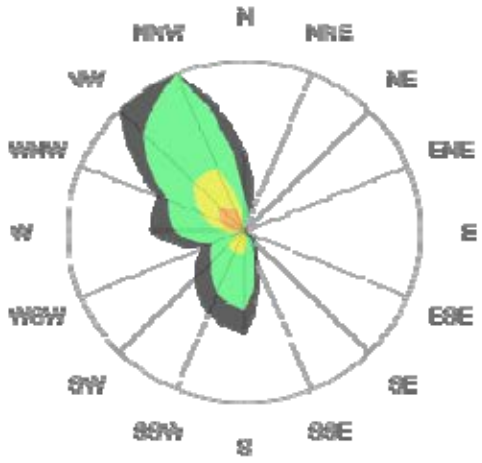
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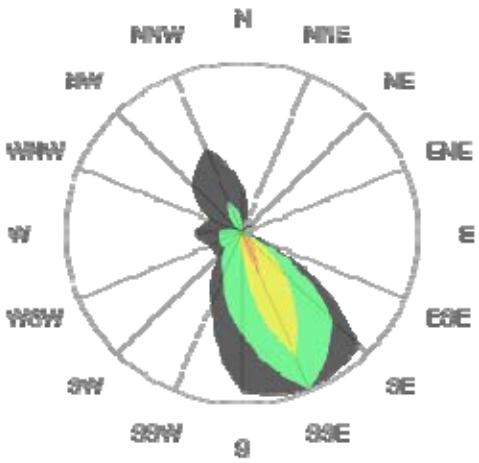
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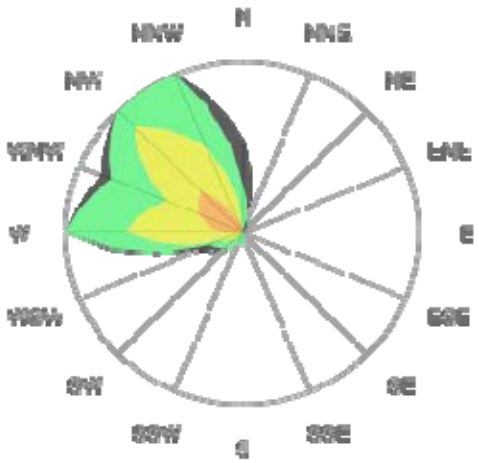
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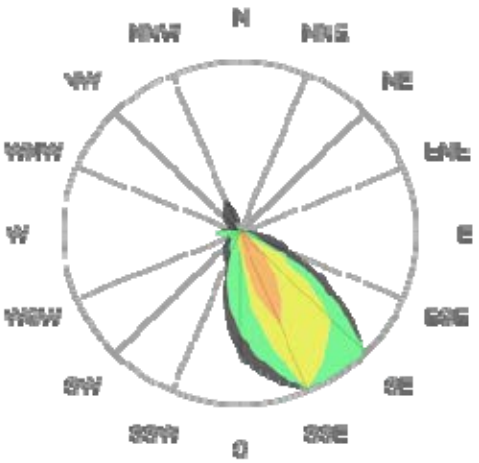
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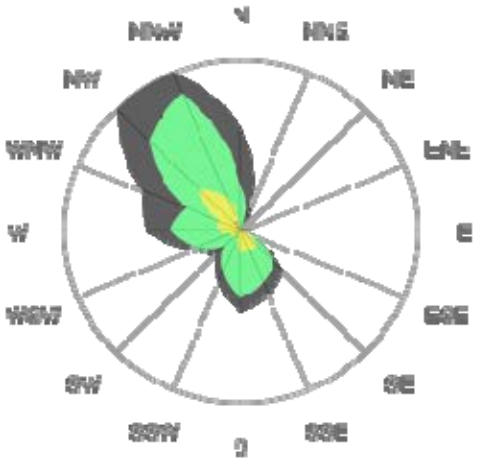
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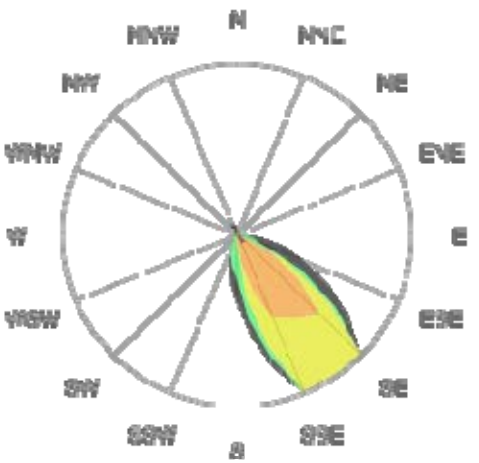
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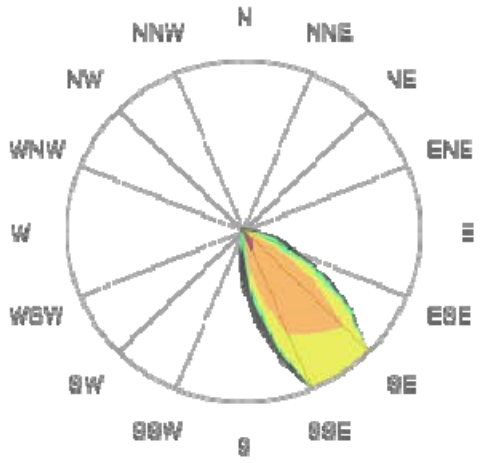
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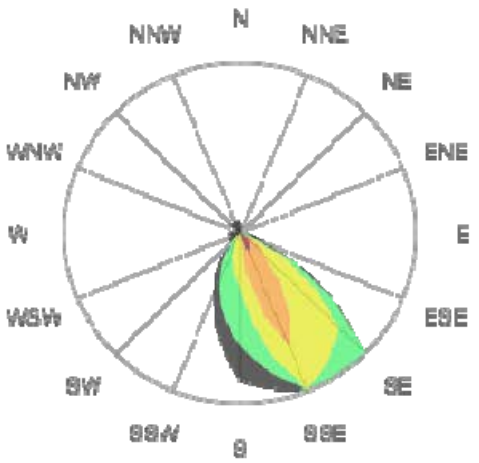
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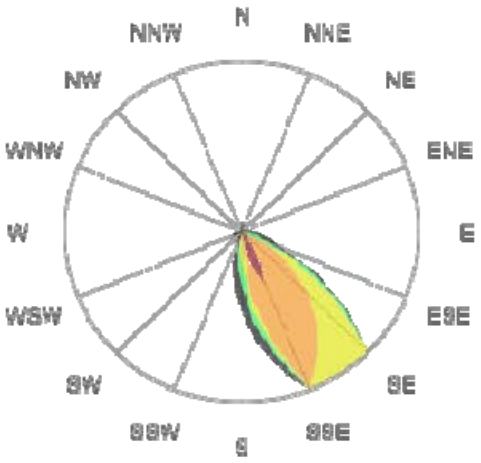
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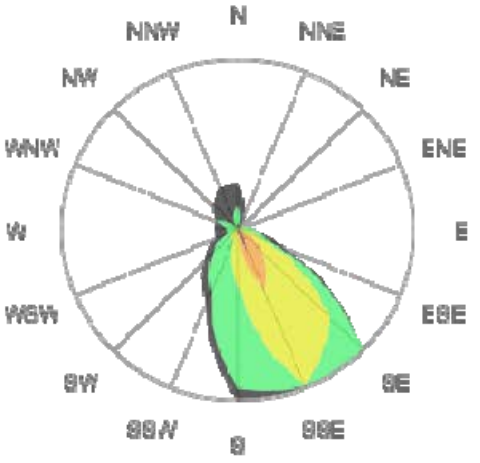
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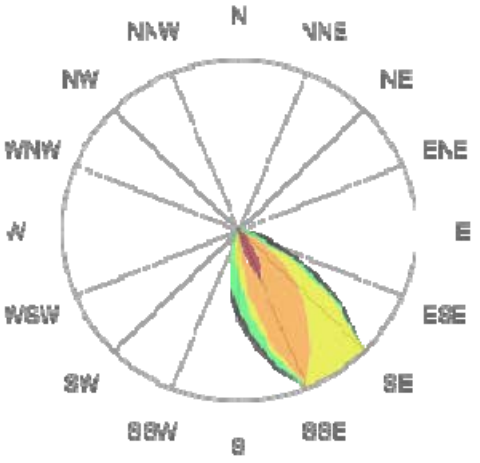
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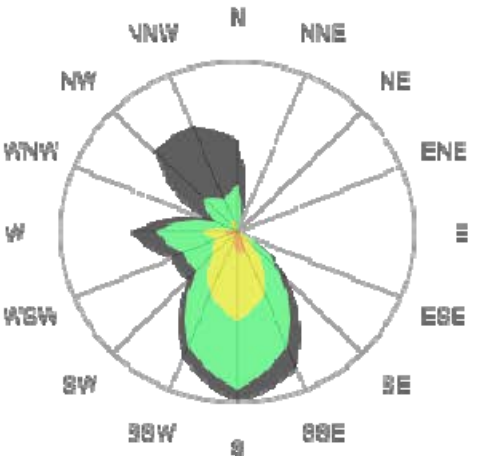
November - All Time - Avg



September - All Time - Avg



December - All Time - Avg



Appendix C Emission Inventory Equations for Particulates

Trucks Loading and Unloading, and Material Handling

Equation 10 of Environment Australia (2012) has been used because it provides a method of varying emission rates with wind speed.

$$E = 0.0016\ k\ \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where

E = Emission Factor with units kg/t of overburden

U = mean wind speed (m/s)

M = soil moisture content (%)

k = 0.74 for TSP

k = 0.35 for PM_{10}

$E_{PM_{2.5}}/E_{PM_{10}} = 0.15$ (USEPA, 2006a)

Bulldozing

Equations 16 and 17 of Environment Australia (2012) have been used.

$$E_{TSP} = 2.6 \times \frac{(s)^{1.2}}{(M)^{1.3}}$$

$$E_{PM_{10}} = 0.34 \times \frac{(s)^{1.5}}{(M)^{1.4}}$$

where

E = Emission factor with units kg/h/vehicle

s = Material silt content (%)

M = Soil moisture content (%)

$E_{PM_{2.5}}/E_{TSP} = 0.019$

Crushing

The emission factors for screening were taken from USEPA AP42 Chapter 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing (USEPA, 2004). The uncontrolled emission factors were used.

$E_{TSP} = 0.0125\ kg/t$

$E_{PM_{10}} = 0.0043\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.15$ (USEPA, 2006a)

For quaternary crushing of quarry materials, the uncontrolled fines crushing emission factors were used.

$E_{TSP} = 0.0195\ kg/t$

$E_{PM_{10}} = 0.0075\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.15$ (USEPA, 2006a)

Screening

The emission factors for screening were taken from USEPA AP42 Chapter 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing (USEPA, 2004). The uncontrolled screening emission factors have been used for screening after primary and secondary crushing. The emission factors are shown below.

$E_{TSP} = 0.0125\ kg/t$

$E_{PM_{10}} = 0.0043\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.15$ (USEPA, 2006a)

For screening after quaternary crushing, the uncontrolled fines screening factors have been used.

$E_{TSP} = 0.15\ kg/t$

$E_{PM_{10}} = 0.0043\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.15$ (USEPA, 2006a)

Fixation

For activities within the fixation area, the emission factors for concrete batching plant were used (USEPA, 2011). The emission factors are shown below:

For cement unloading to silo:

$E_{TSP} = 0.36\ kg/t$

$E_{PM_{10}} = 0.24\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.05/0.31$

For cement supplement unloading to silo:

$E_{TSP} = 1.57\ kg/t$

$E_{PM_{10}} = 0.65\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.05/0.31$

For aggregate transfer:

$E_{TSP} = 0.0035\ kg/t$

$E_{PM_{10}} = 0.0.0017\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.05/0.31$

For sand transfer:

$E_{TSP} = 0.0011\ kg/t$

$E_{PM_{10}} = 0.00051\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.05/0.31$

For mixer loading:

$E_{TSP} = 0.286\ kg/t$

$E_{PM_{10}} = 0.078\ kg/t$

$E_{PM_{2.5}}/E_{PM_{10}} = 0.05/0.31$

Wheel Dust Generation from Vehicles on Roads

The emission factors for paved roads were based on Utah DAQ (2015) which allows for the use of emissions factors for unpaved roads. The emission factors used are as follows:

$$E_{TSP} = 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W}{3}\right)^{0.45} \{lb/VMT\}$$

$$E_{PM10} = 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W}{3}\right)^{0.45} \{lb/VMT\}$$

Where: E = Emission factor
s = Material silt content (%)
W = mean vehicle weight (tonnes)

Note – lb/VMT was converted to kg/VKT by multiplying lb/VMT by 0.2819
– vkt = vehicle kilometres travelled

$E_{PM_{2.5}}/E_{PM_{10}} = 0.15/1.5$

Wind Erosion from Un-vegetated and Unsealed Surfaces

Environment Australia (2012) provides an NPI method for estimating annual emissions of dust from wind erosion based on either a default value published in 1983 or an equation published in 1998, which has several variables including number of rain days and average wind speed. However dispersion modelling is normally based on hourly time-steps and using this equation, the model will predict a small quantity of wind-blown dust every hour of the year. In reality, peak emissions of wind-blown dust will occur only during high wind speeds conditions during dry periods. During low wind speed conditions when particulates from other sources can accumulate, wind-blown dust will be negligible. Thus using the NPI equations will lead to inaccurate and un-timely contribution of wind-blown dust to the peak 24 hour predictions.

ASK calculates variable wind-blown dust emissions from exposed surfaces based on equations 2 and 3 of USEPA (2006b), which combine to become:

$$E = k \times \left(58 \times (u^* - u_t^*)^2 + 25\,(u^* - u_t^*)\right)$$

Where: E = Emission factor with units g/m^2/disturbance hour
k = Constant (1.0 for TSP, 0.5 for PM$_{10}$ and 0.075 for PM$_{2.5}$)
u^* = surface friction velocity (m/s)
u_t^* = threshold friction velocity (m/s)

The surface friction velocity can be calculated for different wind speed classes (at 10 metre anemometer height, based on Equations 13.2.5-6 and 13.2.5-7 of AP-42 (USEPA 2006b) using the following three factors:

(21) Based on Table 13.2.5-3 the ratio of surface wind to 10 metre approach wind over a steep stockpile area ranges from 0.2 to 1.1. Parts of the stockpile where the ratio is 0.2 will likely never be eroded by wind. Parts of the stockpile where the ratio is 0.6 will trigger rarely if ever for coal only. Overburden will only trigger when the ratio reaches 1.1, which is 4% or less of the stockpile. Coal will trigger when the ratio is 0.9 to 1.1, which occurs over 15% of the stockpile.

(22) Using equation 13.2.5-7, the surface friction velocity is one tenth of the surface wind.

(23) However these calculations are based on "fastest-mile" wind speeds, which approximate the fastest 1-minute mean wind speed (Graybeal 2006). The wind speeds used in modelling are one hour means. Ratios ("G_{60}") of 1 minute means to one hour means are estimated by Ashcroft (1994) for different terrain types. For mostly open, fairly level terrain with a few buildings, G_{60} = 1.26.

Therefore for overburden, the surface friction velocity is calculated as 1.1 x 0.1 x 1.26 times the 10 metre approach wind.

For each wind speed category, the geometric mean surface friction velocities are shown in **Table 12.2**.

Table 12.2 Wind Speeds and Corresponding Surface Friction Velocities (m/s) for 4% of Exposed Earth and Overburden

Pasquill Wind Speed Class	Corresponding Surface Friction Velocities	Mean Surface Friction Velocity
0 – 1.54	0 – 0.21	0.11
1.54 – 3.09	0.21 – 0.43	0.30
3.09 – 5.14	0.43 – 0.71	0.55
5.14 – 8.23	0.71 – 1.14	0.90
8.23 – 10.80	1.14 – 1.50	1.31
> 10.80	> 1.50	1.52

The threshold friction velocity (Table 13.2.5-2, USEPA 2006b) for overburden is 1.02 m/s. The resultant emission rates for different Pasquill wind speed classes are given in **Table 12.3**.

Table 12.3 Wind Erosion Emission Rates for Exposed Surfaces

Source	Pasquill Wind Speed Class (m/s)	TSP (kg/ha/hour)	PM10 (kg/ha/hour)	PM2.5 (kg/ha/hour)
Overburden dumps	5.15 – 8.23	0.7	0.3	0.03
Overburden dumps	8.24 – 10.80	5	2	0.2
Overburden dumps	> 10.80	10	5	0.4

Appendix 6
(Noise Assessment Report)

ACOUSTICS & AIR QUALITY
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Integrated Waste Management Facility

Site Portion 2703, Napa Napa Road, Porebada, Central Province, Papua New Guinea

Noise Impact Assessment

Report: 207401.0078.R02V01

Prepared for:

Total Waste Management

19 October, 2020



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1. Introduction

ASK Consulting Engineers (ASK) was commissioned by Total Waste Management (TWM) to provide acoustic consultancy services for the proposed Integrated Waste Management Facility (IWMF) to be located at Site Portion 2703, Napa Napa Road, Porebada, Central Province, Papua New Guinea (PNG). The project location is shown in **Figure 1.1**.



