追加調査

Minutes of Discussions
on the Supplemental Field Survey on the Project for
Rehabilitation of Monrovia Power System
in the Republic of Liberia

In response to the request from the Government of the Republic of Liberia, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), in consultation with the Government of Japan, decided to conduct a Supplemental Field Survey (hereinafter referred to as "the Survey") on the Project for Rehabilitation of Monrovia Power System (hereinafter referred to as "the Project").

JICA sent to the Republic of Liberia a Supplemental Field Survey Team (hereinafter referred to as "the Team"), headed by Mr. Kyoji FUJII, Chef Consultant, Yachiyo Engineering Co., Ltd. The Team is scheduled to stay in the country from August 7th to 10th, 2012.

The Team held discussions with the officials of concerned authorities in Liberia (hereinafter referred to as "the Liberian side"). In the course of the discussions, both sides have confirmed the main items described in the sheets attached hereto.

Monrovia, August 10th, 2012

Mr. Kyoji Fujii
Chief Consultant
JICA Preparatory Survey Team
Yachiyo Engineering Co., Ltd.

Hon. Patrick Sendolo
Minister
Ministry of Lands, Mines and Energy

Mr. Shahid Mohammed 10/8/2012
Chief Executive Officer
Liberia Electricity Corporation

ATTACHMENT

1. Revision of requested components from the Liberian side

The following (1) to (3) are the final items requested from the Liberian side confirmed on the minutes of discussions signed on January 26th, 2012.

(1) Installation of 2x5 MW HFO-fired medium speed diesel generators and construction of new power house in existing Bushrod Power Plant

(2) Construction of new substation in existing Bushrod Power Plant to include the following items
- One (1) 15 MVA 22/66 kV transformer
- Six (6) 22 kV switchgear

(3) Supply of maintenance vehicles
- Five (5) special purpose/dedicated crew trucks/lorries
- One (1) bucket truck
- One (1) pole construction truck
- Two (2) 2.9 ton crane trucks

After the signing of the minutes of discussions, the Liberian side revised its Electric Master Plan (EMP) in June 2012 so as to incorporate the latest progress of power development and the commitment of donor assistance into the plan. In light of the change in the EMP, the Liberian side requested the Japanese side to delete the above item (2), i.e., construction of new substation in existing Bushrod Power Plant including one (1) 15 MVA 22/66 kV transformer and six (6) 22 kV switchgears from its final request. The Liberian side also requested the Japanese side to change the step up voltage of 2x5MW diesel generators from 66/6.6kV to 66/22kV in accordance with the EMP. The Team confirmed the technical appropriateness of the requests from the Liberian side and accepted them. The revised scope and design of the Project is shown in Annex-1. The change in the scope and design will be incorporated into the outline design of the Project. The revision leads the delay in forthcoming cabinet approval, etc. at least 2 months. Liberian side agreed that.

2. Schedule of other donor's assistance

The above mentioned revision of scope necessitates the procurement and installation of 66kV and 22kV substation facilities which other donor's assistance is expected. The Liberian side shall complete such substation works by the end of September 2014.

3. Installation area for new diesel generators

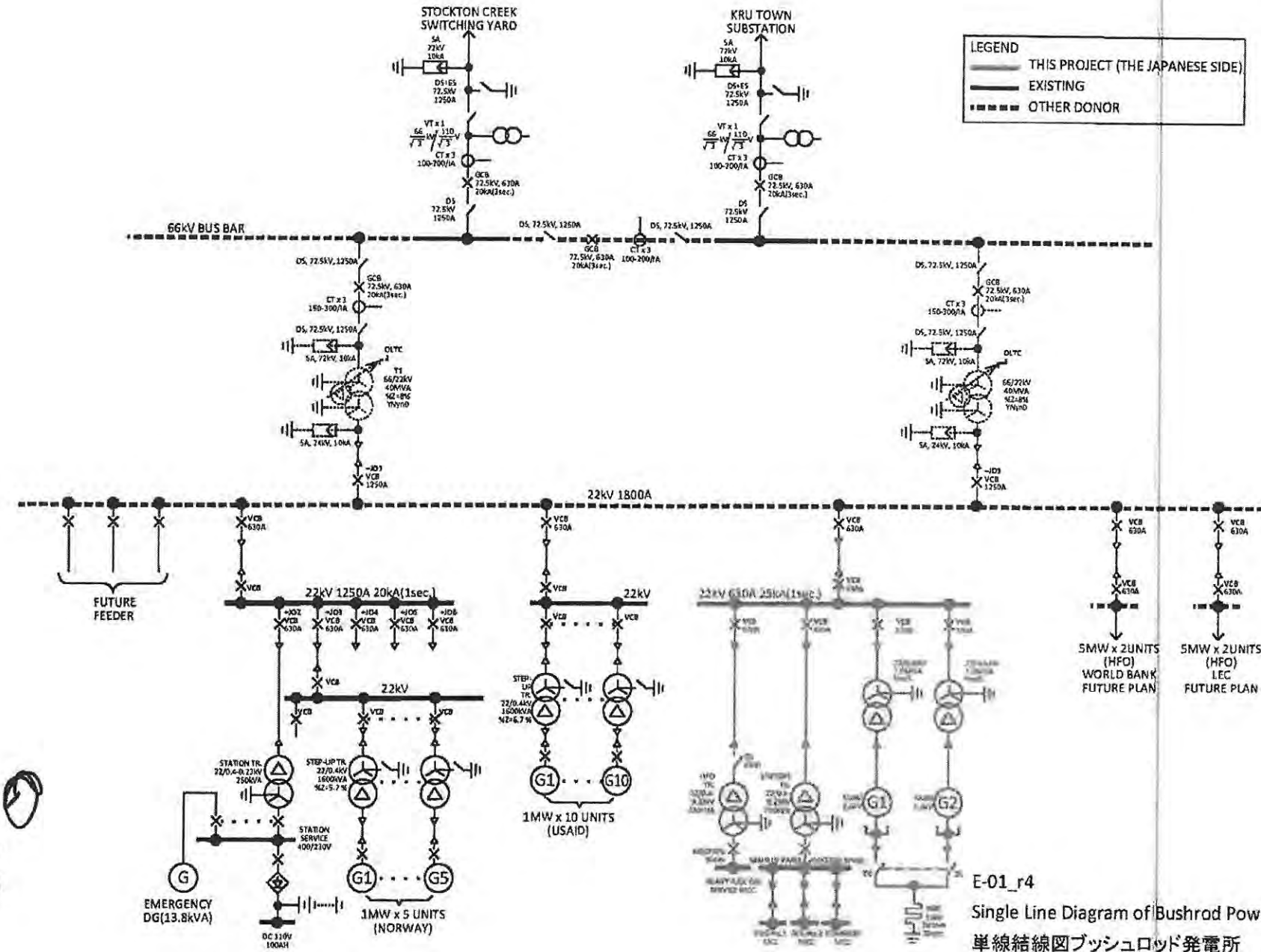
The Liberian side shall take necessary measures to prevent interference of installation areas for new 66/22kV substation facilities (other donor) and 2x5MW diesel generators under Japan's grant aid.

4. Environmental and social considerations

The Liberian side commenced the Environment Impact Assessment for new heavy fuel oil fired diesel generating plants which are to be financed by the Liberian government, the World Bank and the government of Japan and will be completed by April, 2013.

(End)

Annex-1 Single line diagram of Bushrod power station



E-01_r4

Single Line Diagram of Bushrod Power Station

単線結線図ブッシュロッド発電所

DBD 調査

Minutes of Discussions
on the Preparatory Survey on the Project for
Rehabilitation of Monrovia Power System
in the Republic of Liberia
(Explanation on Draft Final Report)

In response to the request from the Government of the Republic of Liberia, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), in consultation with the Government of Japan, decided to conduct a Preparatory Survey (hereinafter referred to as "the Survey") on the Project for Rehabilitation of Monrovia Power System (hereinafter referred to as "the Project").

JICA conducted a first field survey from September 14th to 28th, 2011. Second field survey was conducted from January 10th to February 5th, 2012. Supplemental survey was conducted from August 7th to 10th, 2012. Through discussions, field surveys and the result of technical examination in Japan, JICA prepared a Draft Final Report of the Survey.

In order to explain and to consult with the officials of concerned authorities in Liberia (hereinafter referred to as "the Liberian side") on the contents of the Draft Final Report, JICA dispatched to Liberia the Preparatory Survey Team for Draft Final Report Explanation (hereinafter referred to as "the Team"), which is headed by Mr. Fuyuki SAGARA, Deputy Resident Representative, JICA Ghana Office. The Team is scheduled to stay in Liberia from October 16th to 26th, 2012.

The Team held discussions with the Liberian side. As a result of the discussions, both sides have confirmed the main items described in the sheets attached hereto.

Monrovia, October 25th, 2012

相良 冬木

Mr. Fuyuki SAGARA
Leader
Preparatory Survey Team
Japan International Cooperation Agency

Mr. Patrick Sendolo
Minister
Ministry of Lands, Mines and Energy

Mr. Yancon-Dargbe Nimley
Assistant Minister for Economic Cooperation and Integration
Ministry of Planning and Economic Affairs

25/10/2012

Mr. Shahid Mohammed 25/10/2012
Chief Executive Officer
Liberia Electricity Corporation

ATTACHMENT

1. Objective of the Project

The objective of the Project is to ensure the continuous supply of electric power to most part of Monrovia.

2. Project Site

The Project site is located in Monrovia City as shown in Annex-1.

3. Contents of the Draft Final Report

The Liberian side agreed and accepted in principle the contents of the Draft Final Report and the Draft Technical Specifications of the Survey explained by the Team.

4. Responsible and Implementing Organization

(1) The responsible ministry is the Ministry of Lands, Mines and Energy (MLME).
(2) The implementing organization is the Liberia Electricity Corporation (LEC).
(3) The Organization Structure of LEC is shown in Annex-2.

5. Components of the Project

The following are selected as the Project Components.

(1) Installation of 2x5 MW Heavy Fuel Oil (HFO)-fired medium speed diesel generators
(2) Construction of new power house in existing Bushrod Power Plant
(3) Supply of maintenance vehicles
- Five (5) special purpose/dedicated crew trucks/lorries
- One (1) bucket truck
- One (1) pole construction truck
- Two (2) 2.9 ton crane trucks

6. Confidentiality of the Project

(1) Project Cost

The Team explained the estimated cost of the Project as described in Annex-3. The Liberian side also agreed that the cost for the Project contains procurement cost of equipment, construction cost of facility, transportation cost up to the Project site, installation cost and the Consultant fees.

The Liberian side agreed that the cost for the Project should not exceed the amount agreed on the Exchange of Notes (E/N) to be signed between the governments. The Liberian side understood that the estimated cost for the Project attached as Annex-3 is not the final and is subject to change as a result of the detailed design to be implemented after the E/N.

(2) Detailed specifications of the Facilities and Equipment

Both sides agreed that all the information related to the Project including the estimated cost, detailed drawings and specifications of the facilities and equipment, and other technical information shall not be disclosed to any outside parties (i.e. outside of JICA and the Liberian side) before the conclusion of all contract(s) for the Project.

7. Possibility of Change in Scope, Schedule and Cost of the Project

The Team stressed that the scope, the schedule, and the cost for the Project are tentative and subject to change due to the domestic circumstances in Japan and in Liberia. The Liberian side understood it.

8. Japan's Grant Aid Scheme

(1) JICA confirmed that the Liberian side understood Japan's Grant Aid Scheme explained by the Team as described in Annex-4 and 5.

(2) The Liberian side will take the necessary measures, as described in Annex-6, for smooth implementation of the Project as prerequisites for the Japan's Grant Aid to be implemented.

9. Other Relevant Issues

(1) Coordination among relevant projects

The Team requested the Liberian side to ensure coordination among following projects for smooth implementation of the Project.

a) The project by World Bank, which is to rehabilitate HFO storage facilities and to install 10MW HFO-fired generator in Bushrod power plant.

b) The project by LEC own fund, which is to install 10MW HFO-fired generator in Bushrod power plant.

c) The project by private company, which is to rehabilitate HFO unloading and transfer facilities.

d) The project by Norway, which is to procure and to install 66kV and 22kV substation facilities by the end of January 2014.

The Liberian side realized that it is critical to implement the project by Norway on schedule for the Project. The Liberian side accepted to provide the Team with information regarding the construction schedule, commissioning date and specification of equipment of the above projects. The Team and the Liberian side agreed the facility plan of each 10MW generator in Bushrod power plant as Annex-7.

(2) Operation and Maintenance Cost

The Team emphasized it is essential that the Liberian side ensures to constantly secure the necessary budget for operation and maintenance including major overhauls, of equipment to be procured under the project, to ensure long-term stable power supply. The Liberian side has fully understood and shared the same view.

(3) Customs and Tax exemption

The Liberian side understood that it shall be fully responsible on exemption of taxes, custom duties and any other levies imposed in the Republic of Liberia, in case the Project is implemented.

(4) Operation and Maintenance system of new facilities

The Team emphasized that the allocation of enough number of qualified engineers and skilled technicians for operating and maintaining the new facilities is a prerequisite to implement the Project. The Liberian side under stood the prerequisite.

(5) Counterpart Personnel

The Team requested the Liberian side that the necessary number of counterpart personnel shall be assigned to the Team and the necessary arrangements with related organizations be made during implementing stage in Liberia. The Liberian side has agreed to follow the request.

(6) Environmental and Social Considerations

a) The Team requested the Liberian side to conduct the required environmental procedures, and obtain approval on environmental clearance for implementation of the Project.

b) The Liberian side agreed to comply with the JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as "JICA Guidelines") as well as laws and regulations in Liberia, and was requested to prepare Environmental Checklist and Monitoring Form which are designated by JICA Guidelines for an outline design.

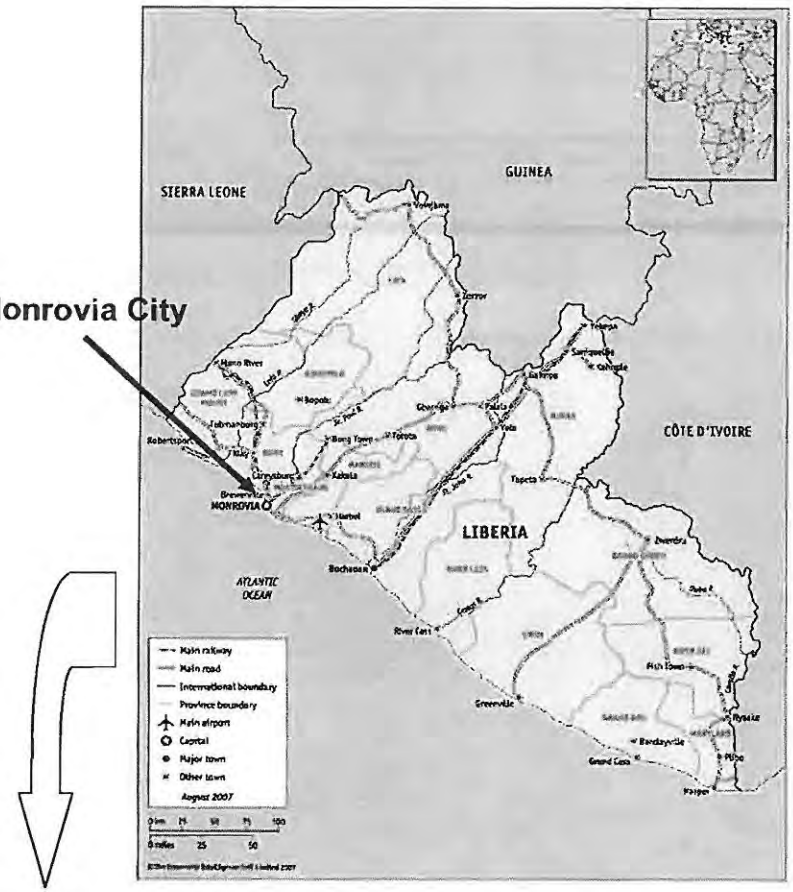
c) The Liberian side agreed to complete the Environment Impact Assessment for new heavy fuel oil fired diesel generating plants which are to be financed by the Liberian government, the World Bank and the government of Japan will be completed by April,

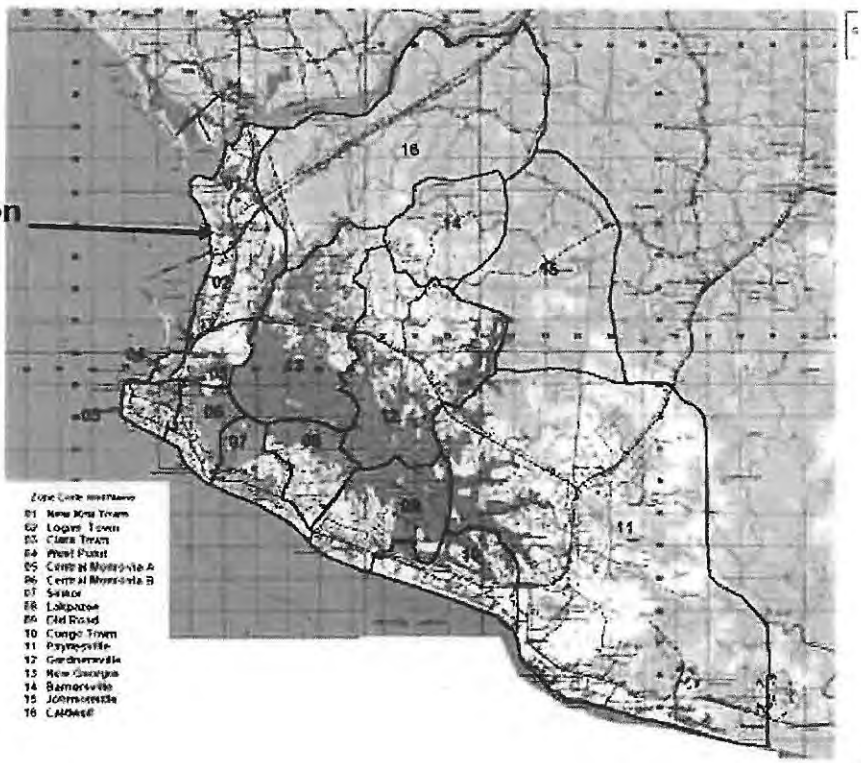
2013.

(End)

Annex-1 Project Site
Annex-2 Organization Chart of LEC
Annex-3 Estimated Project Cost (Confidential)
Annex-4 Japan's Grant Aid
Annex-5 Flow Chart of Japan's Grant Aid Procedures
Annex-6 Major Undertakings to be taken by Each Government
Annex-7 Facility plan in Bushrod power plant

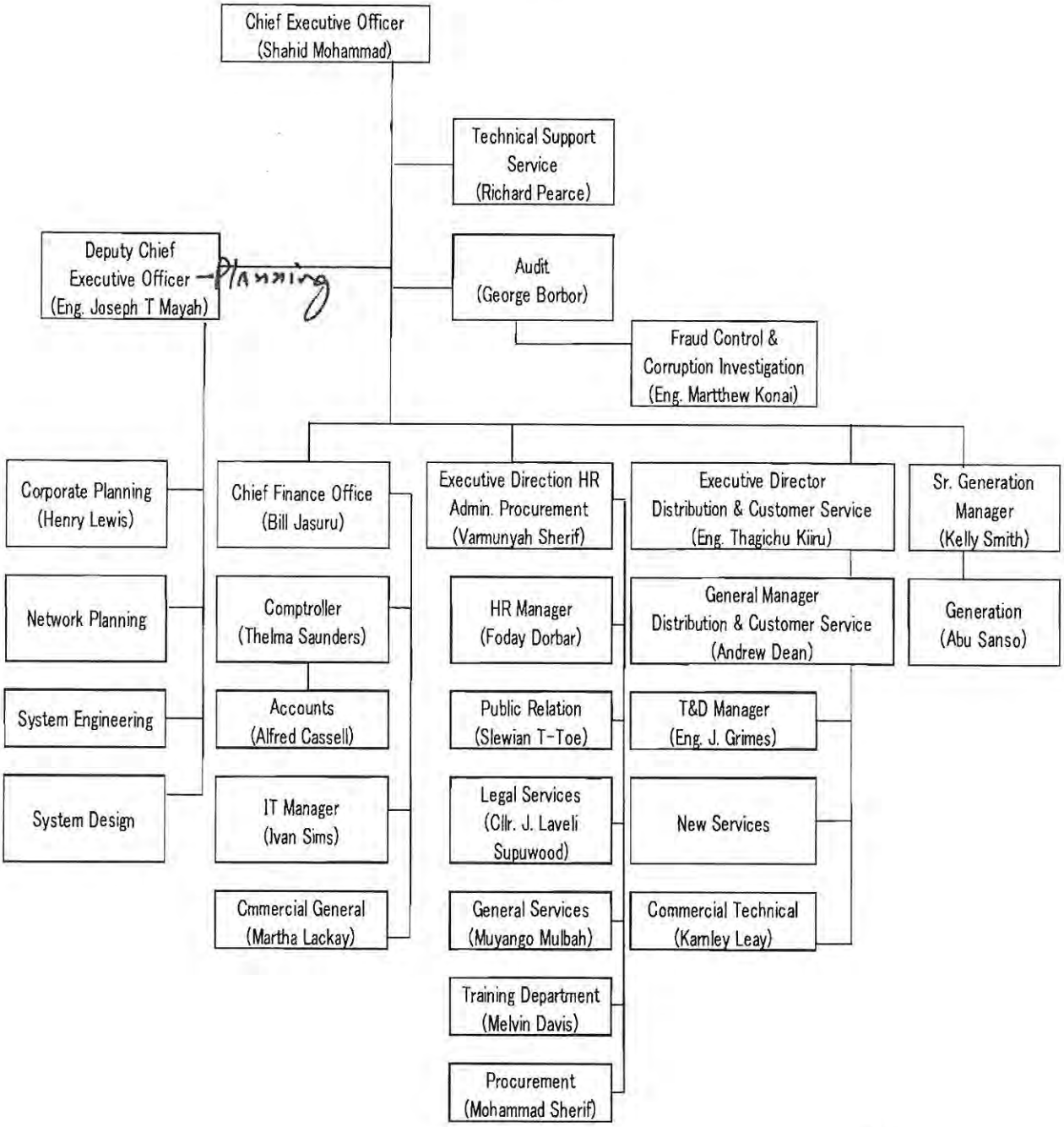
Project Site





Annex 2

Organization Chart of LEC



(Confidential)
Estimated Project Cost

The cost of the Project will be approximately JPY 2,066 million in total. The content of the project cost are shown separately for the Japanese borne portion and the Liberian side borne portion in accordance with the conditions in item 3.(3) below.

This cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant.

1. Cost to be borne by the Japanese side: Approximately JPY 2,032 million

Approximate Total cost for Japanese Portion

Cost Items	Approximate Cost (million JPY)
Equipment Procurement, Installation and Trainings	1,596
Construction	337
Detailed Design & Consultant's Supervision	99
Total	2,032

2. Cost to be borne by the Liberian side: USD 429,000 (=approximately JPY33.56 million)

① Payment of bank commission based on banking US$ 29,000 (= ¥2.27 million)

- A/P commission (US$ 3,000)
- Payment commission (US$ 26,000)

② Fuel oil Initial Charge Cost US$ 400,000 (= ¥31.29 million)

- Tank Capacity 335 m^3 x 2 units =670 m^3
  Minimum required 500 m^3 diesel oil for initial charge
  500 m^3 x US$ 800 = US$ 400,000.-

3. Conditions for estimation
   (1) Time of estimation: February, 2012
   (2) Foreign exchange rates:
   1USD = JPY 78.23
   (3) Others:
   The above estimation was carried out in accordance with relevant rules and the guideline of the Japanese Grant Aid.

Japan's Grant Aid

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on this law and the decision of the GOJ, JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

The Grant Aid is non-reimbursable fund provided to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures

The Japanese Grant Aid is supplied through following procedures :

・Preparatory Survey
- The Survey conducted by JICA

・Appraisal &Approval
-Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet

・Authority for Determining Implementation
-The Notes exchanged between the GOJ and a recipient country

・Grant Agreement (hereinafter referred to as "the G/A")
-Agreement concluded between JICA and a recipient country

・Implementation
-Implementation of the Project on the basis of the G/A

2. Preparatory Survey

(1) Contents of the Survey

The aim of the preparatory Survey is to provide a basic document necessary for the appraisal of the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of a basic design of the Project.

- Estimation of costs of the Project.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed based on the guidelines of the Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization of the recipient country which actually implements the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA employs (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the Report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the appropriateness of the Project.

3. Japan's Grant Aid Scheme

(1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the recipient country to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the recipient country to continue to work on the Project's implementation after the E/N and G/A.

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to fulfill accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as Annex-6.

(6) "Proper Use"

The Government of the recipient country is required to maintain and use properly and effectively the facilities constructed and the equipment purchased under the Grant Aid, to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account under the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

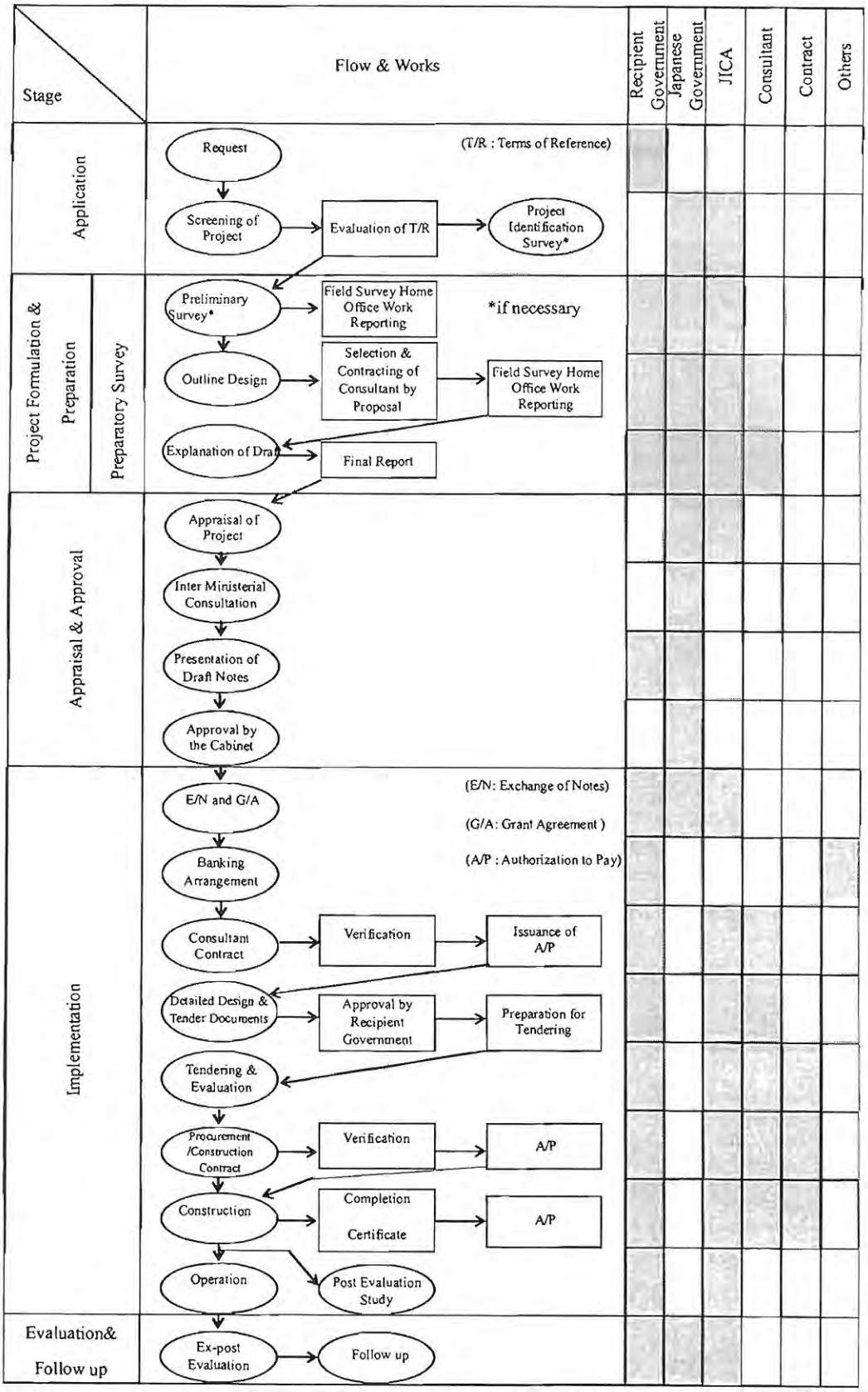
The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions paid to the Bank.

(10) Social and Environmental Considerations

A recipient country must carefully consider social and environmental impacts by the Project and must comply with the environmental regulations of the recipient country and JICA socio-environmental guidelines.

(End)

Flow Chart of Japan's Grant Aid Procedures

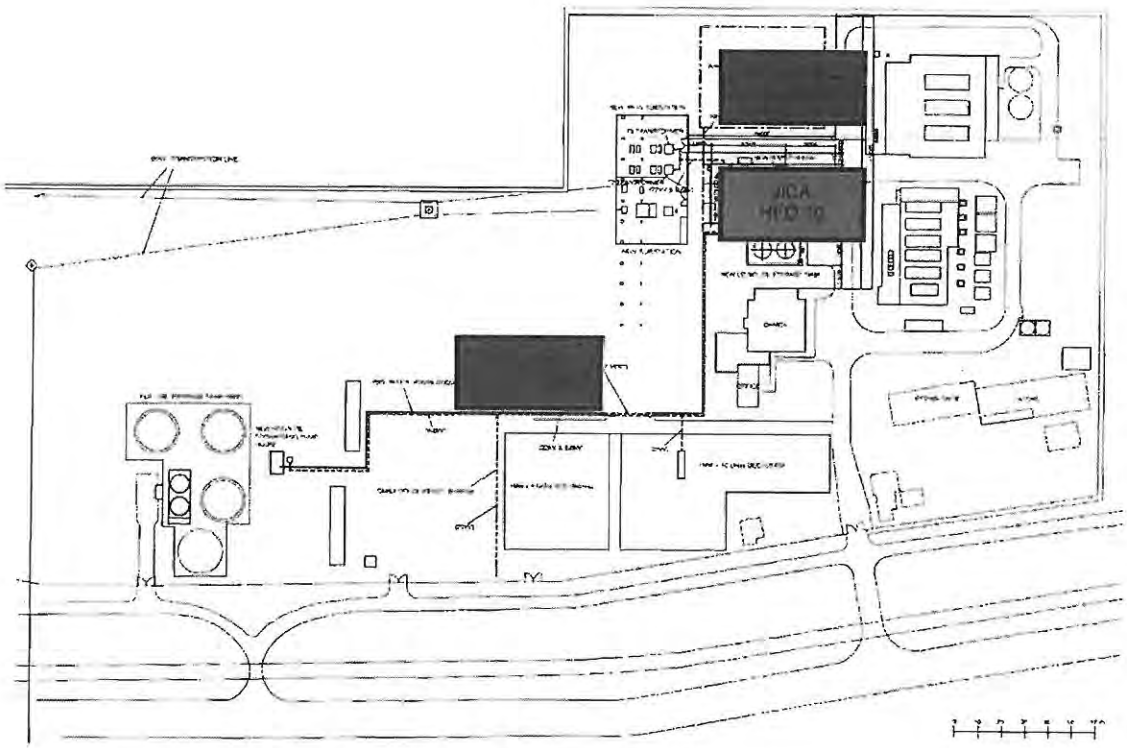


Major undertakings to be taken by each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	to secure [a lot] /[lots] of land necessary for the implementation of the Project and to clear the [site]/[sites];		●
2	To construct the following facilities		
	1) The building	●	
	2) The gates and fences in and around the site		●
	3) The parking lot	●	
	4) The road within the site	●	
	5) The road outside the site		●
3	To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the [site]/[sites]		
	1)Electricity		
	a. The distributing power line to the site		●
	b. The drop wiring and internal wiring within the site	●	
	c. The main circuit breaker and transformer	●	
	2) Water Supply		
	a. The city water distribution main to the site		●
	b. The supply system within the site (receiving and elevated tanks)	●	
	3) Drainage		
	a. The city drainage main (for storm sewer and others to the site)		●
	b. The drainage system (for toilet sewer, common waste, storm drainage and others) within the site	●	
	4) Gas Supply		
	a. The city gas main to the site		●
	b. The gas supply system within the site	●	
	5) Telephone System		
	a. The telephone trunk line to the main distribution frame/panel (MDF) of the building		●
	b. The MDF and the extension after the frame/panel	●	
	6) Furniture and Equipment		
	a. General furniture		●
	b. Project equipment	●	
4	To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the recipient country and to assist internal transportation of the products		
	1) Marine (Air) transportation of the Products from Japan to the recipient country	●	
	2) Tax exemption and custom clearance of the Products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	●	
5	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the products and the services [be exempted] / [be borne by the Authority without using the Grant]		●
6	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		●
7	To ensure that [the Facilities and the products]/[the Facilities]/ [the products] be maintained and used properly and effectively for the implementation of the Project		●
8	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project		●
9	To bear the following commissions paid to the Japanese bank for banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
10	To give due environmental and social consideration in the implementation of the Project.		●

*1 B/A : Banking Arrangement, A/P : Authorization to pay) *2 If the environmental screening category is C, No. 10 is unnecessary

Facility plan in Bushrod power plant



添付資料　A-5　測量・土質調査報告書

TOPOGRAPHIC SURVEY

FOR THE

REHABILITATION OF MONROVIA POWER STATION

IN THE

REPUBLIC OF LIBERIA.

FINAL REPORT

PREPARED BY:

BEZALEEL + TURNKEY CONTRACTORS INC.
77, CAREY STREET
MONROVIA,
LIBERIA.

CLIENT:

YACHIYO ENGINEERING CO. LTD.

May, 2012

CONTENTS

Summary

REPORT OF TOPOGRAPHICAL SURVEY

1.0 INTRODUCTION

The topographical survey of the site covered was 1.218399 acres. The fieldwork commenced on 23.Feb.2012 and completed on 25.Feb.2012. The Topographical survey of the area covered, is as under: The site survey of the proposed Rehabilitation of Monrovia Power Station was carried out on the basis of the boundaries shown by Yachiyo Engineering Co. Ltd.

2.0 METHODOLOGY

The survey team comprised of:

1. Engineering Surveyor
2. Assistant Surveyor
3. Field Assistants.

Instruments used:

1. Garmin GPS-60
2. Compass
3. Nikon DTM 322 Total
4. Station
5. Tripod
6. Prism
7. Prism Pole

The survey team using the **Garmin GPS-60** to operate satellite coordinates **(WGS-UTM-84,29^{0} N -Datum)** transferred the station points B1, B2 and B3. After determining this, the total station was centered to start work.

The survey team used Transvers method to shoot all terrain points from ground, to determine ground Levels (Datum), the horizontal (North) and Vertical (East) angle coordinates was also determined.

3.0 ANALYSIS

After the shooting process, all data downloaded from the instrument was carried out using **Trimble Transfer Software** which is in **DAT** format. These data is later transferred to **Microsoft Excel** and converted to **EXL** file and then downloaded to a survey software for drafting of the final drawing, Printing was done using the **HP 1280** for the A3 size sheet of this work.

The list of Station Points, GPS Coordinates and Bore Hole Coordinates are enlisted below.

STATION POINTS				
SL.NO	POINTS	NORTHING	EASTING	ELEVATION
1	S1	703601.000	302204.000	100.000
2	S2	704234.800	303330.000	100.306
3	S3	704362.300	297645.800	99.982
4	S4	697498.100	301310.560	99.745
5	S5	698793.400	295509.160	99.434
6	S6	704751.900	298365.400	99.702

GPS COORDINATES				
SL.NO	POINTS	NORTHING	EASTING	ELEVATION
1	S1	703601.000	302204.000	14.000 M
2	GROUND LEVEL OF S1	703601.000	302204.000	13.725 M
3	CON.PAD			13.825M
4	TANK AREA 1	703374.000	302286.000	13.825 M
5	TANK AREA 2	704654.490	303076.888	13.860 M

BORE HOLE COORDINATES				
SL.NO	POINTS	NORTHING	EASTING	ELEVATION
1	B1	701513.300	298823.700	99.256
2	B2	699791.500	299483.300	99.239
3	B3	699308.500	296933.900	99.296

ATTACHMENT

SOIL INVESTIGATION WORKS

FOR THE

REHABILITATION OF MONROVIA POWER STATION

IN THE

REPUBLIC OF LIBERIA.

FINAL REPORT

PREPARED BY:

BEZALEEL + TURNKEY CONTRACTORS INC.
77, CAREY STREET
MONROVIA,
LIBERIA.

CLIENT:

YACHIYO ENGINEERING CO. LTD.

May, 2012

CONTENTS.....i-ii

APPENDICES

TABLES

PLATES

LIST OF FIGURES

EXECUTIVE SUMMARY

The depth of the sub soil formation explored is up to the depth of 30m in all the 3No test bores. These were drilled by conducting Standard Penetration Test (SPT) at every 1.5m intervals up to maximum depth of 30m below the existing ground level. The samples obtained at different depths were also tested in the laboratory in order to determine the geotechnical properties of the subsoil at the various boring locations.

Based on the results obtained the sub soils of the various locations and their SPT N value are as presented below.

Table A1: SPT N_{30} Value

Depth (m)	SPT N_{30} VALUE			Lithology
	BH 1	BH 2	BH 3	
0.0-0.6	4	4	2	Fill material and organic soil
1.5-2.1	11	11	9	Fine sand
3.0-3.6	24	16	14	Fine sand
4.5-5.1	29	25	23	Fine sand
6.0-6.6	16	17	19	Coarse sand
7.5-8.1	32	23	27	Coarse sand
9.0-9.6	12	23	23	Fine sand and clay
10.5-11.1	48	39	37	Fine sand and coarse sand
12.0-12.6	80	40	42	Fine sand and coarse sand
13.5-14.1	62	40	37	Fine sand and coarse sand
15.0-15.6	60	36	34	Fine sand
16.5-17.1	72	39	37	Fine sand
18.0-18.6	50	45	46	Fine sand
19.5-20.1	49	22	39	Fine sand, coarse sand and clay
21.0-21.6	53	46	44	Fine sand and coarse sand
22.5-23.1	58	44	42	Fine sand and coarse sand
24.0-24.6	39	52	44	Fine sand
25.5-26.1	51	39	45	Fine sand
27.0-27.6	54	45	47	Fine sand
28.5-29.1	67	57	55	Very dense Sand
30.0-30.6	80	54	54	Very dense Sand
	EB	EB	EB	Very dense Sand

* EB - End of Boring.

The materials encountered at site within the explored depths of 0.0-30.0 are predominantly sands and clay; therefore considering the nature of the subsoil at the boring locations at a depth of between 1.0-.3.0m the foundations of the various structures are recommended as follows;

Transformer Base and Other Installations

The foundation of the structures and plants should be ***CELLULAR RAFT FOUNDATION*** at depth of ***2.0 – 2.50m*** below the existing ground level; considering allowable bearing capacity values of 90 - 240kN/m^2 at that depth.

Alternatively depending on the loading combinations of the structures ***DRIVEN PILES OR BORED PILES*** which could are ***CAST IN PLACE PILES*** at depth of ***15 - 20m*** from the existing ground level could be adopted.

Non Load Bearing Structures

Considering the bearing capacity values of 90 - 110kN/m^2 at depth of 1.50-2.0m, the foundation of the building should be ***GROUND BEAMS*** at depth of ***1.5m*** below the existing ground level.

Due to the depth of water table level observed at the excavated depth of about 2.20 – 2.30m, ***TANKING MATERIAL*** should be utilized at the hardcore level (DPC – damp proof course) to prevent the ingress of water at the foundation base.

As result of the high ground water observed at the depth of 2.20 – 2.30m provision should be made to dewater the site to a safe level to allow for ease of foundation construction. Adequate drainage and pumping methods should be provided around the site to drain away the water during and after construction.

1.0 INTRODUCTION

GENERAL

1.1 The report of the Geotechnical foundation investigation conducted for the Proposed Construction of New Power House and New Substation at Bushrod Island Power Station, Monrovia, Liberia, is presented herein.

Reference your offer to carry out Geotechnical investigations at the above named site. We mobilized to site on 7th March, 2012 for the field work.

SCOPE OF WORK FOR THE INVESTIGATIONS

1.2 The objectives of the investigations were as follows:

i. To Conduct Standard Penetration Tests (SPT) at every 1.5m depth intervals, to the depth of 30m at 3Nos test bores;

ii. Evaluate the bearing capacity of soils for foundation of structures;

iii. To ascertain the depth to bed rock and water table level for design purpose;

iv. Obtain open tube of 50 x 350mm long undisturbed samples and split spoon samples from boreholes for laboratory analyses;

v. Evaluate by conducting laboratory tests the physical properties and strength of the soils obtained for both disturbed and undisturbed samples from the test bores.

1.3 The field work commenced on 11th March, 2012 and it involved rotary drilling as well as sampling materials. A total of 3Nos test bores were drilled up to depths of 30m.

Samples were obtained at different depths in the 3Nos test bores. The samples were carefully identified, preserved and taken for further laboratory tests and analyses.

Table 1 shows the coordinates of the boring locations.

Table 1: Coordinates of Test Locations

S/No.	Borehole No.	Coordinates
1	BH1	E: 298823.700 N: 701513.300
2	BH 2	E: 299483.300 N: 699791.500
3	BH 3	E: 296933.900 N: 699308.500

2.0 GEOMORPHOLOGY

2.1 General Geology

The geology of the project is of the younger sedimentary basins. Along the Atlantic Ocean, the coastline is characterized by lagoons, mangrove swamps, and river-deposited sandbars. It is of the Quaternary age and Neogene – Mosozoic age comprising of sands and clay.

Climate

Liberia is known for its sustained heat and heavy rainfall. Because the republic lies south of the Tropic of Cancer and only a few degrees north of the equator, the days vary little in length. The tropical solar radiation is intense and the radiation is uniform across the country. Temperatures remain warm throughout the country, and there is little change in temperature between seasons.

2.2 Topography

The topography of the area is of a relatively flat terrain and it falls within built up area.

3.0 GEOTECHNICAL INVESTIGATIONS:

3.1 Field Work

Three (3Nos) deep boreholes were drilled using the rotary drilling rig with HW (4'') casing in the overburden.

The test borings were drilled to depths of 30m using the wet drilling technique. In each test bore Standard Penetration Tests (SPT) was conducted at 1.5m interval.

The sampling procedure consisted of driving a standard split spoon as set forth in ASTM D1586-1990 and BS 5930. This was by repeated blows of hammer of 63.5kg weight falling through 760mm height. The relationship between the penetration resistance (N - value) and depth are shown in Appendix B.

Samples recovered from the borings as outlined above were visually classified and geologically logged. After these, they were taken to the laboratory for determination of the parameters outlined in section 5.0.

The layout of boring locations and soil profile are shown in Figure 1 - 3.

Plate A: Position of Rig at Test Location.

Plate B: Drilling Process at Test Location.

4.0 SUBSOIL AND GROUNDWATER CONDITION

4.1 The Stratigraphies of the subsurface deposits as observed from the logs of test bores performed at this site exhibited similarities both in nature and in strength characteristics from the beginning of the boreholes till their termination. A generalised description for the site can thus be as given below;

Abstract of Findings

The materials proved at all the test borings include fine sand, coarse sand, clay and dense sand. These were observed within total explored depth of 0.05 - 30m in all the 3Nos test bores. The bearing capacity of the formation explored range between 20 - 800kN/m^2.

Stratigraphy

Fine Sand

These are strata of fine grained brown sandy material observed between 0.05 - 27.0m.

Coarse Sand

Layers of medium grained sandy material observed between 6.0 - 21.0m.

Clay

These are stiff medium consolidated clayey material with high plasticity as proved at depth of 9.0 and 20m.

Dense Sand

Layers of dense compacted sandy material occurring at different layers proved between 10.0 – 30.0m with good bearing pressures.

4.2 Ground Water Table

The groundwater level in all the test boring locations were observed to be at depth of 2.20 – 2.30m as at the time this investigation was carried out.

The phreatic surfaces were observed from all the borings and were taken twenty-four hours later (static). These values are recorded in each boring logs and are shown in Table 2 below.

Table 2: Observed Water Table Level

S/No	Boring Location	Static Water Table Level (m)
1	BH 1	2.30
2	BH 2	2.20
3	BH 3	2.30

5.0 LABORATORY TESTING.

5.1 Laboratory classification tests and other tests to determine geotechnical parameters were carried out on the undisturbed and disturbed samples obtained from the boreholes to improve on the field identification and classification. The tests were conducted in accordance with the relevant British Standard as Specified in BS 1377 (1990). The tests carried out include:

* Moisture Content Determination
* Atterberg Limit Tests
* Particle Size Distribution Tests.
* PH Value of Water in Soils.
* Sulphate Content of Water in Soils.
* British Standard Compaction Test.
* Undrained Triaxial Compression Test.
* Specific Gravity Test.
* Consolidation (Oedometer) Test.
* Bulk Density Test

5.2 The Geotechnical properties of the soils encountered at the various strata formation of the overburden were obtained from the tests conducted in laboratory. The summary of the results are given below.

