6. SOFT COMPONENT PLAN

6. SOFT COMPONENT PLAN

THE PROJECT FOR POWER SECTOR IMPROVEMENT FOR KOSRAE STATE IN FEDERATED STATES OF MICRONESIA

SOFT COMPONENT PLAN

APRIL 2016

YACHIYO ENGINEERING CO., LTD.

The Project for Power Sector Improvement for Kosrae State in Federated States of Micronesia

Soft Component Plan

Contents

1. Background to Planning the Soft Component

The Project intends to construct and procure a generator house, diesel generating equipment, transformation equipment and distribution equipment, and thereby upgrade the power generating, transformation and distribution equipment and facilities of Kosrae Utilities Authority (KUA), which is the electric power utility operator in Kosrae State, Micronesia and the Executing agency on the Federated States of Micronesia side. KUA will carry out operation and maintenance following the handover of the supplied equipment.

KUA has 23 employees that conduct power supply in Kosrae State, and around seven of these are involved in the technical operation and maintenance. Three diesel generators (G-4, G-6, G-8) are currently in working order and KUA is able to conduct routine maintenance of the generating equipment, however, in the case where new equipment is introduced, it will be necessary to build an organized maintenance structure and implement maintenance capacity building (implementation, recording, sorting, analysis and archiving of routine inspections) in order for the equipment to be operated and maintained appropriately.

Except for small-scale (low voltage connected systems) systems, no large-scale (grid-connected) solar power systems have so far not been installed in Kosrae State, however, a new solar power generating system (200 kWp) was installed under support from the Pacific Environment Community (PEC) Fund in April 2015, while another 100 kWp solar power generating system was introduced based on aid from the EU in December 2015, meaning that 300 kWp has been connected to the 13.8 kW power grid. As a result, the total power of 300 kWp from these solar power systems will come to account for between 32.6% of system capacity in Kosrae State (maximum daytime mean approximately 920 kW). However, KUA has no system stabilizing equipment, etc., and it will need to firmly establish the concept and methodology for operating and maintaining the Project diesel generators in tandem with the solar power systems that will be connected to the 13.8 kW grid.

Equipment maintenance is broadly divided into preventive maintenance and follow-up maintenance. The maintenance activities of KUA largely consist of unplanned emergency follow-up maintenance. Such follow-up maintenance is regarded as a problem for the following reasons: (1) major damage is imparted to equipment and massive costs are incurred in repairs, and (2) equipment operation needs to be stopped for long periods in order to implement repairs.

The technical education that is currently implemented by KUA mainly consists of OJT inside the power station and on the solar power systems. In the Project, OJT (on the job training) focusing on operation and maintenance using actual equipment will be implemented by the equipment suppliers during the works period, trial operation and commissioning, however, in order for the local staff to acquire the technology to conduct the general operation and maintenance of

generating equipment unaided, OJT focusing on operation and maintenance training by equipment suppliers for KUA maintenance personnel will not suffice. Therefore, in the Soft Component, it is planned to conduct a comprehensive package of technical guidance ranging from classroom study on equipment operating principles, structures and systems to preventive maintenance comprising operation, maintenance, patrol inspections and record keeping for the KUA maintenance personnel. Technical guidance will also be conducted on maintenance of interconnected operation with solar power systems.

2. Objectives of the Soft Component

In the Soft Component, the Consultant will conduct technical guidance to KUA (the Executing agency). The guidance will cover the operation and maintenance of the Project diesel generator equipment (two 600kW generators), and interconnected operation with the solar power systems that have been or are being constructed in Kosrae State under assistance from the Pacific Environment Community (PEC) Fund and European Union (EU). The guidance will cover operation methods to ensure that impacts on the diesel generating equipment from the solar power systems are kept to a minimum. The Consultant will implement the Soft Component with the objective of disseminating maintenance (preventive maintenance) via classroom learning of diesel engine and generator operating principles, structure, etc. and guidance on practical knowledge and technology using actual equipment. The goals of the Soft Component are indicated below.

- Transfer of systematic knowledge concerning the structure, functions and theory of internal combustion engines (diesel engines)
- Transfer of systematic knowledge concerning the structure, functions, systems, etc. of generators
- Transfer of systematic knowledge concerning the structure, functions and composition of mechanical equipment systems (lubricating oil systems, cooling water systems, and electrical equipment systems)
- Guidance in systematic knowledge concerning the preventive maintenance of diesel engines, generators, mechanical and electrical equipment systems
- Formulation of plans for the preventive maintenance of diesel engines, generators, mechanical and electrical equipment systems
- Formulation of operation plans and preventive maintenance plans for grid-interconnected solar power systems that are subject to constraints from the operation of diesel engines and mechanical and electrical equipment systems

3. Outputs of the Soft Component

Through introducing the Soft Component, the following outputs will be achieved in terms of preventive maintenance planning.

- KUA will compile plans for the operation and maintenance of diesel engines, generators, mechanical and electrical equipment systems and interconnected operation with grid-interconnected solar power systems in light of structures, functions and theory acquired via the classroom learning and practical training.
  : Formulation of a standard values data sheet for operation management of systems

- KUA will compile plans for preventive maintenance of diesel engines, generators, mechanical and electrical equipment systems and grid-interconnected solar power systems in light of structures, functions and theory acquired via the classroom learning and practical training.
  : Establishment of a table showing periodic inspection intervals

4. Method for Confirming Achievement of Outputs

Tests to confirm understanding will be implemented to check the level of achievement when each of the following categories is completed:

- Structure and functions of internal combustion engines
- Structure and functions of mechanical equipment
- Structure and functions of generators and electrical equipment
- Formulation of operation and maintenance plans for generating equipment (including interconnected operation with solar power systems)
- Formulation of preventive maintenance plans

5. Soft Component Activities (Plan of Inputs)

(1) Contents of Activities

In the Soft Component, in order to implement preventive maintenance activities, the following technical guidance including the necessary classroom learning will be conducted focusing on guidance in operation and maintenance knowledge using actual equipment. Moreover, tests, internal debate and so on will be conducted in order to grasp the degree to which knowledge is being absorbed.

a) Principles of 4-cycle diesel engines and generators
b) Structure of generators including coupling with engines
c) Outline of fuel oil systems, maintenance of thermal efficiency, exhaust gas control, management of fuel oil properties
d) Outline of lubricating oil systems, operating principles of lubricating oil cleaning devices, fluid lubrication, management of lubricating oil properties

e) Outline of cooling water systems, relationship between cooling performance and thermal efficiency, prevention of corrosion in cooling systems, management of cooling water properties
f) Outline of compressed air systems, and diesel engine starting method
g) Structure and connection method of cable connecting terminals on the secondary side of generators
h) Generator test methods and test apparatus
i) Outline of air supply and exhaust systems, and importance of exhaust temperature
j) Attachment of sensors and conditions of wiring
k) Outline of waste oil treatment systems, and important points from the perspective of environmental impact
l) Equipment failures and preventive maintenance (formulation of spare parts purchasing plans)
m) Important points in preventive maintenance of diesel engines
n) Important points in preventive maintenance of mechanical equipment systems
o) Formulation of a periodic inspection interval sheet for diesel engines
p) Formulation of a standard values data sheet for operation management of diesel engines
q) Formulation of a periodic inspection interval sheet for mechanical equipment systems
r) Formulation of a standard values data sheet for operation management of mechanical and electrical equipment systems
s) Diesel generator starting conditions and operation constraints on solar power systems arising from power load
t) Operation planning (weekdays and holidays) of solar power systems interconnected with diesel generators

(2) Plan of Inputs

In implementing the Soft Component, in the work in Japan, the Consultant will appoint ① a Japanese engineer (diesel power generation engineer) who has been involved and is well-versed in design, operation and maintenance of diesel engines, and ② a Japanese person (grid-interconnected system engineer) who has been involved in design of interconnected operation of diesel generators with solar power systems and is well-versed in operation and maintenance technologies. Their terms of activity in the Federated States of Micronesia will be 1.0 month and 0.5 months respectively between the end of the contractor's contract and completion of the handover of facilities and equipment, and staff planning will be conducted to ensure that the technical guidance is finished by the start of Project equipment operation.

In the work in Japan before being dispatched to the Federated States of Micronesia, the instructors will analyze the technical levels of KUA mechanical and electrical engineers based on the gathered KUA operation and maintenance materials, and compile the technical guidance materials (materials on structure, functions and theory of diesel engines, technical materials on

mechanical equipment systems, features of generators that conduct interconnected operation with solar power systems, issues for examination, and test questions) (1.0 month and 0.5 months).

Table-1 shows the contents of activities of Soft Component personnel in Japan, while Table-2 shows the contents of activities in the Federated States of Micronesia.

Table-1 Detailed Plan of Soft Component Activities (in Japan)

Category	Contents of Activities	Implementation Period
Theory of internal combustion engines	Preparation of texts, manuals and test questions concerning the following: ① "Principles of 4-cycle diesel engines" ② "Principles and structure of coupled generators"	0.25 months
Theory of mechanical and electrical equipment systems	Preparation of texts, manuals and test questions concerning the following: ③ "Outline of fuel oil systems, maintenance of thermal efficiency, exhaust gas control, management of fuel oil properties" ④ "Outline of lubricating oil systems, operating principles of lubricating oil cleaning devices, fluid lubrication, management of lubricating oil properties" ⑤ "Outline of cooling water systems, relationship between cooling performance and thermal efficiency, prevention of corrosion in cooling systems, management of cooling water properties" ⑥ Structure and connection of terminals of cables on the secondary side of generator ⑦ "Generator test methods and test apparatus" ⑧ "Outline of air supply and exhaust systems, and importance of exhaust temperature" ⑨ "Outline of air supply and exhaust systems, and importance of air temperature management" ⑩ Attachment of sensors and conditions of wiring ⑪ "Outline of waste oil treatment systems, and important points from the perspective of environmental impact"	0.25 months
Preventive maintenance	Preparation of texts, manuals and test questions concerning the following: ⑫ "Equipment failures and preventive maintenance" ⑬ "Important points in preventive maintenance of diesel engines" ⑭ "Important points in preventive maintenance of mechanical equipment systems"	0.25 months
Formulation of preventive maintenance plan	Preparation of texts, manuals and test questions concerning the following: ⑮ "Formulation of a periodic inspection interval sheet for diesel engines" ⑯ "Formulation of a standard values data sheet for operation management of diesel engines" ⑰ "Formulation of a periodic inspection interval sheet for mechanical equipment systems" ⑱ "Formulation of a standard values data sheet for operation management of mechanical and electrical equipment systems"	0.25 months
Subtotal	Diesel power generation engineer	1.0 month x 1 person
Features and issues of generating equipment that conducts grid-interconnected operation	Preparation of texts, manuals and test questions concerning the following: ① "Principles and basic knowledge of generating equipment that conducts grid-interconnected operation" ② "Features of generating equipment that conducts grid-interconnected operation" ③ "Issues for examination when introducing generating equipment that conducts grid-interconnected operation" ④ "Output fluctuations in generating equipment that conducts grid-interconnected operation"	0.5 months
Subtotal	Grid-interconnected system engineer	0.5 month x 1 person

Table-2 Detailed Plan of Soft Component Activities (in the Federated States of Micronesia)

Category	Contents of Activities	Implementation Period
Theory of internal combustion engines	① Principles of 4-cycle diesel engines, auxiliary units, generators and electrical equipment	0.20 months
Theory of mechanical and electrical equipment systems	② Start and stop training using actual diesel engines and generators (including compressed air systems) ③ Outline of fuel oil systems, maintenance of thermal efficiency, exhaust gas control, management of fuel oil properties ④ Outline of lubricating oil systems, operating principles of lubricating oil cleaning devices, fluid lubrication, management of lubricating oil properties ⑤ Outline of cooling water systems, relationship between cooling performance and thermal efficiency, prevention of corrosion in cooling systems, management of cooling water properties ⑥ Outline of air supply and exhaust systems, importance of exhaust temperature ⑦ Outline of waste oil treatment systems, important points from the perspective of environmental impact	0.40 months
Preventive maintenance	⑧ Equipment failures and preventive maintenance ⑨ Important points in preventive maintenance of diesel engines ⑩ Preventive maintenance of generators and electrical equipment systems ⑪ Important points in preventive maintenance of mechanical equipment systems	0.20 months
Formulation of preventive maintenance plan	⑫ Formulation of a periodic inspection interval sheet for diesel engines ⑬ Formulation of a periodic inspection interval sheet for generators and electrical equipment ⑭ Formulation of a standard values data sheet for operation management of diesel engines ⑮ Formulation of a periodic inspection interval sheet for mechanical equipment systems ⑯ Formulation of a standard values data sheet for operation management of mechanical equipment systems	0.20 months
Subtotal	Diesel power generation engineer	1.0 month x 1 person
Theory and practical training on generating equipment that conducts interconnected operation with solar power systems	⑤ Explanation and lecture concerning “Principles and basic knowledge of generating equipment that conducts grid-interconnected operation” ⑥ Grasping of “Features of generating equipment that conducts grid-interconnected operation” ⑦ Guidance on preparation of materials concerning “Output fluctuations in generating equipment that conducts grid-interconnected operation” ⑧ Guidance concerning “Preparation of operation manual on interconnected operation of diesel generator equipment and solar power systems”	0.5 months
Subtotal	Grid-interconnected system engineer	0.5 months x 1 person

6. Method for Procuring Resources for Soft Component Implementation

Since it will be necessary to provide guidance on coherent knowledge and technology ranging from the functions, structures and theory of diesel engines and generators to operation and maintenance of actual diesel generating equipment, the Japanese Consultant will conduct overall supervision and guidance in the Soft Component of the Project. However, to ensure smooth implementation and effective and efficient operation and maintenance after that, it will be vital for the KUA

maintenance personnel to display initiative and make independent efforts. Therefore, a leader will be appointed from among the KUA trainees when implementing the Soft Component.

7. Soft Component Implementation Schedule

Table-3 shows the implementation schedule of the Project Soft Component.

Table-3 Soft Component Implementation Schedule

Number of Months	1	2
1. Theory of internal combustion engines and generators		
2. Theory and practical training for mechanical and electrical equipment systems		
3. Necessity of preventive maintenance, and practical training		
4. Formulation of preventive maintenance plan		
5. Interconnected operation of diesel generator equipment and solar power systems		

8. Outputs of the Soft Component

The following outputs will be produced through implementation of the Soft Component.

- Soft Component completion report
- Technical materials for diesel generating equipment (English)
- Results of tests for confirming understanding of technical guidance contents (English)
- Periodic inspection interval sheet for diesel generating equipment (English)
- Standard values data sheet for operation management of diesel generating equipment (English)
- Output fluctuation sheet for grid-interconnected operation (English)

9. Soft Component Cost Estimate (Draft)

The cost estimate (draft) is as follows.

Item	**Cost at time of estimation (1000 yen)**	**Remarks**
(1) Direct personnel costs	2,568	• No local subcontracting, etc.
(2) Direct expenses	1,181	
(3) Indirect expenses	3,287	
Total	**7,036**	

10. Obligations of the Counterpart Agency

- To appoint counterparts from KUA for implementing the Soft Component.
- To appoint participants in the Soft Component from KUA.
- To provide a venue for the Soft Component classroom training

7. REFERENCES

7. REFERENCES

(1) Topographic Survey and Soil Investigation Report

REPORT

Yachiyo Engineering Co.Ltd.

Project for Power Station Improvements in the State of Kosrae, Micronesia
Topographical Survey and Soil Explorations

Prepared for:

Yachiyo Engineering Co.Ltd.

Prepared by:

Tonkin & Taylor International Ltd

Distribution:

Yachiyo Engineering Co.Ltd.	2 copies
Tonkin & Taylor International Ltd (FILE)	1 copy

May 2015

Job No: 751122

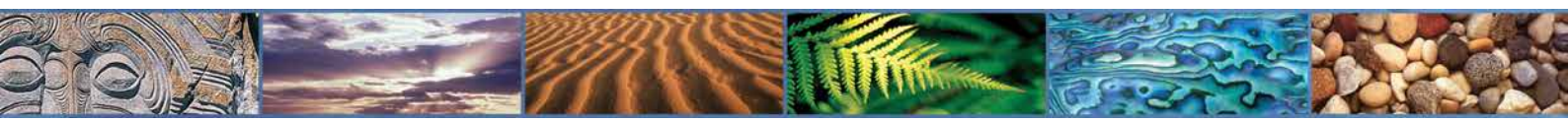


Table of contents

1 Introduction

1.1 General

Tonkin & Taylor International (T&TI) was engaged by Yachiyo Engineering Co., Ltd. (YEC) to undertake soil investigations and a topographic survey for a proposed new power house at the existing Tofol Power Station (defined herein as 'the site') in Kosrae, Micronesia.