Figure 1.1 Location of Site (Source: Google Earth Pro)

This noise impact assessment report is to accompany the application for an Environmental Permit Level 3 (EP L3) application.

The purpose of this report is as follows:

- Outline the relevant project noise criteria.
- Predict and assess the noise emissions from the development.
- Describe noise mitigation requirements, if any.

To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

2. Project Description

TWM is broadly seeking to extend its operations from the current EP L2 to EP L3. This is to include the safe handling, recycling, storage, treatment and disposal of a broad range of solid, liquid and intractable wastes, including quarantine wastes, that may be defined as hazardous contaminants under provisions contained within Section 133 of the Environment (Amendment) Act 2014.

The EP L2-(485) was issued on 15 January 2016 and commenced on 12 February 2016 and has been amended twice since. The latest amendment was on 31 March 2020 to extend the permit to 25 years to 11 February 2041 and granted permission for the treatment and disposal of quarantine and COVID-19 health care facility wastes. As the IWMF already has an EP L2, construction of the site is underway at the time of writing this report, and the incinerator is already operating. The site will be under development for the period to end 2021. The proposed layout of the site is presented in **Appendix B**. The following plant and infrastructure will collectively form the IWMF:

- A receiving hall is for the segregation of recoverable materials from the incoming waste stream utilising both mechanical and manual methodologies.
- Recycling includes baling, shredding, containerising and crushing activities for glass, metals, paper/cardboard, plastics and organic materials. While these activities are approved under the current EP L2 for a capacity greater than 100 tonnes per year, the L3 permit application seeks to extend the type and complexity of recycling with inclusion of e-waste dismantling and plastics reprocessing.
- Composting of organic materials is an activity approved under the current EP L2-(485).
- Incineration plant using high temperature, pollution control system technology is capable of meeting USEPA and EU emission standard for the thermal destruction of medical waste, quarantine wastes, hazardous waste contaminants, contaminated soils and liquid wastes. While this activity is approved under the current EP L2-(485) for a capacity greater than 10 tonnes per year, the L3 permit application will seek to extend the type and complexity of hazardous contaminants able to be thermally destructed through this process.
- Waste oil processing unit (WOPU) for the recycling of waste oils is an activity approved under the current EP L2-(485).
- Industrial services for the cleaning of tanks and wastewater treatment systems is for beneficial reuse and closed loop applications.
- Fixation bays are used for the stabilisation of selected materials prior to landfilling.
- Waste water treatment plant is an activity approved under the current EP L2-(485); however, given the extension of hazardous and industrial liquid waste types to be received and processed at the IWMF, the L3 permit application will seek to operate an industrial waste water treatment plant.
- Quarrying activities in an existing quarry. This is an approved activity under the current EP L2-(485) for extraction of more than 100,000 tonnes per year.
- Engineered industrial landfill activities are for the disposal of stabilised hazardous contaminants, quarantine wastes, asbestos, construction and demolition materials and other wastes unsuitable for recycling and reuse. While the construction and operation of a landfill for the disposal of municipal wastes is an approved activity under the current EP L2-(485), the L3 permit application will seek to construct and operate a hazardous waste landfill to USEPA standard.
- Hazardous waste storage is for the safe consolidation and storage of hazardous contaminants for onsite treatment or export to approved disposal facilities. Temporary storage of waste is approved under the current EP L2-(485). The L3 permit application seeks to extend the type and complexity of hazardous contaminants that can be stored and to treat and dispose at the site.

The proposed hours of operation are 7 am to 5 pm on Monday to Friday and 7 am to 12 pm on Saturday.

3. Site and Receptor Locations

The closest residential and commercial/industrial receptors are shown in **Figure 3.1**. The existing staff accommodation and proposed accommodation within the site are not considered sensitive for the purposes of this assessment. R1 to R3 are residential receptors while R4 to R6 are commercial/industrial receptors. Receptor R1 is a stilted house equivalent to two-story building and therefore receptor height of 4.6m above the ground level is considered in the model. Other receptors (i.e R2 to R6) are considered as 1.8m above the ground level.



Figure 3.1 Site and Receptor Locations (Source: Google Earth Pro)

4. Acoustic Criteria

The Environmental Permit includes the following noise criteria:

> *(45) Comply with the performance criteria, management controls, monitoring, reporting and corrective actions set out in the Noise Management Sub-Plan presented in the EMP in order to comply with the noise criteria set out in Table 2 below:*

Environment Permit Table 2: Noise Criteria Guidelines

Receptor	***Noise Limits $L_{Aeq,1hour}$ (One-hour Equivalent Continuous Sound Pressure Level)***	
	Day: 07:00 – 22:00	***Night: 22:00 – 07:00***
Residential	*55 dBA*	*45 dBA*
Industrial & Commercial	*70 dBA*	*70 dBA*

Given the site is planned to operate within daytime hours, the relevant noise limits are as follows:

- Residential receptors 55 dBA $L_{Aeq,1hour}$
- Industrial and commercial receptors 70 dBA $L_{Aeq,1hour}$

5. Baseline Noise Monitoring

5.1 Overview and Locations

ASK has previously conducted the baseline noise monitoring for the project (ASK ref: 9769R01V01, dated 26/11/2018) and discussed in this section. Acoustic measurements consisted of attended noise measurements and noise logging. The noise measurement locations are shown in **Figure 5.1**.

The noise monitoring was undertaken in general accordance with Australian Standard AS1055 Acoustics – Description and measurement of environmental noise.



Figure 5.1 Noise Monitoring Locations A to E

5.2 Attended Noise Measurements

Attended noise measurements were undertaken at Locations A to E. The measurements were undertaken between 9:00am and 2:00pm on 6/11/2018 over a 15 minute periods using a field and laboratory calibrated Norsonic NOR140 sound level meter. The microphone height was approximately 1.3m above natural ground level and was located in the free field. Weather during the time of monitoring was overcast and warm with 3/4 cloud cover and a slight breeze from the south.

The measured noise levels are summarised in **Table 5.1**.

Table 5.1 Attended Noise Measurement Results

Location	Date & Time	Period (Minutes)	Results & Notes
A	9:21am 06/11/18	15	Statistical noise levels: L_{10} 56 dBA, L_{eq} 52 dBA, L_{90} 44 dBA Noise from crane working on TWM site 44 to 57 dBA Noise from AES site and Harbour 43 to 47 dBA Trucks on local road 45 to 56 dBA Airbrakes from trucks stopping at AES gate 45 to 57 dBA Crows nearby 50 to 52 dBA
B	9:49am 06/11/18	15	Statistical noise levels: L_{10} 44 dBA, L_{eq} 44 dBA, L_{90} 37 dBA Birds nearby 37 to 47 dBA Trucks on local road 50 to 61 dBA Cars on local road 46 to 49 dBA Distant noise from AES site and Harbour audible but difficult to measure. Estimated 37 to 40 dBA Wind in grass and trees 35 to 36 dBA
C	10:55am 06/11/18	15	Statistical noise levels: L_{10} 44 dBA, L_{eq} 44 dBA, L_{90} 37 dBA Distant machinery noise 33 to 34 dBA Noise from insects nearby 36 to 40 dBA Wind rustling grass and trees 34 to 37 dBA Birds nearby 35 to 44 dBA Impact noises from surrounding sites 35 to 42 dBA
D	11:21am 06/11/2018	30sec	Statistical noise levels: L_{10} 58 dBA, L_{eq} 58 dBA, L_{90} 58 dBA Measurement dominated by noise coming from communications tower.
E	11:45am 06/11/18	15	Statistical noise levels: L_{10} 48 dBA, L_{eq} 45 dBA, L_{90} 40 dBA Forklift operating on TWM site 45 to 51 dBA Impact noises from neighbouring site to the northwest 39 to 44 dBA Grinder used on neighbouring site to the northwest 45 to 47 dBA Wind rustling trees and grass 38 to 42 dBA Reverse beepers on TWM site 43 to 45 dBA
A	1:34pm 06/11/18	15	Statistical noise levels: L_{10} 52 dBA, L_{eq} 49 dBA, L_{90} 43 dBA Trucks on local road 47 to 57 dBA Airbrakes from trucks stopping at AES gate 44 to 48 dBA Trucks on AES and harbour road 44 to 55 dBA Impact noises from AES site 44 to 52 dBA Noise from Harbour audible but difficult to measure. Birds nearby 47 to 52 dBA

Note: * The reported noise levels, excluding the statistical noise levels, are the instantaneous levels read from the sound level meter, and generally represent the range in noise levels or maximum noise levels for a particular noise source.

5.3 Noise Logging

Noise logging was undertaken at Location A in the free field. Logging was undertaken from 5/11/2018 to 10/11/2018 using a field and laboratory calibrated ARL NGARA environmental noise logger. The serial numbers of the equipment used are as follows:

- Instrument Serial Number: 87816D
- Microphone Serial Number: 322320
- Pre-amplifier Serial Number: 28460

The measured noise levels are shown in **Figure 5.2**.

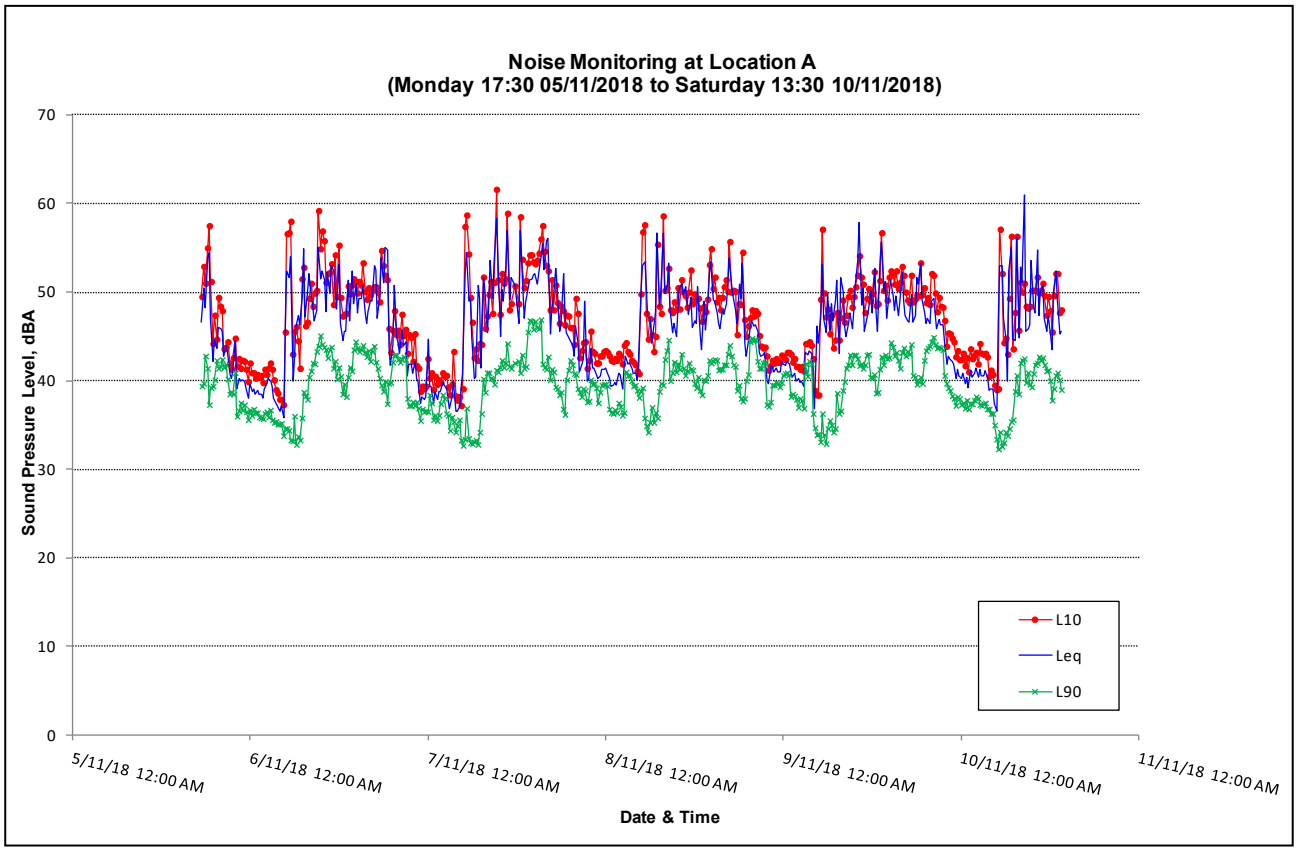


Figure 5.2 Graph of Noise Logging Results at Location A

From the noise logging the statistical results have been summarised in **Table 5.2**.

Table 5.2 Statistical Noise Levels at Location A

Parameter	Noise Levels dBA [Maximum-Top 10%-(Average)-Bottom 10%-Minimum]		
	Day	Evening	Night
L_{max}	87-74-(69)-60-55	84-73-(60)-51-47	74-69-(54)-46-41
L_1	71-67-(60)-53-50	69-65-(53)-45-43	68-62-(49)-42-40
L_{10}	62-54-(50)-48-44	58-51-(47)-43-41	59-48-(43)-39-37
L_{eq}	61-54-(50)-46-41	55-51-(46)-42-40	55-49-(42)-38-36

The background noise levels calculated using the lowest 10th percentile method are shown in **Table 5.3**.

Table 5.3 Background Noise Levels at Location A

Period	Background Noise Level L_{90} dBA
Day (7am to 6pm)	39
Evening (6pm to 10pm)	38
Night (10pm to 7am)	34

The subject site is located in an industrial area and noise levels on the site especially on the northern boundary close to the local road and AES site, are dominated by car and truck movements as well as industrial noise. Moving away from the local road, AES site and harbour the noise levels reduce and insects, birds and wind rustling the grass and trees are the dominant noise sources.

6. Noise Assessment

6.1 Model Description

Noise modelling was carried out using the SoundPLAN v8.2 computer program using the CONCAWE algorithm, which are widely used and accepted for environmental noise modelling.

The SoundPLAN program was used to develop a three-dimensional digital terrain noise model of the Integrated Waste Management Facility and the surrounding area including the location of sensitive receptors. The model incorporates terrain data for the proposed Integrated Waste Management Facility and the surrounding natural topography.

6.2 Meteorology

The industrial noise levels at residential receptors can vary significantly depending upon the meteorology and the industrial activities. Meteorology has a significant effect on the noise levels, particularly due to wind speed and direction and vertical temperature gradients, which include temperature inversions.

It is noted that the facility only operates during daytime and therefore the SoundPLAN model was setup to predict noise levels under following meteorological conditions.

- Day – Calm condition
  - Pasquill Stability Class: D (no temperature inversion)
  - Temperature: 25 °C
  - Wind Speed: 0 m/s
  - Relative Humidity: 40%
- Day – Downwind condition
  - Pasquill Stability Class: D (no temperature inversion)
  - Temperature: 25 °C
  - Wind Speed: 4 m/s
  - Relative Humidity: 40%

These meteorological scenarios are presented to give an indication of the range of noise levels from calm to downwind conditions and are assessed against the criteria. Based on the meteorological modelling in ASK air quality report (207401.0078.R02V01), the most prevailing wind speed varies from 3 to 5 m/s and therefore median 4 m/s wind speed was selected in this modelling. These downwind conditions are most likely to occur in the afternoon especially between 2 and 5 pm.

The SoundPLAN model assumes the wind direction is from the source to each receptor and thus modelling for multiple wind directions is not required.

6.3 Noise Source Data

The model uses the sound power level (L_w) of each noise source to predict noise emissions. The sound power levels used in the model were based on noise source data obtained from previous projects. The sound power levels for the mobile and fixed equipment and activities proposed for the Integrated Waste Management Facility are presented in **Table 6.1**.