Property	**Min.**	**Max.**
Natural Moisture Content (%)	4	36
Liquid Limit (%)	32	34
Plastic Limit (%)	16	17
Plasticity Index (%)	16	17
Passing # 200 Sieve (%)	0.53	50.89
Bulk density (kN/m^3)	15.68	18.26
Apparent Cohesion (kN/m^2)	0	28
Angle of Internal Friction (Ø)	16	31
Coefficient at compressibility (m^2/kN)	3.84×10^{-4}	3.86×10^{-3}
Specific Gravity	2.59	2.75

The detailed laboratory tests results are presented in laboratory result sheet.

5.3. Chemical Test Result

The chemical test results are shown in Table 3. These results indicate sulphate and chloride content of between 171.21 - 187.08mg/l and 285.03 – 292.45mg/l respectively with pH values ranging from 6.63 - 6.71. The PH value is considered slightly acidic while the sulphate and chloride content is considered moderate, within limit.

Table 3: Results of Chemical Tests

S/N	Boring Location	Chemical Results			Remarks
		PH Value	Sulphate content (mg/l)	Chloride content (mg/l)	
1	BH 1	6.71	185.63	285.03	Slightly acidic soil with moderate sulphate and chloride content
2	BH 2	6.67	171.21	292.45	Slightly acidic soil with moderate sulphate and chloride content
3	BH 3	6.63	187.08	287.72	Slightly acidic soil with moderate sulphate and chloride content

6.0 BEARING CAPACITY VALUES

6.1 The allowable bearing pressure imposed by a foundation is a function of characteristics of the shear strength of the soil as well as the depth and dimension of the foundation. The bearing capacities for selected boring locations were calculated from the laboratory shear strength tests conducted on soil samples for a typical boring location for depth between 1.5-3.0m is as shown below;

BH3@2.0m

$Q_{Ultimate} = CNc + \gamma D\,(N_q - 1) + \frac{1}{2}\,\gamma B N\gamma.$

Where C =2kN/m^2, Ø = 26°, γ= 16.87kN/m^3, B = 1.0m, D = 2.0m.

The Bearing capacity coefficients; (shallow foundations)

$N_c = 27.09$, $N_q = 14.21$, $N\gamma = 9.84$.

Therefore, $q_{(Ult.)} = 2 \times 27.09 + 6.87 \times 2.0 \times 13.21 + 0.5 \times 6.87 \times 1 \times 9.84$

$= 54.18 + 181.51 + 33.80$

= <u>296.49kN/m^2</u>

Factor of safety = 3.0

Q (allowable) = **<u>89.83kN/m^2</u>**

Note: Cohesion is only 2kN/m^2 which shows presence of silt in the sand and silt has a small degree of cohesion.

6.2 The bearing capacity of soil at the various depths is based on the standard penetration Tests (SPT) as a function of penetration resistance, which is the undrained shear strength in kN/m^2. The values are as shown in the table 4 below.

Table 4: Bearing Capacity Values

Depth (m)	Bearing Capacity Values (kN/m^2)		
	BH1	BH2	BH3
0.0-0.6	40	40	20
1.5-2.1	110	110	90
3.0-3.6	240	160	140
4.5-5.1	290	250	230
6.0-6.6	160	170	190
7.5-8.1	320	230	270
9.0-9.6	120	230	230
10.5-11.1	480	390	270
12.0-12.6	800	400	420
13.5-14.1	620	400	370
15.0-15.6	600	360	340
16.5-17.1	720	390	370
18.0-18.6	500	450	460
19.5-20.1	490	220	390
21.0-21.6	530	460	440
22.5-23.1	580	440	420
24.0-24.6	390	520	440
25.5-26.1	510	390	450
27.0-27.6	540	450	470
28.5-29.1	670	570	550
30.0-30.6	800	540	540
	EB	EB	EB

* EB - End of Boring.

7.0. SETTLEMENT OF FOUNDATION BY MEYEHORF'S METHOD

This method is used to estimate the settlement of a footing on soil and is given by the relationship.

$$\rho = \frac{\Delta P \times B}{2\ Cr}$$

Where ρ - Settlement

ΔP - The net foundation pressure increase which is simply the foundation loading less the value of vertical effective stress at foundation level (δv)

B - The least dimension of the footing

Cr - The average value of SPT over a depth below the footing equal to B

Cr = 400 x N (kN/m^2)

At 1.50m

$\Delta P = 100 - (6.47 \times 1.5)$

$= 90.30 kN/m^2$

B = 2.0m

Cr = 400 x 10 = 4,000kN/m^2

$$\rho = \frac{90.30 \times 2}{4{,}000 \times 2} = \frac{180.60}{8{,}000}$$

ρ = 22.57mm

at 3.0m

$\Delta P = 180 - (6.46 \times 3.0)$

$= 160.62 kN/m^2$

Cr = 400 x 18 = 7,200kN/m^2

$$\rho = \frac{160.62 \times 2}{7{,}200 \times 2} = \frac{321.24}{14{,}400}$$

ρ = 22.31mm

Settlement analysis for each strata of soils at various depth, are as contained in Table 5 below;

Table 5: Settlement Analysis Result

Depth of layer Below Ground(m)	Net Foundation Pressure ΔP (kN/m^2)	The Average value of SPT Cr (kN/m^2)	Settlement (mm)
1.5	90.30	4000	22.57
3.0	160.62	7200	22.31

The average immediate settlement at 3.0m is 22.31mm and it decreases with depth depending on imposed load.

8.0 SAFE LOAD CAPACITY OF PILES

The predominant materials are sand overburden, which are highly permeable such that pore pressures induced in these soils by the applied loads are dissipated rapidly. The total pile carrying capacity is a function of the frictional resistance and end bearing resistance.

The Total Pile capacity = SF + ER (Skin Friction + End Resistance)

$$q_s = K_s \ \gamma_{vo} \tan \emptyset$$

Where, q_s = Friction resistance

K_s = Coefficient of horizontal soil stress

γ_{vo} = Average effective overburden pressure ($\gamma_s - \gamma_w$)

δ = Angle of wall friction

And

$$q_b = N_q \gamma_{vo} \ A_b$$

q_b = base resistance

N_q = bearing capacity friction

δ_{vo} = effective overburden pressure at length of the soil layer

A_b = Area of base of pile (based on diameter of pile)

BH1

$q_s = K_s \ \delta_{vo} \tan \emptyset$

K_s = 1, for Bored and cast in Place Piles (after Kulhawy); γ_{vo} (average) = 16.73kN/m^3;

δ= 1 x Ø, for cast in place piles, Ø = 27^0, tan Ø = 0.510

Depth (h) = 15m, Area = 0.283m (Ø = 600mm)

q_s = 1 x (16.73 – 10) x 15 x 0.510

= 51.49*kN/m*^{2}

Pile capacity due to friction (SF) = Frictional Resistance (q_s) x Contact Area ($2\pi r_L$)

= 51.49 x $2\pi r_L$

= 51.49 x 2 x 3.142 x 0.3 x 15

= 1,*455.88kN*

End Resistance (ER) = 600kN/m^2

Cross sectional Area (CA) = 0.283m^2 (d = 0.6m)

Pile capacity due to end resistance (ER x CA) = 600 x 0.283 = ***169.80kN***

Total pile capacity (SF + ER) = 1455.88 + 169.80

= ***1625.68kN***

Safe pile capacity = 1625.88/3 = **542*kN***

The diameter of the pile is considered for 600mm and 1000mm.

Table 6a: Safe Load Capacity for Pile (600mm Diameter)

Boring No.	K_S	γ_b	Depth of boring (m)	Tan Ø	Pi (π)	Pile Diameter (m)	Pile length (m)	Skin friction (KN)	A_b (m^2)	End Resistance (KN/m^2)	Total Pile Capacity (KN)	Safe Pile Capacity FOS=3.0 (KN)
BH 1	1.0	6.73	15	0.510	3.142	0.6	15	1455.88	0.283	600	1625.68	542
BH 2	1.0	6.45	15	0.554	3.142	0.6	15	1515.69	0.283	360	1617.57	539
BH 3	1.0	6.64	15	0.532	3.142	0.6	15	1498.37	0.283	340	1594.59	531

FOS=Factor of Safety

Table 6b: Safe Load Capacity for Pile (1000mm Diameter)

Boring No.	K_S	γ_b	Depth of boring (m)	Tan Ø	Pi (π)	Pile Diameter (m)	Pile length (m)	Skin friction (KN)	A_b (m^2)	End Resistance (KN/m^2)	Total Pile Capacity (KN)	Safe Pile Capacity FOS=3.0 (KN)
BH 1	1.0	6.73	15	0.510	3.142	1.0	15	2426.46	0.785	600	2897.47	966
BH 2	1.0	6.45	15	0.554	3.142	1.0	15	2526.14	0.785	360	2808.74	936
BH 3	1.0	6.64	15	0.532	3.142	1.0	15	2497.29	0.785	340	2764.19	921

FOS=Factor of Safety

9.0 FOUNDATION DISCUSSION AND RECOMMENDATIONS

9.1 DISCUSSION

The total depth explored in the entire 3No test bores is 30.0m. These consist of sands and clay, subsoil, these were observed between 0.05 – 30.0m with bearing pressure of 20 – 800kN/m^2.

The ground water levels were observed to at depth of 2.20 – 2.30m.

The standard penetration test (SPT) revealed that the subsoil at the site has average bearing pressure at the shallow depth but was observe to be varying with depth and strata formation as shown in Appendix B.

9.2 RECOMMENDATIONS

* The recommendations as contained in this report are based on careful correlation and interpretation of the results of the field results and analyses.
* The settlement at 3.0m is between 22.31mm and it decreases with depth based on the imposed load on the foundation;
* The materials encountered at site within the explored depths of 0.0-30.0 are predominantly sands and clay; therefore considering the nature of the subsoil at the boring locations at a depth of between 1.0-.3.0m the foundations of the various structures are recommended as follows;

Transformer Base and Other Installations

The foundation of the structures and plants should be ***CELLULAR RAFT FOUNDATION*** at depth of ***2.0 – 2.50m*** below the existing ground level; considering ultimate bearing capacity values of 90 - 240kN/m^2 at that depth.

Alternatively depending on the loading combinations of the structures ***DRIVEN PILES OR BORED PILES*** which could are ***CAST IN PLACE PILES*** at depth of ***15 - 20m*** from the existing ground level could be adopted.

Non Load Bearing Structures

Considering the bearing capacity values of 90 - 110kN/m^2 at depth of 1.50m, the foundation of the building should be ***GROUND BEAMS*** at depth of ***1.5m*** below the existing ground level.

* Due to the depth of water table level observed at the depth of about 2.20 – 2.30m, ***TANKING MATERIAL*** should be utilized at the hardcore level (DPC) to prevent the ingress of water at the foundation base.

As result of the high ground water observed at the depth of 2.20 – 2.30m provision should be made to dewater the site to a safe level to allow for ease of foundation construction. Adequate drainage and pumping methods should be provided around the site to drain away the water during

and after construction.

* The chemical tests on the water in soil samples confirmed the sulphate and chloride content of between 171.21 – 187.08g/l and 285.03 – 292.45mg/l respectively with pH values from 6.63 – 6.71 which is considered slightly acidic with moderate sulphate and chloride content. Therefore, Ordinary Portland Cement with cement content not less than 370kg/m^3 and maximum water cement-ratio of 0.40 could be used.

Table 7: Summary of Foundation Recommendations

Locations	Recommendations	Bearing Capacity Values (KN/m^2)
Transformer Base and Other Installations	***CELLULAR RAFT FOUNDATION*** at depth of ***2.0 - 2.50m*** below existing ground level. Alternatively depending on the loading combinations of the structures ***DRIVEN PILES*** or ***BORED PILES*** which could are ***CAST IN PLACE PILES*** at depth of ***15 - 20m***	90 – 240kN/m^2 at depth of 2.0 - 3.0m
Non Load Bearing Structures	***GROUND BEAMS*** at depth of ***1.5m*** below existing ground level	90 – 110kN/m^2 at depth of 1.5 - 2.0m

KURUGH HART ACHAGH
Civil Engineer
Bezaleel + Turnkey Contractors Inc.
77, Carey Street Monrovia, Liberia

ENGR. M. SHITTU
(Consulting Civil & Geotechnical Engineers)
No 12A Nuhu Bamali Close,
Off Gwamna Road, Kaduna

ATTACHMENT

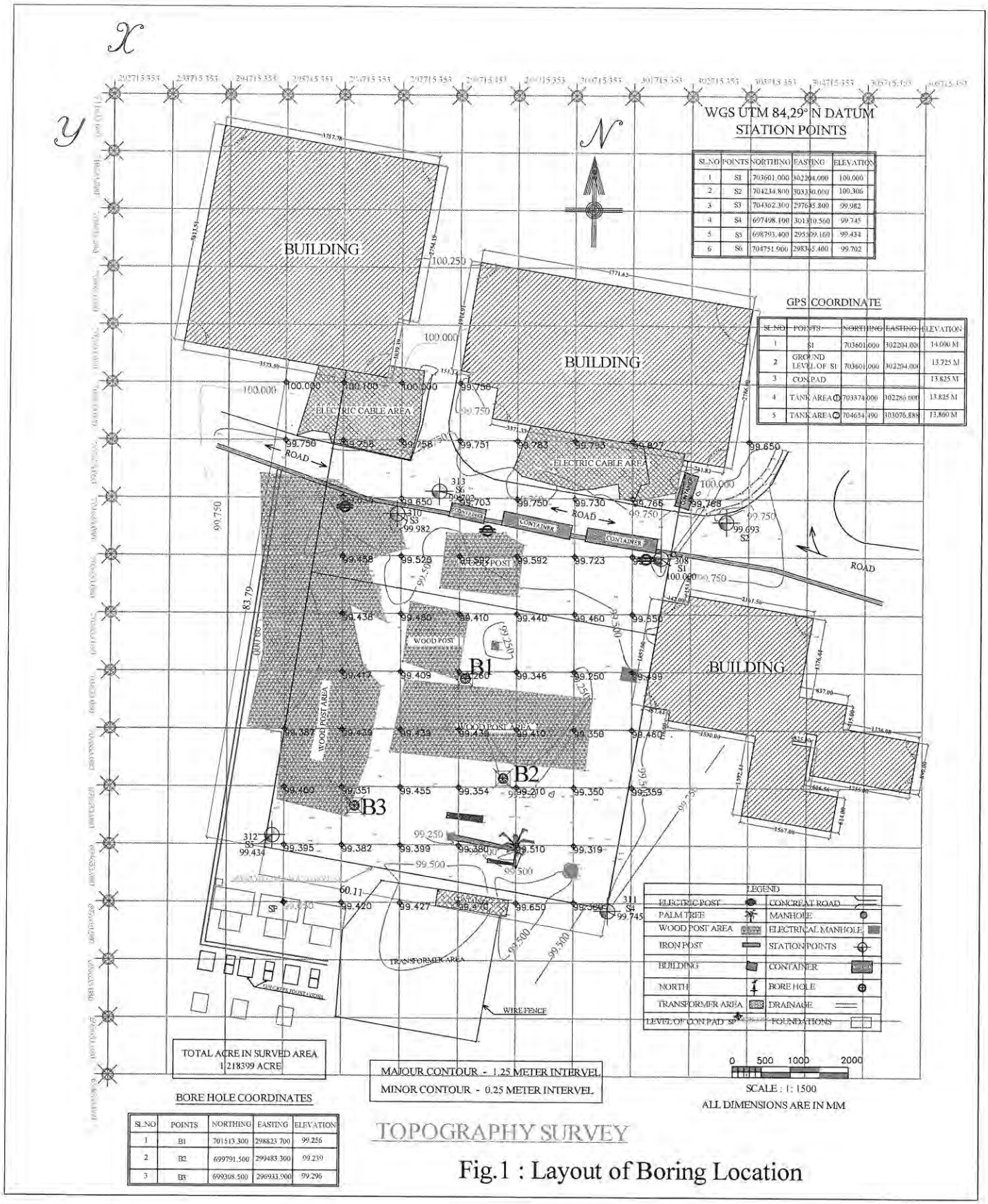


Fig.1 : Layout of Boring Location

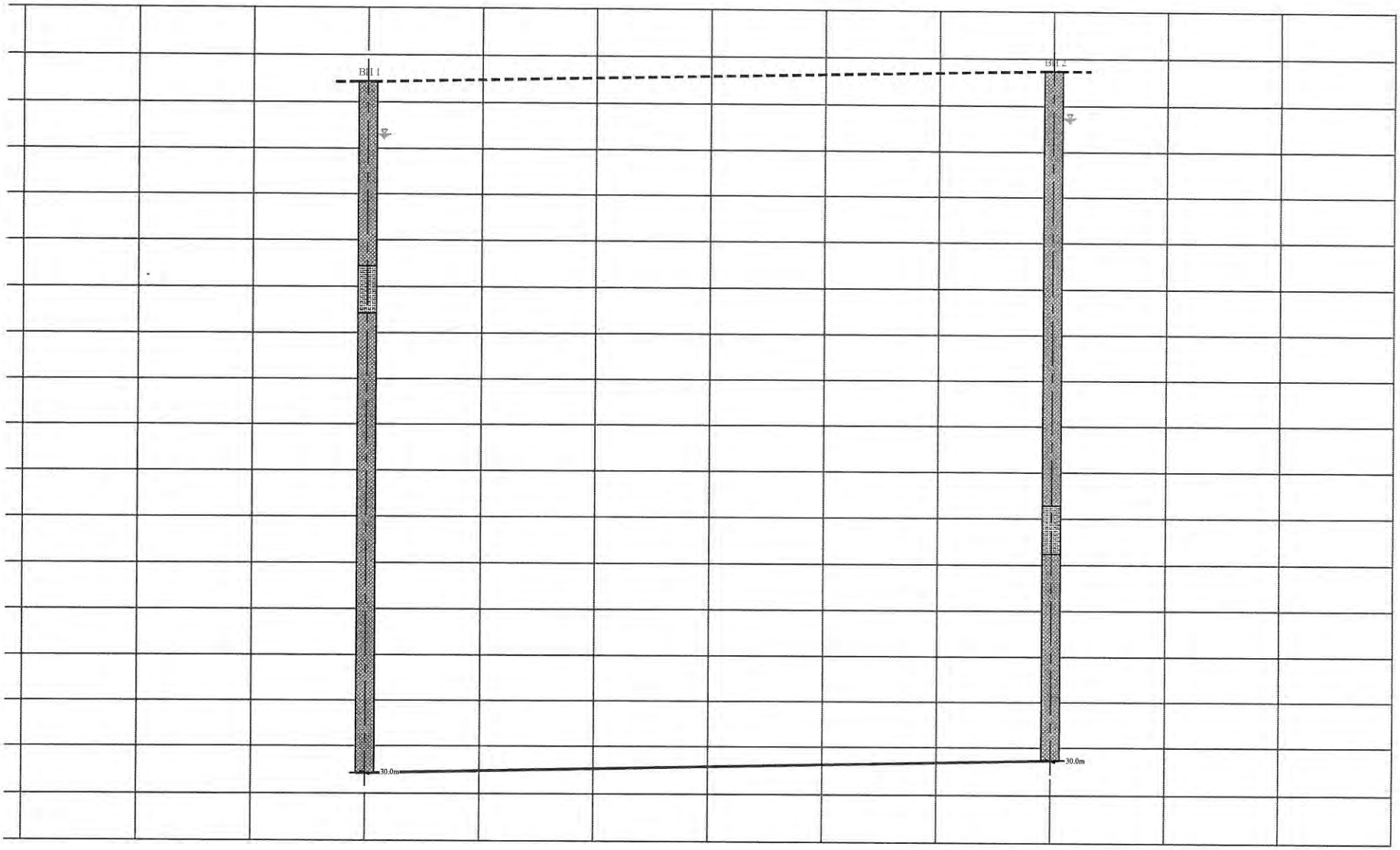


Fig. 2: Soil Profile (1 - 2)

Bezaleel + Turnkey Contractors,Inc.

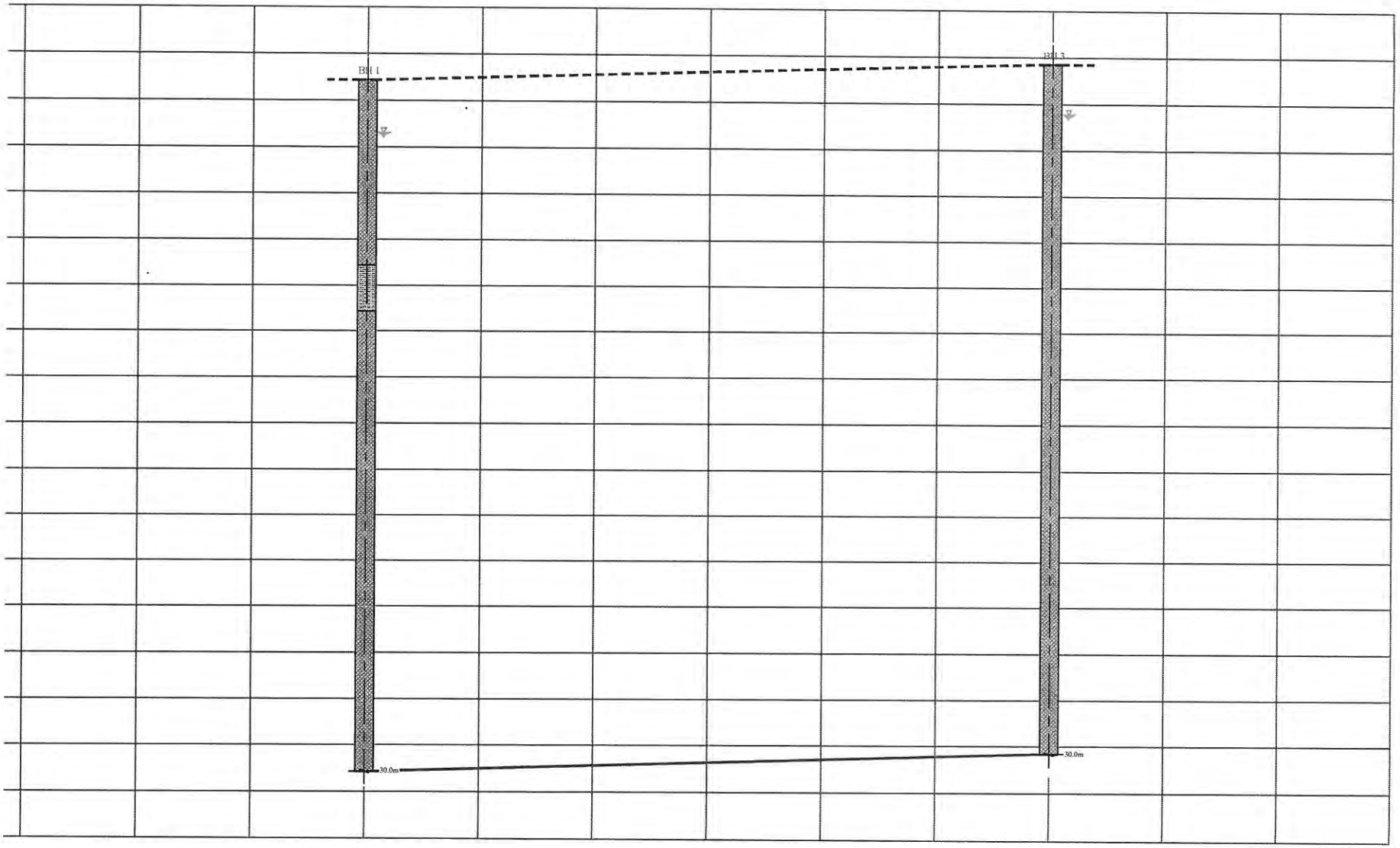


Fig. 3: Soil Profile (1 - 3)

Bezaleel + Turnkey Contractors,Inc.