The investigations and survey have been carried out in accordance with the "Contract of Topographical Survey and Soil Explorations" provided to T&TI by YEC. The soil investigations comprised 6 hand augered boreholes (two of which BH1 and BH5 were carried out through the base of trial pits), 3 trial pits and 7 Scala penetrometer tests, at locations directed by the representative of YEC. Laboratory testing of recovered soil samples from the site was also undertaken. This work scope was agreed with YEC.

The topographic survey of the site was undertaken by New Zealand based topographical surveyors, under the supervision of T&TI.

The geotechnical assessment was undertaken in accordance with our proposal dated 27 February 2015[1].

The scope of the geotechnical investigations has included:

- A review of relevant existing information held in T&TI archives.
- T&TI supervision of the Topographical Survey conducted by a NZ based surveyor.
- 6 hand augered boreholes to a maximum of 5m depth.
- 3 machine excavated trial pits to a maximum to 2.2m depth
- 7 Scala penetrometer tests to a maximum of 5m depth.
- Assessment of suitable foundation solutions for structures on the site.
- Preparation of this report outlining the geology, site subsurface conditions and presenting preliminary geotechnical information and recommendations to support the development of the site.

This report summarises the results of the soils investigations carried out at the site.

1.2 Project Description

Kosrae lies in the eastern Caroline Islands and is a single island State making up part of the Federated States of Micronesia. Kosrae consists of three islands. The main island which is triangular in shape and occupies a total land area of 112 square kilometres while two smaller islands along the eastern coast occupy an area of 0.5km^2 and 100m^2 respectively. Kosrae has a relatively elevated and steep interior which is almost entirely vegetated, surrounded by coastal mangroves and a coral reef in the low lands. The population of Kosrae is approximately 6000.

The project involves construction of a new power house building at the existing Tofol power generation plant in Tofol. Based on preliminary design drawings provided by YEC we understand the proposed power house will consist of a new building with an approximate 20m by 30m footprint. We understand that the northern two thirds of the building will comprise a two storey steel structure housing three new generation units along with electrical control rooms and offices. The southern third of the building will be single level, open air and contain the sludge treatment

[1] Tonkin and Taylor International Ltd. (27 February 2015) , Preparatory Survey on the Project for Power Sector Improvements for the State of Kosrae in the Federated States of Micronesia

area. In addition a concrete access road will also be constructed down the eastern side of the new building.

2 Site Description

The site is located on the main island road at the eastern extent of the village of Tofol, Kosrae. The site is approximately 14km from Kosrae International Airport.

The existing power station site is located on a relatively flat plateau above the main island road. It is bound by the island road to the north and east and steep slopes to the south and west. A number of existing buildings currently occupy the site including the main office building, machinery and maintenance sheds, power generation building, oil tanks and a partially completed solar energy generation area.

It is proposed that the new power house building will be located along the western boundary of the site, directly north of the existing Material Stock Yard Building. The proposed location of the new power house is currently occupied by a 40ft shipping container which has been converted into an office facility which is currently disused. A pig sty and large tree are also present to the northeast. At least three abandoned motor vehicles were located within an overgrown part of the proposed building site.

The proposed new building is to be constructed on a plateau approximately 3 to 4m above the road. The plateau is gently sloping from the south to the north before it drops off rapidly down to the road. Gully features are present to both the east and west of the proposed development area.

Within the proposed building footprint, the site topography varies by approximately 1m from the south to the north (being higher to the south). Accordingly site earthworks are likely to be required to create a level building platform. Based on discussions with YEC representatives, we understand the cut to fill will be designed to try and achieve a balance (i.e. all material cut from the higher southern end of the site will be used to fill the lower northern end of the site to create a level platform).

3 Summary of the Topographic Survey

A topographical survey of the site was undertaken by NZ based surveyors in March 2015 under the supervision of T&TI. The topographical survey details and results are summarised in the following section.

Topographical survey of the site was undertaken from the 21st to 26th March 2015.

Equipment used included:	Sokkia RTK GPS XR1 Base and Rover
	Sokkia SET4130R3-36T Reflectorless Total Station
Local Benchmark used:	N/A
Coordinate system used:	Universal Transverse Mercator (UTM WGS84)
Height Datum:	Assumed Height 100m at BM2 (14m above Lelu Sea level)

The Topographical Survey plans and report have been presented in Appendix B.

4 Summary of the Soils Investigation

4.1 General

The soil investigations were carried out in March 2015 and the scope of the work was completed in accordance with the 'Contract of Topographical Survey and Soil Explorations', presented in Appendix A. All field tests were terminated at refusal or at the target depth provided by YEC.

The following tasks were completed for the soils investigation:

- 6 No. Hand auger boreholes (BH1 to BH6) to 5.0m below existing ground level.
- 7 No. Scala penetrometer tests (SC1 and SC2) to 5.0m below ground level.
- 1 No. excavated trial pit (TP1) to 2.2m below ground level

The subsections below present a summary of the investigation work and laboratory testing results. Site investigation logs are presented in Appendix C and laboratory testing results are presented in Appendix D.

4.2 Hand auger and Scala penetrometer investigations

The soil investigation testing, including hand augered boreholes and Scala penetrometer tests, were located within and surrounding the proposed new building footprint over a period of 6 days (21 March – 26 March 2015). The hand augered boreholes extended to a depth of up to 4.8m below existing ground level. The Scala penetrometer tests were terminated at 5.0m below ground level (except SC1 which met refusal at 4.2m due to the presence of hard ground)

In-situ shear strength testing was carried out in the hand auger boreholes in cohesive materials using a calibrated pilcon shear vane and samples were collected for geotechnical laboratory testing. The subsurface soils were described in accordance with NZ Geotechnical Society guidelines and shear strengths are recorded on the borehole logs presented in Appendix C. The Scala penetrometer provides continuous soil strength data until hard ground/refusal is achieved (10 - 20 blows per 50mm penetration). The results of the Scala penetrometer tests are included in Appendix C.

Published correlations between Scala penetrometer test results and SPT 'N' values have been used to assess the soil material properties used.

4.3 Geotechnical Laboratory Schedule

The recovered samples were transported back to Auckland and geotechnical laboratory testing was carried out by Geotechnics Ltd. The laboratory tests have been completed in accordance with the relevant New Zealand standards and the laboratory is fully accredited with international Accreditation New Zealand (IANZ) registration.

The soil testing consisted of the following:

- Atterberg limits (3 No.)
- Natural moisture contents (3 No.)
- Particle size distribution (3 No.)
- Solid density (3 No.)
- pH for acidity (3 No.)

5 Subsurface Conditions

5.1 Geological Setting

Published Geological information[2] indicates the island of Kosrae is volcanic in origin with the basement rock consisting of either the Kosrae Main Lava series (KMLS) or the Kosrae Nepehlinite Series (KNS). The rocks of the KMLS typically comprise basalts, ankaramited and hawaiites while the rock of the KMS group are typically highly to moderately under-saturated lavas and dikes.

Soils on the island typically fall into one of four categories; highly weathered oxisols (typical of lowland areas), inceptisols (younger, less weathered soils typical of mountainous areas) entisols (typical of low lying swampy areas) and mangrove muds (containing mucky organic peats). Due to the volcanic origin of the soils, the high rainfall on the island and high degree of weathering the soils are typically acidic in nature. In addition the soils typically contain a moderate amount of organic material[3].

Based on the topography and location of the site it is likely that the site is underlain by predominately oxisol residual soils (soils formed from the weathering of parent rock) overlying volcanic rocks (basalt etc.) at varying stages of weathering. The results of the geotechnical investigations across the proposed development area confirmed the presence of volcanic soils as expected.

5.2 Ground and Groundwater Conditions

5.2.1 General

The results of the geotechnical investigations across the proposed development area indicate the subsurface conditions typically comprise topsoil overlying either coral sand (fill) and uncontrolled fill or residual soils. In the south east and north of the proposed development area, uncontrolled fill and coral sands were encountered directly below the topsoil, with either the fill overlying the coral sand (TP1) or coral sand overlying the fill (BH1 and BH5). Below these layers the natural volcanic soils were encountered.

Across the remainder of the site, natural volcanic soils were encountered directly below either the topsoil or coral sand layers. Minor fibrous organic lenses (peat) were encountered in BH3 (4.1m deep, 0.2m thick) and BH5 (2.4m deep and 0.1m thick). The organic material was found to be relatively intact, (still retaining most of its structure) dark purple in colour and moist to wet. However, approximately 5m to the west of the development area (outside the proposed building footprint) a thicker and shallower layer of organic material was encountered in BH4 (2.2m deep, at least 2m thick).

A summary of the ground conditions is presented in Table 1 below.

[2] Hafiz, R. U. et al 2013, *Geological Origin of the Volcanic Islands of the Caroline Group in the Federated States of Micronesia*, *Western Pacific* South Pacific Studies Vol.33, No. 2 2013

[3] Merlin, M. Taulung, R. Juvik, J. 1993, *Sahk Kap Ac Kain In Can Kosrae: Plants and Environments in Kosrae*, University of Hawai'i at Mānoa

Table 1-Summary of typical ground conditions within the building footprint

Depth (Below ground level)	Geological Unit	Soil Description	Soil Undrained shear strength (Cu)
0-0.1m	Topsoil	Silty TOPSOIL with minor organics and some sand and gravels, loose, dry , non- plastic	N/A
0.1-0.5m	Coral Sand (Fill)	Medium to coarse SAND, with fine gravels white grey, medium dense, dry (BH1, BH2 and TP1)	N/A
0.3-1.2m	Uncontrolled fill	SILT to silty CLAY with sand and gravel inclusions and some refuse (tin cans, cloth, car parts), orange brown to dark brown low plasticity, moist (BH1, BH5, and TP1)	45-110kPa
0.2-4.7m	Residual soils	CLAY, Silty CLAY and SILT (some cemented), with occasional fine gravels, low to moderately plastic, orange brown mottled purple and black moist to wet	40-220kPa
2.4-2.5m (BH5) 4.1-4.3m (BH3) 2.2-4.5 (BH4)*	Organics	Fibrous PEAT and rootlets, spongy dark purple colour, non-plastic, wet	N/A

*Note: outside building footprint

Groundwater inflows into the investigation holes were typically encountered at the base of the fill or coral sand layers at the interface between the highly permeability fills / coral sands and the lower permeable volcanic soils. Groundwater levels were typically measured at between 1m and 2.5m depth at the completion of each borehole.

Scala penetrometer tests were carried out adjacent to each of the hand augered boreholes. From this in-situ testing, we can assess the soil strengths at specific depths below the site. The Scala results and inferred soil strengths are summarised in Table 2 below:

Table 2- Summary of Scala penetrometer results

Depth (Below ground level)	Average Scala Blows per 50mm	Soil Type	Inferred Consistency	Equivalent SPT "N" values
0-0.1m	N/A	Topsoil	Loose	N/A
0.1-0.5m	6-8	Coral Sand	Medium Dense	24-32
0.3-1.2m	2-4	Uncontrolled fill (cohesive)	Firm to stiff	8-16
0.2-4.7m	1-4	Residual soils (cohesive)	Firm to very stiff	4-16
2.25 – 4.5	4-7	Organics	Medium Dense	16-28

5.2.2 Summary of Scala Penetrometer results and equivalent SPT "N" value

Tables 3-9 below provide Scala Penetrometer results and equivalent SPT "N" values for SC1 to SC7 at 0.5m intervals.

Table 3- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC1

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	5	Medium Dense	20
1.0	2.5	Stiff	10
1.5	3.5	Stiff	14
2.0	2.5	Stiff	10
2.5	3	Stiff	12
3.0	3	Stiff	12
3.5	3	Stiff	12
4.0	2.5	Stiff	10
4.5	5	Very Stiff	20

Table 4- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC2

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	5	Medium Dense	20
1.0	2	Firm	8
1.5	1.5	Firm	6
2.0	1	Firm	4
2.5	3.5	Stiff	14
3.0	4.5	Stiff	18
3.5	4.5	Stiff	18
4.0	5	Very Stiff	20
4.5	4	Stiff	16
5.0	5	Very Stiff	20

Table 5- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC3

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	2	Loose	8
1.0	1	Firm	4
1.5	1	Firm	4
2.0	2	Stiff	8
2.5	2	Stiff	8
3.0	1.5	Firm	6
3.5	2	Stiff	8
4.0	2.5	Stiff	10
4.5	3	Stiff	12
5.0	5	Very Stiff	20

Table 6- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC4

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	2.5	Loose	10
1.0	2.0	Stiff	8
1.5	3	Stiff	12
2.0	2.5	Stiff	10
2.5	3.5	Stiff	14
3.0	4.5	Stiff	18
3.5	4.5	Stiff	18
4.0	6	Very Stiff	24
4.5	6.5	Very Stiff	26
5.0	7	Very Stiff	28

Table 7- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC5

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	1.5	Loose	6
1.0	2	Stiff	8
1.5	4	Stiff	16
2.0	2.5	Stiff	10
2.5	2.5	Stiff	10
3.0	1.5	Firm	6
3.5	2	Stiff	8
4.0	1.5	Firm	6
4.5	3	Stiff	12
5.0	4.5	Stiff	18

Table 8- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC6

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	1	Loose	4
1.0	10	Dense	40
1.5	7	Medium Dense	28
2.0	3	Stiff	12
2.5	2.5	Stiff	10
3.0	4	Stiff	16
3.5	5	Very Stiff	20
4.0	4.5	Stiff	18
4.5	5	Very Stiff	20

5.0	5	Very Stiff	20

Table 9- Summary of Scala Penetrometer results and equivalent SPT "N" value-SC7

Depth (Below ground level)	Average Scala Blows per 50mm	Inferred Strength	Equivalent SPT "N" values
0.5	3	Medium dense	12
1.0	1.5	Firm	6
1.5	1.5	Firm	6
2.0	2	Stiff	8
2.5	2.5	Stiff	10
3.0	2	Stiff	8
3.5	2	Stiff	8
4.0	2	Stiff	8
4.5	2.5	Stiff	10
5.0	3.5	Stiff	14

6 Geotechnical Laboratory Testing Results

A summary of the geotechnical laboratory testing results is presented in Table 10 below. A full set of the geotechnical testing data sheets is presented in Appendix D.

Table 10 – Summary of the geotechnical laboratory testing

Hand Auger No.	Sample Depth (m)	Solid Density	Grain Size Analysis	Moisture Content	pH
BH1	0.1-0.2	-	Coral SAND with minor silt and trace clay light yellowish orange brown mottled red	-	-
BH1	0.8-0.9	-	-	-	6.4
BH3	0.3-0.6	-	Silty SAND with some clay and some gravel brown mottled orange	-	6.5
BH3	1.3-1.5	-	-	35.2%	-
BH4	0.4-0.6	-	-	41%	-
BH4	1.0-1.2	2.88 t/m3	-	-	-
BH5	0.6-0.7	2.87 t/m3	-	-	-
BH5	1.2-1.3	-	-	38.4%	6.8
BH5	2.7-2.9	-	Silty SAND with some clay and gravel greyish brown mottled orange-red	-	-
BH5	3.9-4.1	2.86 t/m3	-	-	-

7 Discussion and Engineering properties

7.1 General

Recommendations and opinions in this report are based upon data from 6 No. hand augered boreholes, 1 No. trial pit and 7 No. Scala penetrometer tests from the subject site.

The nature and continuity of the subsoil away from the test locations is inferred, but it must be appreciated that actual conditions could vary from the assumed model.

From the results of the soils investigation, geotechnical laboratory testing and published empirical relationships, we have assessed the engineering properties for the underlying soils at the site for the designer's consideration in the following subsections.

During construction actual ground conditions should be confirmed by a geotechnical engineer competent to judge whether the soils exposed in the foundation excavations are compatible with those described within this report.

7.2 Foundation Design

Following discussions with YEC, it is understood that shallow foundations will be constructed for the proposed power house, providing the ground conditions are suitable.