Table 6.1 Noise Source Sound Power Levels

Equipment / Activities	Octave Band Sound Power Level $L_{W,eq}$ dBZ								Overall $L_{W,eq}$	
	63	125	250	500	1k	2k	4k	8k	dBZ	dBA
Unloading waste	101	90	91	88	90	89	85	83	103	95
Unloading metal panels	120	121	114	121	115	106	103	104	126	120
Forklift 1.5T	113	104	98	93	97	96	88	79	114	101
Baling machine	90	85	90	95	87	83	79	76	98	94
Glass Crushing	90	90	88	78	73	72	67	61	95	83
Front end loader 12T	113	107	104	100	99	101	96	89	115	106
Forklift 5T	118	109	103	98	102	101	93	84	119	106
Incinerator	109	115	112	109	114	105	100	95	120	116
Pump	88	89	91	91	94	91	87	81	99	98
High pressure water jetting	87	91	91	94	99	96	96	101	105	104
Water jetting unit	79	87	81	83	88	79	72	78	92	89
Dozer with rippers	121	110	106	108	108	106	98	86	122	112
Excavator	88	99	94	103	97	98	96	94	107	105
Front end loader 18.5T	97	105	108	103	104	99	93	89	112	108
Screen	117	110	106	105	105	102	99	93	119	109
Crusher	98	108	106	103	106	96	92	86	112	108
Air compressor	87	93	91	98	99	100	103	107	110	109
6x4 articulated trucks	118	118	111	106	105	101	98	95	122	110
3 tonne truck	72	80	86	91	94	92	85	78	98	98
4x2 articulated light truck	72	80	86	91	94	92	85	78	98	98
Haulage truck	122	122	115	110	109	105	102	99	126	114
Dump truck	103	105	102	102	103	101	96	91	111	107

The equipment modelled has been chosen to closely reflect the anticipated fleet. However, there is potential for alternate makes and models of equipment to be used in the operations. If the equipment model is changed, the sound power level of the alternative model should be reviewed to determine if noise level increases are expected.

An internal sound pressure level of 70 dBA L_{eq} was modelled in the existing warehouse building which allows for typical warehouse activities.

6.4 Modelling Scenario

Noise emissions from the Integrated Waste Management Facility have been predicted considering multiple operational scenarios.

It was advised that the quarrying and pre-construction activities will be relatively short term (approximately 3 months) and will allow for the construction of the landfill. Therefore, all plant in landfill and quarry areas will not be running continuously or simultaneously. During quarrying it is more likely that the excavator and dozer will operate together, and these activities will be similar to pre-construction earthworks and civil works

activities. For quarrying operations, when the dozer and excavator stop, the screen and crusher will run. During landfill operations the dozer and excavator will only operate for short periods when small loads are received. Therefore, the following three scenarios have been considered in this project.

- Scenario 1 : Quarry/ Pre-construction (Excavator and dozer operating but no crusher and screen) with other operations.
- Scenario 2 : Quarry (Crusher and screen operating but no excavator and dozer) with other operations.
- Scenario 3 : Landfill (No quarry operations) with other operations. This scenario relates to when the quarrying activities have ceased and all components of the IWMF have been commissioned and are fully operational.

Ground elevations, equipment numbers and equipment locations are modelled based on the information provided by Total Waste Management.

The assessment is conducted considering one-hour period as per the project noise criteria. The stationary equipment numbers, location and operation time for the three scenarios are presented in **Table 6.2. T**he detail of the mobile equipment fleet is presented in **Table 6.3**. Source locations and truck movement paths in the SoundPLAN mode are shown in **Appendix C**.

Table 6.2 Stationary Equipment, Locations and Operational Periods

Activities and Location	Number of Equipment/ Activity	Duration of Operation in a One Hour Period		
		Scenario 1	Scenario 2	Scenario 3
Material Sorting and Segregation Area				
Unloading waste	1	5min	5min	5min
Unloading metal panels	1	2min	2min	2min
Forklift 1.5T	1	Continuous	Continuous	Continuous
Recycling Area				
Unloading waste	1	2min	2min	2min
Baling machine	1	Continuous	Continuous	Continuous
Glass Crushing	1	5min	5min	5min
Front end loader 12T	1	15min	15min	15min
Forklift 5T	1	15min	15min	15min
Incineration Plant Area				
Incinerator	1	Continuous	Continuous	Continuous
Pump	1	Continuous	Continuous	Continuous
Waste Oil Recycling Area				
Pump	1	5min	5min	5min
Forklift 1.5T	1	30min	30min	30min
Fixation plant Area				
High pressure water jetting	1	15min	15min	15min
Water jetting unit	1	15min	15min	15min
Wastewater Treatment Area				
Pump	3	Continuous	Continuous	Continuous

Activities and Location	Number of Equipment/ Activity	Duration of Operation in a One Hour Period		
		Scenario 1	Scenario 2	Scenario 3
Quarry and Landfill Area				
Dozer	1	Continuous	0 min	30min
Excavator	1	Continuous	0 min	30min
Front end loader	1	Continuous	Continuous	30min
Screen	1	0 min	Continuous	0 min
Crusher	1	0 min	Continuous	0 min
Air compressor	1	15 min	15 min	15 min
Pump	2	30 min	30 min	30 min
Warehouse Area				
Warehouse	1	Continuous	Continuous	Continuous

Table 6.3 Mobile Equipment Fleet and Locations

Vehicle Type	Number of Vehicles Per Hour	Travel Path Description
6x4 articulated truck	3	Offsite to receiving area
3 tonne truck	1	Receiving area to recycling area
4x2 articulated light truck	1	Recycling area to landfill
	1	Recycling area to Incinerator
Dump truck	2	Receiving area to landfill
Haulage truck	2	Quarry to offsite

6.5 Predicted Noise Levels and Assessment

The predicted noise levels at nearby sensitive receptors for the three scenarios under different meteorological conditions are presented in **Table 6.4**. The noise contours for the worst-case scenario (i.e. Scenario 1) are presented in **Appendix D** and for the long-term scenario (i.e. Scenario 3) are presented in **Appendix E**.

Table 6.4 Predicted Noise Levels

Receptor	Receptor Height (m)	Receptor Type	Predicted Noise Level $L_{eq,1hour}$ dBA Under Two Meteorological Conditions	
			Day – Calm Condition	Day – Downwind Condition
Scenario 1 : Quarry/ Pre-construction (No crusher and screen) with other operations.				
R1	4.6	Residential	52	55
R2	1.8	Residential	49	54
R3	1.8	Residential	26	31
R4	1.8	Commercial	59	61
R5	1.8	Commercial	61	63

Receptor	Receptor Height (m)	Receptor Type	Predicted Noise Level $L_{eq,1hour}$ dBA Under Two Meteorological Conditions	
			Day – Calm Condition	Day – Downwind Condition
R6	1.8	Commercial	62	64
Scenario 2 : Quarry (No excavator and dozer) with other operations.				
R1	4.6	Residential	52	55
R2	1.8	Residential	49	53
R3	1.8	Residential	26	31
R4	1.8	Commercial	59	61
R5	1.8	Commercial	61	63
R6	1.8	Commercial	61	63
Scenario 3 : Landfill (No quarry operations) with other operations.				
R1	4.6	Residential	51	54
R2	1.8	Residential	48	52
R3	1.8	Residential	26	31
R4	1.8	Commercial	59	60
R5	1.8	Commercial	61	62
R6	1.8	Commercial	60	62

From **Table 6.4** It can be seen that:

- The predicted noise levels at all residential receptors (R1, R2 and R3) are between 26 and 55 dBA $L_{Aeq,1hour}$.
- Predicted noise levels at commercial/ industrial receptors (R4, R5 and R6) are 59 to 64 dBA $L_{Aeq,1hour}$.

The proposed daytime noise limit for residential receptors is 55 dBA L_{Aeq} (1 hour) and commercial/industrial receptors is 70 dBA L_{Aeq}(1 hour). Based on the **Table 6.4**, it can be seen that the predicted noise levels are at or below the nominated noise limits and are therefore acceptable.

The predicted noise level at the closest residence is at the noise limit specially during quarrying activities and pre-construction activities (i.e. Scenario 1 and 2). However, it is understood that these will be short-term activities. Scenario 3 relates to when the IWMF is fully operational and the short-term quarrying and pre-construction activities have ceased. In this scenario, it is expected that noise levels at the closest residence will be just under the nominated noise criteria for worst weather conditions. These noise levels are mainly contributed from dozer, front end loaders and forklifts operations. The following measures could be considered in order to reduce noise emissions, where further noise reduction is required.

- Management of mobile equipment locations, such as operating away from residential receivers or shielded areas.
- Reducing the number of items of equipment in operation.
- Attenuation of equipment, including dozers, front end loaders and forklifts.
- Attenuation/acoustic enclosure for the crusher and screen could also be considered, as this is a significant contributor during quarrying period.
- Construction of barriers/bund walls. A barrier/bund of sufficient height and in a location which provides a high level of shielding to the loudest equipment (dozers, excavators, front end loaders and forklifts), could be considered.

7. Recommendations & Conclusion

A noise impact assessment has been conducted for the proposed Integrated Waste Management Facility. The following conclusions are made regarding the assessment:

- Noise criteria for the project have been proposed in **Section 4**, and given the site is planned to operate within daytime hours, the relevant noise limits are as follows:
  - Residential receptors 55 dBA $L_{Aeq,1hour}$
  - Industrial and commercial receptors 70 dBA $L_{Aeq,1hour}$
- Noise emission levels have been predicted for three operational scenarios and two meteorological conditions in **Table 5.4**. Noise contours are provided in **Appendix D** and **Appendix E**. Based on these results, the predicted noise levels are at or below the nominated noise limits and are therefore acceptable.
- Mitigation measures are discussed in **Section 6.5** if further noise reduction is required.

Appendix A Glossary

Parameter or Term	Description
dB	The decibel (dB) is the unit measure of sound. Most noises occur in a range of 20 dB (quiet rural area at night) to 120 dB (nightclub dance floor or concert).
dBA	Noise levels are most commonly expressed in terms of the 'A' weighted decibel scale, dBA. This scale closely approximates the response of the human ear, thus providing a measure of the subjective loudness of noise and enabling the intensity of noises with different frequency characteristics (e.g. pitch and tone) to be compared.
Day	The period between 7am and 6pm.
Evening	The period between 6pm and 10pm.
Night	The period between 10pm and 7am.
Free-field	The description of a noise receiver or source location which is away from any significantly reflective objects (e.g. buildings, walls).
L_1	The noise level exceeded for 1% of the measurement period.
L_{10}	The noise level exceeded for 10% of the measurement period. It is sometimes referred to as the average maximum noise level.
L_{90}	The noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
L_{eq}	The equivalent continuous sound level, which is the constant sound level over a given time period, which is equivalent in total sound energy to the time-varying sound level, measured over the same time period.
$L_{eq,1hour}$	As for L_{eq} except the measurement intervals are defined as 1 hour duration.
L_{max}	Maximum A-weighted sound pressure level.
L_{eq}(24 hour)	The average L_{eq} noise level over the 24-hour period from midnight to midnight.
L_{10}(18 hour)	The arithmetic average of the one-hour L_{10} values between 6am and midnight. This parameter is used in the assessment of road traffic noise.
R_w	Weighted Sound Reduction Index – is a single number evaluation of the property of a partition to attenuate sounds. For the majority of partitions, the value of Rw will be similar to the value for STC. Partitions with particularly poor performance at 100 Hz may have lower values for Rw than for STC. Conversely, partitions with poor performance at 4000 Hz may have higher Rw than for STC. (As per AS1276.1-1999).

Appendix B Project Drawings



LEGEND OF FEATURES

- BUILDINGS
- ROAD
- GRASS
- NATURAL VEGETATION
- POND
- ENGINEERED LAND FILL
- TREES
- SURFACE WATER (SW) DRAINAGE
- SURFACE WATER (SW) DISCHARGE POINT

SYMBOLS & NOTES

- (A) WEIGHBRIDGE AND SCALE STATION
- (B) MATERIAL SORTING AND SEGREGATION
- (C) RECYCLING, COMPOSTING AND BENEFICIAL REUSE
- (D) INCINERATION PLANT
- (E) WASTE OIL RECYCLING
- (F) FIXATION PLANT
- (G) WASTE WATER TREATMENT PLANT
  - G1 COLLECTION STATION, BAR SCREEN, GRIT CHAMBER/GREASE TRAP (INFLUENT WATER)
  - G2 PRIMARY CLARIFIER
  - G3 AERATION BASIN AND BLOWER STATION
  - G4 SECONDARY CLARIFIER
  - G5 DIGESTERS
  - G6 SLUDGE TREATMENT AND STORAGE STATION (TREATED SLUDGE DISPOSED OFF TO ENGINEERED LAND FILL)
  - G7 DISINFECTION STATION
  - G8 FINAL EFFLUENT STATION
- (H) PROPOSED ENGINEERED LAND FILL
- (I) HAZARDOUS WASTE STORAGE
- (J) FUTURE RESIDENTIAL HOUSING AREA - A
- (K) FUTURE RESIDENTIAL HOUSING AREA - B
- (L) FUTURE RESIDENTIAL HOUSING AREA - C

MASTER SITE PLAN

Scale: 1:1000 (A1) 1:2000 (A3)

CONCEPT DESIGN

Revisions

No.	by	date	Description	Ckd
A	AJM	19.06.18	Concept Design Issue	JBT

Client: TWM Total Waste Management — Lukautim kantri bilong yumi — Caring for our country

Architect: SELADI-85 ARCHITECTURAL DESIGN STUDIO
P.O BOX 1851
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E: jegabwasi@gmail.com
W: info@seladi85.com
ARCHITECTURAL DESIGN STUDIO

job title: **TOTAL WASTE MANAGEMENT**
PROPOSED ROKU DEVELOPMENT MASTER SITE PLAN

sheet title: PROPOSED MASTER SITE PLAN

drawn	scale
AJM	AS SHOWN
architect	date
JBT	JUNE 18
checked	date
JBT	JUNE 18

job no. 18.03.01

sheet no. A01.01

revision no. A

Appendix C SoundPLAN Source Locations

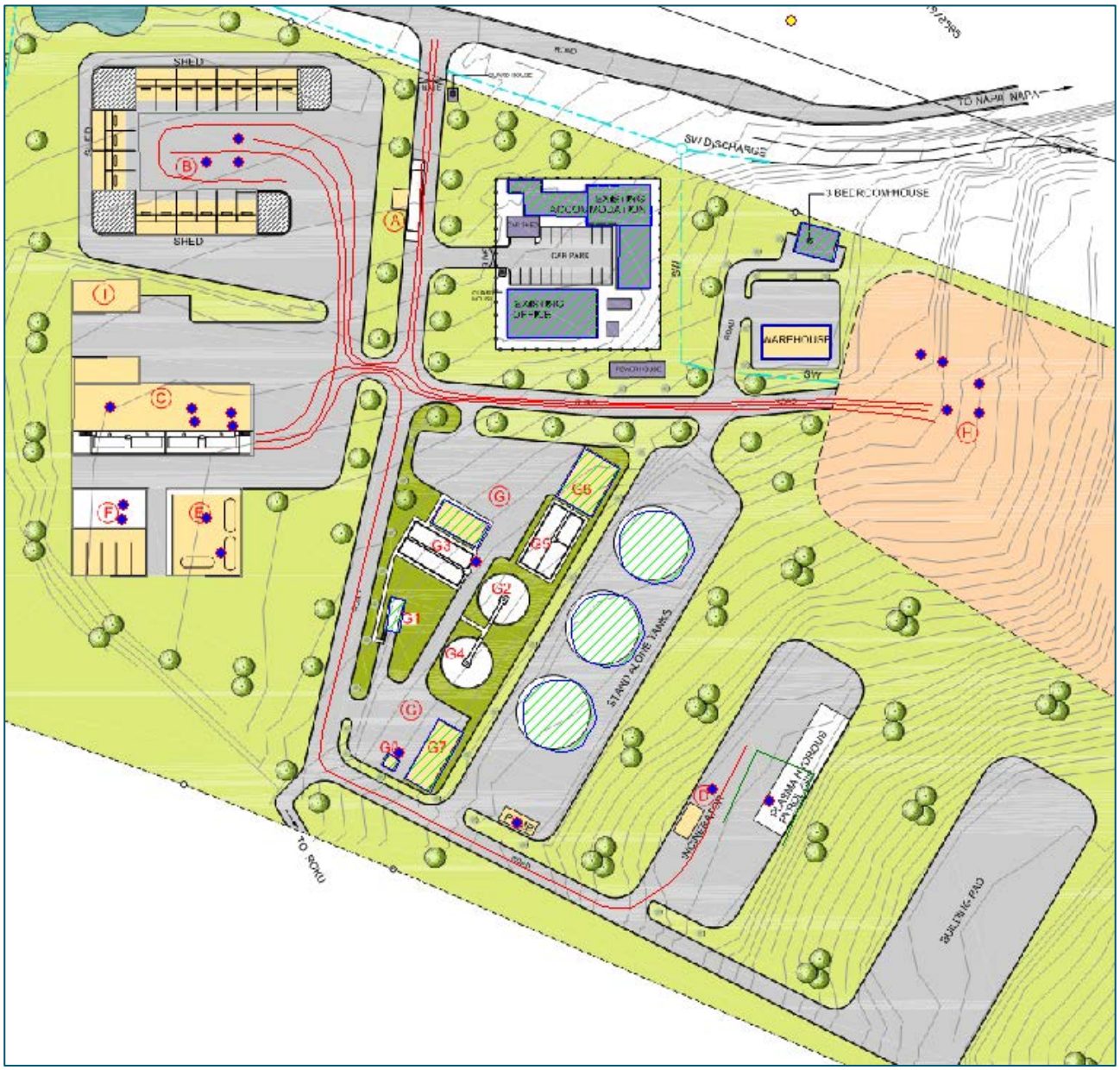


Figure C.1 Equipment Locations in Noise Model (Note: Equipment shown as blue dots and truck paths shown as red lines)