APPENDIX A

STANDARD PENETRATION TEST: FIELD RESULT

Start date: 11/03/2012 **End date: 12/03/2012**

PROJECT: Proposed Construction of New Power House and New Subsation at Bushrod Island Power Station, Monrovia, Liberia.

BORING: BH 1

RIG: Mobile Drill Rig

STATION:

METHOD OF BORING: Rotary

CA SIZE : 4"

DRILLER: Mohammed

FIELD TECHNICIAN: Ahmed

WL = 2.30m

Depth (m)	Number of Blows at 0.15 m interval	Description of Layer
0.00 - 0.60	2, 2, 2	Brownish loose organic top soil
1.5 - 2.1	3, 5, 6	Greyish medium dense SAND
3.0 - 3.6	9, 11, 13	Brownish medium dense fine SAND
4.5 - 5.1	10, 13, 16	Brownish medium dense fine SAND
6.0 - 6.6	11, 8, 8	Brownish medium dense coarse SAND
7.5 - 8.1	8, 14, 18	Brownish dense coarse SAND
9 - 9.6	2, 4, 8	Greyish stiff CLAY
10.5 - 11.1	9, 28, 20	Brownish dense coarse SAND
12 - 12.6	10, 32, 48	Brownish very dense coarse SAND
13.5 - 14.1	11, 28, 34	Brownish very dense coarse SAND
15 - 15.6	11, 28, 32	Brownish very dense fine SAND
16.5 - 17.1	12, 30, 42	Brownish very dense fine SAND
18.0 - 18.6	12, 21, 29	Brownish very dense coarse SAND
19.5 - 20.1	13, 22, 27	Brownish dense fine SAND

APPENDIX A

STANDARD PENETRATION TEST: FIELD RESULT

Start date: 11/03/2012 End date: **12/03/2012**

PROJECT: Proposed Construction of New Power House and New Subsation at Bushrod Island Power Station, Monrovia, Liberia.
RIG: Mobile Drill Rig
METHOD OF BORING: Rotary
DRILLER: Mohammed

BORING: BH 1 Cont'd
STATION:
CA SIZE : 4"
FIELD TECHNICIAN: Ahmed

Depth (m)	Number of Blows at 0.15 m interval	Description of Layer
21.0 - 21.6	18, 21, 32	Brownish very dense fine SAND
22.5 - 23.1	19, 28, 30	Brownish very dense fine SAND
24.0 - 24.6	11, 18, 21	Brownish dense SAND
25.5 - 26.1	14, 21, 30	Brownish very dense fine SAND
27.0 - 27.6	18, 21, 33	Brownish very dense SAND
28.5 - 29.1	15, 28, 39	Brownish very dense SAND
30.0 - 30.6	21, 32, 48	Brownish very dense SAND
31.5 - 32.1		
33.0 - 33.6		
34.5 - 35.1		
36.0 - 36.6		
37.5 - 38.1		
39.0 - 39.6		
40.5 - 41.1		

APPENDIX A

STANDARD PENETRATION TEST: FIELD RESULT

PROJECT: Proposed Construction of New Power House and New Subsation at Bushrod Island Power Station, Monrovia, Liberia.

Start date: 13/03/2012 **End date: 14/03/2012**

RIG: Mobile Drill Rig
METHOD OF BORING: Rotary
DRILLER: Mohammed

BORING: BH 2
STATION:
CA SIZE : 4"
FIELD TECHNICIAN: Ahmed

WL = 2.20m

Depth (m)	Number of Blows at 0.15 m interval	Description of Layer
0.00 - 0.60	1, 2, 2	Loose fill material
1.5 - 2.1	4, 6, 5	Greyish medium dense fine grain SAND
3.0 - 3.6	6, 9, 7	Brownish grey medium dense fine SAND
4.5 - 5.1	8, 11, 14	Brownish grey medium dense fine SAND
6.0 - 6.6	7, 8, 9	Brownish medium dense coarse SAND
7.5 - 8.1	9, 11, 12	Brownish medium dense coarse SAND
9 - 9.6	10, 13, 10	Brownish medium dense fine SAND
10.5 - 11.1	13, 18, 21	Brownish red dense fine SAND
12 - 12.6	14, 17, 23	Brownish dense fine SAND
13.5 - 14.1	11, 18, 22	Brownish red dense fine SAND
15 - 15.6	19, 17, 19	Greyish dense fine SAND
16.5 - 17.1	14, 18, 21	Brownish dense fine SAND
18.0 - 18.6	11, 21, 24	Brownish dense fine SAND
19.5 - 20.1	8, 10, 12	Greyish very stiff CLAY

APPENDIX A

STANDARD PENETRATION TEST: FIELD RESULT

PROJECT: Proposed Construction of New Power House and New Subsation at Bushrod Island Power Station, Monrovia, Liberia.
RIG: Mobile Drill Rig
METHOD OF BORING: Rotary
DRILLER: Mohammed

Start date: 13/03/2012 **End date: 14/03/2012**
BORING: BH 2 Cont'd
STATION:
CA SIZE : 4"
FIELD TECHNICIAN: Ahmed

Depth (m)	Number of Blows at 0.15 m interval	Description of Layer
21.0 - 21.6	16, 22, 24	Brownish dense coarse SAND
22.5 - 23.1	18, 23, 21	Brownish dense coarse SAND
24.0 - 24.6	16, 24, 28	Brownish very dense fine grain SAND
25.5 - 26.1	11, 18, 21	Brownish dense fine grain SAND
27.0 - 27.6	13, 21, 24	Brownish dense fine SAND
28.5 - 29.1	18, 25, 32	Brownish very dense SAND
30.0 - 30.6	19, 24, 30	Brownish very dense SAND
31.5 - 32.1		
33.0 - 33.6		
34.5 - 35.1		
36.0 - 36.6		
37.5 - 38.1		
39.0 - 39.6		
40.5 - 41.1		

APPENDIX A

STANDARD PENETRATION TEST: FIELD RESULT

PROJECT: Proposed Construction of New Power House and New Subsation at Bushrod Island Power Station, Monrovia, Liberia.
Start date: 16/03/2012 **End date: 17/03/2012**
RIG: Mobile Drill Rig
METHOD OF BORING: Rotary
DRILLER: Mohammed
BORING: BH 3
STATION:
CA SIZE : 4"
FIELD TECHNICIAN: Ahmed

WL = 2.30m

Depth (m)	Number of Blows at 0.15 m interval	Description of Layer
0.00 - 0.60	1, 1, 1	Brownish loose fill material
1.5 - 2.1	3, 5, 4	Dark brownish loose fine SAND
3.0 - 3.6	5, 8, 6	Dark brownish medium dense fine SAND
4.5 - 5.1	9, 10, 13	Brownish medium dense fine SAND
6.0 - 6.6	8, 9, 10	Brownish medium dense coarse SAND
7.5 - 8.1	7, 12, 15	Brownish medium dense coarse SAND
9 - 9.6	11, 14, 9	Brownish medium dense fine SAND
10.5 - 11.1	12, 17, 20	Brownish red medium dense fine SAND
12 - 12.6	13, 18, 24	Brownish dense fine SAND
13.5 - 14.1	10, 17, 20	Brownish dense fine SAND
15 - 15.6	18, 16, 18	Brownish dense fine SAND
16.5 - 17.1	13, 17, 20	Reddish brown dense fine SAND
18.0 - 18.6	11, 21, 25	Brownish red dense fine SAND
19.5 - 20.1	11, 18, 21	Brownish dense fine SAND

APPENDIX A

STANDARD PENETRATION TEST: FIELD RESULT

PROJECT: Proposed Construction of New Power House and New Subsation at Bushrod Island Power Station, Monrovia, Liberia.
RIG: Mobile Drill Rig
METHOD OF BORING: Rotary
DRILLER: Mohammed

Start date: 16/03/2012 **End date: 17/03/2012**
BORING: BH 3 Cont'd
STATION:
CA SIZE : 4"
FIELD TECHNICIAN: Ahmed

Depth (m)	Number of Blows at 0.15 m interval	Description of Layer
21.0 - 21.6	15, 21, 23	Brownish dense fine SAND
22.5 - 23.1	17, 22, 20	Brownish dense fine SAND
24.0 - 24.6	15, 20, 24	Brownish dense fine SAND
25.5 - 26.1	11, 21, 24	Brownish dense fine SAND
27.0 - 27.6	14, 22, 25	Brownish dense fine SAND
28.5 - 29.1	18, 26, 29	Brownish very dense SAND
30.0 - 30.6	19, 25, 29	Brownish very dense SAND
31.5 - 32.1		
33.0 - 33.6		
34.5 - 35.1		
36.0 - 36.6		
37.5 - 38.1		
39.0 - 39.6		
40.5 - 41.1		

Bezaleel + Turnkey Contractors,Inc.

FIGURE: APPENDIX B
BORING: BH 1
STATION:
DATE: MARCH, 2012.

PROJECT: PROPOSED STRUCTURES FOR LEC EXPANSION, BUSHROD ISLAND, MONROVIA, LIBERIA.

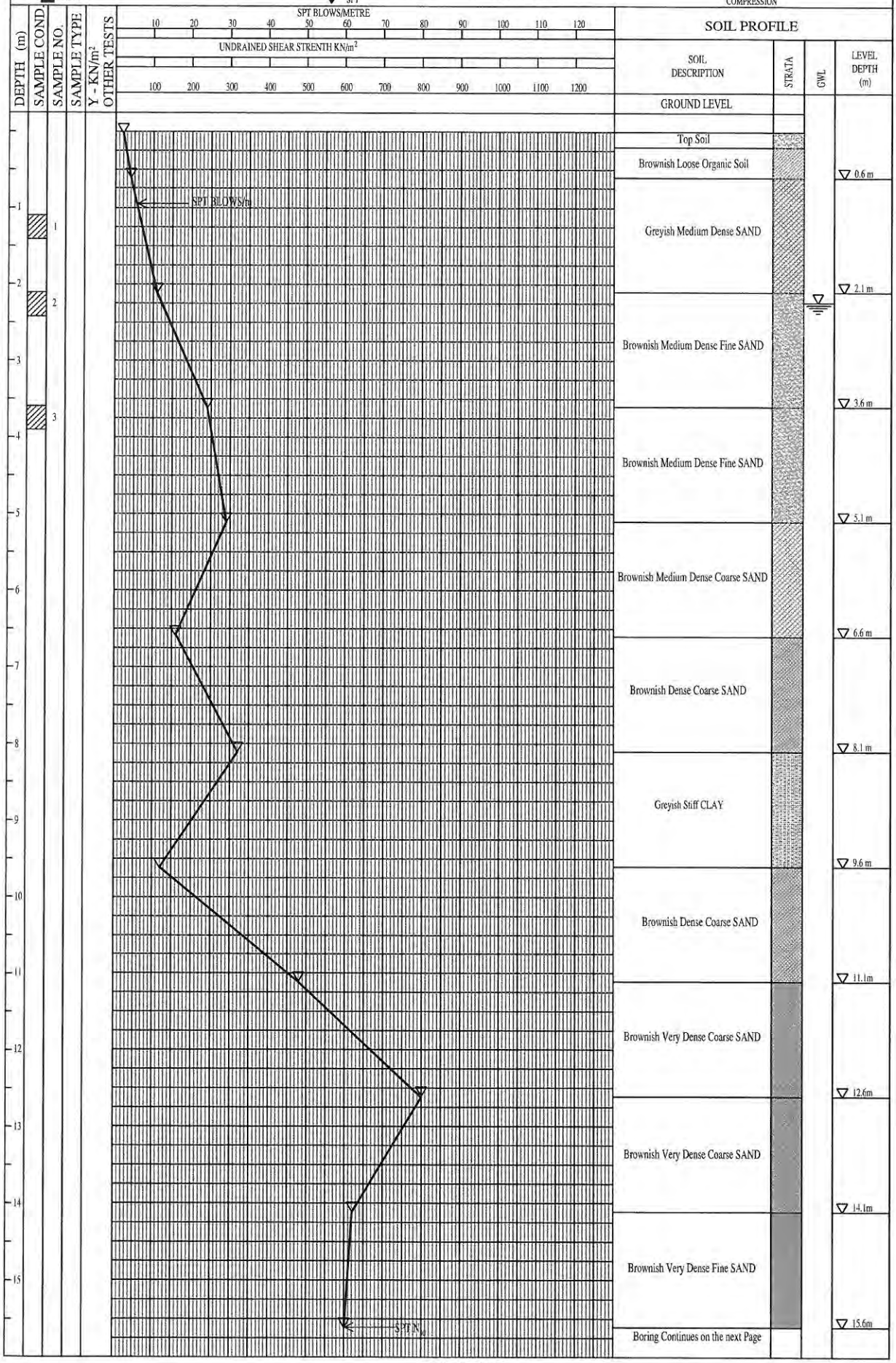
DRILLER: MOHAMMED SPOON OD: 1 1/2" CASING SIZE: 4" CORE SIZE: 2"

SAMPLE CONDITION
- UNDISTURBED
- DISTURBED
- LOST

SAMPLE TYPE
- A.S. AUGER
- S.S. SPLIT SPOON
- T.O. OPEN TUBE
- P.S. PISTON
- R.C. ROCK CORE

FIELD AND LABORATORY TESTS
- + INSITU-VANE UNDIST
- × INSITU-VANE REMOULDED
- ● WATER CONTENT
- ATTERBERG LIMITS
- UNDRAINED COMPRESSION
- SPT
- G GRAIN SIZE
- C CONSOLIDATION
- U UNCONFINED
- Q UNDRAINED TRIAXIAL
- Y WET UNIT WEIGHT

4 - 0%
13 - 0 - 5%
10%
STRAIN AT FAILURE FOR UNDRAINED COMPRESSION



SITECH ENGINEERING LIMITED

FIGURE: APPENDIX B
BORING: BH 1 Cont'd
STATION:
DATE: MARCH, 2012.

PROJECT: PROPOSED STRUCTURES FOR LEC EXPANSION, BUSHROD ISLAND, MONROVIA, LIBERIA.

DRILLER: MOHAMMED SPOON OD: 1 1/2" CASING SIZE: 4" CORE SIZE: 2"

SAMPLE CONDITION
- UNDISTURBED
- DISTURBED
- LOST

SAMPLE TYPE
- A.S. AUGER
- S.S. SPLIT SPOON
- T.O. OPEN TUBE
- P.S. PISTON
- R.C. ROCK CORE

FIELD AND LABORATORY TESTS
- + INSITU-VANE UNDIST
- × INSITU-VANE REMOULDED
- ● WATER CONTENT
- ⊢ ATTERBERG LIMITS
- O UNDRAINED COMPRESSION
- ▼ SPT
- G GRAIN SIZE
- C CONSOLIDATION
- U UNCONFINED
- Q UNDRAINED TRIAXIAL
- Y WET UNIT WEIGHT

4 - 0%
13 - 0 - 5%
10%
STRAIN AT FAILURE FOR UNDRAINED COMPRESSION

SPT BLOWS/METRE: 10 20 30 40 50 60 70 80 90 100 110 120

UNDRAINED SHEAR STRENTH KN/m²: 100 200 300 400 500 600 700 800 900 1000 1100 1200

DEPTH (m)	SAMPLE COND	SAMPLE NO.	SAMPLE TYPE	Y - KN/m²	OTHER TESTS	SOIL DESCRIPTION	STRATA	GWL	LEVEL DEPTH (m)
						GROUND LEVEL			
15.6									▽ 15.6 m
						Brownish Very Dense Fine SAND			
16.6									▽ 17.1 m
						Brownish Very Dense Coarse SAND			
17.6									▽ 18.6 m
18.6						Brownish Dense Coarse SAND			▽ 20.1 m
19.6									
20.6						Brownish Very Dense Fine SAND			▽ 21.6 m
21.6						Brownish Very Dense Fine SAND			▽ 23.1 m
22.6									
23.6						Brownish Dense SAND			▽ 24.6 m
24.6						Brownish Very Dense Fine SAND			▽ 26.1 m
25.6									
26.6						Brownish Very Dense SAND			▽ 27.6 m
27.6						Brownish Very Dense SAND			▽ 29.1 m
28.6									
29.6						Brownish Very Dense SAND			▽ 30.6 m
30.6						End of Boring			

Bezaleel + Turnkey Contractors Inc.

FIGURE: APPENDIX B
BORING: BH 2
STATION:
DATE: MARCH, 2012.

PROJECT: PROPOSED STRUCTURES FOR LEC EXPANSION, BUSHROD ISLAND, MONROVIA, LIBERIA.

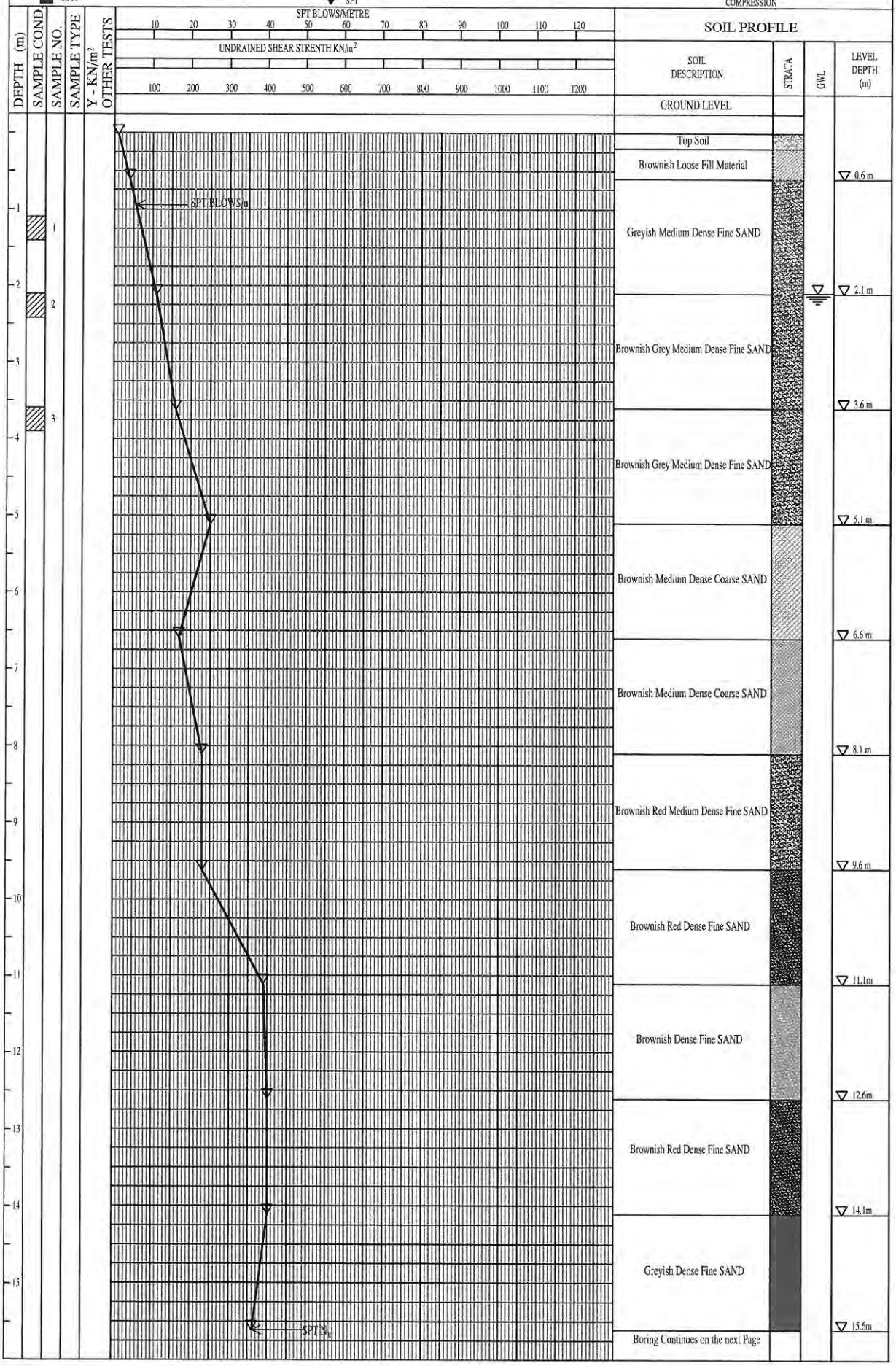
DRILLER: MOHAMMED SPOON OD: 1 1/2" CASING SIZE: 4" CORE SIZE: 2"