The site investigation data has indicated the presence of uncontrolled fill across the south east and north of the site. Due to the highly variable nature of its placement and properties as well as the presence of refuse (tin cans, cloth and car parts etc.) throughout we do not consider this material to be suitable for founding the new structure on. We recommend that the fill is removed prior to construction and replaced with compacted crushed gravel to an engineered standard (where required). The coral sand will also require removal to excavate the uncontrolled fill. However, the coral sand should be stockpiled for re-use on-site with the engineered fill.

As outlined in Section 5.2 above, fibrous organic peat was encountered across the western and northern areas of the site (in BH3 at 4.1m depth and BH5 at 2.2m depth). As the thickness of the organic layers encountered within these boreholes is relatively thin, it is unlikely that significant settlements will result from foundation loading. The overlying residual soils can be expected to reduce the applied bearing stress from foundations

However we do note that a significant deposit of organic material was encountered in BH4, approximately 5m west of the proposed building footprint. Constructing foundations over this deposit would likely result in moderate to relatively high settlements which could require mitigation measures such as pre-loading with vertical drains or deep / pile foundation options to be considered. It is therefore recommended that the building be constructed as far to the east as practical to mitigate this risk.

It is expected that shallow foundations bearing on the residual volcanic soils or compacted gravel fill may be utilised as a founding layer for the proposed power house depending on the actual loads. We have provided bearing capacities for these material types.

We recommend using a strength reduction factor of 0.5 (Φ_G =0.5) to give an ultimate limit state (ULS) bearing capacity, in accordance with New Zealand Design Standards (ref: NZS 1170). For serviceability limit state design we recommend a strength reduction factor of 0.33 (Φ_G =0.3) to give an allowable bearing capacity. Recommended bearing capacities are presented in Tables 11 - 17 below. These values have been evaluated based on empirical design charts between allowable bearing pressure, to give 25mm of settlement, and SPT 'N' values as developed by Terzaghi and Peck 1948 for a 1.5m wide footing. Note: ULS =Ultimate Limit State (ref. NZS1170)

Table 11- Bearing Capacities of volcanic soils for SC1

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	N/A-Fill	-	-	Shallow strip footings up to 1m wide
1m	N/A-Fill	-	-	
1.5m	150	225	450	
2m	100	200	300	
2.5m	120	225	450	
3m	150	225	450	Deep Foundation (i.e. Bored piles) '3 x B' Embedment into the founding layer (volcanic soils)
3.5m	150	225	450	
4m	150	225	450	
4.5m	200	300	600	
5m	200	300	600	

Table 12- Bearing Capacities of volcanic soils for SC2

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	N/A-Fill	-	-	Shallow strip footings up to 1m wide
1m	80	120	240	
1.5m	50	75	150	
2m	50	75	150	
2.5m	150	225	450	
3m	150	225	450	Deep Foundation (i.e. Bored piles) '3 x B' Embedment into the founding layer (volcanic soils)
3.5m	170	250	500	
4m	170	250	500	
4.5m	200	300	600	
5m	200	300	600	

Table 13- Bearing Capacities of volcanic soils for SC3

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	80	120	240	Shallow strip footings up to 1m wide
1m	50	75	150	

1.5m	50	75	150	
2m	80	120	240	
2.5m	80	120	240	
3m	80	120	240	Deep Foundation (i.e. Bored piles) ‘3 x B’ Embedment into the founding layer (volcanic soils)
3.5m	80	120	240	
4m	100	150	300	
4.5m	150	225	450	
5m	200	300	600	

Table 14- Bearing Capacities of volcanic soils for SC4

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	100	150	300	Shallow strip footings up to 1m wide
1m	80	120	240	
1.5m	120	180	360	
2m	100	150	300	
2.5m	150	225	450	
3m	150	225	450	Deep Foundation (i.e. Bored piles) ‘3 x B’ Embedment into the founding layer (volcanic soils)
3.5m	170	250	500	
4m	170	250	500	
4.5m	200	300	600	
5m	200	300	600	

Table 15- Bearing Capacities of volcanic soils for SC5

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	N/A-Fill	-	-	Shallow strip footings up to 1m wide
1m	N/A-Fill	-	-	
1.5m	160	240	480	
2m	100	150	300	
2.5m	100	150	300	
3m	150	225	450	Deep Foundation (i.e. Bored piles) ‘3 x B’ Embedment into the founding layer (volcanic soils)
3.5m	170	250	500	
4m	170	250	500	
4.5m	200	300	600	

5m	200	300	600	

Table 16- Bearing Capacities of volcanic soils for SC6

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	N/A-Fill	-	-	Shallow strip footings up to 1m wide
1m	N/A-Fill	-	-	
1.5m	N/A-Fill	-	-	
2m	120	180	360	
2.5m	100	150	300	
3m	150	225	450	Deep Foundation (i.e. Bored piles) '3 x B' Embedment into the founding layer (volcanic soils)
3.5m	170	250	500	
4m	170	250	500	
4.5m	200	300	600	
5m	200	300	600	

Table 17- Bearing Capacities of volcanic soils for SC7

Depth (Below existing ground level)	Geotechnical Bearing Capacities			Foundation Type
	Allowable - (kPa or kN/m2) (FoS=3)	ULS* - (kPa or kN/m2)	Ultimate(kPa or kN/m2)	
500mm	120	180	360	Shallow strip footings up to 1m wide
1m	50	75	150	
1.5m	50	75	150	
2m	80	120	240	
2.5m	100	150	300	
3m	100	150	300	Deep Foundation (i.e. Bored piles) '3 x B' Embedment into the founding layer (volcanic soils)
3.5m	100	150	300	
4m	100	150	300	
4.5m	100	150	300	
5m	150	225	450	

7.3 Solid Density, Undrained Shear Strength, Cohesion and Internal Friction Angle Range

Table 18 below summarises the approximate solid densities, undrained shear strengths, cohesion and effective internal friction angles for the different sites. These have been assessed using results of the site investigations and laboratory testing.

Table 18- Summary of Solid Density, Undrained Shear Strength, Cohesion and Internal Friction Angle- Proposed Transmission House

Depth (Below existing ground level)	Soil Description	Unit Weight (KN/m^3)	Undrained Shear Strength (kPa)	Cohesion (kPa)	Effective Internal Friction Angle (deg)
0-0.1m	Topsoil	16	N/A	N/A	N/A
Compacted gravel	Gravel Fill	20	N/A	0	38°
0.2-4.7m	Residual soils	17	40-220kPa	5	30°
2.25 – 4.5	Organics	16	N/A	0	25°

7.4 Site Seismic Classification

7.4.1 General

It is appropriate to design the foundations and structure in accordance with the New Zealand Standard NZS 1170.5:2004 subject to confirmation with the local Government authorities. From the geotechnical investigations undertaken we consider that the site should be classified as a Class C- (Shallow soil site).

Alternatively the U.S. International Building Code should be applied given that Kosrae is a former U.S. Trust Territory.

7.4.2 Importance Level

In accordance with NZS 1170.0:2002[4] we have completed this assessment on the basis that the proposed development will be an Importance Level 2 structure. If this is changed during detailed design then updates will be required to this report.

7.4.3 Peak Ground Acceleration

The probabilistic earthquake hazard assessment for Australia and the South Pacific prepared by McCue[5] provides recommendations with respect to estimated ground accelerations. Peak ground accelerations (PGAs) expected from the design earthquakes under serviceability limit state (SLS) and ultimate limit state (ULS) conditions are presented in Table 19 below.

[4] NZS 1170:0: 2002 *Structural design actions – Part 0: General Principles*

[5] McCue, K. (1999). Seismic Hazard Mapping in Australia, the Southwest Pacific and Southeast Asia, Annali Di Geofisica 42, 1191-1198.

Table 19: Design Peak Ground Accelerations

Design Life (years)*	Serviceability Limit State (SLS)		Ultimate Limit State (ULS)	
	Return Period	Peak Ground Accelerations	Return Period	Peak Ground Accelerations
50	1 in 25 years	0.05g	1 in 500 years	0.20g

** Design Life to be confirmed by the structural engineer/architect as appropriate. If different from that assumed, or if this changes during the project life then these values and the opinions in this report may require reviewing and amending as and where necessary.*

8 Applicability

This report has been prepared for the benefit of YEC with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor International Ltd

Environmental and Engineering Consultants

Report prepared by:

Chris Thurlow

Geotechnical Engineer

Reviewed for Tonkin & Taylor International Ltd by:

Andy Pomfret

Project Manager

Authorised for Tonkin & Taylor International Ltd by:

Chris Freer

Project Director

Appendix A: Contract of Topographical Survey and Soils Explorations

PREPARATORY SURVEY
ON
THE PROJECT
FOR
The Project for Power Sector Improvement for the State of Kosrae
IN
THE FEDERATED STATES OF MICRONESIA

CONTRACT
OF
TOPOGRAPHICAL SURVEY AND SOIL EXPLORATIONS

THIS CONTRACT is entered into on this **16th day of March 2015** by and between **Yachiyo Engineering Co., Ltd.** (hereinafter referred to as "YEC") and **Tonkin & Taylor International**, duly organized and existing under the laws of New Zealand, (hereinafter referred to as "the Contractor").

WHEREAS, YEC requested the Contractor to perform the Topographical Survey and Soil Explorations work which is outlined in Annex (hereinafter referred to as "the Work").

WHEREAS, the Contractor has accepted to perform the Work in accordance with the specifications and conditions set forth in this Contract and Annex hereto.

THEREFORE, based on and in consideration of the foregoing premises and of the terms and conditions hereinafter provided, both parties hereto agree as follows:

Clause 1 : WORK

The Contractor shall implement the Work as hereinafter defined under the terms and conditions of this Contract.

Clause 2 : YEC's REPRESENTATIVE

YEC shall assign a representative (hereinafter referred to as "the Representative") at the site. The Representative shall have the right to supervise, inspect and give approval for the Work.

Clause 3 : SPECIFICATIONS

The Work shall be performed in accordance with specifications in Annex.

Clause 4 : SITE LOCATION

Location of site is shown in Annex.

Clause 5 : WORK ITEMS

The Work shall cover the followings;

1) Topographical Survey
   (a) Preparation for topographical survey
   (b) Survey work at the site and data collections
   (c) Making drawing(s)
   (d) Reporting
   (e) Attending the site meeting with State of Kosrae Government for confirmation of boundary line of project site.
2) Soil Exploration
   (a) Preparation for field test
   (b) Dynamic cone penetration test and Soil sampling
   (c) Soil laboratory test
   (d) Reporting

Clause 6 : PREPARATION FOR THE WORK

The Contractor shall prepare all the necessary highly-skilled personnel and all of the required materials, facilities and equipment for the performance of the Work at the site and laboratory. The Representative shall have the right to check and review such materials, facilities and equipment at any time during the execution of the Work.

Clause 7 : REPORTING

The Contractor shall submit a written daily report of the Work in English to YEC.

Clause 8 : INSPECTIONS OF RESULTS

The Contractor shall request YEC for an inspection of results immediately at the completion of each item of the Work. If such results are not accepted by YEC, the Contractor shall redeem those works as soon as possible to the satisfaction of YEC, the Contractor shall once more submit the results to YEC for inspection.

Clause 9 : TIME FOR COMMENCEMENT AND COMPLETION

The Contractor shall commence the Work at the site on **23rd day of March 2015** and submit a DRAFT copy of the report (without the result of laboratory testing) by **27th day of March 2015**. The Contractor shall complete all the Work including both Topographical Survey and Soil Exploration by **27th day of March 2015**. The Contractor shall submit the final report for

approval by YEC. If such the final report is not accepted by YEC, the Contractor shall redeem the final report as soon as possible to the satisfaction of YEC. The Contractor shall complete to submit the final report to YEC by posting after confirming acceptance of YEC by **30th day of April 2015.**

Clause 10 : CONTRACT AMOUNT

The Contract amount shall be **39,950 US. Dollars.**

Clause 11 : METHOD OF PAYMENT

(a) Advance payment

YEC shall pay an advance payment of thirty (30) percent of the Contract amount to the Contractor upon signing of the Contract.

(b) Final payment

Payment of the remaining balance of the Contract amount shall be effected to the Contractor immediately after the Work has been finished and approved by YEC.

Clause 12 : PENALTY

A penalty of one/one hundred (1/100) of the Contract amount shall be imposed upon the Contractor per day by YEC, with maximum of ten (10) percent of the total Contract amount for a delay in the performance of the Work for which the Contractor is responsible to complete within the period as set forth in Clause 9.

The penalty amount shall be deducted from the final payment amount to be made to the Contractor.

Clause 13 : FORCE MAJEURE

The Contractor shall not be responsible for any delay caused by Force Majeure such as change in laws and regulations of The Federated States of Micronesia, strikes and sabotage, natural disasters, declared or undeclared war, blockades, revolutions, and natural calamities and severe weather conditions (e.g. cyclone) beyond the control of the Contractor. If it appears that such Force Majeure continues to the end of the Contract period mentioned in Clause 9, YEC shall have the right to terminate this Contract at any time.

Clause 14 : LIABILITY

YEC shall be exempted from or kept harmless against any damage, loss and/or accident incurred by or arising from a third party in connection with any activity of the Contractor during the period of the Work.

Clause 15 : TERMINATION OF CONTRACT

YEC has the right to terminate the Contract by giving a written prior notice to the Contractor, in case of any of the following cases;

(a) Due to causes attributable to the Contractor, if YEC judges that completion of the Work cannot be expected within the time set forth in Clause 9, and in accordance with the detailed time schedule submitted by the Contractor and approved by YEC.

(b) If the Work is not fully performed by the Contractor in accordance with the Contract and specifications without (at YEC's discretion) justified reasons.

(c) If the Contractor does not commence the Work or if the Contractor suspends the Work for a certain period without (at YEC's discretion) justified reasons after the effective date of this Contract.

(d) If the Contractor violates any provision of this Contract and does not rectify it within ten (10) days after the Contractor has received notice of breach of contract from YEC.

Clause 16 : ASSIGNMENT AND/OR SUBCONTRACT

Without prior written consent of YEC, the Contractor shall not assign any or this entire Contract to a third party.

Clause 17 : EFFECTIVE DATE OF THIS CONTRACT

This Contract shall become effective on the date first above written.

Clause 18 : CHANGES IN WORKING PROGRAM

YEC has the right to change the contents of the Work, if modifications are necessary. In case of such change, the time for completion and the Contract amount may be modified by mutual agreement in writing of both parties hereto. However, if extension of Contract period or increase in contract amount is required due to reasons attributable to the improper execution of the Work by the Contractor, such request from the Contractor shall not be approved by YEC. Should the YEC order additional works, an additional fee shall be paid to the Contractor, however, the Contractor shall not refuse to carry out the additional works without satisfactory reasons.

Clause 19 : DOUBTS OR UNSPECIFIED ITEMS

Any doubts in connection with this Contract or anything not specified in this Contract shall be determined amicably by mutual agreement between both parties.

Clause 20 : MAINTENANCE OF SECRECY

Without obtaining YEC's prior written approval, the Contractor shall not disclose, not only during the effective period of this Contract but also after the termination or completion of the

Contract, any information and/or data etc., which has been made known to the Contractor in executing the Work.

Clause 21 : EVALUATION OF ADDITIONAL AND OMITTED WORK

All work added or omitted under the instructions of YEC shall be evaluated at rates and prices set out in this Contract. If no applicable rates or prices are set out in this Contract, then suitable rates or prices shall be agreed upon between YEC and the Contractor. In the event of disagreement, YEC shall determine such rates or prices as shall, in his opinion, be reasonable and proper.

IN WITNESS WHEREOF; the parties hereto have executed this Contract by there duly authorized representatives as of the date first above written.