Appendix D Noise Contours – Worst Case Scenario (i.e. Scenario 1)



Integrated Waste Management Facility
Project Number: 207401.0078

Figure

D.1a

Scenario 1: Quarry/ Pre-construction (No crusher and screen) with other operations

Day Calm Condition
Calculation Height = 1.8m

Date: 16/10/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

ask ACOUSTICS & AIR QUALITY
A Trinity Consultants Company

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Integrated Waste Management Facility
Project Number: 207401.0078

Figure

D.1b

Scenario 1: Quarry/ Pre-construction (No crusher and screen) with other operations

Day Calm Condition
Calculation Height = 4.6m

Date: 16/10/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

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Integrated Waste Management Facility
Project Number: 207401.0078

Figure

D.2a

Scenario 1: Quarry/ Pre-construction (No crusher and screen) with other operations

Day Downwind Condition
Calculation Height = 1.8m

Date: 16/10/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

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Integrated Waste Management Facility
Project Number: 207401.0078

Figure

D.2b

Scenario 1: Quarry/ Pre-construction (No crusher and screen) with other operations

Day Downwind Condition
Calculation Height = 4.6m

Date: 16/10/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

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Appendix E Noise Contours – Long-term Scenario (i.e. Scenario 3)



Integrated Waste Management Facility
Project Number: 207401.0078

Figure

E.1a

Scenario 3: Landfill (No quarry operations) with other operations

Day Calm Condition
Calculation Height = 1.8m

Date: 22/09/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

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Integrated Waste Management Facility
Project Number: 207401.0078

Figure

E.1b

Scenario 3: Landfill (No quarry operations) with other operations

Day Calm Condition
Calculation Height = 4.6m

Date: 22/09/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

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Integrated Waste Management Facility
Project Number: 207401.0078

Figure

E.2a

Scenario 3: Landfill (No quarry operations) with other operations

Day Downwind Condition
Calculation Height = 1.8m

Date: 22/09/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

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Z:\Large project files\207401\0078 - Roku PNG\Noise Model\20.0078 Model\Figure E2a.sgs



Integrated Waste Management Facility
Project Number: 207401.0078

Figure

E.2b

Scenario 3: Landfill (No quarry operations) with other operations

Day Downwind Condition
Calculation Height = 4.6m

Date: 22/09/2020
Drawn By: PJ
Prepared For: Total Waste Management

Levels Leq (1 hour) dB(A)

		<=	50
50 <		<=	55
55 <		<=	60
60 <		<=	65
65 <		<=	70
70 <			

Signs and symbols

- Point receiver
- Point source
- Line source
- Industrial building
- Buildings

ask ACOUSTICS & AIR QUALITY
A Trinity Consultants Company

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Appendix 7
(Sediment Quality Laboratory Analysis)

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Brendon Wurr
Client	SGS EHS PNG
Address	5267 901 EHS PNG C/- TELIKOM DEPOST 4 MILE PORT MORESBY 121
Telephone	+675 325 6274
Facsimile	+675 323 1697
Email	Brendon.Wurr@sgs.com
Project	**ERIAS Group Ply Ltd**
Order Number	**PG04593**
Samples	5

LABORATORY DETAILS

Manager	Anthony Nilsson
Laboratory	SGS Cairns Environmental
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SGS Reference	**CE147513 R0**
Date Received	31 Jul 2020
Date Reported	14 Aug 2020

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146/19038)

TRH/BTEX/PAH/PCBs subcontracted to SGS Sydney, Unit 16 33 Maddox St Alexandria NSW 2015, NATA Accreditation Number: 2562, Site Number: 4354, SE209554.

SIGNATORIES

Alyson BERGAMO
Senior Laboratory Technician

Anthony Nilsson
Operations Manager

Jon Dicker
Lab Manager

Maristela GANZAN
Metals Team Leader

Parameter	Units	LOR	Sample Number: CE147513.001 Sample Matrix: Soil Sample Name: TWM 1	CE147513.002 Soil TWM 2	CE147513.003 Soil TWM 3	CE147513.004 Soil TWM 4-A
Moisture Content Method: AN002 Tested: 11/8/2020						
% Moisture	%w/w	1	**17.0**	**8.9**	**13.0**	**10.8**
VOC's in Soil Method: AN433 Tested: 11/8/2020						
Monocyclic Aromatic Hydrocarbons						
Benzene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Toluene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Ethylbenzene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
m/p-xylene	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
o-xylene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Polycyclic VOCs						
Naphthalene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Surrogates						
d4-1,2-dichloroethane (Surrogate)	%	-	**83**	**85**	**80**	**87**
d8-toluene (Surrogate)	%	-	**80**	**82**	**76**	**83**
Bromofluorobenzene (Surrogate)	%	-	**73**	**74**	**70**	**74**
Totals						
Total Xylenes*	mg/kg	0.3	<0.3	<0.3	<0.3	<0.3
Total BTEX*	mg/kg	0.6	<0.6	<0.6	<0.6	<0.6
Volatile Petroleum Hydrocarbons in Soil Method: AN433 Tested: 11/8/2020						
TRH C6-C10	mg/kg	25	<25	<25	<25	<25
TRH C6-C9	mg/kg	20	<20	<20	<20	<20
Surrogates						
d4-1,2-dichloroethane (Surrogate)	%	-	**83**	**85**	**80**	**87**
d8-toluene (Surrogate)	%	-	**80**	**82**	**76**	**83**
Bromofluorobenzene (Surrogate)	%	-	**73**	**74**	**70**	**74**

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name CE147513.001 Soil TWM 1	CE147513.002 Soil TWM 2	CE147513.003 Soil TWM 3	CE147513.004 Soil TWM 4-A
Volatile Petroleum Hydrocarbons in Soil Method: AN433 Tested: 11/8/2020 (continued)						
VPH F Bands						
Benzene (F0)	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
TRH C6-C10 minus BTEX (F1)	mg/kg	25	<25	<25	<25	<25
TRH (Total Recoverable Hydrocarbons) in Soil Method: AN403 Tested: 11/8/2020						
TRH C10-C14	mg/kg	20	<20	<20	<20	<20
TRH C15-C28	mg/kg	45	<45	<45	<45	<45
TRH C29-C36	mg/kg	45	<45	<45	<45	<45
TRH C37-C40	mg/kg	100	<100	<100	<100	<100
TRH C10-C36 Total	mg/kg	110	<110	<110	<110	<110
TRH >C10-C40 Total (F bands)	mg/kg	210	<210	<210	<210	<210
TRH F Bands						
TRH >C10-C16	mg/kg	25	<25	<25	<25	<25
TRH >C10-C16 - Naphthalene (F2)	mg/kg	25	<25	<25	<25	<25
TRH >C16-C34 (F3)	mg/kg	90	<90	<90	<90	<90
TRH >C34-C40 (F4)	mg/kg	120	<120	<120	<120	<120
PAH (Polynuclear Aromatic Hydrocarbons) in Soil Method: AN420 Tested: 11/8/2020						
Naphthalene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
2-methylnaphthalene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
1-methylnaphthalene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b&j)fluoranthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(k)fluoranthene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(ah)anthracene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(ghi)perylene	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Carcinogenic PAHs, BaP TEQ <LOR=0*	TEQ (mg/kg)	0.2	<0.2	<0.2	<0.2	<0.2
Carcinogenic PAHs, BaP TEQ <LOR=LOR*	TEQ (mg/kg)	0.3	<0.3	<0.3	<0.3	<0.3
Carcinogenic PAHs, BaP TEQ <LOR=LOR/2*	TEQ (mg/kg)	0.2	<0.2	<0.2	<0.2	<0.2
Total PAH (18)	mg/kg	0.8	<0.8	<0.8	<0.8	<0.8
Total PAH (NEPM/WHO 16)	mg/kg	0.8	<0.8	<0.8	<0.8	<0.8
Surrogates						
d5-nitrobenzene (Surrogate)	%	-	**84**	**83**	**83**	**77**
2-fluorobiphenyl (Surrogate)	%	-	**92**	**83**	**83**	**78**
d14-p-terphenyl (Surrogate)	%	-	**93**	**86**	**90**	**86**
PCBs in Soil Method: AN420 Tested: 11/8/2020						
Arochlor 1016	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1221	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1232	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1242	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1248	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1254	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1260	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1262	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Arochlor 1268	mg/kg	0.2	<0.2	<0.2	<0.2	<0.2
Total PCBs (Arochlors)	mg/kg	1	<1	<1	<1	<1

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name CE147513.001 Soil TWM 1	CE147513.002 Soil TWM 2	CE147513.003 Soil TWM 3	CE147513.004 Soil TWM 4-A
PCBs in Soil Method: AN420 Tested: 11/8/2020 (continued)						
Surrogates						
Tetrachloro-m-xylene (TCMX) (Surrogate)	%	-	**103**	**101**	**101**	**94**
Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 10/8/2020						
Arsenic, As	mg/kg	0.5	**1.3**	**1.8**	**8.6**	**1.3**
Cadmium, Cd	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Chromium, Cr	mg/kg	0.5	**13**	**14**	**68**	**12**
Copper, Cu	mg/kg	0.5	**34**	**33**	**45**	**46**
Nickel, Ni	mg/kg	0.5	**17**	**11**	**39**	**18**
Lead, Pb	mg/kg	0.5	**6.7**	**4.9**	**22**	**7.5**
Zinc, Zn	mg/kg	0.5	**46**	**110**	**61**	**22**
Mercury in Soil Method: AN312 Tested: 10/8/2020						
Mercury	mg/kg	0.01	**0.01**	<0.01	<0.01	<0.01
Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 11/8/2020						
Total Organic Carbon	%w/w	0.05	**2.2**	**0.16**	**0.68**	**0.12**
Organic Matter	%w/w	0.1	**3.8**	**0.27**	**1.2**	**0.20**

Parameter	Units	LOR	Sample Number: CE147513.005 Sample Matrix: Soil Sample Name: TWM 4-B
Moisture Content Method: AN002 Tested: 11/8/2020			
% Moisture	%w/w	1	**11.7**
VOC's in Soil Method: AN433 Tested: 11/8/2020			
Monocyclic Aromatic Hydrocarbons			
Benzene	mg/kg	0.1	<0.1
Toluene	mg/kg	0.1	<0.1
Ethylbenzene	mg/kg	0.1	<0.1
m/p-xylene	mg/kg	0.2	<0.2
o-xylene	mg/kg	0.1	<0.1
Polycyclic VOCs			
Naphthalene	mg/kg	0.1	<0.1
Surrogates			
d4-1,2-dichloroethane (Surrogate)	%	-	**88**
d8-toluene (Surrogate)	%	-	**83**
Bromofluorobenzene (Surrogate)	%	-	**75**
Totals			
Total Xylenes*	mg/kg	0.3	<0.3
Total BTEX*	mg/kg	0.6	<0.6
Volatile Petroleum Hydrocarbons in Soil Method: AN433 Tested: 11/8/2020			
TRH C6-C10	mg/kg	25	<25
TRH C6-C9	mg/kg	20	<20

Parameter	Units	LOR	Sample Number: CE147513.005 Sample Matrix: Soil Sample Name: TWM 4-B
Volatile Petroleum Hydrocarbons in Soil Method: AN433 Tested: 11/8/2020 (continued)			
Surrogates			
d4-1,2-dichloroethane (Surrogate)	%	-	**88**
d8-toluene (Surrogate)	%	-	**83**
Bromofluorobenzene (Surrogate)	%	-	**75**
VPH F Bands			
Benzene (F0)	mg/kg	0.1	<0.1
TRH C6-C10 minus BTEX (F1)	mg/kg	25	<25
TRH (Total Recoverable Hydrocarbons) in Soil Method: AN403 Tested: 11/8/2020			
TRH C10-C14	mg/kg	20	<20
TRH C15-C28	mg/kg	45	<45
TRH C29-C36	mg/kg	45	<45
TRH C37-C40	mg/kg	100	<100
TRH C10-C36 Total	mg/kg	110	<110
TRH >C10-C40 Total (F bands)	mg/kg	210	<210
TRH F Bands			
TRH >C10-C16	mg/kg	25	<25
TRH >C10-C16 - Naphthalene (F2)	mg/kg	25	<25
TRH >C16-C34 (F3)	mg/kg	90	<90
TRH >C34-C40 (F4)	mg/kg	120	<120
PAH (Polynuclear Aromatic Hydrocarbons) in Soil Method: AN420 Tested: 11/8/2020			
Naphthalene	mg/kg	0.1	<0.1
2-methylnaphthalene	mg/kg	0.1	<0.1
1-methylnaphthalene	mg/kg	0.1	<0.1
Acenaphthylene	mg/kg	0.1	<0.1
Acenaphthene	mg/kg	0.1	<0.1
Fluorene	mg/kg	0.1	<0.1
Phenanthrene	mg/kg	0.1	<0.1
Anthracene	mg/kg	0.1	<0.1
Fluoranthene	mg/kg	0.1	<0.1
Pyrene	mg/kg	0.1	<0.1
Benzo(a)anthracene	mg/kg	0.1	<0.1
Chrysene	mg/kg	0.1	<0.1
Benzo(b&j)fluoranthene	mg/kg	0.1	<0.1
Benzo(k)fluoranthene	mg/kg	0.1	<0.1
Benzo(a)pyrene	mg/kg	0.1	<0.1
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	<0.1
Dibenzo(ah)anthracene	mg/kg	0.1	<0.1
Benzo(ghi)perylene	mg/kg	0.1	<0.1
Carcinogenic PAHs, BaP TEQ <LOR=0*	TEQ (mg/kg)	0.2	<0.2
Carcinogenic PAHs, BaP TEQ <LOR=LOR*	TEQ (mg/kg)	0.3	<0.3
Carcinogenic PAHs, BaP TEQ <LOR=LOR/2*	TEQ (mg/kg)	0.2	<0.2
Total PAH (18)	mg/kg	0.8	<0.8
Total PAH (NEPM/WHO 16)	mg/kg	0.8	<0.8

Parameter	Units	LOR	Sample Number: CE147513.005 Sample Matrix: Soil Sample Name: TWM 4-B
PAH (Polynuclear Aromatic Hydrocarbons) in Soil Method: AN420 Tested: 11/8/2020 (continued)			
Surrogates			
d5-nitrobenzene (Surrogate)	%	-	**81**
2-fluorobiphenyl (Surrogate)	%	-	**79**
d14-p-terphenyl (Surrogate)	%	-	**99**
PCBs in Soil Method: AN420 Tested: 11/8/2020			
Arochlor 1016	mg/kg	0.2	<0.2
Arochlor 1221	mg/kg	0.2	<0.2
Arochlor 1232	mg/kg	0.2	<0.2
Arochlor 1242	mg/kg	0.2	<0.2
Arochlor 1248	mg/kg	0.2	<0.2
Arochlor 1254	mg/kg	0.2	<0.2
Arochlor 1260	mg/kg	0.2	<0.2
Arochlor 1262	mg/kg	0.2	<0.2
Arochlor 1268	mg/kg	0.2	<0.2
Total PCBs (Arochlors)	mg/kg	1	<1
Surrogates			
Tetrachloro-m-xylene (TCMX) (Surrogate)	%	-	**98**
Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 10/8/2020			
Arsenic, As	mg/kg	0.5	**1.6**
Cadmium, Cd	mg/kg	0.1	<0.1
Chromium, Cr	mg/kg	0.5	**14**
Copper, Cu	mg/kg	0.5	**45**
Nickel, Ni	mg/kg	0.5	**19**
Lead, Pb	mg/kg	0.5	**10**
Zinc, Zn	mg/kg	0.5	**22**

Parameter	Units	LOR	Sample Number: CE147513.005 Sample Matrix: Soil Sample Name: TWM 4-B
Mercury in Soil Method: AN312 Tested: 10/8/2020			
Mercury	mg/kg	0.01	<0.01
Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 11/8/2020			
Total Organic Carbon	%w/w	0.05	**0.18**
Organic Matter	%w/w	0.1	**0.31**

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Mercury in Soil **Method: ME-(AU)-[ENV]AN312**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB081282	mg/kg	0.01	<0.01	0%	108%	105%

Total Organic Carbon by Heanes Oxidation **Method: ME-(AU)-[ENV]AN273**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Organic Carbon	LB081322	%w/w	0.05	<0.05	2 - 5%	107%	91%
Organic Matter	LB081322	%w/w	0.1		2 - 5%		