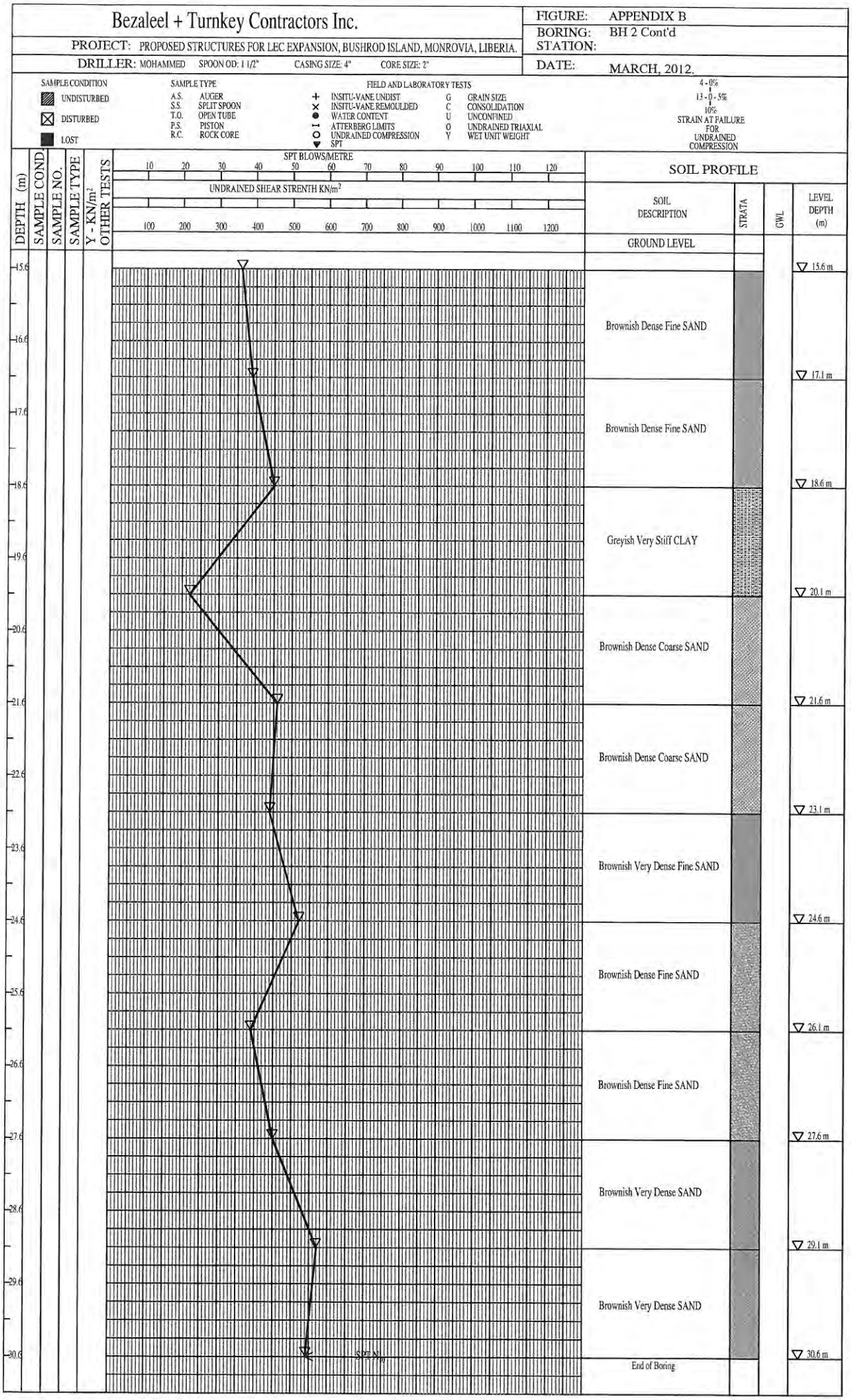
SAMPLE CONDITION: UNDISTURBED; DISTURBED; LOST

SAMPLE TYPE: A.S. AUGER; S.S. SPLIT SPOON; T.O. OPEN TUBE; P.S. PISTON; R.C. ROCK CORE

FIELD AND LABORATORY TESTS: + INSITU-VANE UNDIST; × INSITU-VANE REMOULDED; ● WATER CONTENT; O I ATTERBERG LIMITS; UNDRAINED COMPRESSION; ▼ SPT; G GRAIN SIZE; C CONSOLIDATION; U UNCONFINED; O UNDRAINED TRIAXIAL; Y WET UNIT WEIGHT

4 - 0%
13 - 0 - 5%
10%
STRAIN AT FAILURE FOR UNDRAINED COMPRESSION




Bezaleel + Turnkey Contractors Inc.
FIGURE: APPENDIX B
BORING: BH 2 Cont'd
STATION:
PROJECT: PROPOSED STRUCTURES FOR LEC EXPANSION, BUSHROD ISLAND, MONROVIA, LIBERIA.
DRILLER: MOHAMMED SPOON OD: 1 1/2" CASING SIZE: 4" CORE SIZE: 2"
DATE: MARCH, 2012.
SAMPLE CONDITION
UNDISTURBED
DISTURBED
LOST
SAMPLE TYPE
A.S. AUGER
S.S. SPLIT SPOON
T.O. OPEN TUBE
P.S. PISTON
R.C. ROCK CORE
FIELD AND LABORATORY TESTS
INSITU-VANE UNDIST
INSITU-VANE REMOULDED
WATER CONTENT
ATTERBERG LIMITS
UNDRAINED COMPRESSION
SPT
G GRAIN SIZE
C CONSOLIDATION
U UNCONFINED
Q UNDRAINED TRIAXIAL
Y WET UNIT WEIGHT
4 - 0%
13 - 0 - 5%
10%
STRAIN AT FAILURE FOR UNDRAINED COMPRESSION
DEPTH (m)
SAMPLE COND
SAMPLE NO.
SAMPLE TYPE
Y - KN/m²
OTHER TESTS
SPT BLOWS/METRE
10 20 30 40 50 60 70 80 90 100 110 120
UNDRAINED SHEAR STRENTH KN/m²
100 200 300 400 500 600 700 800 900 1000 1100 1200
SOIL PROFILE
SOIL DESCRIPTION
STRATA
GWL
LEVEL DEPTH (m)
GROUND LEVEL
15.6 m
Brownish Dense Fine SAND
17.1 m
Brownish Dense Fine SAND
18.6 m
Greyish Very Stiff CLAY
20.1 m
Brownish Dense Coarse SAND
21.6 m
Brownish Dense Coarse SAND
23.1 m
Brownish Very Dense Fine SAND
24.6 m
Brownish Dense Fine SAND
26.1 m
Brownish Dense Fine SAND
27.6 m
Brownish Very Dense SAND
29.1 m
Brownish Very Dense SAND
30.6 m
End of Boring
15.6
16.6
17.6
18.6
19.6
20.6
21.6
22.6
23.6
24.6
25.6
26.6
27.6
28.6
29.6
30.6
SPT N₆₀

Bezaleel + Turnkey Contractors Inc.

FIGURE: APPENDIX B
BORING: BH 3
STATION:
DATE: MARCH, 2012.

PROJECT: PROPOSED STRUCTURES FOR LEC EXPANSION, BUSHROD ISLAND, MONROVIA, LIBERIA.

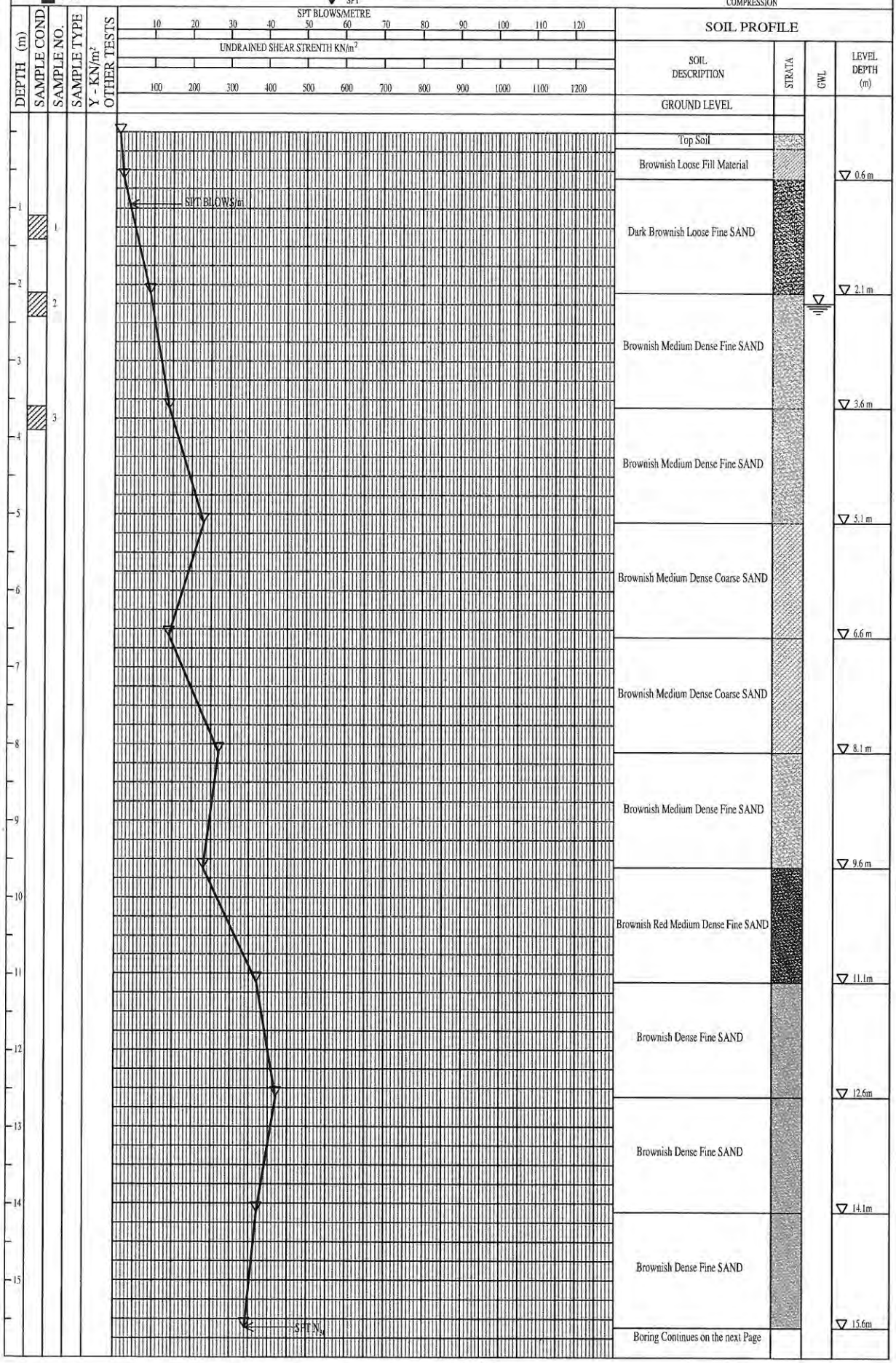
DRILLER: MOHAMMED SPOON OD: 1 1/2" CASING SIZE: 4" CORE SIZE: 2"

SAMPLE CONDITION
- UNDISTURBED
- DISTURBED
- LOST

SAMPLE TYPE
- A.S. AUGER
- S.S. SPLIT SPOON
- T.O. OPEN TUBE
- P.S. PISTON
- R.C. ROCK CORE

FIELD AND LABORATORY TESTS
- + INSITU-VANE UNDIST
- × INSITU-VANE REMOULDED
- ● WATER CONTENT
- ⊢ ATTERBERG LIMITS
- ○ UNDRAINED COMPRESSION
- ▼ SPT
- G GRAIN SIZE
- C CONSOLIDATION
- U UNCONFINED
- Q UNDRAINED TRIAXIAL
- Y WET UNIT WEIGHT

4 - 0%
13 - 0 - 5%
10%
STRAIN AT FAILURE FOR UNDRAINED COMPRESSION



Bezaleel + Turnkey contractors,Inc.

FIGURE: APPENDIX B
BORING: BH 3 Cont'd
STATION:
DATE: MARCH, 2012.

PROJECT: PROPOSED STRUCTURES FOR LEC EXPANSION, BUSHROD ISLAND, MONROVIA, LIBERIA.

DRILLER: MOHAMMED SPOON OD: 1 1/2" CASING SIZE: 4" CORE SIZE: 2"

SAMPLE CONDITION
- UNDISTURBED
- DISTURBED
- LOST

SAMPLE TYPE
- A.S. AUGER
- S.S. SPLIT SPOON
- T.O. OPEN TUBE
- P.S. PISTON
- R.C. ROCK CORE

FIELD AND LABORATORY TESTS
- + INSITU-VANE UNDIST
- × INSITU-VANE REMOULDED
- ● WATER CONTENT
- ⊢ ATTERBERG LIMITS
- ○ UNDRAINED COMPRESSION
- ▼ SPT
- G GRAIN SIZE
- C CONSOLIDATION
- U UNCONFINED
- Q UNDRAINED TRIAXIAL
- Y WET UNIT WEIGHT

4 - 0%
13 - 0 - 5%
10%
STRAIN AT FAILURE FOR UNDRAINED COMPRESSION

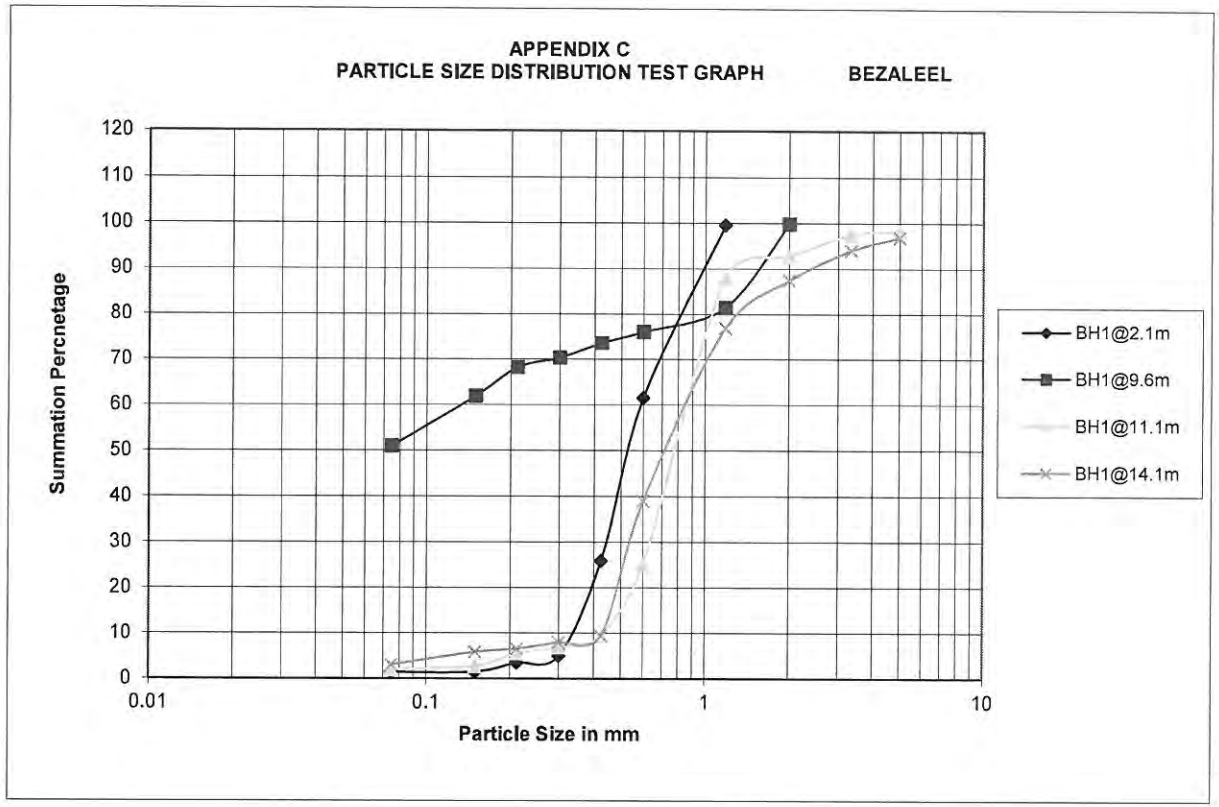
SPT BLOWS/METRE: 10 20 30 40 50 60 70 80 90 100 110 120

UNDRAINED SHEAR STRENTH KN/m²: 100 200 300 400 500 600 700 800 900 1000 1100 1200

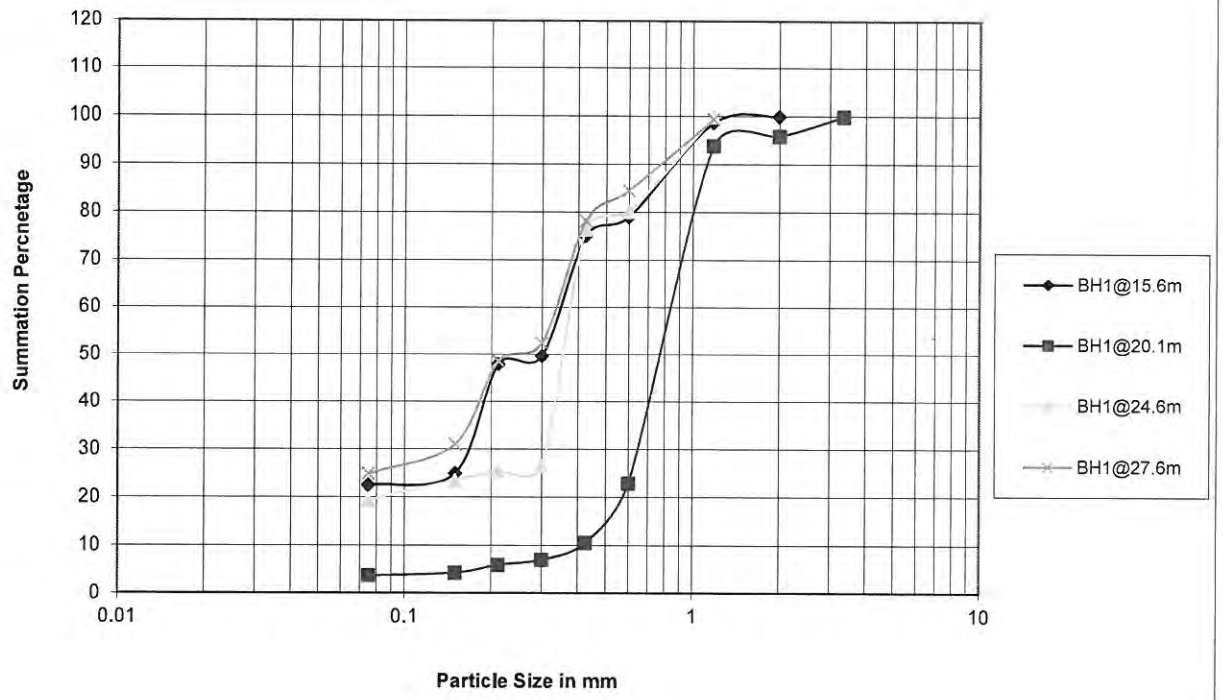
DEPTH (m)	SAMPLE COND	SAMPLE NO.	SAMPLE TYPE	Y - KN/m²	OTHER TESTS	SOIL DESCRIPTION	STRATA	GWL	LEVEL DEPTH (m)
						SOIL PROFILE			
						GROUND LEVEL			
15.6									▽ 15.6 m
						Reddish Brown Dense Fine SAND			
16.6									▽ 17.1 m
						Brownish Red Dense Fine SAND			
17.6									▽ 18.6 m
18.6						Brownish Dense Fine SAND			▽ 20.1 m
19.6									
20.6						Brownish Dense Fine SAND			▽ 21.6 m
21.6						Brownish Dense Fine SAND			▽ 23.1 m
22.6									
23.6						Brownish Dense Fine SAND			▽ 24.6 m
24.6						Brownish Dense Fine SAND			▽ 26.1 m
25.6									
26.6						Brownish Dense Fine SAND			▽ 27.6 m
27.6						Brownish Very Dense SAND			▽ 29.1 m
28.6									
29.6						Brownish Very Dense SAND			▽ 30.6 m
30.6						End of Boring			