For and On Behalf of
The YEC

Mitsuhisa Nishikawa
Chief Consultant
Yachiyo Engineering Co., Ltd.
(JICA Study Team)

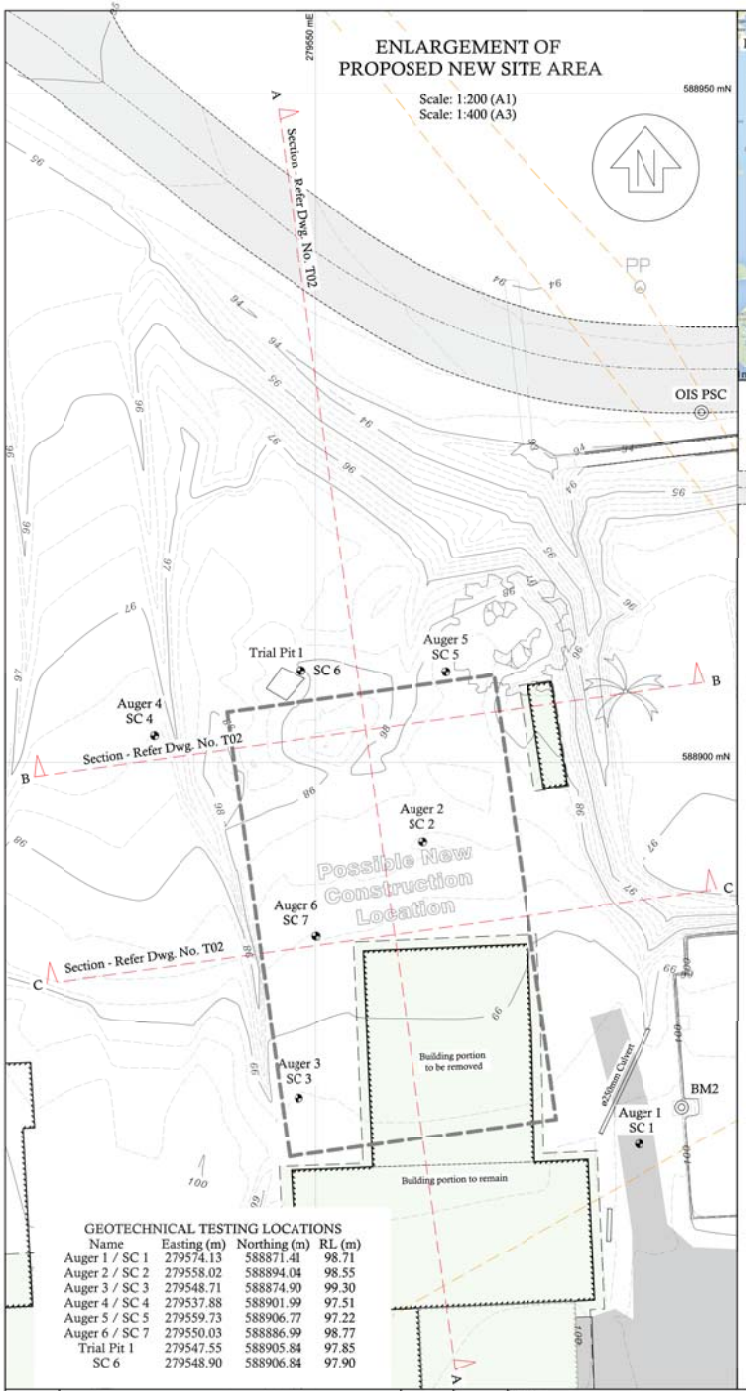
For and On Behalf of
The Contractor

Chris Freer
Project Director
Tonkin & Taylor International

Appendix B: Topographical Survey and Geotechnical Investigation Location Plans

ENLARGEMENT OF PROPOSED NEW SITE AREA

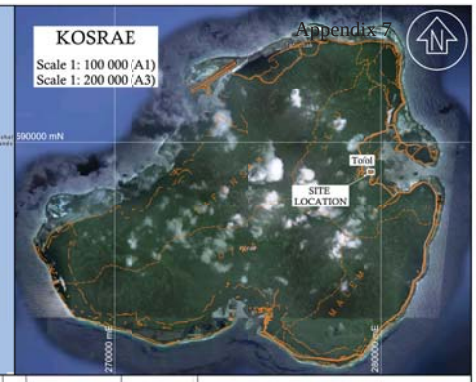
Scale: 1:200 (A1)
Scale: 1:400 (A3)



GEOTECHNICAL TESTING LOCATIONS

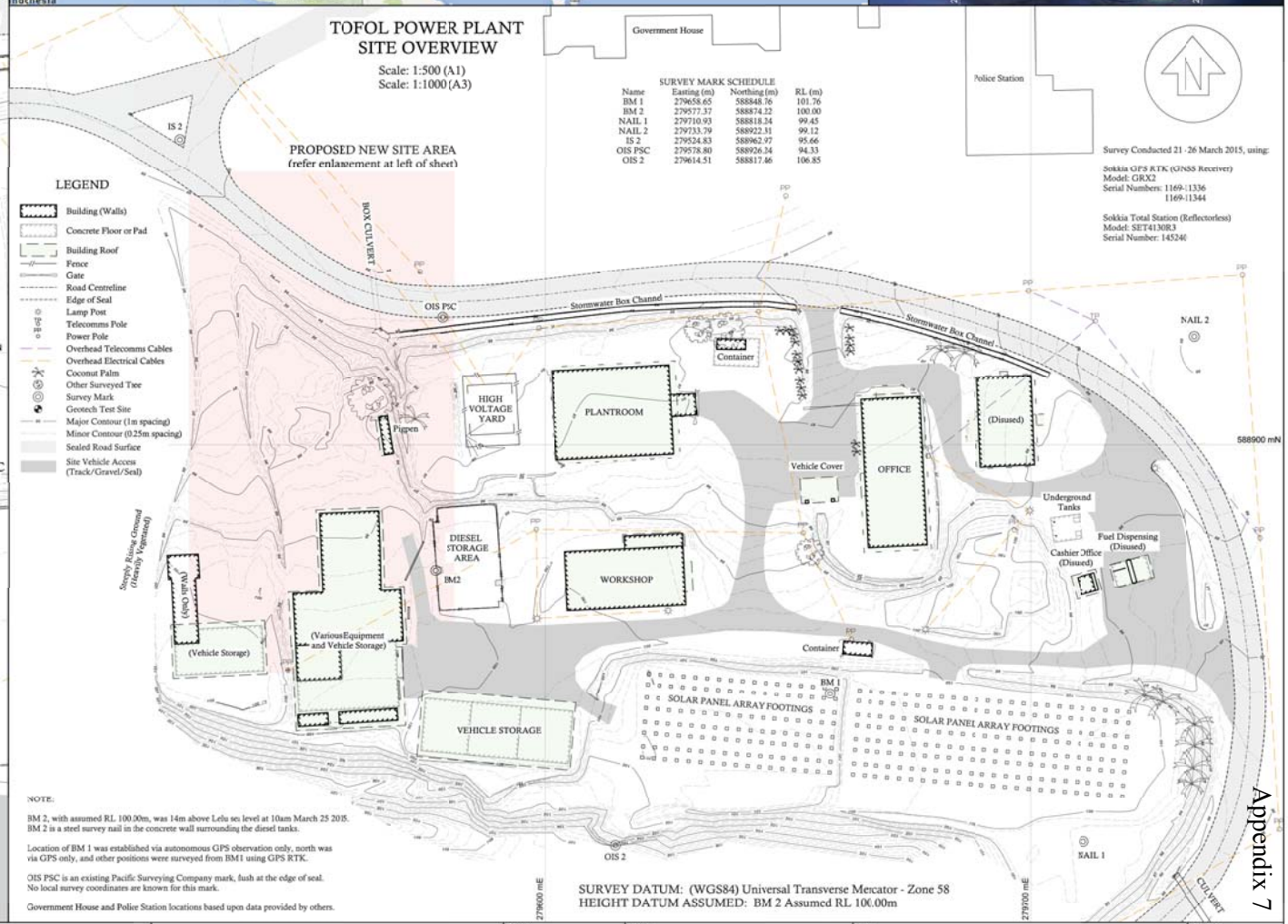
Name	Easting (m)	Northing (m)	RL (m)
Auger 1 / SC 1	279574.13	588871.41	98.71
Auger 2 / SC 2	279558.02	588894.04	98.55
Auger 3 / SC 3	279548.71	588874.90	99.30
Auger 4 / SC 4	279537.88	588901.99	97.51
Auger 5 / SC 5	279559.73	588906.77	97.22
Auger 6 / SC 7	279550.03	588886.99	98.77
Trial Pit 1	279547.55	588905.84	97.85
SC 6	279548.90	588906.84	97.90

LOCATION GUIDE
(not to scale)



TOFOL POWER PLANT SITE OVERVIEW

Scale: 1:500 (A1)
Scale: 1:1000 (A3)



SURVEY MARK SCHEDULE

Name	Easting (m)	Northing (m)	RL (m)
BM 1	279658.65	588848.76	101.76
BM 2	279577.37	588874.22	100.00
NAIL 1	279710.93	588818.24	99.45
NAIL 2	279733.79	588922.31	99.12
IS 2	279524.83	588962.97	95.66
OIS PSC	279578.80	588926.24	94.33
OIS 2	279614.51	588817.66	106.85

Survey Conducted 21 -26 March 2015, using:

Sokkia GPS RTK (GNSS Receiver)
Model: GRX2
Serial Numbers: 1169-11336
1169-11344

Sokkia Total Station (Reflectorless)
Model: SET4130R3
Serial Number: 145246

LEGEND

- Building (Walls)
- Concrete Floor or Pad
- Building Roof
- Fence
- Gate
- Road Centreline
- Edge of Seal
- Lamp Post
- Telecomms Pole
- Power Pole
- Overhead Telecomms Cables
- Overhead Electrical Cables
- Coconut Palm
- Other Surveyed Tree
- Survey Mark
- Geotech Test Site
- Major Contour (1m spacing)
- Minor Contour (0.25m spacing)
- Sealed Road Surface
- Site Vehicle Access (Track/Gravel/Seal)

NOTE:

BM 2, with assumed RL 100.00m, was 14m above Lelu sea level at 10am March 25 2015. BM 2 is a steel survey nail in the concrete wall surrounding the diesel tanks.

Location of BM 1 was established via autonomous GPS observation only, north was via GPS only, and other positions were surveyed from BM1 using GPS RTK.

OIS PSC is an existing Pacific Surveying Company mark, flush at the edge of seal. No local survey coordinates are known for this mark.

Government House and Police Station locations based upon data provided by others.

SURVEY DATUM: (WGS84) Universal Transverse Mercator - Zone 58
HEIGHT DATUM ASSUMED: BM 2 Assumed RL 100.00m

Revision	Description	Approved	Date
DRAFT2	For Information		04-05-15
DRAFT	For Information		30-01-15

Client

Tonkin & Taylor

A-7-26

Drawn	ES
Designed	
Surveyed	ES
Project:	Kosrae Topo
Scale	As Shown

Title

Topographical Survey Plan
Kosrae Utilities Authority Site
Tofol, Kosrae
Federated States of Micronesia

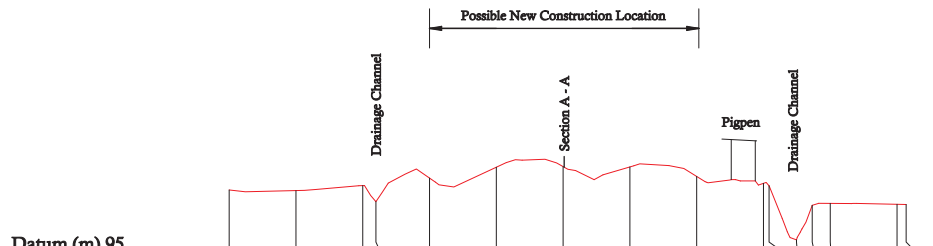
Dwg. No.	T01
Job No.	15009
Revision	DRAFT2

Date Plotted: Mon May 04 08:26:55 2015

A-7-26

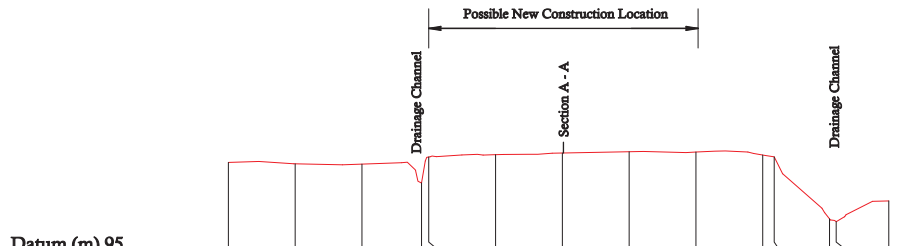
Appendix 7

REFER Dwg. No. T01 for Section Locations



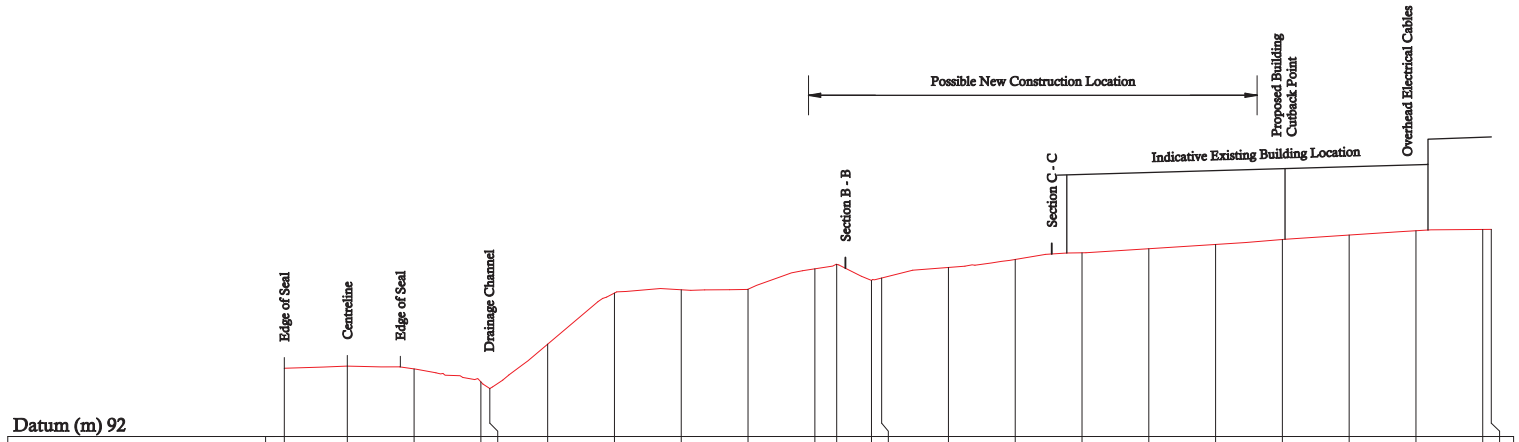
Datum (m) 95																					
Existing Ground Levels	97.45	97.43	97.61	97.01	97.89	98.30	98.32	98.31	97.95	97.70	97.60	95.58	96.87	96.95	96.91	96.90					
Distance	0.00	5.00	10.00	10.99	15.00	20.00	25.00	30.00	35.00	40.00	40.42	42.47	43.65	45.00	50.00	50.68					

Section B - B



Datum (m) 95																					
Existing Ground Levels	98.48	98.43	98.42	97.72	98.68	98.77	98.83	98.88	98.87	98.76	98.69	96.37	96.26	97.04							
Distance	0.00	5.00	10.00	14.46	15.00	20.00	25.00	30.00	35.00	40.00	40.86	45.00	45.50	49.44							

Section C - C



Datum (m) 92																							
Existing Ground Levels	94.56	94.64	94.53	94.05	93.80	95.46	97.37	97.49	97.51	98.28	98.44	97.84	97.93	98.33	98.63	98.88	99.03	99.19	99.38	99.54	99.70	99.75	99.75
Distance from Road Centreline	-4.72	0.00	5.00	10.00	10.67	15.00	20.00	25.00	30.00	35.00	36.63	39.24	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00	85.00	85.64

Section A - A

HEIGHT DATUM ASSUMED: BM 2 Assumed RL 100.00m

Revision	Description	Approved	Date
DRAFT	For Information		04-05-15

Client: Tonkin & Taylor

A-7-27

Drawn: ES
Designed:
Surveyed: ES
Project: Kosrae Topo

Scale: H - 1:200 (A1), V - 1:100 (A1); H -1:400 (A3), V -1:200 (A3)

Title: Sections A–A, B–B, and C–C
Tofol Power Plant site,
Tofol, Kosrae
Federated States of Micronesia

Dwg. No. T02
Job No. 15009
Revision DRAFT

Date Plotted: Sun May 03 22:56:12 2015

Appendix C: Geotechnical Investigation Data

- **Hand auger borehole Logs**
- **Scala Penetrometer results**

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH1
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant | LOCATION: Tofol Kosrae | JOB No: 751122