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES **Method: ME-(AU)-[ENV]AN040/AN320**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Arsenic, As	LB081277	mg/kg	0.5	<0.5	3%	101%	
Cadmium, Cd	LB081277	mg/kg	0.1	<0.1	0%	98%	95%
Chromium, Cr	LB081277	mg/kg	0.5	<0.5	2%	103%	99%
Copper, Cu	LB081277	mg/kg	0.5	<0.5	2%	101%	101%
Nickel, Ni	LB081277	mg/kg	0.5	<0.5	0%	99%	94%
Lead, Pb	LB081277	mg/kg	0.5	<0.5	3%	99%	93%
Zinc, Zn	LB081277	mg/kg	0.5	<0.5	2%	96%	92%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN040/AN320	A portion of sample is digested with nitric acid to decompose organic matter and hydrochloric acid to complete the digestion of metals. The digest is then analysed by ICP OES with metals results reported on the dried sample basis. Based on USEPA method 200.8 and 6010C.
AN273	The sample is digested in Dichromate / Sulfuric Acid to oxidise the organic carbon. The determination is completed colourimetrically by Aquakem Discrete Analyser at 600 nm. Based on Rayment & Higginson 6B1.
AN312	Mercury by Cold Vapour AAS in Soils: After digestion with nitric acid, hydrogen peroxide and hydrochloric acid, mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500
AN403	Total Recoverable Hydrocarbons: Determination of Hydrocarbons by gas chromatography after a solvent extraction. Detection is by flame ionisation detector (FID) that produces an electronic signal in proportion to the combustible matter passing through it. Total Recoverable Hydrocarbons (TRH) are routinely reported as four alkane groupings based on the carbon chain length of the compounds: C6-C9, C10-C14, C15-C28 and C29-C36 and in recognition of the NEPM 1999 (2013), >C10-C16 (F2), >C16-C34 (F3) and >C34-C40 (F4). F2 is reported directly and also corrected by subtracting Naphthalene (from VOC method AN433) where available.
AN403	Additionally, the volatile C6-C9 fraction may be determined by a purge and trap technique and GC/MS because of the potential for volatiles loss. Total Recoverable Hydrocarbons - Silica (TRH-Si) follows the same method of analysis after silica gel cleanup of the solvent extract. Aliphatic/Aromatic Speciation follows the same method of analysis after fractionation of the solvent extract over silica with differential polarity of the eluent solvents .
AN403	The GC/FID method is not well suited to the analysis of refined high boiling point materials (ie lubricating oils or greases) but is particularly suited for measuring diesel, kerosene and petrol if care to control volatility is taken. This method will detect naturally occurring hydrocarbons, lipids, animal fats, phenols and PAHs if they are present at sufficient levels, dependent on the use of specific cleanup/fractionation techniques. Reference USEPA 3510B, 8015B.
AN420	(SVOCs) including OC, OP, PCB, Herbicides, PAH, Phthalates and Speciated Phenols (etc) in soils, sediments and waters are determined by GCMS/ECD technique following appropriate solvent extraction process (Based on USEPA 3500C and 8270D).
AN420	SVOC Compounds: Semi-Volatile Organic Compounds (SVOCs) including OC, OP, PCB, Herbicides, PAH, Phthalates and Speciated Phenols in soils, sediments and waters are determined by GCMS/ECD technique following appropriate solvent extraction process (Based on USEPA 3500C and 8270D).
AN433	VOCs and C6-C9 Hydrocarbons by GC-MS P&T: VOC`s are volatile organic compounds. The sample is presented to a gas chromatograph via a purge and trap (P&T) concentrator and autosampler and is detected with a Mass Spectrometer (MSD). Solid samples are initially extracted with methanol whilst liquid samples are processed directly. References: USEPA 5030B, 8020A, 8260.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

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LABORATORY REPORT COVER SHEET

Date: **17 August 2020**

To: **ERIAS Group Pty Ltd**
13-25 Church SI, Hawthom
Melbourne, Victoria
Australia

Attention: **Scott Breschkin**

YOUR REFERENCE: **Sediment TWM1-TWM 4-B**
Date Sampled: 20/07/2020
Date Tested: 21/07/20

LABORATORY REPORT NUMBER: PG04593
NUMBER OF SAMPLES: 5 Sediment Analysis

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

BRENDON WURR

EHS PNG LAB MANAGER

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Client: ERIAS Group Pty Ltd
Project: Water Quality Monitoring

Date Received: 21/07/20
Report Date: 17/08/20

LABORATORY REPORT

C O N T E N T S

Our Reference	Your Reference	Date Sampled
PG04593-1	TWM 1	20/07/2020
PG04593-2	TWM 2	20/07/2020
PG04593-3	TWM 3	20/07/2020
PG04593-4	TWM 4-A	20/07/2020
PG04593-5	TWM 4-B	20/07/2020

Client: ERIAS Group Pty Ltd
Project: Water Quality Monitoring

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LABORATORY REPORT

Our Reference Your Reference Date Sampled	Units	PG04593-1 TWM 1 20/07/2020	PG04593-2 TWM 2 20/07/2020	PG04593-3 TWM 3 20/07/2020	PG04593-4 TWM 4-A 20/07/2020
Moisture ^	%	17	8.9	13	11
Benzene * ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Toluene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Ethylbenzene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Meta - & Para Xylene ^	mg/kg	<0.20	<0.20	<0.20	<0.20
O-Xylene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Napthalene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
d4-1,2-dichloroethane (Surrogat	%	83	85	80	87
d8-toluene (Surrogate) ^	%	80	82	76	83
Bromofluoroben zene (Surogate)	%	73	74	70	74
Total Xylenes ^	mg/kg	<0.30	<0.30	<0.30	<0.30
Total BTEX ^	mg/kg	<0.60	<0.60	<0.60	<0.60
TRH C6-C10 ^	mg/kg	<25	<25	<25	<25
TRH C6-C9 ^	mg/kg	<20	<20	<20	<20
d4-1,2-dichloroethane (Surogat)	%	83	85	80	87
d8-toluene (Surrogate) ^	%	80	82	76	83
Bromofluoroben zene(Surrogate)	%	73	74	70	74
Benzene (F0) ^	mg/kg	<0.10	<0.10	<0.10	<0.10
TRH C6 - C10 minus BTEX (F1) ^	mg/kg	<25	<25	<25	<25

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Our Reference Your Reference Date Sampled	Units	PG04593-1 TWM 1 20/07/2020	PG04593-2 TWM 2 20/07/2020	PG04593-3 TWM 3 20/07/2020	PG04593-4 TWM 4-A 20/07/2020
TRH C10-C14 (mg/L) AN403* ^	mg/kg	<20	<20	<20	<20
TRH C15-C28 (mg/L) AN403* ^	mg/kg	<45	<45	<45	<45
TRH C29-C36 (mg/L) AN403* ^	mg/kg	<45	<45	<45	<45
TRH C37-C40 ^	mg/kg	<100	<100	<100	<100
TRH C10-C36 Total ^	mg/kg	<110	<110	<110	<110
TRH C10-C40 Total ^	mg/kg	<210	<210	<210	<210
TRH > C10-C16 (F2) ^	mg/kg	<25	<25	<25	<25
TRH>C10-C16 (F2)minusNapthalene	mg/kg	<25	<25	<25	<25
TRH > C16_C34 (F3) ^	mg/kg	<90	<90	<90	<90
TRH > C34-C40 (F4) ^	mg/kg	<120	<120	<120	<120
Napthalene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
2-methylnaphthalene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
1-methylnaphthalene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Acenaphthylene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Acenaphthene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Fluorene ^	mg/kg	<0.10	<0.10	<0.10	<0.10

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Our Reference Your Reference Date Sampled	Units	PG04593-1 TWM 1 20/07/2020	PG04593-2 TWM 2 20/07/2020	PG04593-3 TWM 3 20/07/2020	PG04593-4 TWM 4-A 20/07/2020
Phenanthrene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Anthracene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Fluoranthene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Pyrene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Benzo (a)anthracene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Chrysene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Benzo (b&j)fluoranthene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Benzo (k)fluoranthene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Benzo(a)pyrene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Indeno(1,2,3-cd)pyrene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Dibenzo (ah)anthracene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Benzo (ghi)perylene ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Carcinogenic PAHs <LOR=0 ^	TEQ	<0.20	<0.20	<0.20	<0.20
Carcinogenic PAHs <LOR=LOR ^	TEQ (mg/kg)	<0.30	<0.30	<0.30	<0.30
Carcinogenic PAHs <LOR=LOR/2 ^	TEQ (mg/kg)	<0.20	<0.20	<0.20	<0.20
Tetrachloro-m-xylene (TCMX)^	%	103	101	101	94
d5-nitrobenzene ^	%	84	83	83	77

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Our Reference Your Reference Date Sampled	Units	PG04593-1 TWM 1 20/07/2020	PG04593-2 TWM 2 20/07/2020	PG04593-3 TWM 3 20/07/2020	PG04593-4 TWM 4-A 20/07/2020
2-fluorobiphenyl ^	%	92	83	83	78
d14-p-terphenyl (Surrogate) ^	%	93	86	90	86
Aroclor 1016 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
Aroclor 1221 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
Aroclor 1232 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
Aroclor 1242 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
Aroclor 1248 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
Aroclor 1254 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
Aroclor 1260 ^	mg/kg	<0.20	<0.20	<0.20	<0.20
PCB mg/kg (ASTM D4059) ^	mg/kg	<1.0	<1.0	<1.0	<1.0
Arsenic (As) mg/kg ^	mg/kg	1.3	1.8	8.6	1.3
Cadmium (Cd) mg/L ^	mg/kg	<0.10	<0.10	<0.10	<0.10
Chromium (Cr) mg/L ^	mg/kg	13	14	68	12
Copper (Cu) mg/kg ^	mg/kg	34	33	45	46
Nickel (Ni) mg/kg ^	mg/kg	17	11	39	18
Lead (Pb) mg/kg ^	mg/kg	6.7	4.9	22	7.5
Zinc (Zn) mg/kg ^	mg/kg	46	110	61	22
Mercury (Hg) mg/kg ^	mg/kg	0.02	<0.02	<0.02	<0.02
TOC's ^	%w/w	2.20	0.16	0.68	0.12

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LABORATORY REPORT

Our Reference Your Reference Date Sampled	Units	PG04593-5 TWM 4-B 20/07/2020
Moisture ^	%	12
Benzene * ^	mg/kg	<0.10
Toluene ^	mg/kg	<0.10
Ethylbenzene ^	mg/kg	<0.10
Meta - & Para Xylene ^	mg/kg	<0.20
O-Xylene ^	mg/kg	<0.10
Napthalene ^	mg/kg	<0.10
d4-1,2-dichloroethane (Surrogat	%	88
d8-toluene (Surrogate) ^	%	83
Bromofluoroben zene (Surogate)	%	75
Total Xylenes ^	mg/kg	<0.30
Total BTEX ^	mg/kg	<0.60
TRH C6-C10 ^	mg/kg	<25
TRH C6-C9 ^	mg/kg	<20
d4-1,2-dichloroethane (Surogat)	%	88
d8-toluene (Surrogate) ^	%	83
Bromofluoroben zene(Surrogate)	%	75
Benzene (F0) ^	mg/kg	<0.10
TRH C6 - C10 minus BTEX (F1) ^	mg/kg	<25

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Our Reference Your Reference Date Sampled	Units	PG04593-5 TWM 4-B 20/07/2020
TRH C10-C14 (mg/L) AN403* ^	mg/kg	<20
TRH C15-C28 (mg/L) AN403* ^	mg/kg	<45
TRH C29-C36 (mg/L) AN403* ^	mg/kg	<45
TRH C37-C40 ^	mg/kg	<100
TRH C10-C36 Total ^	mg/kg	<110
TRH C10-C40 Total ^	mg/kg	<210
TRH > C10-C16 (F2) ^	mg/kg	<25
TRH>C10-C16 (F2)minusNapthalene	mg/kg	<25
TRH > C16_C34 (F3) ^	mg/kg	<90
TRH > C34-C40 (F4) ^	mg/kg	<120
Napthalene ^	mg/kg	<0.10
2-methylnaphthalene ^	mg/kg	<0.10
1-methylnaphthalene ^	mg/kg	<0.10
Acenaphthylene ^	mg/kg	<0.10
Acenaphthene ^	mg/kg	<0.10
Fluorene ^	mg/kg	<0.10

LABORATORY REPORT

Our Reference Your Reference Date Sampled	Units	PG04593-5 TWM 4-B 20/07/2020
Phenanthrene ^	mg/kg	<0.10
Anthracene ^	mg/kg	<0.10
Fluoranthene ^	mg/kg	<0.10
Pyrene ^	mg/kg	<0.10
Benzo (a)anthracene ^	mg/kg	<0.10
Chrysene ^	mg/kg	<0.10
Benzo (b&j)fluoranthene ^	mg/kg	<0.10
Benzo (k)fluoranthene ^	mg/kg	<0.10
Benzo(a)pyrene ^	mg/kg	<0.10
Indeno(1,2,3-cd)pyrene ^	mg/kg	<0.10
Dibenzo (ah)anthracene ^	mg/kg	<0.10
Benzo (ghi)perylene ^	mg/kg	<0.10
Carcinogenic PAHs <LOR=0 ^	TEQ	<0.20
Carcinogenic PAHs <LOR=LOR ^	TEQ (mg/kg)	<0.30
Carcinogenic PAHs <LOR=LOR/2 ^	TEQ (mg/kg)	<0.20
Tetrachloro-m-xylene (TCMX)^	%	98
d5-nitrobenzene ^	%	81

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Our Reference Your Reference Date Sampled	Units	PG04593-5 TWM 4-B 20/07/2020
2-fluorobiphenyl ^	%	79
d14-p-terphenyl (Surrogate) ^	%	99
Aroclor 1016 ^	mg/kg	<0.20
Aroclor 1221 ^	mg/kg	<0.20
Aroclor 1232 ^	mg/kg	<0.20
Aroclor 1242 ^	mg/kg	<0.20
Aroclor 1248 ^	mg/kg	<0.20
Aroclor 1254 ^	mg/kg	<0.20
Aroclor 1260 ^	mg/kg	<0.20
PCB mg/kg (ASTM D4059) ^	mg/kg	<1.0
Arsenic (As) mg/kg ^	mg/kg	1.6
Cadmium (Cd) mg/L ^	mg/kg	<0.10
Chromium (Cr) mg/L ^	mg/kg	14
Copper (Cu) mg/kg ^	mg/kg	45
Nickel (Ni) mg/kg ^	mg/kg	19
Lead (Pb) mg/kg ^	mg/kg	10
Zinc (Zn) mg/kg ^	mg/kg	22
Mercury (Hg) mg/kg ^	mg/kg	<0.02
TOC's ^	%w/w	0.18

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LABORATORY REPORT

QUALITY ASSURANCE / QUALITY CONTROL

Tests	Units	Blank	Laboratory Reference / Sample #	Replicate
Moisture ^	%	1.0	PG04593-1	17 || N/T
Benzene * ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Toluene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Ethylbenzene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Meta - & Para Xylene ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
O-Xylene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Napthalene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
d4-1,2-dichloroethane (Surrogat	%	-	PG04593-1	83 || N/T
d8-toluene (Surrogate) ^	%	-	PG04593-1	80 || N/T
Bromofluorobenzene (Surogate)	%	-	PG04593-1	73 || N/T
Total Xylenes ^	mg/kg	0.30	PG04593-1	<0.30 || N/T
Total BTEX ^	mg/kg	0.60	PG04593-1	<0.60 || N/T
TRH C6-C10 ^	mg/kg	25	PG04593-1	<25 || N/T
TRH C6-C9 ^	mg/kg	20	PG04593-1	<20 || N/T
d4-1,2-dichloroethane (Surogat)	%	-	PG04593-1	83 || N/T
d8-toluene (Surrogate) ^	%	-	PG04593-1	80 || N/T
Bromofluorobenzene (Surrogate)	%	-	PG04593-1	73 || N/T
Benzene (F0) ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
TRH C6 - C10 minus BTEX (F1) ^	mg/kg	25	PG04593-1	<25 || N/T

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Tests	Units	Blank	Laboratory Reference / Sample #	Replicate
TRH C10-C14 (mg/L) AN403* ^	mg/kg	20	PG04593-1	<20 || N/T
TRH C15-C28 (mg/L) AN403* ^	mg/kg	45	PG04593-1	<45 || N/T
TRH C29-C36 (mg/L) AN403* ^	mg/kg	45	PG04593-1	<45 || N/T
TRH C37-C40 ^	mg/kg	100	PG04593-1	<100 || N/T
TRH C10-C36 Total ^	mg/kg	110	PG04593-1	<110 || N/T
TRH C10-C40 Total ^	mg/kg	210	PG04593-1	<210 || N/T
TRH > C10-C16 (F2) ^	mg/kg	25	PG04593-1	<25 || N/T
TRH>C10-C16 (F2)minusNapthalene	mg/kg	25	PG04593-1	<25 || N/T
TRH > C16_C34 (F3) ^	mg/kg	90	PG04593-1	<90 || N/T
TRH > C34-C40 (F4) ^	mg/kg	120	PG04593-1	<120 || N/T
Napthalene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
2-methylnaphthalene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
1-methylnaphthalene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Acenaphthylene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Acenaphthene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Fluorene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Phenanthrene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Anthracene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Fluoranthene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Pyrene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Benzo(a)anthracene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Chrysene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Benzo(b&j)fluoranthene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Benzo(k)fluoranthene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Benzo(a)pyrene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T