SPT N=70

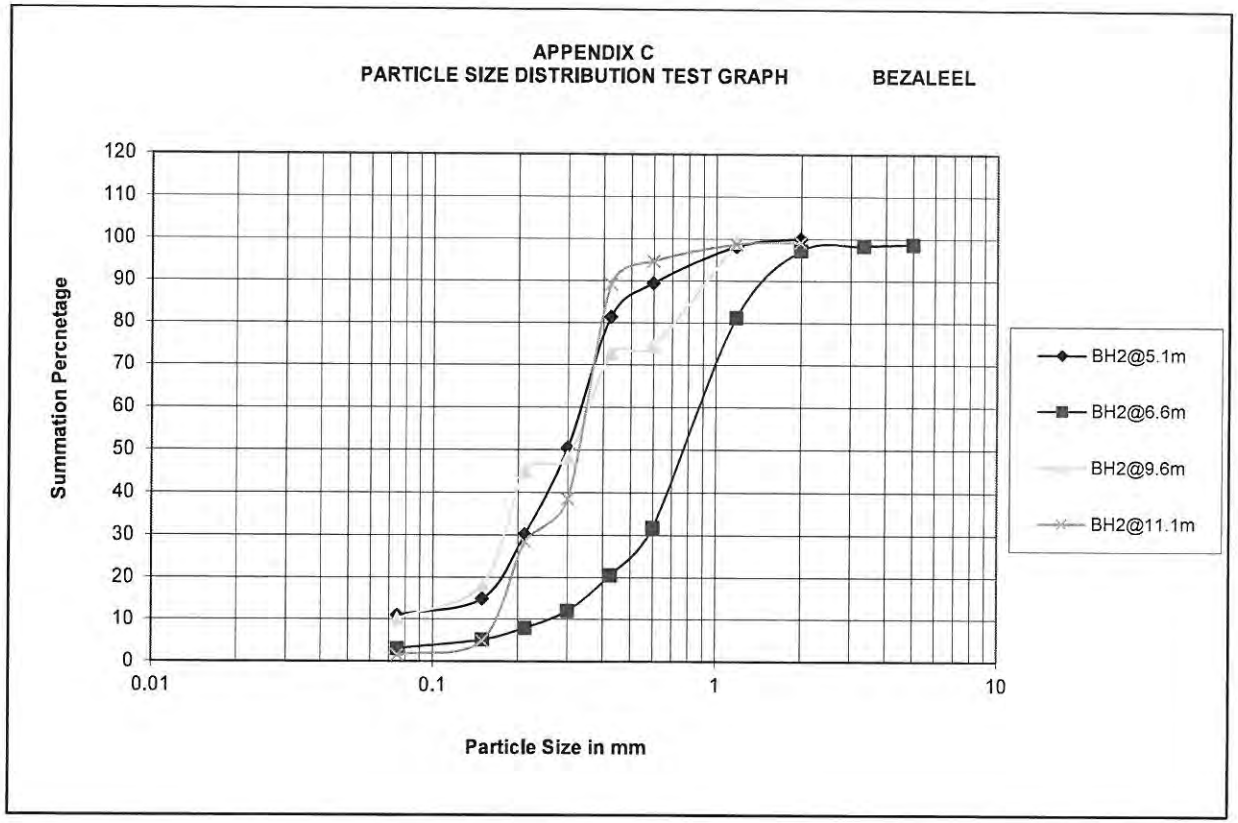
APPENDIX C
PARTICLE SIZE DISTRIBUTION TEST GRAPH BEZALEEL



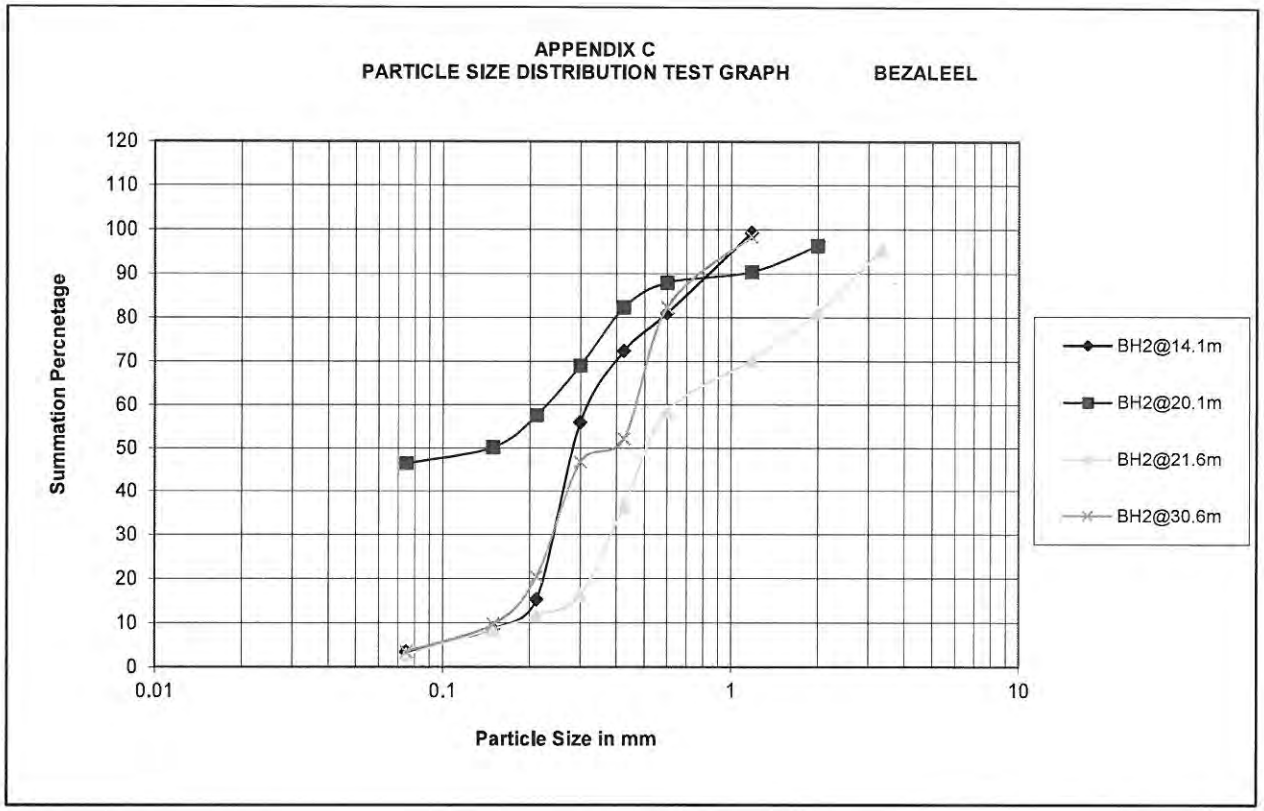
APPENDIX C
PARTICLE SIZE DISTRIBUTION TEST GRAPH BEZALEEL



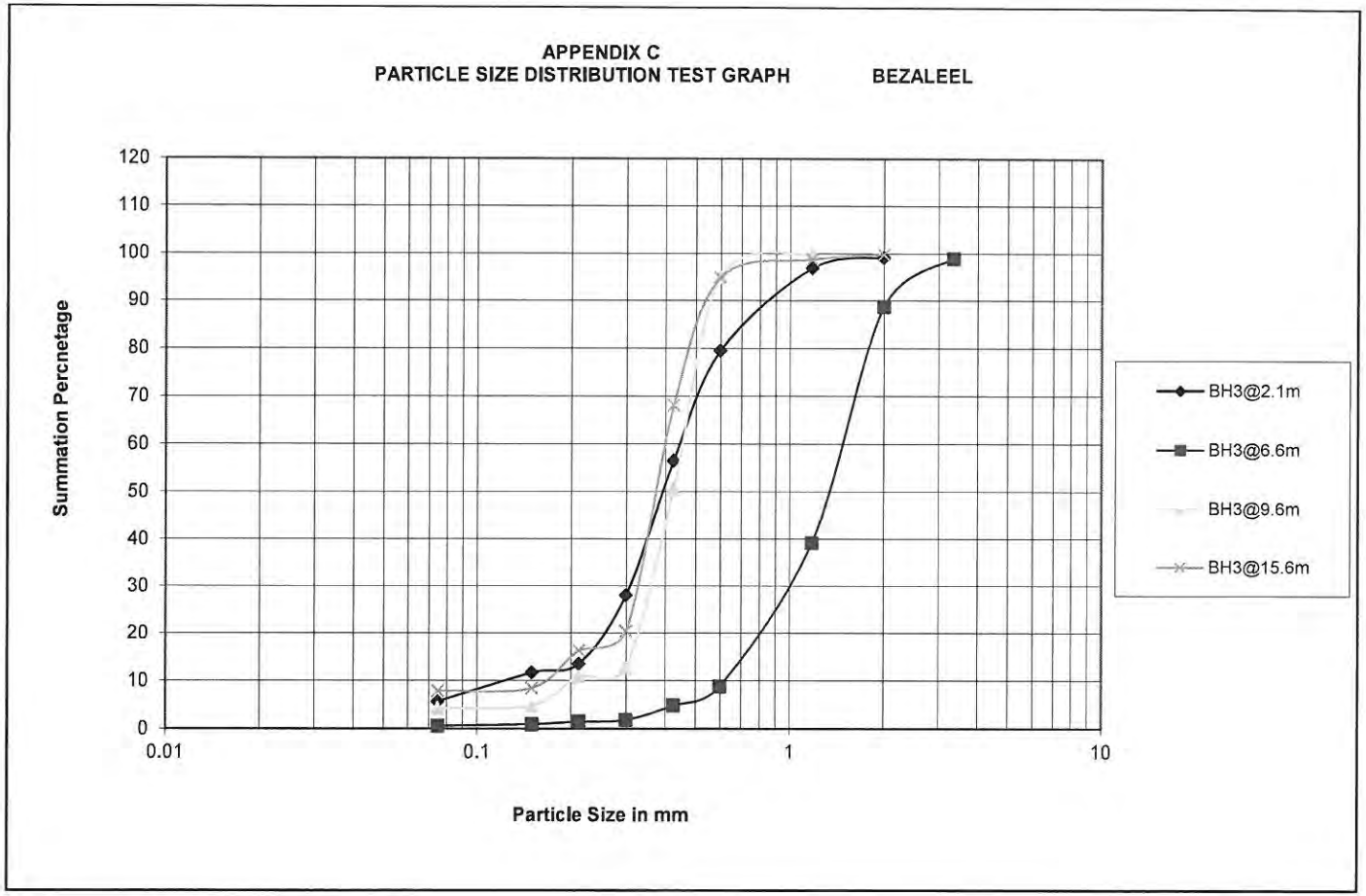
APPENDIX C
PARTICLE SIZE DISTRIBUTION TEST GRAPH **BEZALEEL**

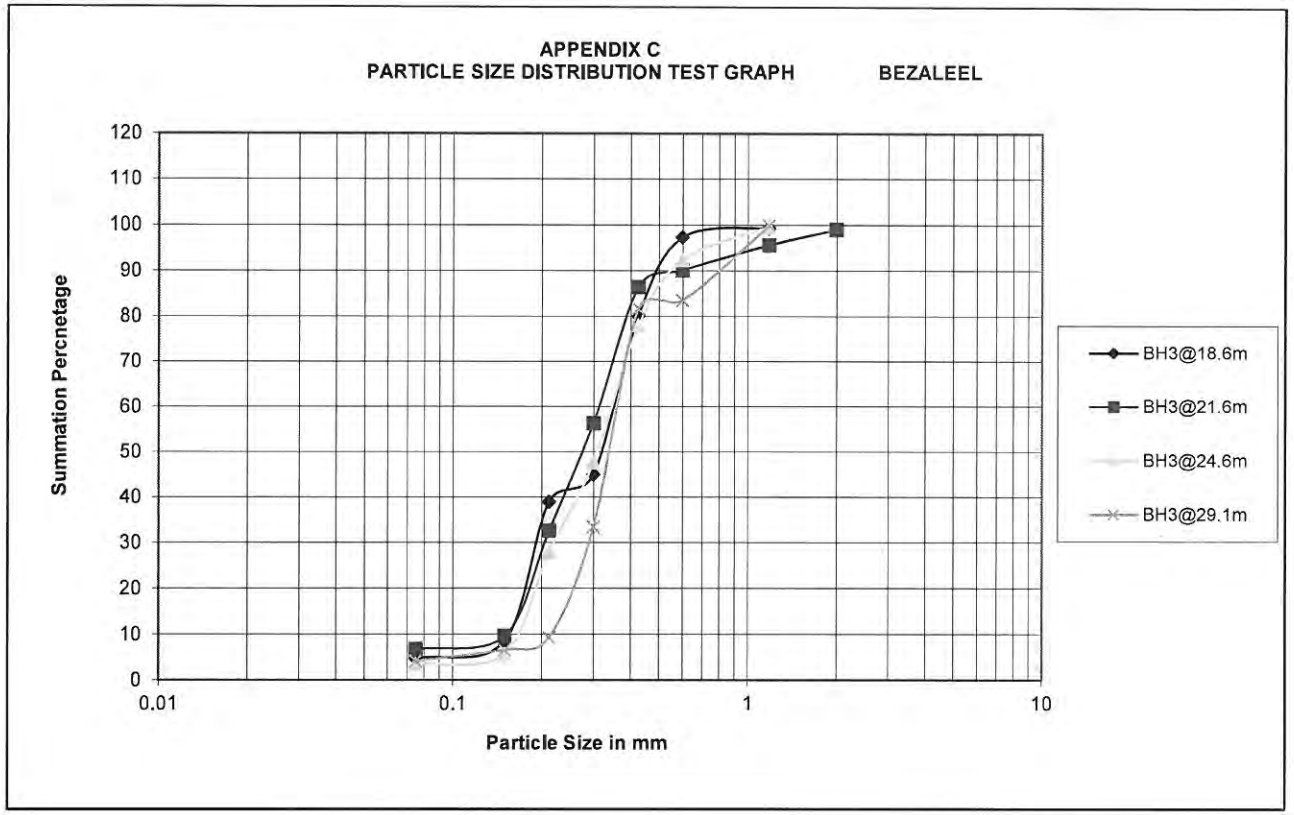


APPENDIX C
PARTICLE SIZE DISTRIBUTION TEST GRAPH **BEZALEEL**

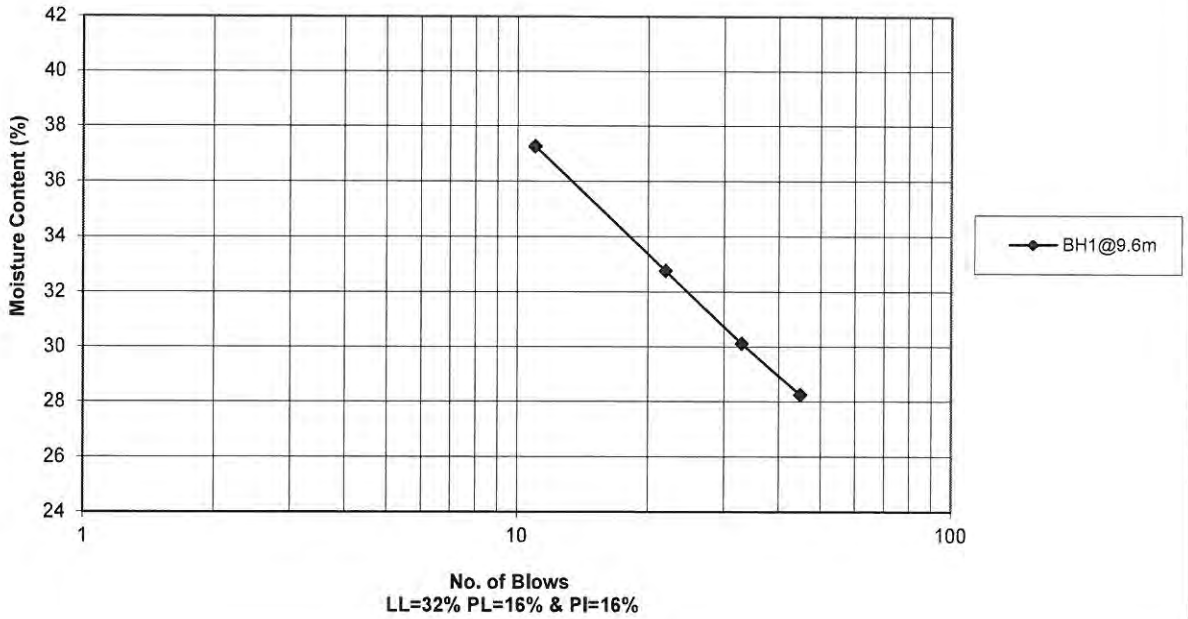


APPENDIX C
PARTICLE SIZE DISTRIBUTION TEST GRAPH BEZALEEL

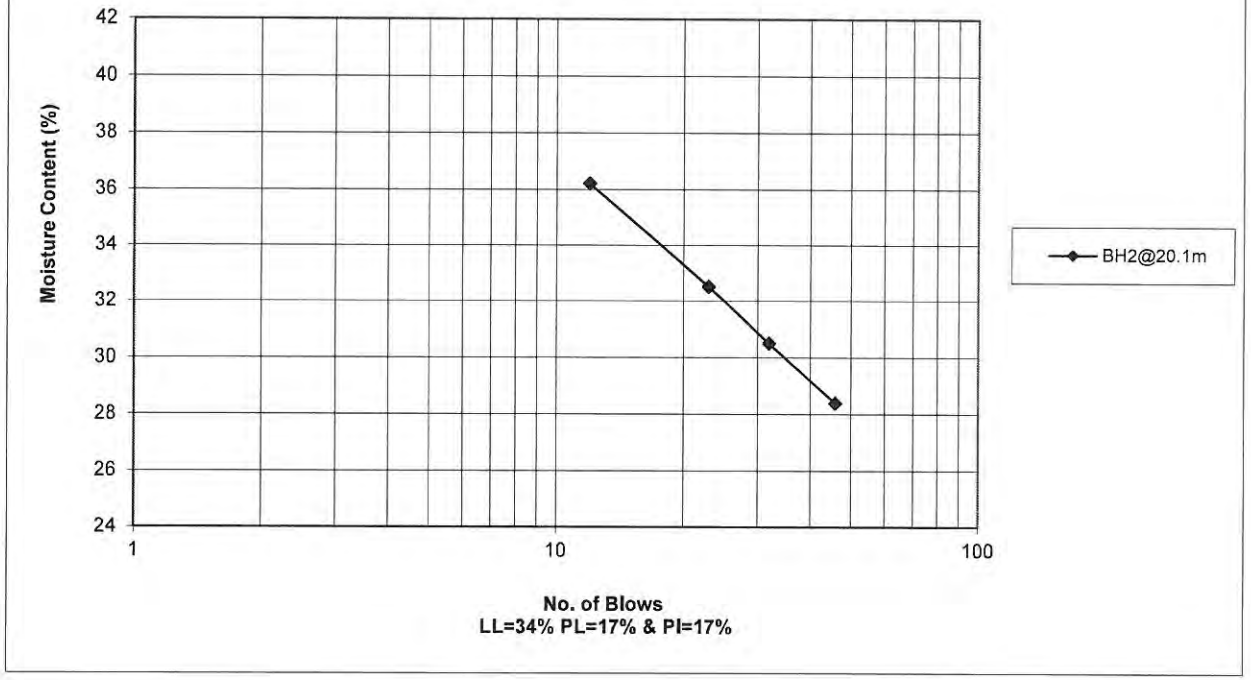



APPENDIX C
PARTICLE SIZE DISTRIBUTION TEST GRAPH
BEZALEEL
Summation Percnetage
120
110
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
Particle Size in mm
BH3@18.6m
BH3@21.6m
BH3@24.6m
BH3@29.1m

APPENDIX D
ATTERBERG LIMITS TEST GRAPH **BEZALEEL**



APPENDIX D
ATTERBERG LIMITS TEST GRAPH **BEZALEEL**



Ref: BS 1377 (1990)

Bezaleel + Turnkey Contractors

UNDRAINED DIRECT SHEAR BOX TEST

APPENDIX E

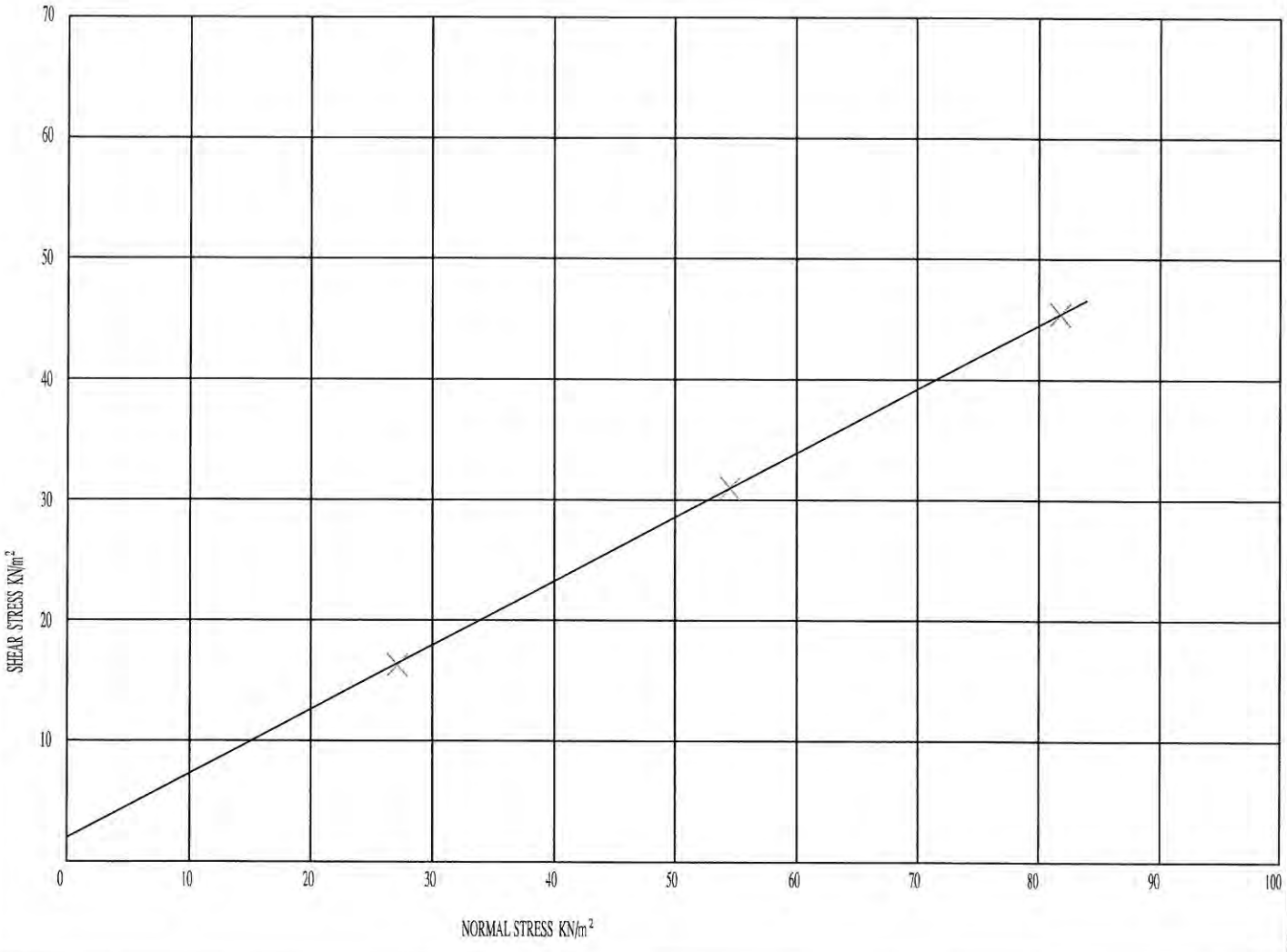
Project No. _____ Project Name: PROPOSED CONSTRUCTION OF NEW POWER HOUSE AND SUBSTATION AT BUSHROD ISLAND, MONROVIA.

Bore Hole No. BH 1 Sample No. 01/02

Depth of Sample 2.10 metres

Test No.	Load Kg	Normal Stress KN/m^2	Shear Stress KN/m^2
1	10	27.25	16.29
2	20	54.50	31.01
3	30	81.75	45.47

COHESION = 02.00 KN/m^2	ϕ = 28°	BULK DENSITY = 16.87 KN/m^3



Ref: BS 1377 (1990)

UNDRAINED TRIAXIAL TEST

B + T,Inc.