CO-ORDINATES: 588871 mN, 279574.13 mE | DRILL TYPE: 50mm Hand Auger | HOLE STARTED: 21/3/15

DRILL METHOD: HAND AUGER | HOLE FINISHED: 21/3/15

R.L.: 99.62 m | DRILLED BY: CJT

DATUM: UTM WGS84 | DRILL FLUID: N/A | LOGGED BY: CJT | CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION / ROCK DESCRIPTION
TOPSOIL							Bag	99.5	0			D	MD				TOPSOIL, organic silt inclusions; dark brown. Non-plastic.
CORAL SAND / FILL				Digger Excavated		48/5kPa			0.5				F				Medium to coarse SAND, with regular fine to coarse gravel (coral) inclusions; light brown and white colour. Dry, non-plastic.
								99.0				M					SILT, with medium to coarse gravels; orange brown. Non-plastic, weakly cemented. 0.5
						193/43kPa	Bag						VSt				Silty CLAY, with some medium gravel inclusions and refuse (tin can); blue grey colour. Moist, low plasticity.
RESIDUAL SOIL						96/32kPa		98.5	1.0				St				1.0 CLAY, some silt, with occasional sand inclusions; orangey brown. Moist, plastic.
						72/24kPa		98.0	1.5								1.5
						72/16kPa						M/W					
		On completion				129/16kPa		97.5	2.0				VSt				2.0 CLAY, with occasional fine gravel and weakly cemented silt (purple brown); dark orange brown. Becoming wet (sticky).
				Hand Auger		125/29kPa			2.5								2.5
						120/16kPa		97.0				W					Silty CLAY, some minor sand inclusions; bright orange. Wet, plastic.
						96/24kPa			3.0				St				Sandy SILT; purple black. Damp, weakly cemented. 3.0 SILT, with some sand; green brown mottled purple black. Saturated, low plasticity.
						145/24kPa		96.5					VSt				
						>225kPa		96.0	3.5			S	H				3.5 SILT; grey blue stained orange red. Damp, weakly cemented. Clayey SILT, minor sand; orange brown mottled purple/red. Saturated, plastic.
						UTP			4.0								Silty CLAY, some sand; bright orange. Saturated, moderate plasticity. 4.0
								95.5									**END OF BOREHOLE AT 4.1m.** Unable to auger.
								95.0	4.5								4.5
									5								

T+T DATATEMPLATE.GDT ilb

Log Scale 1:25

BORELOG 751122.GPJ 10-Apr-2015

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH2
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant | LOCATION: Tofol Kosrae | JOB No: 751122

CO-ORDINATES: 588894.04 mN, 279558.02 mE | DRILL TYPE: 50mm Hand Auger | HOLE STARTED: 21/3/15

DRILL METHOD: HAND AUGER | HOLE FINISHED: 21/3/15 | DRILLED BY: CJT

R.L.: 98.54 m | DRILL FLUID: N/A | LOGGED BY: CJT | CHECKED:

DATUM: UTM WGS84

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
TOPSOIL								98.5				D	MD				Organic SILT; dark brown. Dry, non-plastic.
FILL																	Medium to coarse GRAVEL; dark grey. Moderately strong, angular.
CORAL SAND									0.5								Medium to coarse SAND, with gravel (coral); white/light grey. Non-plastic, moderately strong. 0.5
RESIDUAL SOIL		On completion		Hand Auger				98.0				M	L				SILT, some fine to medium, weakly cemented gravel inclusions; dark brown green. Moist, non-plastic.
									1.0								1.0
								97.5				W					- becoming wet.
									1.5								1.5
								97.0									- orangy yellow staining.
						201/40kPa							H				SILT, some sand; grey blue. Saturated, non-plastic.
									2.0			M					2.0
						UTP		96.5									Clayey SILT, some weakly cemented and some sand; orange brown. Moist, low plasticity.
						UTP											- minor blue grey staining.
								96.0	2.5								2.5
						UTP											- purple black, cemented silt inclusions.
						UTP		95.5	3.0								- medium weathered gravel inclusions; black with yellow red staining. Strong, angular. 3.0
																	- fine gravel inclusions becoming more regular.
																	END OF BOREHOLE AT 3.2m.
								95.0	3.5								Unable to auger. 3.5
								94.5	4.0								4.0
								94.0	4.5								4.5
									5								

T+T DATATEMPLATE.GDT jlb

Log Scale 1:25

BORELOG 751122.GPJ 10-Apr-2015

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH3
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant | LOCATION: Tofol Kosrae | JOB No: 751122

CO-ORDINATES: 588874.9 mN, 279548.71 mE | DRILL TYPE: 50mm Hand Auger | HOLE STARTED: 23/3/15

DRILL METHOD: HAND AUGER | HOLE FINISHED: 23/3/15

R.L.: 99.30 m | DRILLED BY: CJT

DATUM: UTM WGS84 | DRILL FLUID: N/A | LOGGED BY: CJT | CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | WEATHERING / MOISTURE CONDITION | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) | COMPRESSIVE STRENGTH (MPa) | DEFECT SPACING (mm)

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

TOPSOIL											D/M	H				TOPSOIL, silt, with gravels, with organic inclusions; dark brown. Non-plastic.
RESIDUAL SOIL					>225kPa	Bag	99.0	0.5								Silty CLAY; orangey brown. Dry to moist, plastic.
					106/17kPa		98.5					VSt				- occasional sand inclusions.
	On completion				61/29kPa			1.0				St				- some fine to medium gravel inclusions.
					193/14kPa						W					SILT, some clay, with fine to coarse sand inclusions; grey green mottled orange colour. Wet, moderate plasticity.
					154/13kPa	Bag	98.0	1.5				VSt				
					96/8kPa		97.5					St				- occasional red/purple, highly weathered, fine to medum gravel inclusions.
			Hand Auger		40/24kPa			2.0				F				
					124/21kPa		97.0					VSt				SILT, some minor clay, with regular gravel inclusions; green. Wet, low plasticity; gravel highly weathered, purple grey, weak rock.
					48/32kPa		96.5	2.5				F				
					108/32kPa			3.0				VSt				SILT, some cemented with fine to coarse sand inclusions; grey green. Wet, low plasticity.
					48/32kPa		96.0					F				- becomes brown orange colour.
					145/32kPa			3.5				VSt				- grey blue.
					64/32kPa		95.5					St				
					80/35kPa		95.0	4.0								Fibrous PEAT; purple black. Firm, saturated, non-plastic.
					193/40kPa		94.5	4.5								Clayey SILT; grey purple. Wet, plastic.
								5								**END OF BOREHOLE AT 4.5m.**

T+T DATATEMPLATE.GDT jlb

Log Scale 1:25

BORELOG 751122.GPJ 10-Apr-2015

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH4
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant | LOCATION: Tofol Kosrae | JOB No: 751122

CO-ORDINATES: 588901.99 mN, 279537.88 mE | DRILL TYPE: 50mm Hand Auger | HOLE STARTED: 23/3/15

R.L.: 97.51 m | DRILL METHOD: HAND AUGER | HOLE FINISHED: 23/3/15

DATUM: UTM WGS84 | DRILL FLUID: N/A | DRILLED BY: CJT | LOGGED BY: CJT | CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION / ROCK DESCRIPTION
TOPSOIL AND HARDFILL								98.0				M					Organic SILT, with regular to fine coarse gravel inclusions (hardfill); dark brown. Moist, non-plastic.
RESIDUAL SOIL								97.5									Silty CLAY; orange brown. Dry, non-plastic.
		On completion		Hand Auger		>225kPa	Bag	97.0	0.5			D	H				Clayey SILT, with some minor sand; dark green. Dry, low plasticity. 0.5
						141/29kPa							VSt				- highly weathered, fine gravel inclusions; purple orange. - occasional weakly cemented silt inclusions.
						116/19kPa	Bag	96.5	1.0			M					Silty CLAY, with some cemented silt inclusions; brown green. Moist, moderate plasticity. 1.0
						112/16kPa											SILT, with some sand and minor clay; dark green. Moist, moderate plasticity.
						85/19kPa		96.0	1.5				L				SAND lense with fine gravel inclusions; dark green. Non-plastic. 1.5
						61/29kPa						W	St				SILT, with some sand and regular firm, highly weathered gravel inclusions; grey green/purple green. Wet, low plasticity. 2.0
						64/17kPa		95.5	2.0								
						>225kPa	Bag	95.0	2.5				H				Fibrous PEAT; dark purple black. Wet, non-plastic, spongy. 2.5
						>225kPa											
						64/28kPa		94.5	3.0				St				3.0
						80/16kPa											
						146/32kPa		94.0	3.5				VSt				SILT, some clay, sand and fine gravel; grey purple blue. Wet, plastic. 3.5
						64/45kPa			4.0				St				Fibrous PEAT; dark purple black. Wet, non-plastic, spongy. 4.0
						72/32kPa											
						72/24kPa		4.5									END OF BOREHOLE AT 4.5m. 4.5
								5									

SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

T+T DATATEMPLATE.GDT jlb

Log Scale 1:25

BORELOG 751122.GPJ 10-Apr-2015

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH5
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant | LOCATION: Tofol Kosrae | JOB No: 751122

CO-ORDINATES: 588906.51 mN, 279560.65 mE | DRILL TYPE: 50mm Hand Auger | HOLE STARTED: 24/3/15

R.L.: 98.40 m | DRILL METHOD: HAND AUGER | HOLE FINISHED: 24/3/15

DATUM: UTM WGS84 | DRILL FLUID: N/A | DRILLED BY: CJT | LOGGED BY: CJT | CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION / ROCK DESCRIPTION
TOPSOIL												M					Organic SILT, with gravels. Moist, non-plastic.
FILL				Digger Excavated		80/16kPa		98.0	0.5				St				Clayey SILT, some cemented with highly weathered gravels, some refuse present (cloth); orangey brown. Moist, low plasticity. 0.5
						104/24kPa	Bag						VSt				
						129/16kPa		97.5	1.0								Coarse coral SAND, with silt; white/light grey. Moist, non-plastic. 1.0
RESIDUAL SOIL						104/16kPa	Bag										
						90/24kPa		97.0	1.5				St				Silty CLAY, with some minor coarse sand to fine gravel inclusions; orange brown. Moist, moderate plasticity. 1.5
						80/19kPa		96.5	2.0								
						109/27kPa							VSt				- highly weathered, fine gravel inclusions becoming more regular; grey with purple-orange staining. 2.0
		On completion				UTP		96.0	2.5			M/W	H				- minor organic inclusions. - becoming wet. 2.5
				Hand Auger		206/61kPa	Bag					W					Clayey SILT, some weakly cemented, with regular, highly weathered coarse sand to medium gravels; brown mottled grey-green and orange. Wet, moderate plasticity.
						188/16kPa		95.5	3.0				VSt				3.0
						169/48kPa		95.0	3.5				H				SILT, some clay; brown mottled yellow white and red. Wet, moderate plasticity. - grading to grey blue/green. 3.5
						>225kPa											
RESIDUAL SOIL/COMPLETELY WEATHERED ROCK						>225kPa	Bag	94.5	4.0								Cemented SILT, with some some completely weathered gravel inclusions; grey blue mottled orange and white. Moist, non-plastic. 4.0
						UTP											- highly weathered gravel inclusions becoming regular.
								94.0	4.5								**END OF BOREHOLE AT 4.3m.** 4.5
								93.5	5								

T+T DATATEMPLATE.GDT ilb

Log Scale 1:25

BORELOG 751122.GPJ 10-Apr-2015

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:BH6
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant | LOCATION: Tofol Kosrae | JOB No: 751122

CO-ORDINATES: 588886.99 mN, 279550.03 mE | DRILL TYPE: 50mm Hand Auger | HOLE STARTED: 26/3/15

R.L.: 98.70 m | DRILL METHOD: HAND AUGER | HOLE FINISHED: 26/3/15 | DRILLED BY: CJT

DATUM: UTM WGS84 | DRILL FLUID: N/A | LOGGED BY: CJT | CHECKED:

GEOLOGICAL														ENGINEERING DESCRIPTION
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION / ROCK DESCRIPTION
TOPSOIL								98.5	0			M					Organic SILT, with regular fine to coarse gravels. Moist, non-plastic.
RESIDUAL SOIL						>225kPa			0.5			D/M	H				SILT, some clay, occasional highly weathered (red/purple colour), fine to medium gravels; yellow brown colour. Dry to moist, moderate plasticity. 0.5
		On completion				117/21kPa		98.0				M	VSt				Clayey SILT, some weakly cemented with occasional fine to medium gravel; greeny brown colour. Moist, low plasticity.
						64/16kPa			1.0				St				
						>225kPa		97.5				W					- becoming wet. 1.0
						152/16kPa			1.5				H				
						UTP		97.0				M	VSt				1.5
						80/40kPa			2.0				St				SILT, some cemented, with regular highly weathered gravel inclusions and some minor sand; dark yellow brown colour, mottled orange red. Moist, low plasticity.
						88/39kPa		96.5									- gravels becoming less regular. 2.0
						80/40kPa			2.5			W/S					2.5
						72/16kPa		96.0									Silty CLAY, some sand and occasional gravel; orange brown colour. Wet to saturated, moderate plasticity.
						128/38kPa			3.0								3.0
						64/19kPa		95.5					VSt				3.5
						88/48kPa			3.5			D	St				SILT; bright orange colour. Dry, non-plastic.
						104/40kPa		95.0				W					Silty CLAY, some sand and occasional gravel; orange brown colour. Wet, moderate plasticity.
						64/24kPa			4.0								4.0
								94.5									4.5
								94.0	4.5								END OF BOREHOLE AT 4.6m.
									5								

T+T DATATEMPLATE.GDT ilb

Log Scale 1:25

BORELOG 751122.GPJ 10-Apr-2015

TONKIN & TAYLOR LTD

EXCAVATION LOG

EXCAVATION No: TP1
Hole Location: Refer to site plan.