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Tests	Units	Blank	Laboratory Reference / Sample #	Replicate
Indeno(1,2,3-cd)pyrene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Dibenzo(ah)anthracene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Benzo(ghi)perylene ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Carcinogenic PAHs <LOR=0 ^	TEQ	0.20	PG04593-1	<0.20 || N/T
Carcinogenic PAHs <LOR=LOR ^	TEQ (mg/kg)	0.30	PG04593-1	<0.30 || N/T
Carcinogenic PAHs <LOR=LOR/2 ^	TEQ (mg/kg)	0.20	PG04593-1	<0.20 || N/T
Tetrachloro-m-xylene (TCMX)^	%	-	PG04593-1	103 || N/T
d5-nitrobenzene ^	%	-	PG04593-1	84 || N/T
2-fluorobiphenyl ^	%	-	PG04593-1	92 || N/T
d14-p-terphenyl (Surrogate) ^	%	-	PG04593-1	93 || N/T
Aroclor 1016 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
Aroclor 1221 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
Aroclor 1232 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
Aroclor 1242 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
Aroclor 1248 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
Aroclor 1254 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
Aroclor 1260 ^	mg/kg	0.20	PG04593-1	<0.20 || N/T
PCB mg/kg (ASTM D4059) ^	mg/kg	1.0	PG04593-1	<1.0 || N/T
Arsenic (As) mg/kg ^	mg/kg	0.50	PG04593-1	1.3 || N/T
Cadmium (Cd) mg/L ^	mg/kg	0.10	PG04593-1	<0.10 || N/T
Chromium (Cr) mg/L ^	mg/kg	0.5	PG04593-1	13 || N/T
Copper (Cu) mg/kg ^	mg/kg	0.5	PG04593-1	34 || N/T
Nickel (Ni) mg/kg ^	mg/kg	0.5	PG04593-1	17 || N/T
Lead (Pb) mg/kg ^	mg/kg	0.50	PG04593-1	6.7 || N/T
Zinc (Zn) mg/kg ^	mg/kg	0.5	PG04593-1	46 || N/T
Mercury (Hg) mg/kg ^	mg/kg	0.02	PG04593-1	0.02 || N/T
TOC's ^	%w/w	0.050	PG04593-1	2.20 || N/T

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Notes
Duplicates has to be within 15% RPD

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Tests	Units	LOR	Method
Moisture ^	%	1	AN002
Benzene * ^	mg/kg	0.1	AN433_AN434
Toluene ^	mg/kg	0.1	AN433_AN434
Ethylbenzene ^	mg/kg	0.1	AN433_AN434
Meta - & Para Xylene ^	mg/kg	0.2	AN433_AN434
O-Xylene ^	mg/kg	0.1	AN 433
Napthalene ^	mg/kg	0.1	AN433_AN434
d4-1,2-dichloroethane (Surrogat	%	-	AN433_AN434_AN410
d8-toluene (Surrogate) ^	%	-	AN433_AN434_AN410
Bromofluorobenzene (Surogate)	%	-	AN 433
Total Xylenes ^	mg/kg	0.3	AN 433
Total BTEX ^	mg/kg	0.6	AN 433
TRH C6-C10 ^	mg/kg	25	AN433_AN434_AN410
TRH C6-C9 ^	mg/kg	20	AN433_AN434_AN410
d4-1,2-dichloroethane (Surogat)	%		AN433_AN434_AN410
d8-toluene (Surrogate) ^	%		AN433_AN434_AN410
Bromofluorobenzene (Surrogate)	%		AN433_AN434_AN410
Benzene (F0) ^	mg/kg	0.1	AN433_AN434_AN410
TRH C6 - C10 minus BTEX (F1) ^	mg/kg	25	AN433_AN434_AN410
TRH C10-C14 (mg/L) AN403* ^	mg/kg	20	AN403

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Tests	Units	LOR	Method
TRH C15-C28 (mg/L) AN403* ^	mg/kg	45	AN403
TRH C29-C36 (mg/L) AN403* ^	mg/kg	45	AN403
TRH C37-C40 ^	mg/kg	100	AN403
TRH C10-C36 Total ^	mg/kg	110	AN433_AN434_AN410
TRH C10-C40 Total ^	mg/kg	210	AN433_AN434_AN410
TRH > C10-C16 (F2) ^	mg/kg	25	
TRH>C10-C16 (F2)minusNapthalene	mg/kg	25	AN403
TRH > C16_C34 (F3) ^	mg/kg	90	AN403
TRH > C34-C40 (F4) ^	mg/kg	120	AN403
Napthalene ^	mg/kg	0.1	AN 420
2-methylnaphthalene ^	mg/kg	0.1	AN 420
1-methylnaphthalene ^	mg/kg	0.1	AN 420
Acenaphthylene ^	mg/kg	0.1	AN 420
Acenaphthene ^	mg/kg	0.1	AN 420
Fluorene ^	mg/kg	0.1	AN 420
Phenanthrene ^	mg/kg	0.1	AN 420
Anthracene ^	mg/kg	0.1	AN 420
Fluoranthene ^	mg/kg	0.1	AN 420
Pyrene ^	mg/kg	0.1	AN 420
Benzo(a)anthracene ^	mg/kg	0.1	AN 420
Chrysene ^	mg/kg	0.1	AN 420
Benzo(b&j)fluoranthene ^	mg/kg	0.1	AN 420
Benzo(k)fluoranthene ^	mg/kg	0.1	AN 420
Benzo(a)pyrene ^	mg/kg	0.1	AN 420
Indeno(1,2,3-cd)pyrene ^	mg/kg	0.1	AN 420

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Tests	Units	LOR	Method
Dibenzo(ah)anthracene ^	mg/kg	0.1	AN 420
Benzo(ghi)perylene ^	mg/kg	0.1	
Carcinogenic PAHs <LOR=0 ^	TEQ	0.2	AN 420
Carcinogenic PAHs <LOR=LOR ^	TEQ(mg/kg)	0.3	AN 420
Carcinogenic PAHs <LOR=LOR/2 ^	TEQ (mg/kg)	0.2	AN 420
Tetrachloro-m-xylene (TCMX)^	%	-	AN420
d5-nitrobenzene ^	%	-	AN 420
2-fluorobiphenyl ^	%	-	AN 420
d14-p-terphenyl (Surrogate) ^	%	-	AN 420
Aroclor 1016 ^	mg/kg	0.2	AN 420
Aroclor 1221 ^	mg/kg	0.2	AN 420
Aroclor 1232 ^	mg/kg	0.2	AN 420
Aroclor 1242 ^	mg/kg	0.2	AN 420
Aroclor 1248 ^	mg/kg	0.2	AN 420
Aroclor 1254 ^	mg/kg	0.2	AN 420
Aroclor 1260 ^	mg/kg	0.2	AN 420
PCB mg/kg (ASTM D4059) ^	mg/kg	1	ASTM D4059-00
Arsenic (As) mg/kg ^	mg/kg	0.5	AN 040/AN 320
Cadmium (Cd) mg/L ^	mg/kg	0.1	AN 040/AN 320
Chromium (Cr) mg/L ^	mg/kg	0.5	AN040/AN320
Copper (Cu) mg/kg ^	mg/kg	0.5	AN 040/AN 320
Nickel (Ni) mg/kg ^	mg/kg	0.5	AN 040/AN 320
Lead (Pb) mg/kg ^	mg/kg	0.5	AN 040/AN 320
Zinc (Zn) mg/kg ^	mg/kg	0.5	AN 040/AN 320
Mercury (Hg) mg/kg ^	mg/kg	0.01	AN 312
TOC's ^	%w/w	0.05	

Client:	ERIAS Group Pty Ltd	Date Received:	21/07/20
Project:	Water Quality Monitoring	Report Date:	17/08/20

LABORATORY REPORT

NOTES

LOR - Limit of Reporting
† This test is not covered by our NATA accreditation.
^ Analyses at our Cairns Lab NATA Accrediation No 2562 (3146)
*Indicative data, theoretical holding time exceeded
OMR - Over Measuring Range

Unless it has been reported that sampling was performed by SGS, samples have been analysed as received.
SGS Terms and Conditions are available at www.au.sgs.com
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CHAIN OF CUSTODY DOCUMENTATION

CLIENT: ERIAS Group Pty Ltd	SAMPLER: Ninkama Yoba
ADDRESS / OFFICE: Suite 9 13-25 Church St, Hawthorn, Vic, 3121	MOBILE: +675 70049242
PROJECT MANAGER (PM): Scott Breschkin	PHONE:
PROJECT ID: 01375A	EMAIL REPORT TO: scott.breschkin@eriasgroup.com
SITE: Roku P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (Date): 5 day turn around QUOTE NO.: ERIAS - EHS - MAY 20 -116475	ANALYSIS REQUIRED including SUITES (note - suite codes must be listed to attract suite prices)

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

MPLE INFORMATION (note:FW=Freshwater EW = Estuarine water MW = marine w

#	SAMPLE ID	MATRIX	DATE	Time	CONTAINER INFORMATION Number and Type of Jars	CL8 (TRH C6-C40 + BTEXN F1 + PAHs)	8 total metals (Total metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn))	PCBs	Total organic carbon	Notes
	TWM 1	SEDIMENT	20/07/20	11:20	1	✓	✓	✓	✓	
	TWM 2	SED	20/07/20	13:00	1	✓	✓	✓	✓	
	TWM 3	SED	20/07/20	14:00	1	✓	✓	✓	✓	
	TWM 4-A	SED	20/07/20	14:30	1	✓	✓	✓	✓	
	TWM 4-B	SED	20/07/20	14:30	1	✓	✓	✓	✓	
										SAMPLES TO BE DISPATCHED

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Ninkama Yoba	Date: 20/07/20	Name: J. Tuguru	Date: 20/07/2020	Con' Note No:
Of: ERIAS Group	Time: 4:33PM	Of: SGS Lab	Time: 16:33	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

x5 soil samples

PG04593

COC Page 1 of 1

ENFM (204/5)

Appendix 8
(Flora and Fauna Survey Notes)

Survey Tool – Biodiversity

Survey undertaken by:	Ninkama Yoba
Date of survey (Day/month/year)	21/07/2020
Location (i.e., address, closest town, nearest reserves, ownership)	Within the study areas marked. Refer to map from ERIAS. Areas closer to Roku village, TWM area and the surroundings. No reserves. Walking areas all marked with GPS coordinates (Refer to GPS coordinates below.
Weather conditions (including cloud cover, temperature, prevailing wind etc)	Clear sky, wind around 5-20 knots, high temperature (32^0C), humidity (97%)
Survey participants/informants	Ninkama Yoba (Consultant) Crony Henry (NYAL Field Assistant) Nicole Frani (TWM Environment Officer) Eva Riggen (TWM Environment Officer) Jack Kone (Roku Villager) Valentine Pundi (Roku Villager)

Prior to undertaking the field survey, the following should already have occurred:

- If available, review colour aerial photography, geological maps, and topographical maps for the survey area including FIMS mapping.
- Obtain all available relevant literature regarding vegetation and flora for the site, including species lists, papers, reports, and herbarium records. Compile a brief history of previous botanical exploration (if any), including where and when threatened plant species have been recorded. Provide location data and species detail to ERIAS to enable preparation of maps that overlay the locations for threatened species on site maps.
- Prepare images of threatened plant species, ideally colour photographs and/or photographs of herbarium specimens.
- Undertake research on likely listed species that may occur in consultation with CEPA specialists.
- Identify major environments and vegetation classes present based on FIMS mapping and considering the drainage and soils and climate/altitude (based on PNGRIS).

The results of this assessment should be recorded in Table 1.

Table 1 – Survey Location Overview

Recognised International/ National/ State/ Regional Conservation Value	Yes / No If yes, specify:
Describe Mapped Vegetation Complex/es (use FIMS descriptions)	Grassland Eucalypt savannah
Mapped Soil Type/s (use PNGRIS)	Ustorthents
Mapped Special Purpose Areas (incl wetlands)	Yes / No If yes, specify:
Nearby Conservation Areas	Yes / No If yes, specify:
Mapped Priority weed species? (Record location of Priority 1 and 2 weed species) and record all identifiable weed species noted in general description of vegetation.	Yes / No If yes, specify: The study area is already disturbed sites. Most of the weeds/ grasses are listed with pictures in Appendix 1. Tree species in Appendix 2
Surrounding land use(s) (include estimates of distances to nearby towns, industry, agriculture etc)	The surrounding sites are all infrastructures with the existing settings. The Roku village is approximately 1km from TWM facility.
Other comments	

Table 2 – Site 1

<table>
<tr><th>Item</th><th>Description</th><th>Photos#</th></tr>
<tr><td>GPS Coordinates*</td><td>GPS locations walking from one site to another
Start to Finish
<table>
<tr><td></td><td colspan="2">Approximate Locations</td></tr>
<tr><td>Start to finish</td><td>Easting</td><td>Northings</td></tr>
<tr><td></td><td>E 147^0 04.985’</td><td>S 09^0 27.028’</td></tr>
<tr><td></td><td>E 147^0 04.698’</td><td>S 09^0 27.334’</td></tr>
<tr><td></td><td>E 147^0 04.971’</td><td>S 09^0 27.165’</td></tr>
<tr><td></td><td>E 147^0 05.123’</td><td>S 09^0 27.168’</td></tr>
<tr><td></td><td>E 147^0 05.112’</td><td>S 09^0 27.305’</td></tr>
<tr><td></td><td>E 147^0 05.115’</td><td>S 09^0 27.307’</td></tr>
<tr><td></td><td>E 147^0 05.099’</td><td>S 09^0 27.242’</td></tr>
<tr><td></td><td>E 147^0 05.240’</td><td>S 09^0 27.545’</td></tr>
<tr><td></td><td>E 147^0 05.414’</td><td>S 09^0 27.454’</td></tr>
<tr><td></td><td>E 147^0 05.232’</td><td>S 09^0 27.070’</td></tr>
<tr><td></td><td>E 147^0 05.127’</td><td>S 09^0 27.169’</td></tr>
</table></td><td>NA</td></tr>
<tr><td>Soil type (visual observation of road cuttings to confirm PNGRIS soil mapping)</td><td>Ustorthents
With Vertisols soil order on calcareous rocks</td><td></td></tr>
<tr><td>Drainage observed (creeks, drainage lines, other)</td><td>Apart from the drainage from the sediment sampling site there were 4 others drainage observed during the walking.

Most of those drainage are dry and only flow during the storm events (rainy periods).</td><td> 
  </td></tr>
<tr><td>Vegetation classification (using FIMS descriptions – confirm or otherwise state FIMS classification)</td><td>The vegetation type is mainly Savannah which are classified into two main types:
Eucalypt savannah; and
Grassland</td><td></td></tr>
<tr><td>Flora species (common and botanical names where known) – obtain photos and voucher specimens, if necessary, to confirm species.</td><td>It’s a savannah forest type with no recognised forest formation. There is no schematic representation of the forest structure with no recognizable strata at all sites. The survey sites are often and mostly burnt during dry periods. Only Eucalyptus sp. (Eucalyptus alba, Eucalyptus confertiflora, Eucalyptus teteticornis) are common and stand out and can withstand the burning. Grasses (Kangaroos grass, Themeda sp, and Black spear grass, Heteropogon contortus) are common and wide spread mostly common of as grassland type and under the eucalypt stands.

Species list and photos are presented as appendix 2.

Canopy species:
N/A

Mid-storey species:
N/A

Groundcover species:
N/A</td><td></td></tr>
</table>

Item	**Description**	**Photos#**
Description of vegetation health/ condition (weed infestation, dieback, fire)	Forests are mostly burnt often and during dry periods. Scattered *Eucalyptus* sp. are stand out at all sites. The condition are typical of savannah grassland forest with weeds and grasses dominating the floor of forest. Forest experienced some die back from bush fire mainly from the villagers.  There is presence of termites in the forest as well.  *Eucalyptus* sp. and *Cycas circinalis* are often burnt but seem to grow back during the burning.  There are other diseases/ deformation 	Refer to all photos sent earlier
Weed species (list all species sighted. Include local language and scientific names where possible) ***Take photos of all species sighted***	Please refer to Appendix 1	
Threatening processes (describe whether there has been site disturbance caused by clearing, grazing, hunting, fire or other factors)	Bush fire is the only threatening process from people's ignorance. Sometimes bush are burnt to catch bandicoots or wallabies. However, most times are just for fun by the villagers. Some of the study sites are mainly infrastructure by different companies operating along the Napa Napa road.	
Fauna observations (Note whether the	Tree roots burrow (believed to be from a marsupial)	

observation is direct or indirect.
Indirect = scats, burrows, scratchings, prints, nests, hollows etc.
Direct = actual fauna sighting.