APPENDIX E

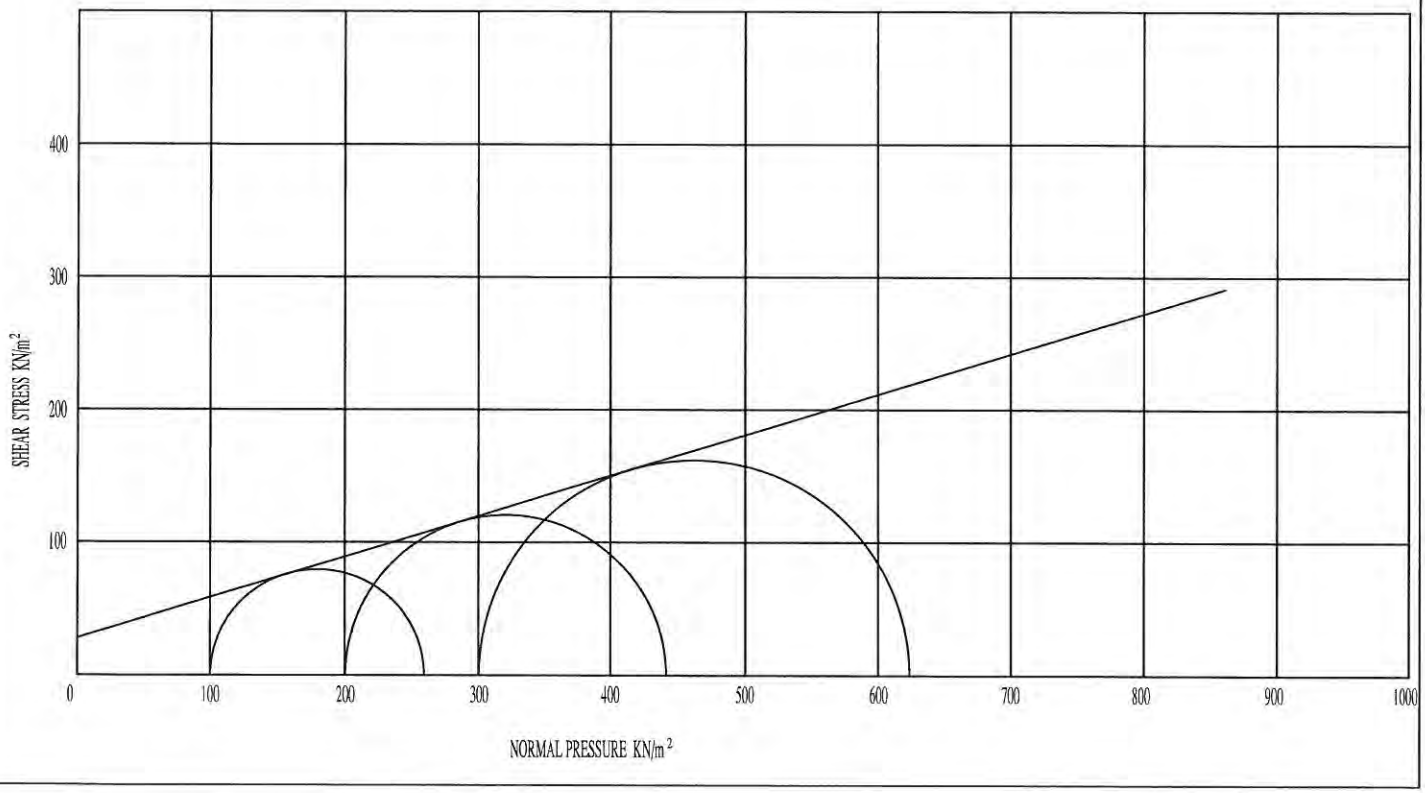
Project No. _____ Project Name: PROPOSED CONSTRUCTION OF NEW POWER HOUSE AND SUBSTATION AT BUSHROD ISLAND, MONROVIA.

Bore Hole No. BH 1 Sample No. 01/07

Depth of Sample 9.60 metres

Test No.	Normal pressure KN/m^2	Deviator Stress KN/m^2	Maximum Shear Stress KN/m^2
1	100	158.83	258.83
2	200	240.85	440.85
3	300	323.70	623.70

COHESION = 28.00 KN/m^2	ϕ = 17°	BULK DENSITY = 18.17KN/m^3



Ref: BS 1377 (1990)

UNDRAINED DIRECT SHEAR BOX TEST

B + T,Inc.

APPENDIX E

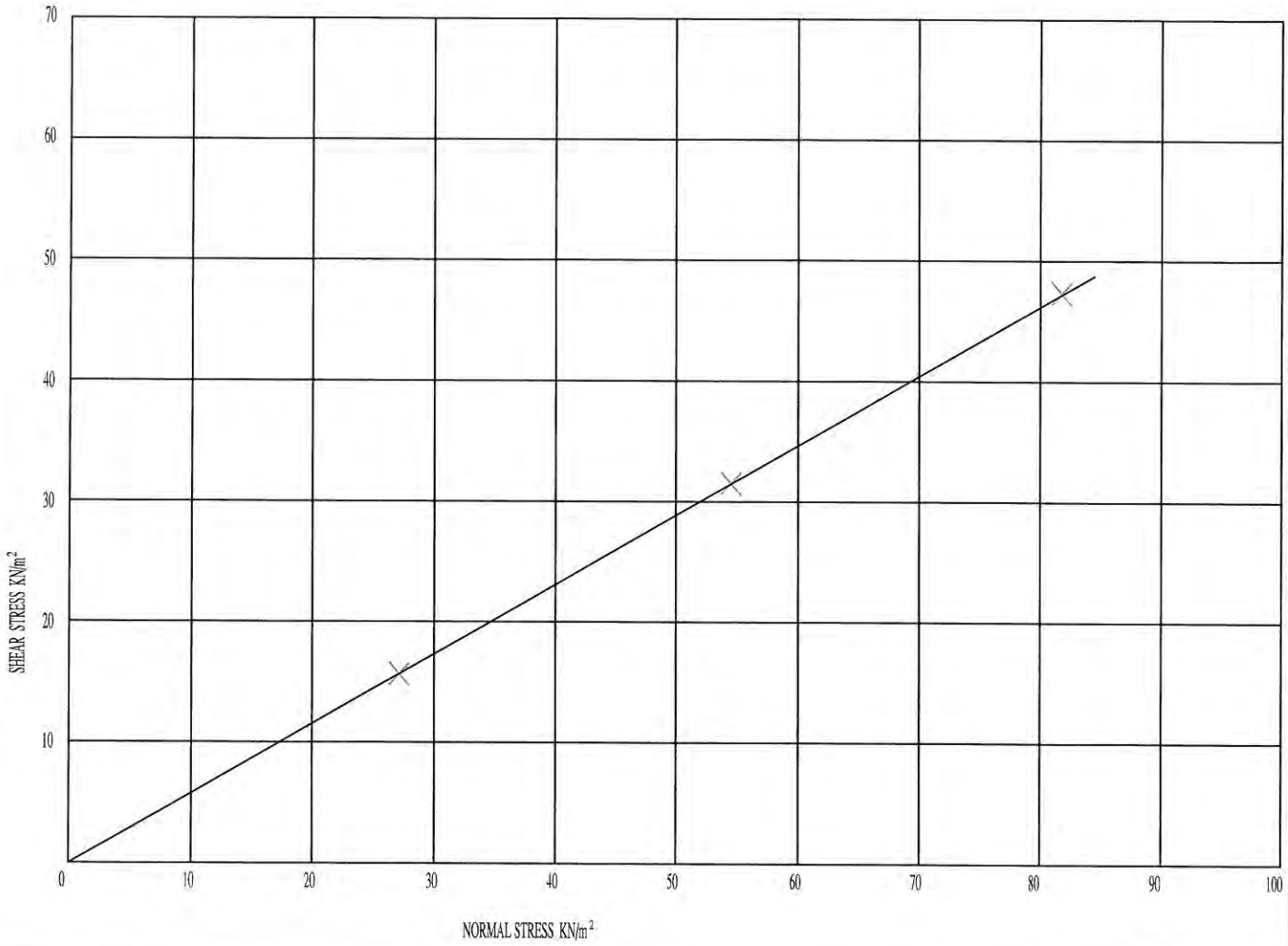
Project No. _____ Project Name: PROPOSED CONSTRUCTION OF NEW POWER HOUSE AND SUBSTATION AT BUSHROD ISLAND, MONROVIA.

Bore Hole No. BH 2 Sample No. 02/05

Depth of Sample 6.60 metres

Test No.	Load Kg	Normal Stress KN/m^2	Shear Stress KN/m^2
1	10	27.25	15.89
2	20	54.50	31.52
3	30	81.75	47.24

COHESION = 00.00 KN/m^2	ϕ = 30°	BULK DENSITY = 16.40 KN/m^3



Ref: BS 1377 (1990)

UNDRAINED TRIAXIAL TEST

B + T,Inc.

APPENDIX E

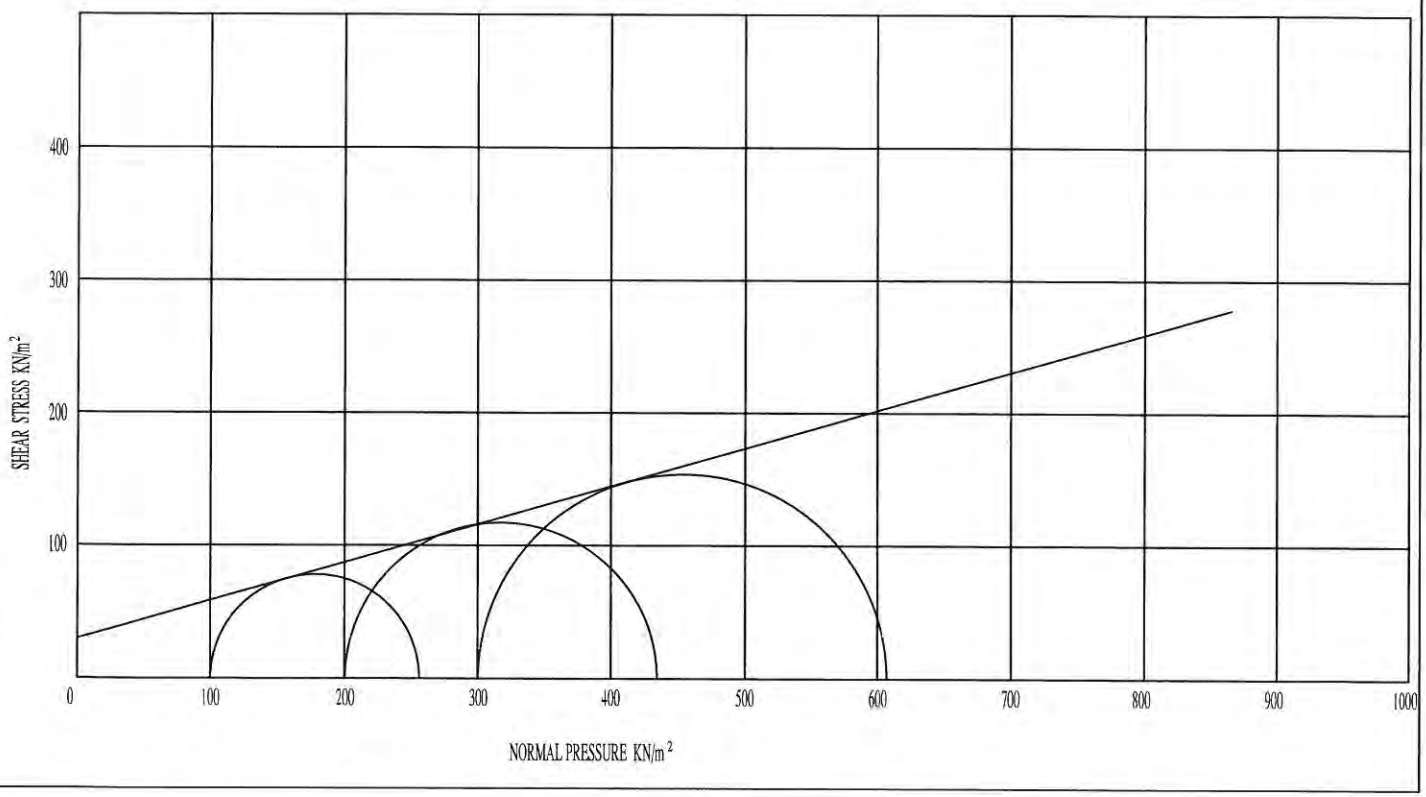
Project No. _____ Project Name: PROPOSED CONSTRUCTION OF NEW POWER HOUSE AND SUBSTATION AT BUSHROD ISLAND, MONROVIA.

Bore Hole No. BH 2 Sample No. 02/14

Depth of Sample 20.10 metres

Test No.	Normal pressure KN/m^2	Deviator Stress KN/m^2	Maximum Shear Stress KN/m^2
1	100	156.04	256.04
2	200	233.86	433.86
3	300	307.23	607.23

COHESION = 30.00 KN/m^2	ϕ = 16°	BULK DENSITY = 18.26KN/m^3



Ref: BS 1377 (1990)

UNDRAINED DIRECT SHEAR BOX TEST

BEZALEEL

APPENDIX E

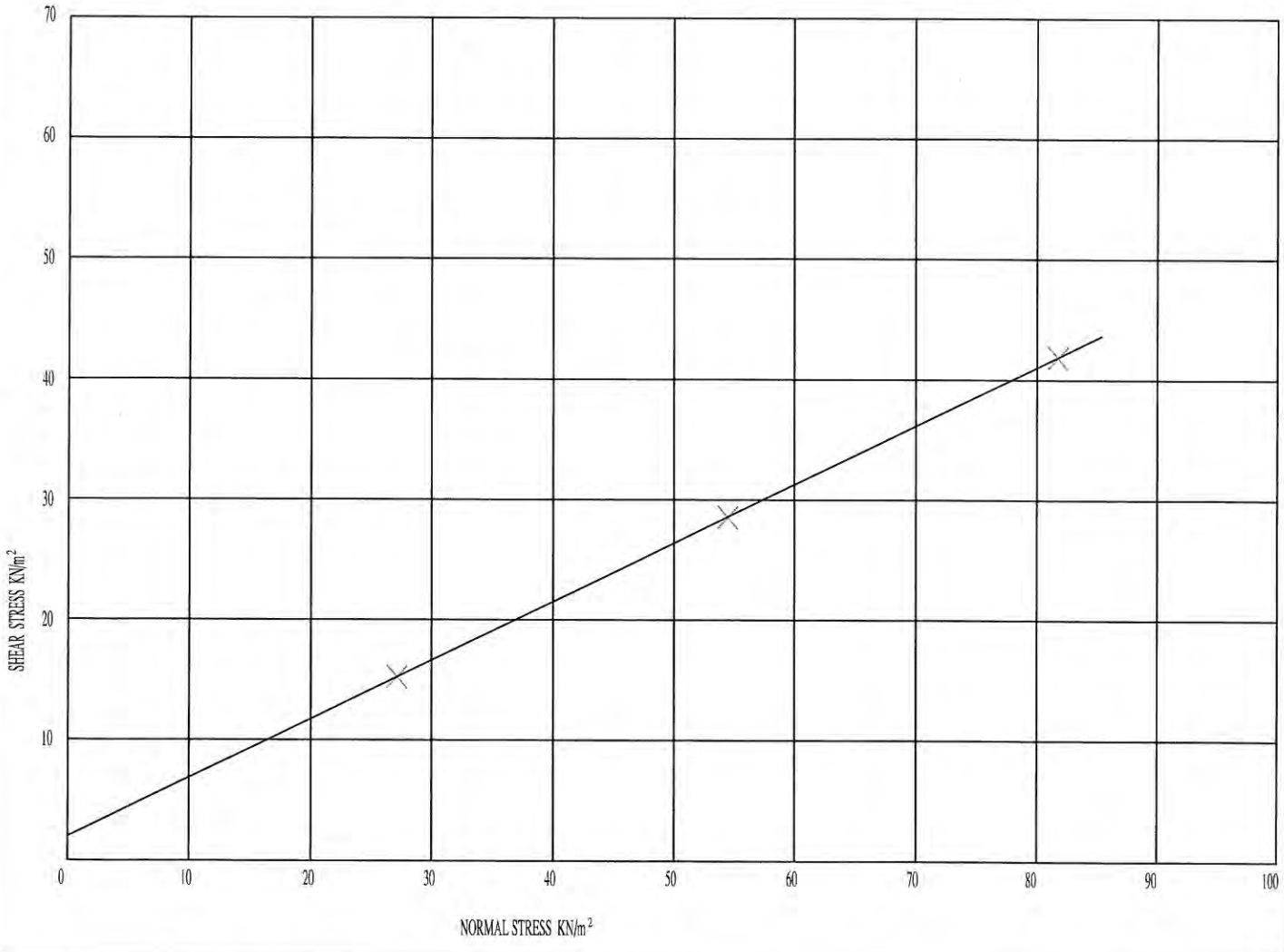
Project No. _____ Project Name: PROPOSED CONSTRUCTION OF NEW POWER HOUSE AND SUBSTATION AT BUSHROD ISLAND, MONROVIA.

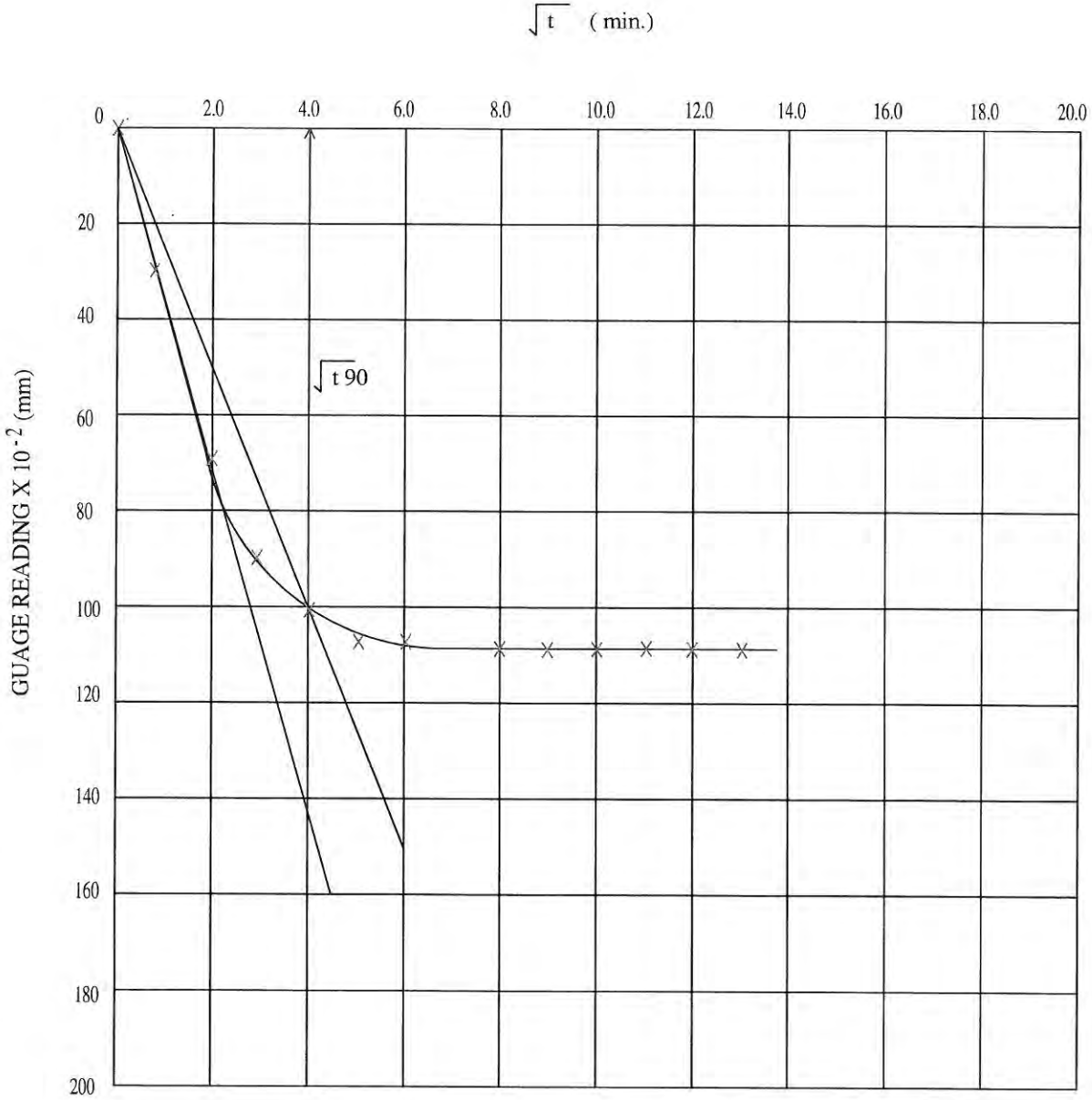
Bore Hole No. BH 3 Sample No. 03/02

Depth of Sample 2.10 metres

Test No.	Load Kg	Normal Stress KN/m^2	Shear Stress KN/m^2
1	10	27.25	15.28
2	20	54.50	28.66
3	30	81.75	41.91

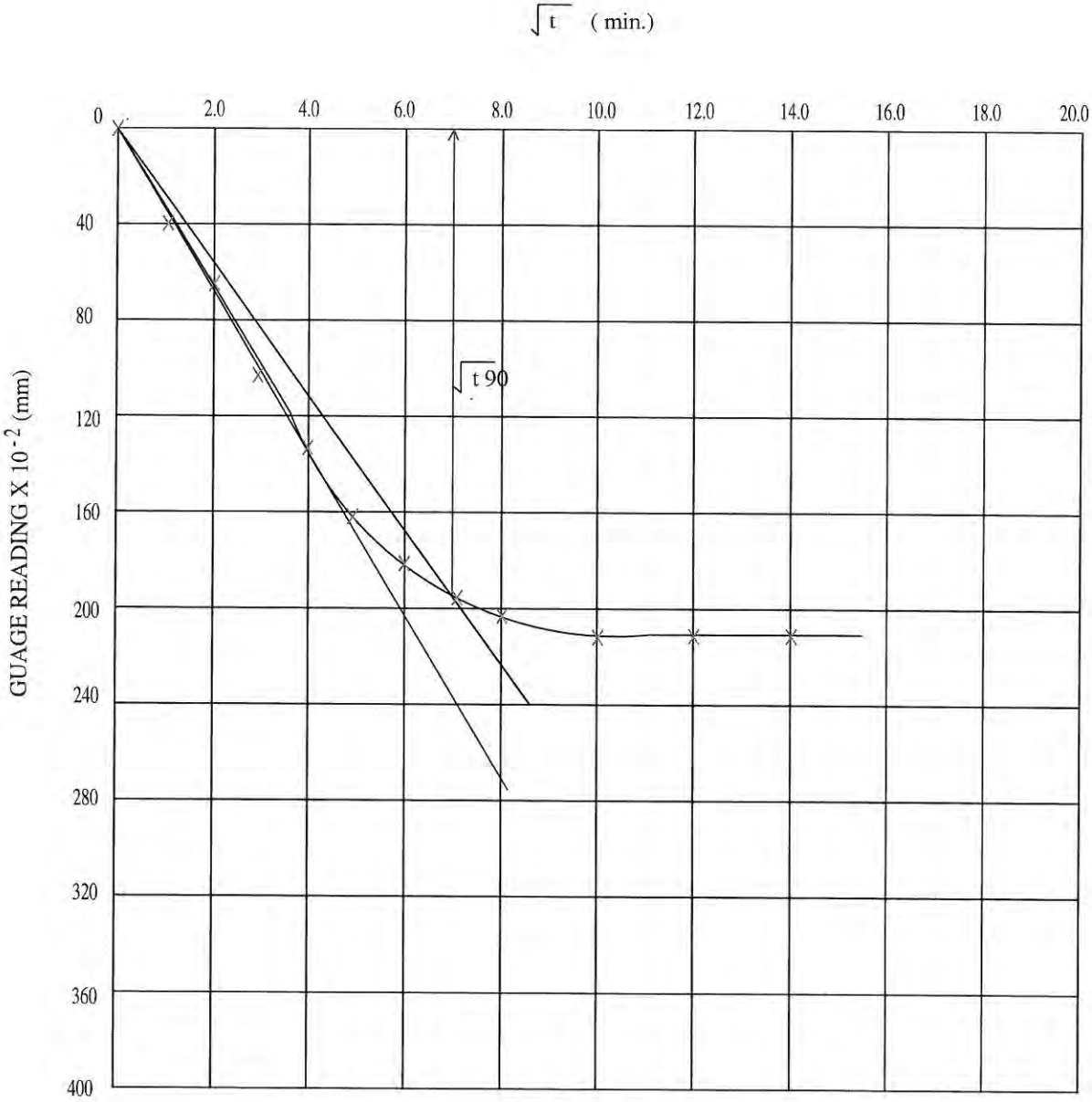
COHESION = 02.00 KN/m^2	ϕ = 26°	BULK DENSITY = 15.68 KN/m^3





Height of sample	2.00	cm	Soil description: GREYISH STIFF CLAY	
Compression area	44.18	cm		
Coefficient of Consolidation, Cv	1.40×10^{-2}	m^2/yr	Boring No: BH 1	Location.:
Coefficient of Compressibility, Mv	3.84×10^{-4}	m^2/KN	Level:	Depth 9.6m
Unit weight before consolidation	18.17	KN/m^3	P_o = vertical, effective stress in situ	10 - 100 KN/m^2

Bezaleel + Turnkey Contractors,Inc.		CONSOLIDATION TEST	
Test: SITECH	Drawn: A. DARAMOLA	Project: PROPOSED NEW POWER HOUSE & SUBSTATION, BUSHROD ISLAND, MONROVIA.	
Check: SITECH	Appr. M. SHITTU	Date: MAY, 2012	Figure No.: APPENDIX F



Height of sample	2.00	cm	Soil Description: GREYISH VERY STIFF CLAY	
Compression area	44.18	cm		
Coefficient of Compressibility, Cv	1.89×10^{-2}	m^2/yr	Boring No: BH 2	Location.:
Coefficient of Consolidation, Mv	3.86×10^{-3}	m^2/KN	Level:	Depth: 20.10m
Unit weight before consolidation	18.26	KN/m^3	P_o = vertical, effective stress in situ	10 - 100 KN/m^2

Bezaleel + Turnkey Contractors,Inc.		CONSOLIDATION TEST	
Test: SITECH	Drawn: A. DARAMOLA	Project: PROPOSED NEW POWER HOUSE & SUBSTATION, BUSHROD ISLAND, MONROVIA.	
Check: SITECH	Appr. M. SHITTU	Date: MAY, 2012	Figure No.: APPENDIX F

APPENDIX G

BEZALEEL +TURNKEY CONTRACTORS INC.