SHEET 1 OF 1

PROJECT: Kosrae Power Plant		LOCATION: Tofol Kosrae	JOB No: 751122
CO-ORDINATES:	588905.84 mN 279547.55 mE	EXPOSURE TYPE: DIGGER BUCKET	EXCAV. STARTED: 25/3/15
		EQUIPMENT: Excavator	EXCAV FINISHED: 25/3/15
R.L.	97.85 m	OPERATOR: Local Contractor	LOGGED BY: CJT
DATUM	UTM WGS84	DIMENSIONS:	CHECKED BY:

EXCAVATION TESTS				ENGINEERING DESCRIPTION							GEOLOGICAL	
PENETRATION 1 2 3	SUPPORT	WATER	SAMPLES, TESTS	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	SOIL NAME, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION / WEATHERING	STRENGTH / DENSITY CLASSIFICATION	ESTIMATED SHEAR STRENGTH (kPa) 10 25 50 100 200	ORIGIN TYPE, MINERAL COMPOSITION, DEFECTS, STRUCTURE	UNIT
				97.5	0.5			Organic SILT, with regular fine to coarse gravels. Moist, non-plastic.	M	L		TOPSOIL	
				97.0	1.0			SILT, with some clay, sand and fine to coarse gravel; dark brown colour. Moist, low plasticity. Occasional rubbish/refuse including: cans, car bodies, organics.		MD		FILL	
				96.5	1.5			Medium to coarse SAND to medium GRAVEL (coral); light brown. Medium dense, dry, non-plastic.				CORAL SAND (FILL)	
								Medium to coarse GRAVELS, with some silt and sand infilling; dark blue colour. Non-plastic. Gravels moderately to slightly weathered, weak to moderately strong,.				GRAVEL FILL	
			●>225kPa	96.0	2.0			Clayey SILT, with some occasional fine gravel; orange/yellow brown colour. Moist, moderate plasticity.		H		RESIDUAL SOIL	
			●>225kPa					- minor fibrous organic inclusions.					
			●>225kPa	95.5									
					2.5			**END OF TEST PIT AT 2.4m.**					
				95.0									

SKETCH

T+T DATATEMPLATE.GDT 11b

Log Scale 1:25

EXCAVLOG 751122.GPJ 10-Apr-2015

Scala results.xlsx

TONKIN & TAYLOR

SCALA PENETROMETER LOG

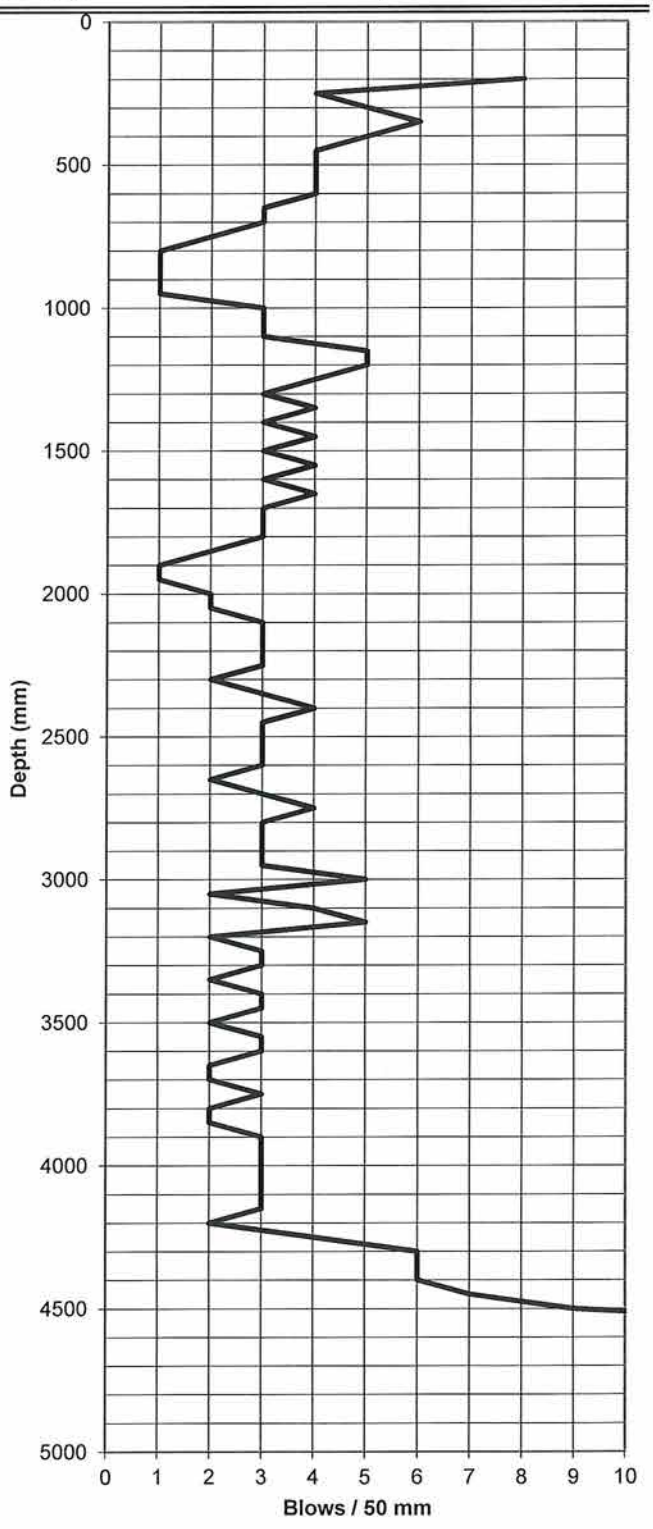
Job No: *751122*
Project: *Kosrae Power Sttion*
Location: *tofol, Kosrae*
RL:

Date: *21/03/2015*
Operated by: *CJT*
Logged by: *CJT*
Checked by:

Test No. *SC1*
Sheet *1*
of *1*

mm Driven	No. of Blows
50	
100	
150	
200	8
250	4
300	5
350	6
400	5
450	4
500	4
550	4
600	4
650	3
700	3
750	2
800	1
850	1
900	1
950	1
1000	3
1050	3
1100	3
1150	5
1200	5
1250	4
1300	3
1350	4
1400	3
1450	4
1500	3
1550	4
1600	3
1650	4
1700	3
1750	3
1800	3
1850	2
1900	1
1950	1
2000	2
2050	2
2100	3
2150	3
2200	3
2250	3
2300	2
2350	3
2400	4
2450	3
2500	3

mm Driven	No. of Blows
2550	3
2600	3
2650	2
2700	3
2750	4
2800	3
2850	3
2900	3
2950	3
3000	5
3050	2
3100	4
3150	5
3200	2
3250	3
3300	3
3350	2
3400	3
3450	3
3500	2
3550	3
3600	3
3650	2
3700	2
3750	3
3800	2
3850	2
3900	3
3950	3
4000	3
4050	3
4100	3
4150	3
4200	2
4250	4
4300	6
4350	6
4400	6
4450	7
4500	9
4550	14
4600	20
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Scala results.xlsx

TONKIN & TAYLOR

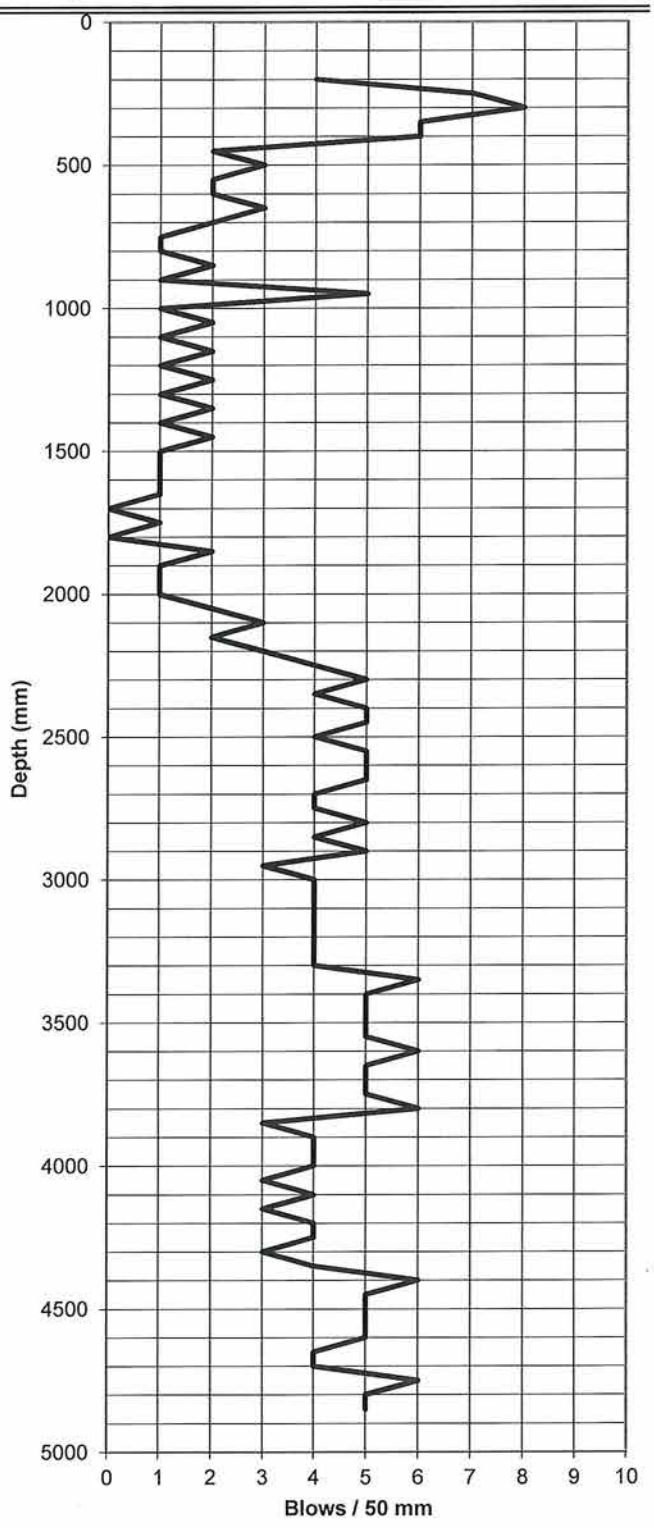
SCALA PENETROMETER LOG

Job No: *751122*
Project: *Kosrae Power Station*
Location: *Tofol Kosrae*
RL:

Date: *21/03/2015*
Operated by: *CJT*
Logged by: *CT*
Checked by:

Test No. *SC2*
Sheet *1*
of *1*

mm Driven	No. of Blows	mm Driven	No. of Blows
50		2550	4
100		2600	5
150		2650	5
200	4	2700	5
250	7	2750	4
300	8	2800	4
350	6	2850	5
400	6	2900	4
450	2	2950	5
500	3	3000	3
550	2	3050	4
600	2	3100	4
650	3	3150	4
700	2	3200	4
750	1	3250	4
800	1	3300	4
850	2	3350	4
900	1	3400	6
950	5	3450	5
1000	1	3500	5
1050	2	3550	5
1100	1	3600	5
1150	2	3650	6
1200	1	3700	5
1250	2	3750	5
1300	1	3800	5
1350	2	3850	6
1400	1	3900	3
1450	2	3950	4
1500	1	4000	4
1550	1	4050	4
1600	1	4100	3
1650	1	4150	4
1700	0	4200	3
1750	1	4250	4
1800	0	4300	4
1850	2	4350	3
1900	1	4400	4
1950	1	4450	6
2000	1	4500	5
2050	2	4550	5
2100	3	4600	5
2150	2	4650	5
2200	3	4700	4
2250	4	4750	4
2300	5	4800	6
2350	4	4850	5
2400	5	4900	5
2450	5	4950	
2500	4	5000	



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Scala results.xlsx

TONKIN & TAYLOR

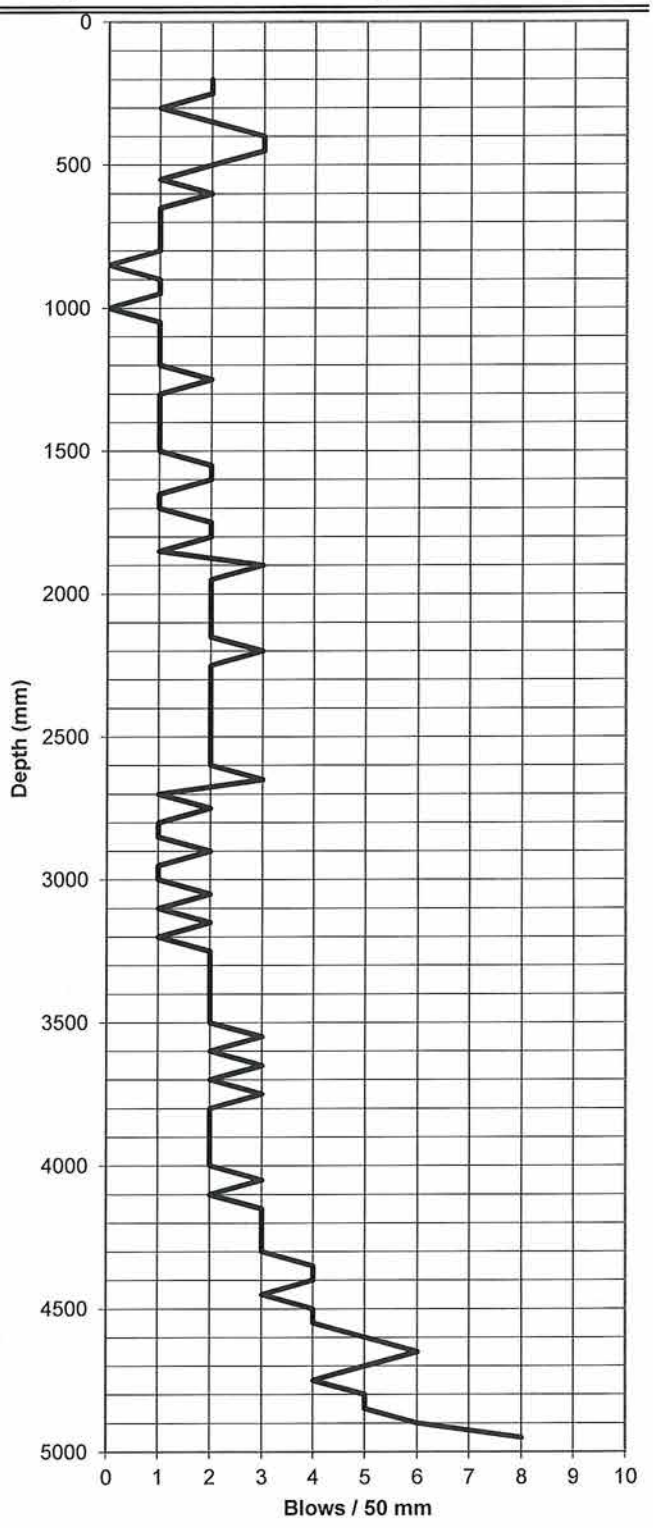
SCALA PENETROMETER LOG

Job No: *751122*
Project: *Kosrae Power Station*
Location: *Tofol, Kosrae*
RL:

Date: *24/03/2015*
Operated by: *CJT*
Logged by: *CJT*
Checked by:

Test No. *SC3*
Sheet *1*
of *1*

mm Driven	No. of Blows	mm Driven	No. of Blows
50		2550	2
100		2600	2
150		2650	3
200	2	2700	1
250	2	2750	2
300	1	2800	1
350	2	2850	1
400	3	2900	2
450	3	2950	1
500	2	3000	1
550	1	3050	2
600	2	3100	1
650	1	3150	2
700	1	3200	1
750	1	3250	2
800	1	3300	2
850	0	3350	2
900	1	3400	2
950	1	3450	2
1000	0	3500	2
1050	1	3550	3
1100	1	3600	2
1150	1	3650	3
1200	1	3700	2
1250	2	3750	3
1300	1	3800	2
1350	1	3850	2
1400	1	3900	2
1450	1	3950	2
1500	1	4000	2
1550	2	4050	3
1600	2	4100	2
1650	1	4150	3
1700	1	4200	3
1750	2	4250	3
1800	2	4300	3
1850	1	4350	4
1900	3	4400	4
1950	2	4450	3
2000	2	4500	4
2050	2	4550	4
2100	2	4600	5
2150	2	4650	6
2200	3	4700	5
2250	2	4750	4
2300	2	4800	5
2350	2	4850	5
2400	2	4900	6
2450	2	4950	8
2500	2	5000	



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Scala results.xlsx

TONKIN & TAYLOR

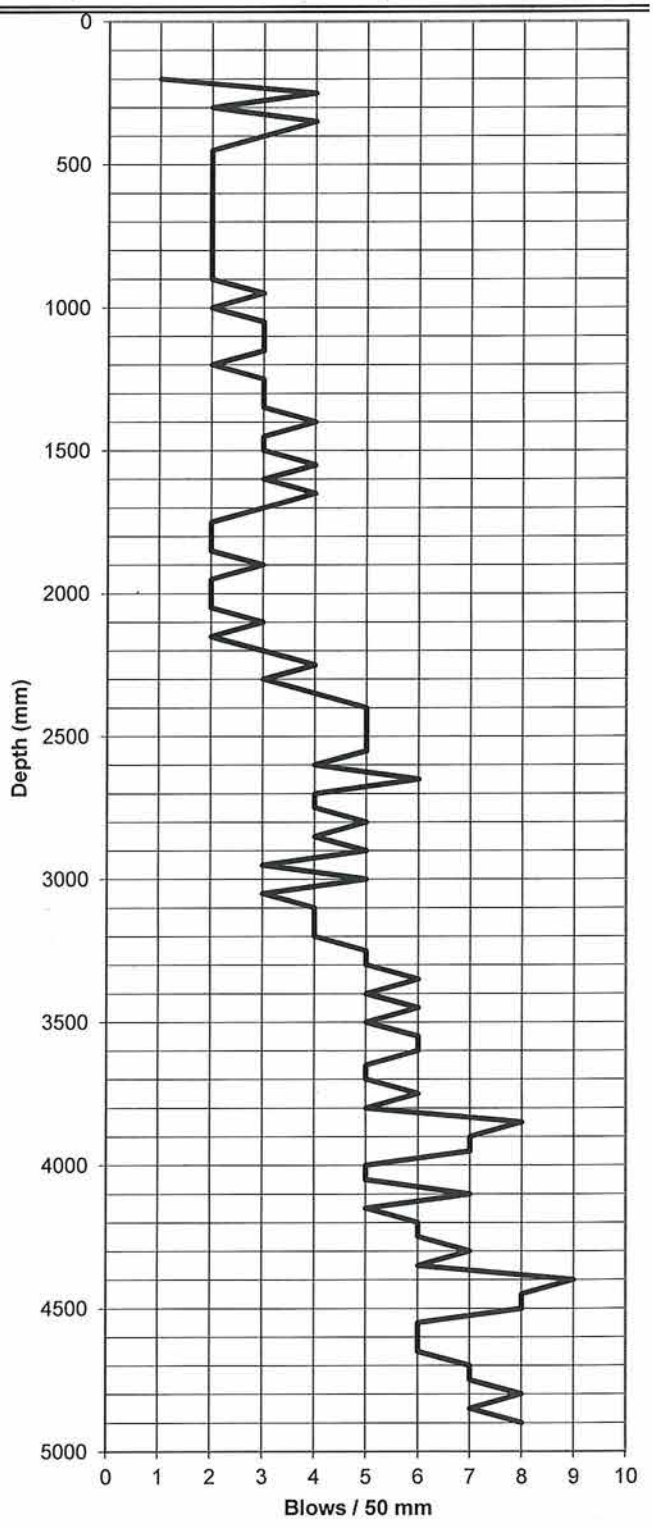
SCALA PENETROMETER LOG

Job No: *751122*
Project: *Kosrae Power Station*
Location: *Tofol, Kosrae*
RL:

Date: *24/03/2015*
Operated by: *CJT*
Logged by: *CJT*
Checked by:

Test No. *SC4*
Sheet *1*
of *1*

mm Driven	No. of Blows	mm Driven	No. of Blows
50		2550	5
100		2600	4
150		2650	6
200	1	2700	4
250	4	2750	4
300	2	2800	5
350	4	2850	4
400	3	2900	5
450	2	2950	3
500	2	3000	5
550	2	3050	3
600	2	3100	4
650	2	3150	4
700	2	3200	4
750	2	3250	5
800	2	3300	5
850	2	3350	6
900	2	3400	5
950	3	3450	6
1000	2	3500	5
1050	3	3550	6
1100	3	3600	6
1150	3	3650	5
1200	2	3700	5
1250	3	3750	6
1300	3	3800	5
1350	3	3850	8
1400	4	3900	7
1450	3	3950	7
1500	3	4000	5
1550	4	4050	5
1600	3	4100	7
1650	4	4150	5
1700	3	4200	6
1750	2	4250	6
1800	2	4300	7
1850	2	4350	6
1900	3	4400	9
1950	2	4450	8
2000	2	4500	8
2050	2	4550	6
2100	3	4600	6
2150	2	4650	6
2200	3	4700	7
2250	4	4750	7
2300	3	4800	8
2350	4	4850	7
2400	5	4900	8
2450	5	4950	
2500	5	5000	



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Scala results.xlsx

TONKIN & TAYLOR

SCALA PENETROMETER LOG

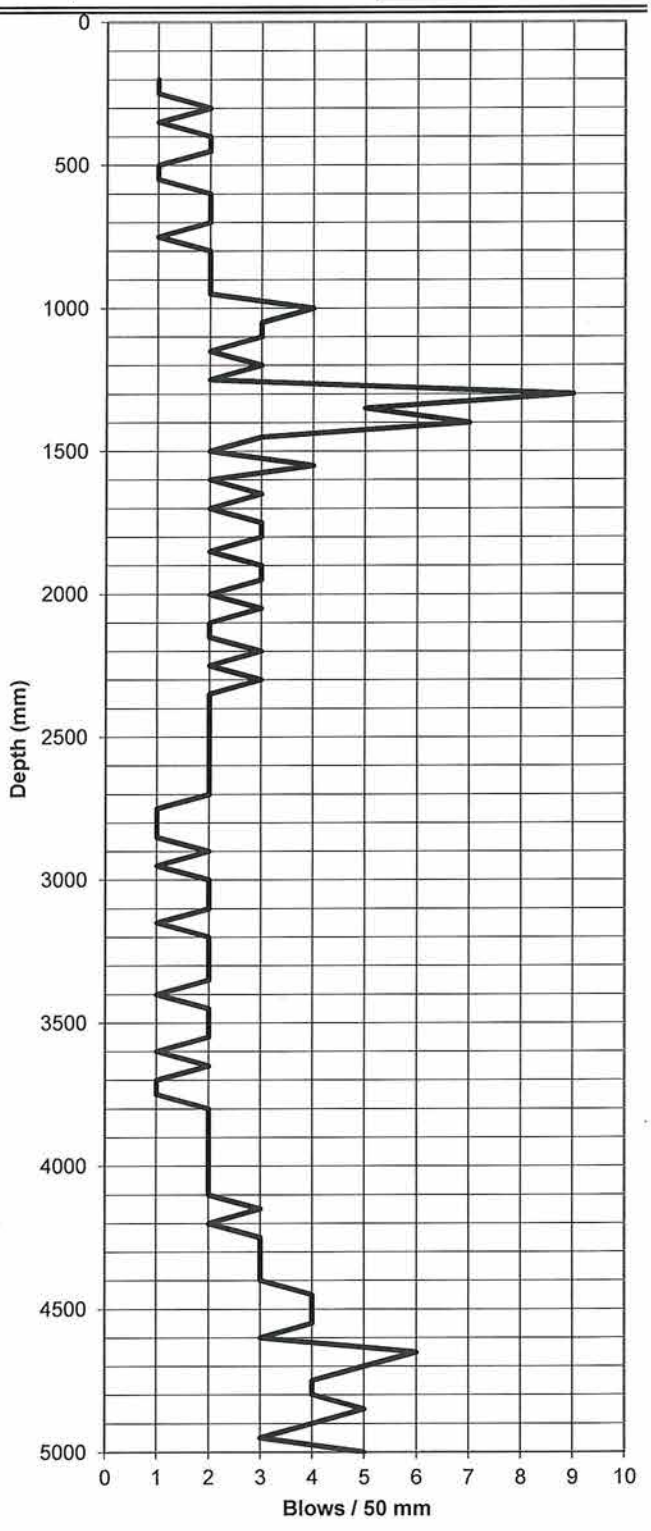
Job No: *751122*
Project: *Kosrae Power Station*
Location: *Tofol, Kosrae*
RL:

Date: *25/03/2015*
Operated by: *CJT*
Logged by: *CJT*
Checked by:

Test No. *SC5*
Sheet *1*
of *1*

mm Driven	No. of Blows
50	
100	
150	
200	1
250	1
300	2
350	1
400	2
450	2
500	1
550	1
600	2
650	2
700	2
750	1
800	2
850	2
900	2
950	2
1000	4
1050	3
1100	3
1150	2
1200	3
1250	2
1300	9
1350	5
1400	7
1450	3
1500	2
1550	4
1600	2
1650	3
1700	2
1750	3
1800	3
1850	2
1900	3
1950	3
2000	2
2050	3
2100	2
2150	2
2200	3
2250	2
2300	3
2350	2
2400	2
2450	2
2500	2

mm Driven	No. of Blows
2550	2
2600	2
2650	2
2700	2
2750	1
2800	1
2850	1
2900	2
2950	1
3000	2
3050	2
3100	2
3150	1
3200	2
3250	2
3300	2
3350	2
3400	1
3450	2
3500	2
3550	2
3600	1
3650	2
3700	1
3750	1
3800	2
3850	2
3900	2
3950	2
4000	2
4050	2
4100	2
4150	3
4200	2
4250	3
4300	3
4350	3
4400	3
4450	4
4500	4
4550	4
4600	3
4650	6
4700	5
4750	4
4800	4
4850	5
4900	4
4950	3
5000	5



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Scala results.xlsx

TONKIN & TAYLOR

SCALA PENETROMETER LOG

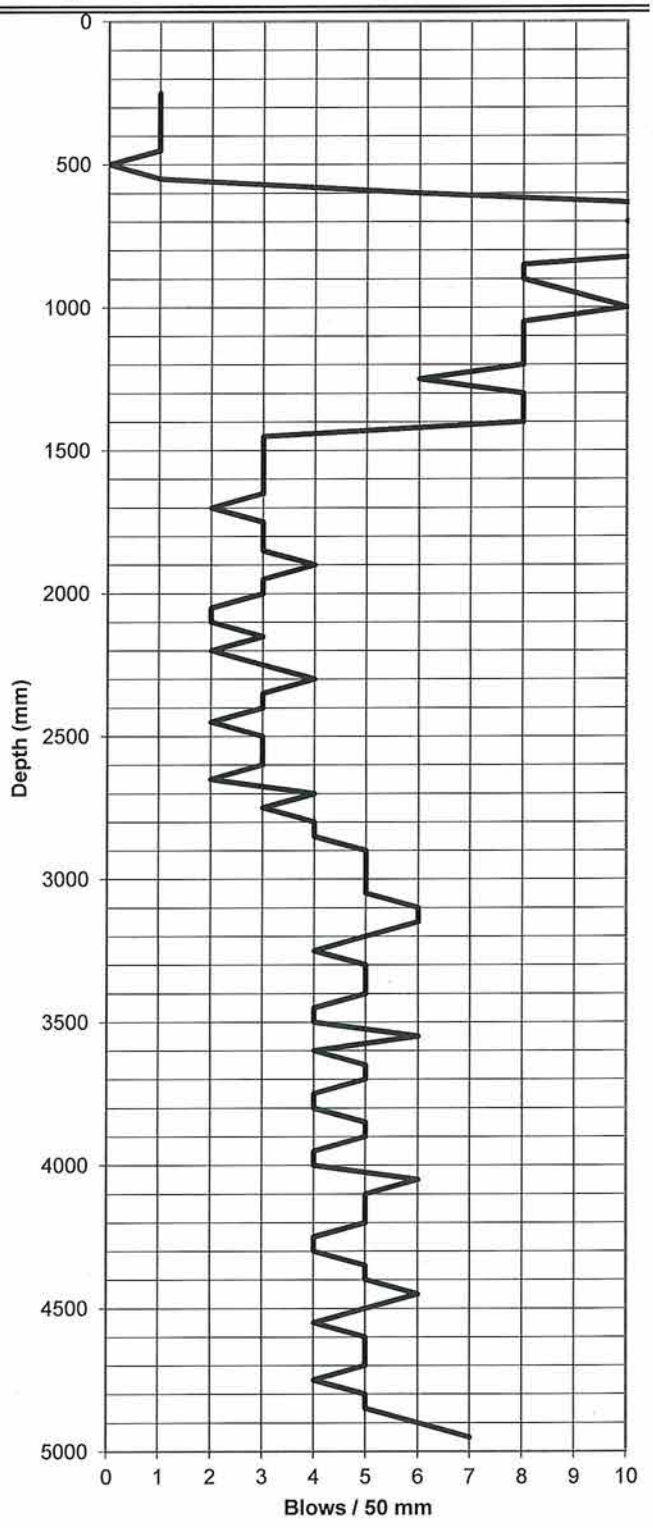
Job No: *751122*
Project: *Kosrae Power Station*
Location: *Tofol, Kosrae*
RL:

Date: *26/03/2015*
Operated by: *CJT*
Logged by: *CJT*
Checked by:

Test No. *SC6*
Sheet *1*
of *1*

mm Driven	No. of Blows
50	
100	
150	
200	
250	1
300	1
350	1
400	1
450	1
500	0
550	1
600	6
650	12
700	10
750	20
800	12
850	8
900	8
950	9
1000	10
1050	8
1100	8
1150	8
1200	8
1250	6
1300	8
1350	8
1400	8
1450	3
1500	3
1550	3
1600	3
1650	3
1700	2
1750	3
1800	3
1850	3
1900	4
1950	3
2000	3
2050	2
2100	2
2150	3
2200	2
2250	3
2300	4
2350	3
2400	3
2450	2
2500	3

mm Driven	No. of Blows
2550	3
2600	3
2650	2
2700	4
2750	3
2800	4
2850	4
2900	5
2950	5
3000	5
3050	5
3100	6
3150	6
3200	5
3250	4
3300	5
3350	5
3400	5
3450	4
3500	4
3550	6
3600	4
3650	5
3700	5
3750	4
3800	4
3850	5
3900	5
3950	4
4000	4
4050	6
4100	5
4150	5
4200	5
4250	4
4300	4
4350	5
4400	5
4450	6
4500	5
4550	4
4600	5
4650	5
4700	5
4750	4
4800	5
4850	5
4900	6
4950	7
5000	



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Scala results.xlsx

TONKIN & TAYLOR

SCALA PENETROMETER LOG

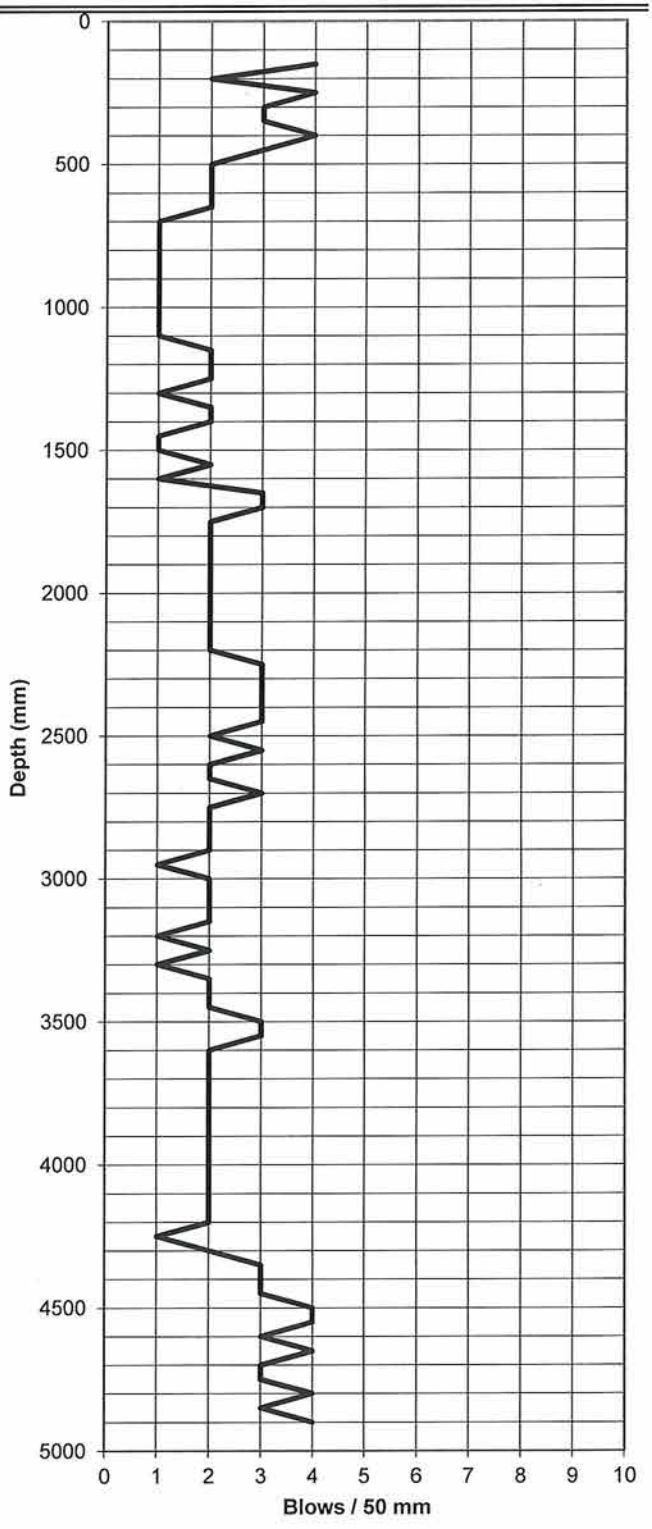
Job No: *751122*
Project: *Kosrae Power Station*
Location: *Tofol, Kosrae*
RL:

Date: *26/03/2015*
Operated by: *CJT*
Logged by: *CJT*
Checked by:

Test No. *SC7*
Sheet *1*
of *1*

mm Driven	No. of Blows
50	
100	
150	4
200	2
250	4
300	3
350	3
400	4
450	3
500	2
550	2
600	2
650	2
700	1
750	1
800	1
850	1
900	1
950	1
1000	1
1050	1
1100	1
1150	2
1200	2
1250	2
1300	1
1350	2
1400	2
1450	1
1500	1
1550	2
1600	1
1650	3
1700	3
1750	2
1800	2
1850	2
1900	2
1950	2
2000	2
2050	2
2100	2
2150	2
2200	2
2250	3
2300	3
2350	3
2400	3
2450	3
2500	2

mm Driven	No. of Blows
2550	3
2600	2
2650	2
2700	3
2750	2
2800	2
2850	2
2900	2
2950	1
3000	2
3050	2
3100	2
3150	2
3200	1
3250	2
3300	1
3350	2
3400	2
3450	2
3500	3
3550	3
3600	2
3650	2
3700	2
3750	2
3800	2
3850	2
3900	2
3950	2
4000	2
4050	2
4100	2
4150	2
4200	2
4250	1
4300	2
4350	3
4400	3
4450	3
4500	4
4550	4
4600	3
4650	4
4700	3
4750	3
4800	4
4850	3
4900	4
4950	
5000	



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Appendix D: Laboratory testing

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

File: P:\616587.000\Working Material\pH Value_summary.xlsx

Page of

Your Job No.: 751122

Site : Kosrae, Micronesia

Our Job No.: 616587.000

Test Method Used: NZS 4402:1986 Test 3.3.1 Determination of the pH value by electrometric method.