Scats (believed to be from wild cat)



Death animal skeleton



Birds sighted



From left to right Papuan Frogmouth (*Podargus papuertsi*s), White-bellied Cuckoo-shrike (*Coracina papuensis*), Black Cuckoo-shrike (*Coracina schisticeps*)

Birds nest sighted



Green tree frogs (*Ranoidea caerulea*)



Gecko

	  **Snake-eyed skink Lizard (*Cryptoblepharus yulensis*)** 	
Item	**Description**	**Photos#**

Informant comments/ observations (record any information about natural resources commonly used by local informants). Specific questions: Medicine trees? Housing materials – posts, roofing? Canoes trees? Or only modern boats (banana boats) used? Trees/vines used for rope? Fauna hunted, trapped, fished? Other fauna present? Purpose of fauna hunting (food, sale)? Eggs collected? Native seeds/fruit collected? What methods of hunting are used (rifle, bow & arrow, snare traps, pit traps, log traps)?	Housing post taken from the local forest mainly the *Eucalyptus* species. Any of the 3 species of Eucalyptus are taken raw from forest left under sea for a week dry it then left in sea for a month before erecting as house post. Below are the photos.  **Eucalyptus natural standing to drying to making house post** Neem tree (*Azadirachta indica*) is an introduced species and popular in Port Moresby (outside of Roku village), however, there are few standings at Roku Village mainly used for malaria, fever, joint pains, etc. It is used by boiling the leaves and steam bathing.  The crawling parasitic plant (Scaldweed, *Cuscuta gronovii)*below is used for broken joints  Noni Plant (*Morinda citrifolia*) is a introduced domesticated plant around Roku Village. It is mainly used for skin therapy, diarrhea, high blood pressure and other medicinal purposes. Only the fruit is used.  Canoes are not often used by Roku Village. The	

manufactured banana boats are now used often and replaces canoes. There ar not canoe trees around Roku or neighbouring villages. If required big logs are bought from a local sawmill nearby. The photo below shows a canoe from Roku village



Every household in Roku village go fishing and it the daily task. They use fish for daily consumption and marketing for cash income. Below are some of the photos taken at Roku Village on fish catch.





Most of these fishes are reef depended. Fish identified just from the photos where possible.
Scarlet-breasted Maori Wresse (*Cheilinus fasciatus*), Black and White Snapper (*Macolor niger*), Anchor Tuskfish (*Choerodon anchorago*), Twospot Maori Wrasse (*Cheilinus bimacuatus*), Moses Perch (*Lutjanus russelli*),



Yellowtail Barracuda (*Sphyraena flavicauda*)

No bush ropes used for building house. Nails are used these days.

Hunting were used to be done using dogs, spears and bus burning for bandicoots, wallabies, etc but it is the thing of the past.

There is no egg collection or other related hunting methods apart from what has been specified above.

Notes:
* The GPS unit should be set to record waypoints in the World Geodetic System 1984 (WGS84) as the standard Horizontal Datum.
# Provide unique reference numbers for all photos taken on site and record these numbers on the data sheet.

Completion Checklist:
At the end of each day of survey, you should have:

- Completed and checked this form, photographed each page of this form, plus any additional notes taken during the survey, and emailed to Melanie Brown (melanie.brown@erisagroup.com).
- Downloaded all site photos to a laptop and backed them up on a storage device (e.g., thumb drive).

At the end of the desktop review and survey, you should have:

- Developed a species lists for flora and fauna species present or likely to be present in the study area (including conservation significant species).
- Developed a list of weed species present or likely to be present in the study area.
- Described observed habitats (terrestrial and aquatic) including vegetation types, structure and condition, and have completed the Aquatic Habitat Assessment form for any aquatic habitats present.
- Confirmed the presence/absence of any protected or special purpose areas (i.e., wetland areas).
- Identified threatening processes relevant to the study area (e.g., clearing, hunting, fire etc).
- Identified areas of remnant vegetation and areas of remnant bushland.
- Ranked the sites described in order of overall conservation priority.
- Held meetings/interviews with key informants and documented natural resources (i.e., wild plants, animals, timber etc) commonly used and for what purpose(s) (i.e., food, shelter/building materials, firewood, medicines etc).
- Have GPS coordinates for each site surveyed.
- Have photos with unique reference numbers where relevant, to support each section of Table 2.

QA AND COMPLETION CHECKLIST COMPLETED

Nin

SIGNATURE of ecologist/biologist

Ninkama Yoba 03/08/20

PRINT NAME / DATE

Appendix 1 – Weed species

Family	Species	Remarks	Photos
Passifloraceae	*Passiflora foetida*		
Cycadaceae	*Cycas circinalis*		
Verbenaceae	*Stachytarpheta jamaicensis*		
Amaranthaceae	*Celosia argentea*		
Leguminosae	*Crotalaria zanzibarica*		
			
Euphorbiaceae	*Euphorbia geniculata*		
Nyctaginaceae	*Boerhavia erecta*		
Compositae	*Tridax procumbens*		
Leguminosae	*Clitoria ternatea*		
Leguminosae	*Calopogonium mucunoides*		

Convolvulaceae	Ipomoea triloba		
Euphorbiaceae	*Euphorbia hirta*		
Convolvulaceae	*Ipomoea aquatica*	Introduced	
Poaceae	*Heteropogon contortus*	Dominating	
Poaceae	*Themeda triandra*	Dominating	

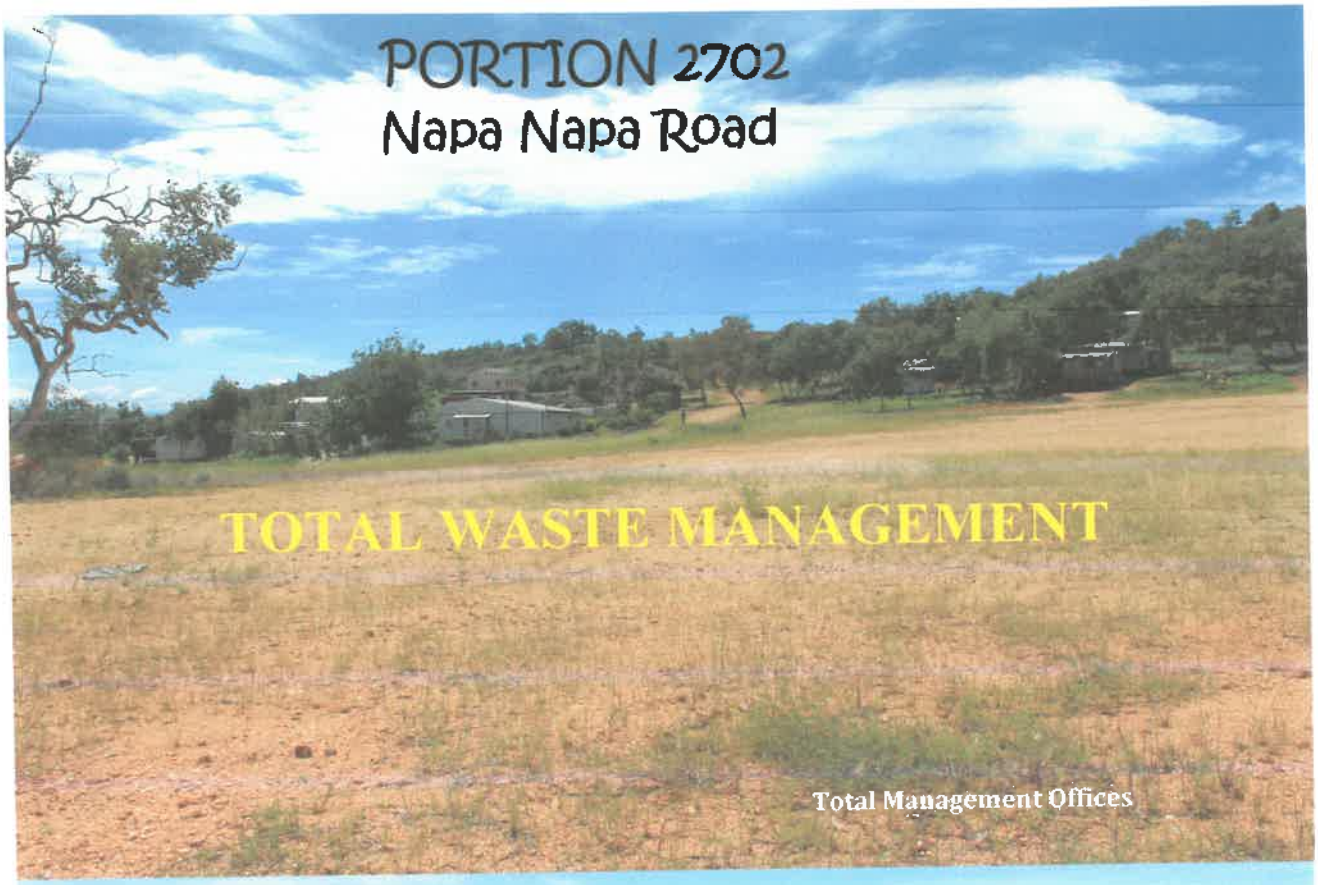
Appendix 2 – Tree Species

Famiy	Species	Remarks	Photos
Lauraceae	*Cryptocarya* sp (?)		
Ulmaceae	*Trema orientalis*	Disturbed site at lower plain	
Meliaceae	*Azadirachta indica*	Introduced	
Myrtaceae	*Eucalyptus alba, Eucalyptus confertiflora, Eucalyptus teteticornis*	Dominating tree species	
Buchanania	*Mangifera indica*	Domesticated mango planted by Roku villagers near the village	
Burseraceae	*Canarium* sp	At the lower plain closer to Roku village	
Combretaceae	*Terminalia catappa*	Believed to be taken to TWM camp site. Native to PNG but not locally to the study site	

Leguminosae	*Acacia* sp	Found at the lower plain	
Pandanaceae	*Pandanus* sp	Found at the lower plain	
Fabaceae	*Leucaena* sp	The the lower plain closer to Roku village	
Burseraceae	*Garuga* sp	Sported all around.	

Appendix 9
(Archaeological Site Survey)

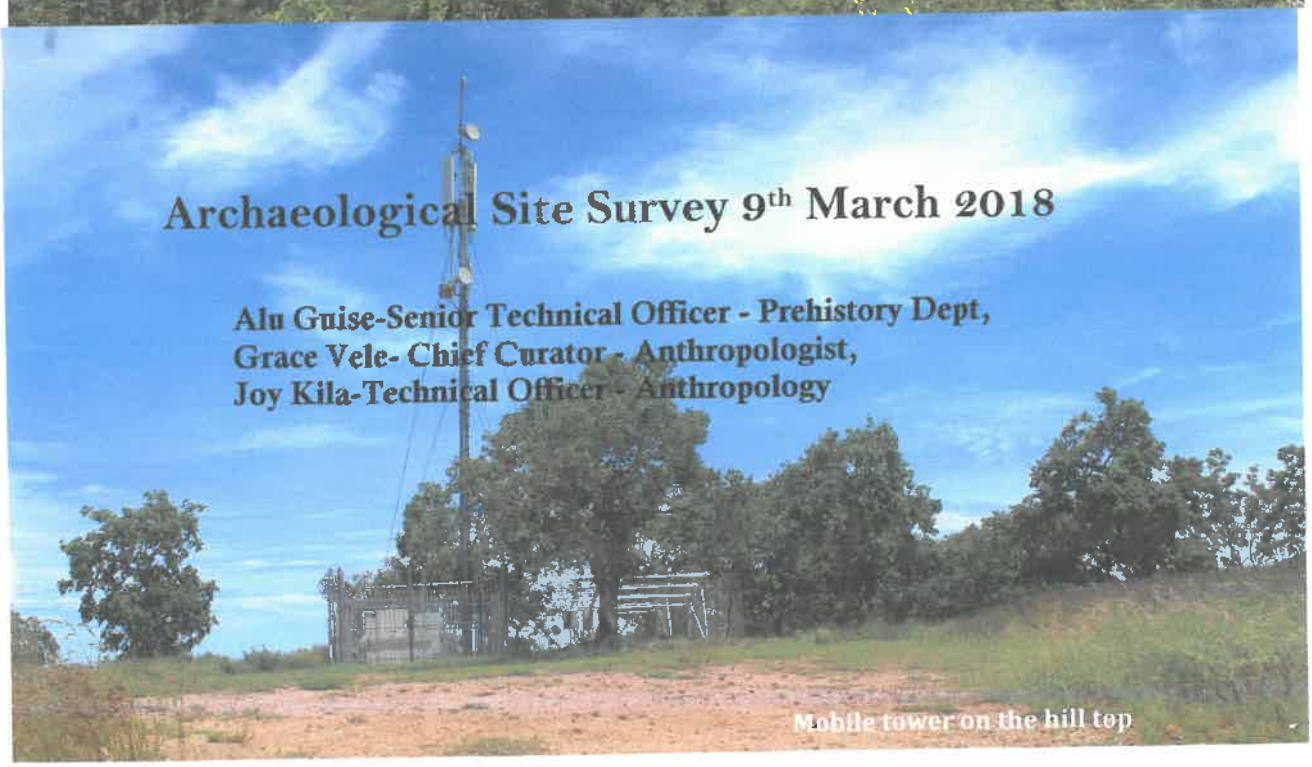
PORTION 2702
Napa Napa Road



Total Management Offices



Fisherman Island (back ground, view from site)



Mobile tower on the hill top

Content **page**

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2.	Methodology	3
3.	Idlers Bay Sites	3
4.	Napa Napa Sites	3
5.	Ranvetutu Site	3
6.	Radio carbon dated sites in the area	4
7.	Site Assessment	4
8.	Surface Observation	6
9.	Result of Surface Observation	6

Introduction

This is a report as per Archaeology and Cultural Heritage Assessment with regards to the **Total Waste Management** development of portion 2702 located on Napa Napa road on the hill directly above the Koitabu village of Roku.

The Company owners of **Total Waste Management** bought this property from **Firewall logistics limited.** The company wanted a cultural heritage clearance from the National Museum and Art Gallery and environmental clearance from CEPA. The inspection was carried out on 9th March 2018.

Methodology

Ground trudge survey

Ground trudge, survey maps, photographs, research into the National Archaeological Site Register and interview with Total Management personal.

Preliminary Literature Survey

Desktop research including reading of maps, reading previous field reports, and assessing the location of the site and the amount of surface disturbance on the lands surrounding Portion 2702.

Archaeological sites in the area

Idlers Bay Sites

AHR -*Idlers Bay, Grid ref. 095535.*
AAN -*Stamara point (northern Headland) Grid ref. EK086532, observation only.*
AGI -*Idlers Bay beach front, shards and shells collected, Grid ref. EK098530.*
AHQ -*Idlers Bay Grid ref. 098522 also* ***ARC****, large boulder on site*
AAS -*Mavarololorarol Hill, Eroded midden on slope to west of road, Grid ref. EK108320.*

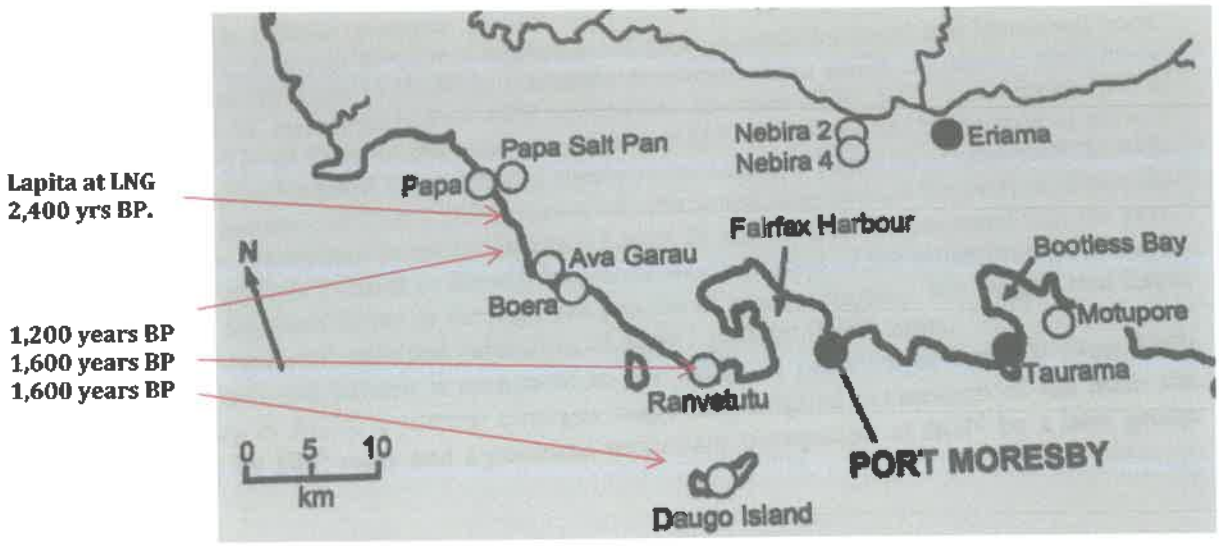
Napa Napa Sites

AAHA -*On ridge grid ref EK118545, surface collection of clay pot shards, site cleared for oil refinery.*
AAHB -*On hill top grid ref. EK114554, surface collection ofclaypot shards.*
AAHC -*On hill top west of Napa Napa grid ref. 113553, surface collection of clay pot shards.*

Ranvetutu Site

AFD -*West of Roku village dated 1,600 BP.*

Radio carbon dated sites in the area



Site Assessment

Site Location

Portion 2703 is located on the Napa Napa road iand is on the hill above Roku village, its grid reference is **EK 105542** on the 1:100,000 topographic map. The **AES** Companyis located next to it on the north side and on the south is the **Idlers Bay** and Roku village.