TEST RESULTS

Table 1: pH Test Results Summary

BH No.	1	3	5
Depth (m)	0.8-0.9	0.3-0.6	1.2-1.3
Average pH Value	6.4	6.5	6.8

Remarks : A standard soil:water ratio of (**1 : 2.5**) was used to perform the test.

The average pH value reported to the nearest 0.1 of the soil suspension.

Tested by: ST Date: 22/4/15 Checked by: MP Date: 22/4/15

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

File: P:\616585.000\Working material\Solid density_Summary.xlsx

Page of Your Job No.: 751122

Site : Kosrae, Micronesia Our Job No.: 616585.000

Test Method Used:NZS 4402:1986 Test 2.7.2 Determination of Solid Density of Soil Particles - Vacuum Method

SOLID DENSITY TEST RESULTS

Table 1: Solid Density

BH No.:		4	5	5
Depth	(m)	1.0-1.2	0.6-0.7	3.9-4.1
Average Solid Density	(t/m^3)	2.88	2.87	2.86

Remarks : The average solid density was reported to the nearest 0.01 t/m^3.

Tested by: ST Date: 22/4/15 Checked by: MP Date: 22/4/15

GEOTECHNICS
23 Morgan Street, Newmarket
Auckland 1023, New Zealand
p. +64 9 356 3510
w. www.geotechnics.co.nz

File: P:\616587.000\Working Material\Atterberg Limits_summary.xlsx

Page of

Your Job No.: 751122

Site : Kosrae, Micronesia

Our Job No.: 616587.000

Test Method Used: NZS 4402:1986

Test 2.1 Determination of the Water Content

Test 2.2 Determination of the Liquid Limit

Test 2.3 Determination of the Plastic Limit

Test 2.4 Determination of the Plasticity Index

TEST RESULTS

Atterberg Limits Test Results Summary

BH No.:	3	4	5
Deoth (m)	1.3-1.5	0.4-0.6	1.2-1.3
Water Content (%)	35.2	41.0	38.4
Liquid Limit	70	69	73
Plastic Limit	39	40	39
Plasticity Index	31	29	34

Remarks : Atterberg limits performed on material passing 0.425mm test sieve.

Tested by: ST Date: 22/4/15 Checked by: MP Date: 22/4/15

GEOTECHNICS

19 - 23 Morgan Street
Newmarket
Auckland 1023
New Zealand

p. +64 9 356 3510

Geotechnics Project ID 616587

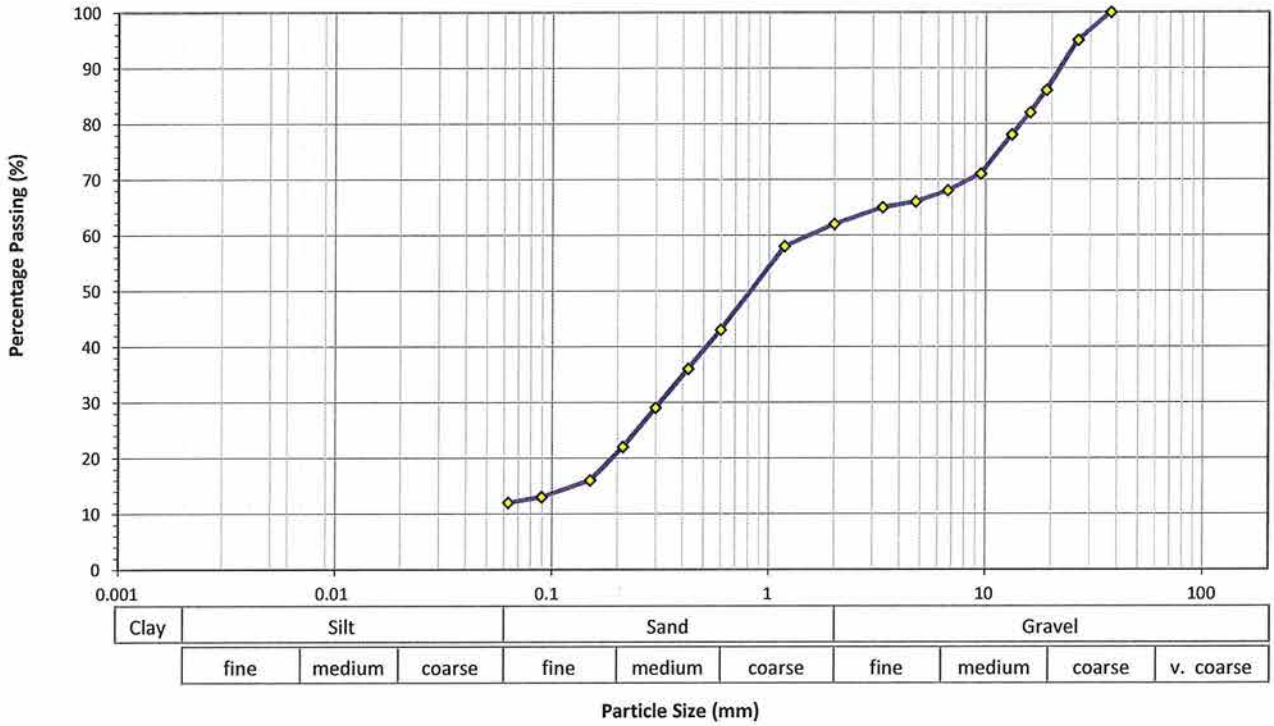
Customer Project ID 751122

Determination of the Particle Size Distribution - NZS 4402:1986 Test 2.8.1 (Wet Sieve)

Sample Details

Geotechnics Sample ID	Kosrae, Micronesia
Date Tested	9/04/2015
Sample	**Kosrae, Micronesia - BH1_0.1-0.2m**
Sample Description	Coral SAND with minor silt and trace of clay, loose, White mixed with light to dark grey and light yellowish orange brown, mottled red.
Specimen	N/A
Specimen Description	N/A

Test Result



Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)
150	-	26.5	95	4.75	66	0.300	29
100	-	19.0	86	3.35	65	0.212	22
75.0	-	16.0	82	2.00	62	0.150	16
63.0	-	13.2	78	1.18	58	0.090	13
53.0	-	9.50	71	0.600	43	0.075	-
37.5	100	6.70	68	0.425	36	0.063	12

Test Remark(s)

• The material used for testing was natural, whole soil. • The percentage passing the <0.063mm was obtained by difference. • The minimum mass of sample required for sieving is 15 kg, but due to insufficient sample mass the sieving was caried out on ~ 1.47 kg. The sample description is not IANZ accredited.

This test is not IANZ accredited and the results are therefore not endorsed.

Approved By ST Date 21/04/2015

GEOTECHNICS

19 - 23 Morgan Street
Newmarket
Auckland 1023
New Zealand

p. +64 9 356 3510

Geotechnics Project ID 616587

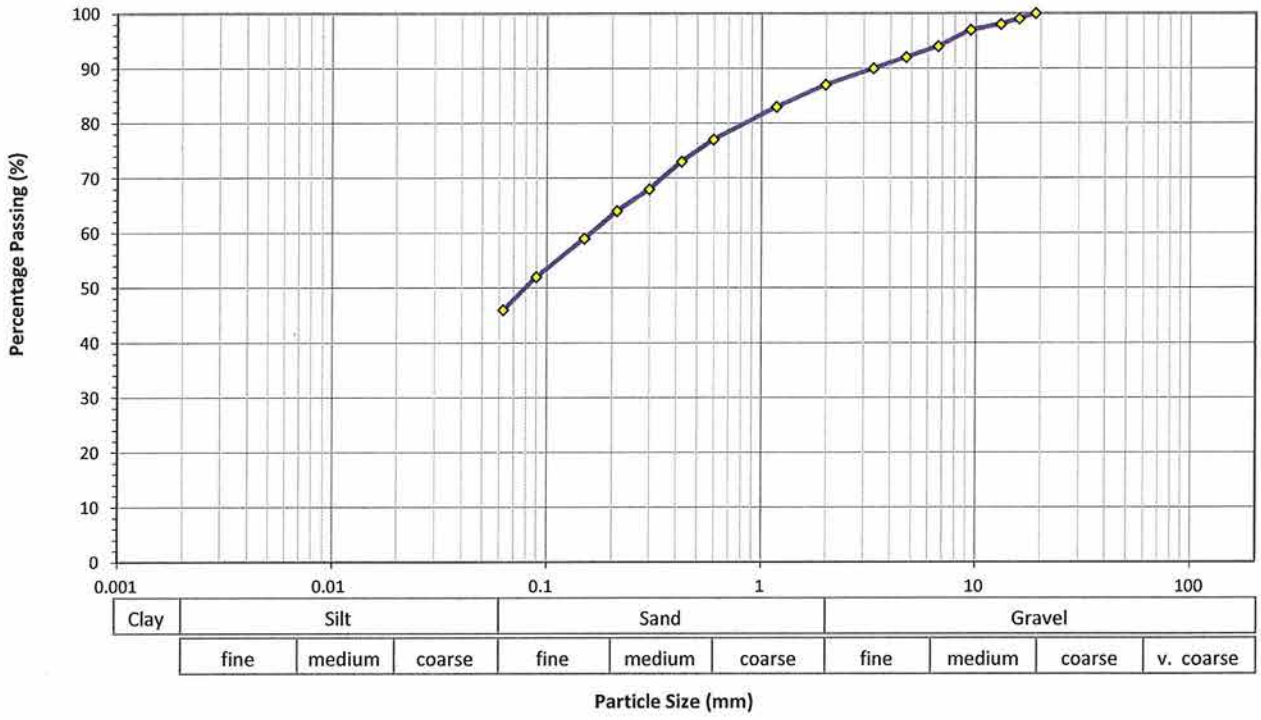
Customer Project ID 751122

Determination of the Particle Size Distribution - NZS 4402:1986 Test 2.8.1 (Wet Sieve)

Sample Details

Geotechnics Sample ID	Kosrae, Micronesia
Date Tested	9/04/2015
Sample	**Kosrae, Micronesia - BH3_0.3-0.6m**
Sample Description	silty SAND with minor to some clay and some gravel, soft, brown, mottled orange.
Specimen	N/A
Specimen Description	N/A

Test Result



Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)
150	-	26.5	-	4.75	92	0.300	68
100	-	19.0	100	3.35	90	0.212	64
75.0	-	16.0	99	2.00	87	0.150	59
63.0	-	13.2	98	1.18	83	0.090	52
53.0	-	9.50	97	0.600	77	0.075	-
37.5	-	6.70	94	0.425	73	0.063	46

Test Remark(s)

• The material used for testing was natural, whole soil. • The percentage passing the <0.063mm was obtained by difference. • The minimum mass of sample required for sieving is 2 kg, but due to insufficient sample mass the sieving was caried out on ~ 0.71 kg. The sample description is not IANZ accredited.

This test is not IANZ accredited and the results are therefore not endorsed.

Approved By ST Date 21/04/2015

GEOTECHNICS

19 - 23 Morgan Street
Newmarket
Auckland 1023
New Zealand

p. +64 9 356 3510

Geotechnics Project ID 616587

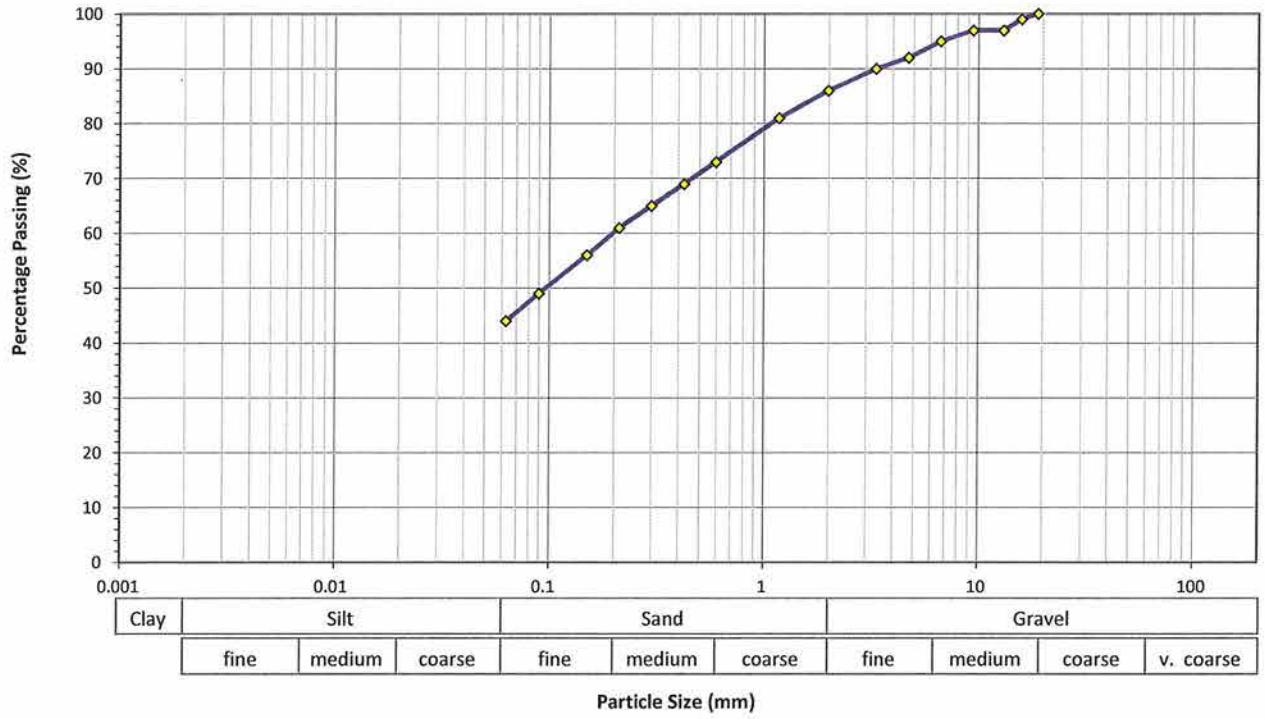
Customer Project ID 751122

Determination of the Particle Size Distribution - NZS 4402:1986 Test 2.8.1 (Wet Sieve)

Sample Details

Geotechnics Sample ID	Kosrae, Micronesia
Date Tested	9/04/2015
Sample	**Kosrae, Micronesia - BH5_2.7-2.9m**
Sample Description	silty SAND with minor to some clay and some gravel, soft, greyish brown, mottled orange-red.
Specimen	N/A
Specimen Description	N/A

Test Result



Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)	Sieve Size (mm)	Percentage Passing (%)
150	-	26.5	-	4.75	92	0.300	65
100	-	19.0	100	3.35	90	0.212	61
75.0	-	16.0	99	2.00	86	0.150	56
63.0	-	13.2	97	1.18	81	0.090	49
53.0	-	9.50	97	0.600	73	0.075	-
37.5	-	6.70	95	0.425	69	0.063	44

Test Remark(s)

• The material used for testing was natural, whole soil. • The percentage passing the <0.063mm was obtained by difference. • The minimum mass of sample required for sieving is 2 kg, but due to insufficient sample mass the sieving was caried out on ~ 0.59 kg. The sample description is not IANZ accredited.

This test is not IANZ accredited and the results are therefore not endorsed.

Approved By ST Date 21/04/2015