Graded areas

Mobile Tower

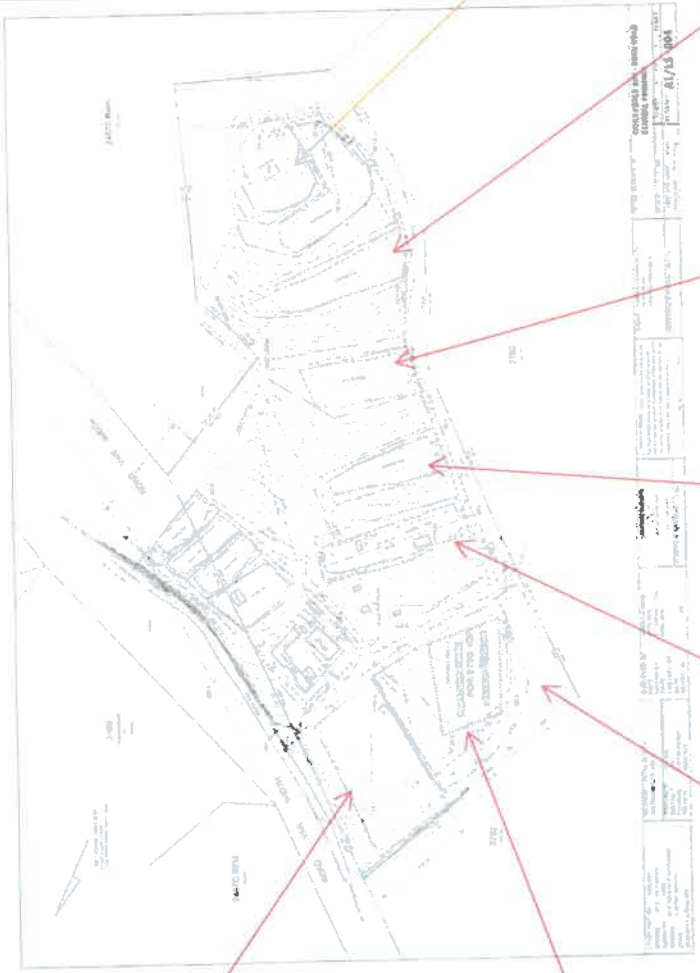


















Surface Observation

Ground trudge

During the observation of the property, it was partly developed with several existing buildings at the foot of the hill. The front area is flat and was graded level with two sections. The road was graded on the eastern perimeter of the two flat lands and then traversing up to the hill top on the south perimeter of the property. Several areas were leveled along the slope of the hill to the summit for construction purposes.

We trudged along the edges of the property where the surface soil was deposited, to see any sign of cultural materials, and along wall of the road and grading areas for construction.

Result of the surface observation

No material of cultural importance was observed on the either disturbed land or in situ. The Company **Total Management Waste** is congratulated in taking the initiative to comply with the National Cultural Property Act (1965) in concert with the Environment Act (2000), broadly asserts due diligence care when dealing with tangible and in tangible cultural heritage properties. Under the aegis of the NCP Act (1965), PNG National Museum and Art Gallery is required;

1. Under section 9 (NCP Act 1965) to ensure cultural heritage sites are not illegally damaged nor destroyed.
2. and under section 20(1) requires that any person (developer) discovering any material of cultural heritage material to report it to the Museum.



Joy and Grace trudging up hill



Idlers Bay, Roku village below

Attachment 1
(Cross-Reference of CEPA Guidelines and Requirements to EIS Sections)

Table 1 provides reconciliation between the contents of the IWMF EIS with the Department of Environment and Conservation (DEC) Guideline for Conduct of Environmental Impact Assessment and Preparation of Environmental Impact Statement. The main EIS chapters or appendices where the guidelines' requirement has been primarily addressed are listed. Other EIS sections may address the requirement, but they are not documented in this table.

Table 1 – Cross-reference Between the EIS and CEPA Guideline

	CEPA Guideline	EIS Chapter/Appendix Where Requirement Is Addressed
Letter of Transmittal or Cover Letter		
	It is important that an Environmental Impact Statement on the proposal must be transmitted to DEC* with a cover letter signed by the responsible company official or its authorised representative (i.e., consultant - engaged by the company to act on its behalf). If an external consultant is used, the letter must also authorise the consultant to make statements and provide further information on behalf of the company in relation to the application	Submitted with EIS
1.	***Executive Summary or Overview of Proposal***	
	Information provided in the Executive Summary shall concisely describe:	
	• The proposed development activity and its objectives	Executive Summary
	• Anticipated bio-physical and socio-economic impacts (direct/indirect, reversible/irreversible) of the activity	Executive Summary
	• Remedial actions that are proposed	Executive Summary (further detail provided in Chapter 10 and Chapter 11)
	• All benefits to be derived from the project	Executive Summary
	• The consultation program undertaken by the applicant, including degree of public interest	Executive Summary
	• Rehabilitation and/or end-use plans for the development activity in relation to community needs	Executive Summary
2.	***Purpose of the Development***	
	This section shall include but not be limited to the following:	
	• Describe if the development is in line with the Fourth National Goal and Directive Principle of the National Constitution of PNG	Chapter 2
	• Explain if the proposed development is compatible with National, Provincial and Local Level Government development goals and planning guidelines	Chapter 2
	• Detail the economic benefits to the Nation, Province, Local Level Governments and to the local community being impacted	Chapter 1 Chapter 2 Chapter 11
3.	***Viability of the Project***	
	Provide information on the viability of the proposed development activity. These details shall include but not be limited to the following:	

	CEPA Guideline	EIS Chapter/Appendix Where Requirement Is Addressed
	• Information on the capital cost associated with the development	Chapter 4
	• Details of the proponent's technological expertise and resources	Chapter 1 Chapter 2
	• Results of any feasibility investigations that have been carried out	Chapter 2 Chapter 5
	• Information on the extent of landowner and/or resource owner support	The Project will utilise State Lease land (see Chapter 2 and Chapter 4)
	• Details of the life-span and development phases of the project	Chapter 1 Chapter 4
4.	***Description of the Proposed Development Activity***	
	All relevant details on the proposed development activity required under this section should be provided where it is applicable to the proposal. Details to be provided under this section may include the following:	
	• Background information to the proposal, process technologies to be employed etc	Chapter 2 Chapter 4
	• Detailed location maps (drawn to scale), site layout, etc.	Chapter 1 Chapter 4
	• Information on method of site selection including alternatives investigated, plant or building designs, relevant diagrams and drawings	Chapter 4 Chapter 5
	• Detailed flowcharts, mass balances (including feedstocks, products and wastes generated), etc	Chapter 4
	• Description of nearby development activities that may contribute to additive effects on background pollution levels or other baseline conditions	Chapter 9
	• Information on associated infrastructure/facilities that is to be constructed	Chapter 4
5.	***Development Timetable***	
	Information on the development timetable provided under this section should be clear and easy for DEC# to understand the different phases in the development proposal. For reasons of clarity, a Flow chart, Gantt or PERT chart should be used where appropriate. Information provided in this section shall include but not limited to the following:	
	• Information on funding arrangement for proposed activity or if availability of funds subjected to this or other approvals being granted	Chapter 2
	• Details of pre-construction activities	Chapter 4
	• Information on consultation program with all affected parties (i.e., parties that may be directly and indirectly affected)	Chapter 6
	• Details of construction schedule, staging, etc	Chapter 1 Chapter 4
	• Details of commissioning and operational schedules	Chapter 1 Chapter 4

	CEPA Guideline	EIS Chapter/Appendix Where Requirement Is Addressed
	• Details of infrastructure development schedule	Chapter 1 Chapter 4
	• Details of closure and rehabilitation schedule	Chapter 4
6.	***Characteristics of the Receiving Environment***	
6.1	***Available Environmental Studies and Investigations***	
	Information provided in this sub-section shall include but not be limited to the following:	
	• Historic or current baseline data on physical, biological and social systems • A written estimate of research and/or study time already expended and to be further undertaken	Chapter 8 Chapter 9 Appendix 3 Appendix 4 Appendix 5 Appendix 6 Appendix 9
6.2	***Physical Environment***	
	Provide details on the existing physical environment including data on ambient environmental quality of various segments of the environment. Information provided in this sub-section shall include but not be limited to the following:	
	• Geomorphological, topographical and geological characteristics	Chapter 8
	• Any natural or induced hazard in the area (e.g., flood, earthquake, volcanic zone, etc.)	Chapter 8
	• Climatic regime (e.g., rainfall, temperature, etc.)	Chapter 8
	• Air quality and meteorological data set for air dispersion modelling, etc	Chapter 8 Appendix 3 Appendix 5
	• Seasonal surface water quality and hydrological information	Chapter 8
	• Seasonal ground water quality and flow regime	Chapter 8
	• Noise levels	Chapter 8 Appendix 3 Appendix 6
6.3	***Biological Environment***	
	Detailed information should be provided on the existing biological environment and shall include but not be limited to the following:	
	• Presence of a protected area (Conservation Area or Wildlife Management Area), if any	Chapter 8
	• Details of any special purpose areas (e.g., wetland area, etc.)	Chapter 8
	• Aquatic and terrestrial ecology of the area	Chapter 8
	• Information on vulnerable (endangered) species	Chapter 8
	• Other relevant biological information	Chapter 8
6.4	***Social Environment***	
	Issues that may arise within and outside of the project area should be identified including whether this is a direct or indirect outcome of the physical, biological or socio-economic	

	CEPA Guideline	EIS Chapter/Appendix Where Requirement Is Addressed
	effects of the proposed development activities. Information provided in this sub-section shall include but not be limited to the following:	
	• Demographic information	Chapter 9
	• Information on existing infrastructure	Chapter 9
	• Information on public health issues (if applicable)	Chapter 9
	• Information on present economic status of the project area	Chapter 9
	• Description of existing social services	Chapter 9
	• Details of archaeological, historical, cultural or religious features of the project area under consideration, etc	Chapter 9
7	***Waste Minimisation, Cleaner Production and Energy Balance***	
	Information detailed in this section should include consideration of options associated with waste minimisation, cleaner production and energy balance and the ability of the proponent to employ these strategies in its proposed activities. Information to be covered in this section shall include but not limited to the following:	
	• Details of other alternative "cleaner production" technologies or processes that has been considered	Chapter 4
	• Information on the basis for choosing the proposed technology or process	Chapter 4 Chapter 5
	• Available technical background on the process chosen.	Chapter 4
	• Details of the Waste Minimisation Strategy developed for the proposal.	Chapter 4 Chapter 5
	• Details of an "energy balance" for the proposal	Chapter 4
8.	***Environmental Management, Monitoring and Reporting***	
	Information to be covered in this section shall include but not limited to the following:	
	• Details of information on plant operating conditions, including management and monitoring strategy	Chapter 4 Chapter 10 Chapter 11 Chapter 12 Chapter 13
	• Information on socio-economic management and monitoring strategy	Chapter 11 Chapter 13
	• Mechanism and frequency for reporting monitoring results to DEC* and other stakeholders, especially to directly affected stakeholder groups	Chapter 13
	• Availability of contingency and/or emergency plans drawn up for the proposal	Chapter 12 Chapter 13
	• Details of Environment Improvement Plan	Chapter 13
	• Details of Waste Minimisation and/or Management Plans	Chapter 11 Chapter 13
	• Information on potential rehabilitation issues and its strategies including Rehabilitation Plan	Chapter 10 Chapter 13
9.	***Other Statutory Decisions***	

	CEPA Guideline	EIS Chapter/Appendix Where Requirement Is Addressed
	Provide detailed information on other statutory decision(s) that are relevant to this proposed development activity. Provide the draft or finalised Project Development Contract, Memorandum of Agreements or other similar legal decisions that are relevant to the proposal	Chapter 1 Chapter 3
10.	***Confidential Information***	
	Details of classified information relating to a manufacturing or industrial process or trade secret used in carrying on or operating any particular undertaking or equipment or information of a business or financial nature in relation to the proposed activity should be clearly defined Such information would be classified as "confidential information" and excluded from the EIS before the document is made available for public review	Chapter 15
11.	***References***	
	Provide details of reference materials used in sourcing information and/or data used in the EIS	References are provided at the end of Chapters 2, 3, 4, 5, 6, 7, 8, 9, 1, 12 and 13, relevant to each chapter
12.	***Acknowledgements***	
	Detail relevant acknowledgments	Chapter 14
13.	***Study Team***	
	Provide detailed information on persons who assisted in the conduct of the environmental impact assessment study and compilation of the EIS	Chapter 14

* Now CEPA.

Attachment 2
(TWM Environmental Policy)

TWM | Total Waste Management

Lukautim kantri bilong yumi

Caring for our country

Environmental Policy

Total Waste Management is committed to ensuring that our operations are conducted in an environmentally responsible manner at all times.

We will achieve this status by our commitment to implement and maintain an Integrated Management System which will be certified to international standard:

AS/NZS ISO 14001:2015 for Environmental Management

and

we will meet the requirements of the national standards, including the **PNG Environment Act 2000 and Client customised QHSE requirements**.

Within this management system we will maintain an Environmental Management Programme that identifies any environmental impacts that may occur from our business activities. These impacts will be eliminated or controlled to the lowest possible level of risk to ensure compliance with the PNG Environment Act and Regulations.

Our prime objective is to ensure that our workplaces are free of any environmental incidents that impact the environmental receptors of air, water, soil, natural resources and people. We will continually improve our environmental performance and will at all times prevent pollution. We will ensure that our Environmental Management Programme is based on continuous improvements and the prevention of pollution.

Our Employees will be trained to know what work activities can affect the environment and to ensure that they work in the most controlled manner at all times.

We will review our environmental performance on a regular basis.

Signed: 

_____

Managing Director

Date: Tuesday 25th June 2019

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Attachment 3
(TWM Quality Policy)

TWM | Total Waste Management

Lukautim kantri bilong yumi

Caring for our country

Quality Policy

Total Waste Management is committed to maintaining its quality of products and services by implementing a Quality Management System which will align to AS/NZ ISO 9001:2015 for Quality Management, including any client specific requirements.

Our key objective is to reduce our non-conformances in a timely manner by way of corrective action. We treat all reported complaints as a non-conformance and ensure that they are investigated and a response goes to all concerned within a fortnight of the report.

Through our processes of Internal Audit and Management Review, we will ensure that all opportunities to improve the system are captured and actioned. We will have a process for and a focus on continuous improvement to achieve our objective.

Total Waste Management will be known throughout the Industry as a Quality Provider of Products and Services in Waste Management.

Signed: 

Managing Director

Date: Saturday 1st February 2020

Attachment 4
(TWM Workplace Health and Safety Policy)

TWM | Total Waste Management

Lukautim kantri bilong yumi

Caring for our country

Workplace Health & Safety Policy

Total Waste Management aims to achieve zero harm through its operations and is committed to providing a Safe Workplace.

We will achieve this aim through our commitment to implementing and maintaining certification to:

OHSAS 18001:2007 for WHS Management

and

by achieving a high level of compliance with the following Workplace Health & Safety Standards and industry best practice:

- **PNG Industrial Safety, Health & Welfare Act 1961**
- **Safe Work Australia Model WHS Act and Regulations - 2011**
- **Client customized QHSE requirements**

Our prime objective is to provide workplaces that are free from workplace hazards that can cause injuries and illnesses as specified in the above standards.

We will achieve this aim by our commitment to:

- Hazard identification and reporting
- Risk Management through Risk Assessment and Risk Control
- Incident/Accident (Injury) Reporting and Investigation

In all cases, we will investigate all reported incidents and, where appropriate, corrective action will be undertaken to eliminate or control the nonconformance to an acceptable level of risk.

Through the process of Internal Audits and Management Review, we will ensure our system remains compliant to the Standards and the requirements of the Legislations.

Signed: 

Managing Director

Date: Saturday 1st February 2020

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