DETAILED LABORATORY TEST RESULTS

Sample No.	Sample No.	Sample Depth (m)	Description of Sample	INDEX PROPERTIES				PARTICLE SIZE ANALYSIS										Direct Shear Strength		TRIAXIAL Shear Strength parameters		Bulk Density kN/m³	Specific Gravity	Consolidation	
				EMC (%)	LL (%)	PL (%)	PI (%)	5 (5mm)	#.7 (3.35mm)	#.10 (2mm)	#.14 (1.18mm)	#.25 (600μm)	#.36 (425μm)	#.52 (300μm)	#.72 (212μm)	#.100 (150μm)	#.200 (75μm)	C KN/m²	ø	C KN/m²	ø			Cv m²/yrs	Mv m²/KN
BH1	2	2.1	Greyish medium dense SAND	17	Non - plastic			-	-	-	99.53	61.47	25.9	4.90	3.43	1.40	1.37	2	28	-	-	16.87	2.70	-	-
BH1	3	3.6	Brownish medium dense fine SAND	21	Non - plastic			-	-	-	99.93	97.13	86.4	14.1	11.80	4.87	2.20	1	26	-	-	16.48	2.68	-	-
BH1	5	6.6	Brownish medium dense coarse SAND	16	Non - plastic			95.13	92.53	85.43	70.73	59.73	55.10	40.33	35.63	19.03	16.47	0	30	-	-	16.26	2.67	-	-
BH1	7	9.6	Greyish stiff CLAY	36	32	16	16	-	-	99.89	81.38	76.00	73.49	70.25	68.19	61.87	50.89	-	-	28	17	18.17	2.72	$1.40x10^{-2}$	$3.84x10^{-4}$
BH1	8	11.1	Brownish dense coarse SAND	9	Non - plastic			98.17	97.49	92.70	87.96	24.96	9.38	6.8	5.49	2.65	1.89	0	31	-	-	16.05	2.69	-	-
BH1	10	14.1	Brownish very dense coarse SAND	11	Non - plastic			96.86	94.00	87.4	76.89	38.96	9.40	7.96	6.50	5.78	2.96	1	31	-	-	16.49	2.65	-	-
BH1	11	15.6	Brownish very dense fine SAND	16	Non - plastic			-	-	99.89	98.6	79.00	74.96	49.6	47.89	24.96	22.49	1	27	-	-	16.78	2.69	-	-
BH1	13	18.6	Brownish very dense coarse SAND	13	Non - plastic			-	99.53	97.8	94.83	21.80	8.97	5.47	4.90	3.90	2.43	0	30	-	-	16.54	2.67	-	-
BH1	14	20.1	Brownish dense fine coarse SAND	12	Non - plastic			-	99.87	95.8	93.78	22.89	10.49	6.96	5.89	4.20	3.60	1	31	-	-	16.70	2.70	-	-
BH1	15	21.6	Brownish very dense fine grained SAND	14	Non - plastic			-	-	99.9	91.49	83.35	28.96	22.49	20.87	19.49	18.96	2	26	-	-	17.89	2.62	-	-
BH1	17	24.6	Brownish dense grained SAND	16	Non - plastic			-	-	-	99.86	80.11	76.40	26.49	25.48	23.49	19.40	2	27	-	-	17.40	2.69	-	-
BH1	19	27.6	Brownish very dense fine SAND	18	Non - plastic			-	-	-	99.27	84.5	78.19	52.38	48.57	30.96	24.87	1	25	-	-	17.60	2.70	-	-
BH1	21	30.6	Brownish very dense fine SAND	16	Non - plastic			-	-	-	99.38	74.96	68.90	41.89	34.96	27.96	23.46	0	28	-	-	17.90	2.74	-	-
BH2	2	2.1	Greyish medium dense fine grained SAND	17	Non - plastic			-	99.97	99.2	98.78	86.38	70.98	39.80	34.6	18.96	11.87	1	28	-	-	16.87	2.60	-	-
BH2	4	5.1	Brownish grey medium dense fine SAND	14	Non - plastic			-	-	100.0	98.19	89.38	81.40	50.38	30.19	14.86	10.96	2	27	-	-	16.49	2.61	-	-
BH2	5	6.6	Brownish medium dense coarse SAND	16	Non - plastic			98.68	98.34	97.2	81.16	31.68	20.5	12.02	7.96	5.09	3.01	0	30	-	-	15.98	2.70		
BH2	7	9.6	Reddish medium dense fine SAND	18	Non - plastic			-	-	-	99.17	74.41	72.57	48.17	44.92	18.19	10.14	1	29	-	-	16.86	2.65	-	-

APPENDIX G

Sample No.	Sample No.	Sample Depth (m)	Description of Sample	INDEX PROPERTIES				PARTICLE SIZE ANALYSIS										Direct Shear Strength		TRIAXIAL Shear Strength parameters		Bulk Density kN/m³	Specific Gravity	Consolidation	
				EMC (%)	LL (%)	PL (%)	PI (%)	5 (5mm)	#.7 (3.35mm)	#.10 (2mm)	#.14 (1.18mm)	#.25 (600μm)	#.36 (425μm)	#.52 (300μm)	#.72 (212μm)	#.100 (150μm)	#.200 (75μm)	C KN/m²	ø	C KN/m²	ø			Cv m²/yrs	Mv m²/KN
BH2	8	11.1	Brownish red dense fine SAND	22	Non - plastic			-	-	99.1	98.7	94.67	89.13	38.5	28.37	4.9	1.53	1	29	-	-	16.10	2.69	-	-
BH2	10	14.1	Brownish red dense fine SAND	19	Non - plastic			-	-	-	99.29	81.0	72.39	55.91	15.28	8.61	3.45	0	30	-	-	16.40	2.67	-	-
BH2	12	17.1	Brownish dense fine SAND	23	Non - plastic			-	99.83	99.73	99.6	98.7	96.17	34.53	29.93	5.60	2.97	0	29	-	-	16.38	2.71	-	-
BH2	14	20.1	Greyish very stiff CLAY	32	34	17	17	-	-	96.38	90.41	87.95	82.30	68.95	57.61	50.15	46.39	-	-	30	16	18.26	2.75	$1.89x10^{-2}$	$3.86x10^{-3}$
BH2	15	21.6	Brownish dense coarse SAND	11	Non - plastic			-	95.61	81.15	70.29	58.4	36.45	16.19	11.59	8.56	2.78	0	31	-	-	17.8	2.70	-	-
BH2	17	24.6	Brownish very dense fine grained SAND	20	Non - plastic			-	-	-	97.11	90.6	69.51	47.82	25.61	4.56	1.95	2	28	-	-	17.59	2.69	-	-
BH2	19	27.6	Brownish dense fine SAND	17	Non - plastic			-	-	-	99.9	88.4	67.20	32.30	28.77	7.86	5.10	0	29	-	-	17.6	2.72	-	-
BH2	21	30.6	Brownish very dense fine SAND	21	Non - plastic			-	-	-	98.41	82.39	52.15	46.78	20.38	9.64	3.45	1	30	-	-	17.96	2.74	-	-
BH3	2	2.1	Dark brownish loose fine SAND	16	Non - plastic			-	-	99.15	96.89	79.48	56.51	27.95	13.48	11.61	5.61	2	26	-	-	15.68	2.59	-	-
BH3	3	3.6	Dark brownish medium dense fine grained SAND	18	Non - plastic			-	-	-	99.1	62.93	34.23	7.89	5.80	3.13	1.87	2	27	-	-	16.4	2.70	-	-
BH3	5	6.6	Brownish medium dense coarse SAND	4	Non - plastic			-	98.93	88.73	39.23	8.77	4.77	1.77	1.40	0.90	0.53	0	30	-	-	15.96	2.63	-	-
BH3	7	9.6	Brownish medium dense fine SAND	18	Non - plastic			-	-	-	99.93	95.00	50.5	12.7	10.77	4.70	4.23	0	29	-	-	16.87	2.68	-	-
BH3	9	12.6	Brownish dense fine SAND	20	Non - plastic			-	-	98.78	95.14	79.96	65.2	20.33	18.53	4.38	2.98	1	27	-	-	17.40	2.70	-	-
BH3	11	15.6	Brownish dense fine SAND	22	Non - plastic			-	-	99.78	98.70	94.90	68.1	20.4	16.17	8.40	7.83	0	28	-	-	17.00	2.68	-	-
BH3	13	18.6	Brownish red dense fine SAND	21	Non - plastic			-	-	-	99.34	97.33	80.06	44.9	38.92	8.47	4.71	1	28	-	-	17.18	2.60	-	-
BH3	15	21.6	Brownish dense fine SAND	19	Non - plastic			-	-	98.99	95.61	90.11	86.38	56.26	32.61	9.58	6.69	1	30	-	-	17.01	2.64	-	-
BH3	17	24.6	Brownish dense fine SAND	23	Non - plastic			-	-	-	99.58	92.38	77.98	47.56	27.81	5.65	3.45	0	30	-	-	16.89	2.66	-	-

Sample No.	Sample No.	Sample Depth (m)	Description of Sample	INDEX PROPERTIES				PARTICLE SIZE ANALYSIS									Direct Shear Strength		TRIAXIAL Shear Strength parameters		Bulk Density kN/m³	Specific Gravity	Consolidation	
				EMC (%)	LL (%)	PL (%)	PI (%)	5 (5mm)	#.7 (3.35mm)	#.10 (2mm)	#.14 (1.18mm)	#.25 (600μm)	#.36 (425μm)	#.52 (300μm)	#.72 (212μm)	#.100 (150μm)	#.200 (75μm)	C KN/m²	Ø	C KN/m²	Ø			Cv m²/yrs	Mv m²/KN
BH3	20	29.1	Brownish very dense fine SAND	21	Non - plastic			-	-	-	99.85	83.45	81.68	33.41	9.25	6.58	4.16	0	30.00	-	-	17.67	2.69	-	-
BH3	21	30.6	Brownish very dense fine SAND	24	Non - plastic			-	-	-	99.01	80.2	69.15	46.28	14.39	9.35	2.09	1	29.00	-	-	17.98	2.71	-	-

添付資料 A-6　参考資料／入手資料リスト

6. 参考資料･入手資料リスト/ Appendices-6 List of Reference Documents and Collecting Documents

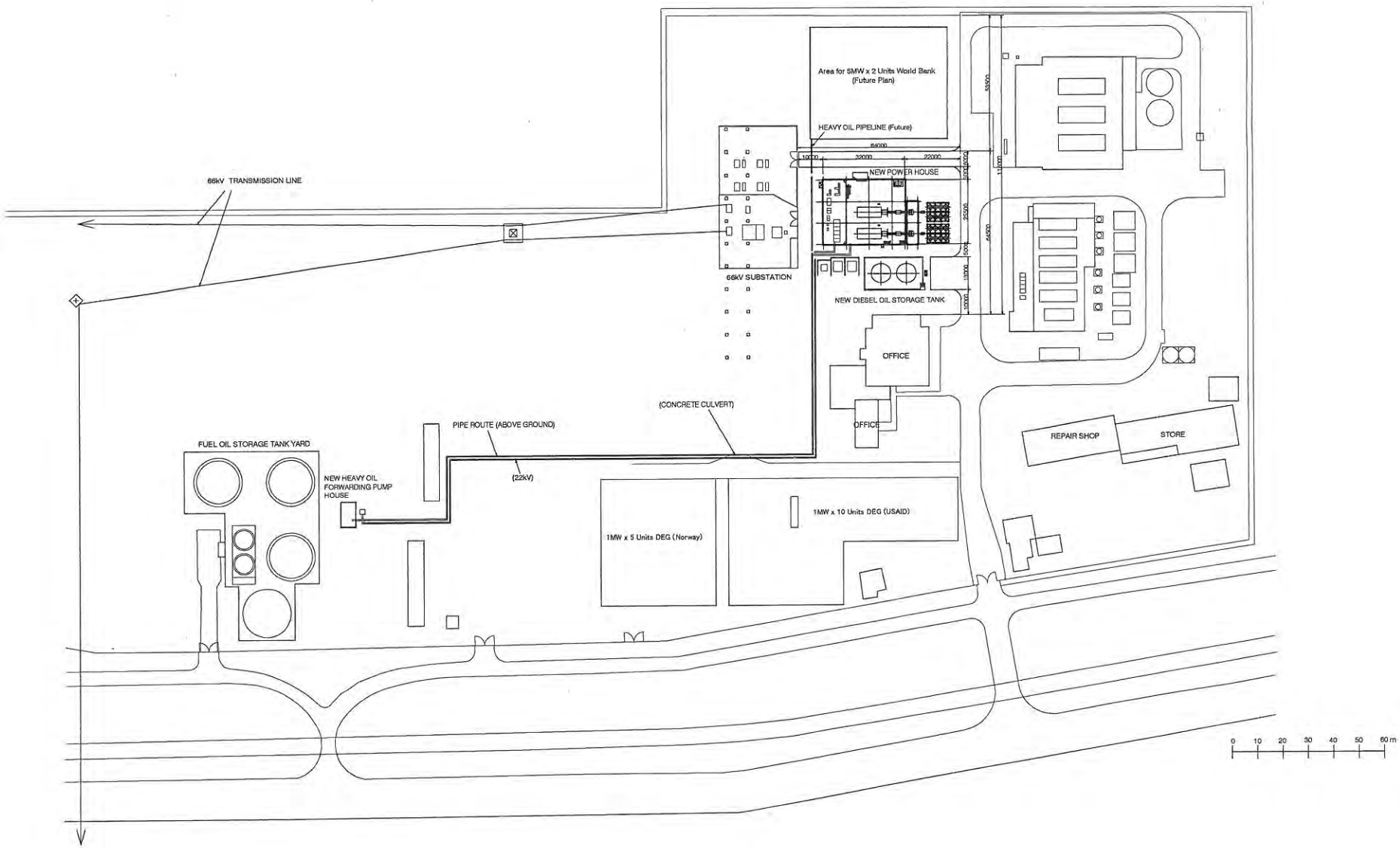
調査名： リベリア国 モンロビア市緊急電力復旧計画準備調査

On the Preparatory Survey on the Project for Rehabilitation of Monrovia Power System in the Republic of Liberia

番号 No.	名 称 Title	形態/Shape 図書･文書･等/ Book, Document	ｵﾘｼﾞﾅﾙ･ｺﾋﾟｰ/ Original, Copy	発 行 機 関/ Issued Organization	発行年 Year
1	Poverty Reduction Strategy	図書/ Book	オリジナル/ Original	The Government of the Republic of Liberia	2008
2	National Energy Policy an Agenda for Action and Economic and Social Development	図書/ Book	オリジナル/ Original	Ministry of Lands, Mines and Energy Monrovia, Liberia	2009
3	Feasibility Study for the Supply of Heavy fuel Oil from Monrovia Port to the Liberia Electricity Corporation Facility on Bushrod Island, Monrovia, and Rehabilitation of HFO Storage Tanks.	図書/ Book	オリジナル/ Original	Optec Energy Services (OPTEC-JV) A subsidiary of Johnston-Vermette Consulting Group Inc.	2011
4	Options for the Development of Liberia's Energy Sector	図書/ Book	オリジナル/ Original	The World Bank	2011
5	Emergency Project Paper on a Proposed Credit in the Amount of SDR 6.5 million to the Republic of Liberia for an Electricity System Enhancement Project	図書/ Book	オリジナル/ Original	The World Bank	2010
6	Electric Master Plan	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2011
7	Minutes of Discussion on the Preparatory Survey on the Project for the Rehabilitation of the Monrovia Power System in the Republic of Liberia	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2011
8	Annual Report-2009	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2009
9	Ground Floor Plan of Generator Sets Monrovia, Liberia	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2011
10	Generation Department-Monthly Data Summary (July 2010-April 2011)	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2011
11	66 kV and 226 V Network Diagram	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2010
12	Requested 22 kV Distribution Line for the Project	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2011

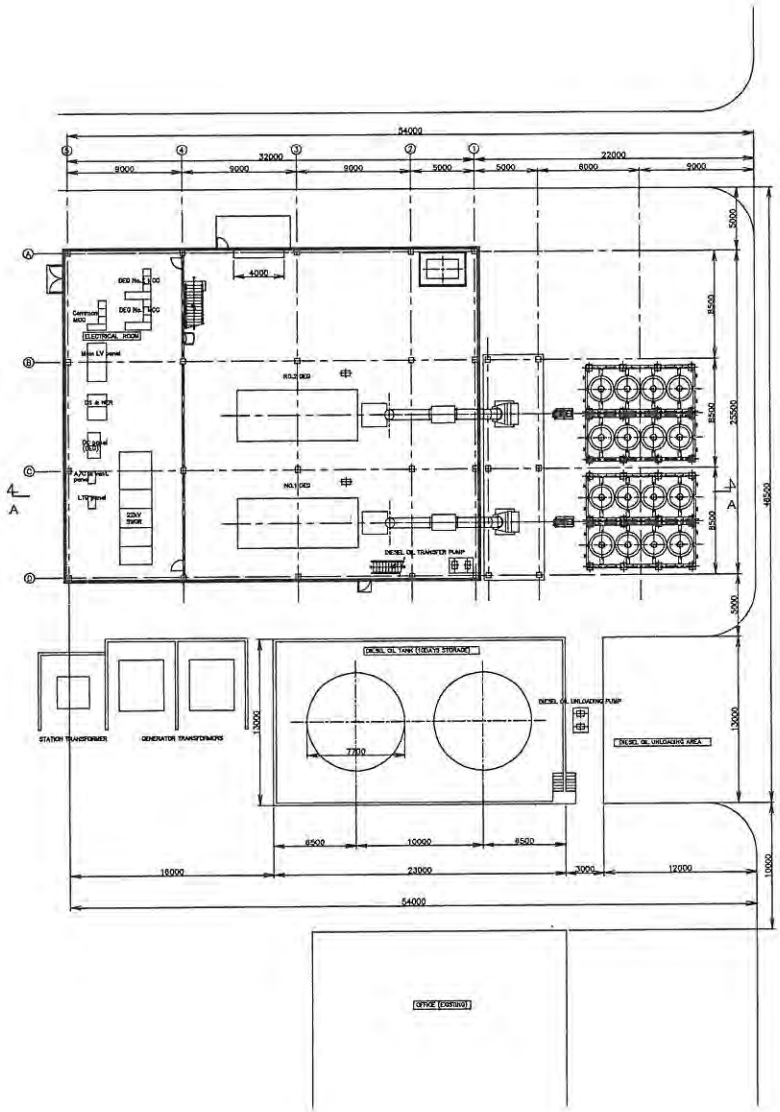
番号 No.	名 称 Title	形態/Shape 図書・文書・等/ Book, Document	ｵﾘｼﾞﾅﾙ・ｺﾋﾟｰ/ Original, Copy	発 行 機 関/ Issued Organization	発行年 Year
13	Sales Record from 2006 to 2011	文書/ Document	オリジナル/ Original	Liberia Electricity Corporation	2011
14	Feasibility Study on the Man (Côte d'lovire) - Yekepa (Liberia) – Nzerekore (Guinea) – Buchanan (Liberia) – Monrovia (Liberia) – Bumbuna (Sierra Leone) – Linsan (Guinea) Interconnection Project	図書/ Book	オリジナル/ Original	West African Power Pool	2009
15	Environmental Impact Assessment Procedural Guidelines	図書/ Book	ソフトコピー/ Soft Copy	Republic of Liberia Environmental Protection Agency	2006
16	An Act Creating the Environment Protection Agency of the Republic of Liberia	図書/ Book	ソフトコピー/ Soft Copy	Ministry of Foreign Affairs	2002
17	The National Environmental Policy of the Republic of Liberia	図書/ Book	ソフトコピー/ Soft Copy	Ministry of Foreign Affairs	2002
18	Resettlement Policy Framework for the Energy Programs of the World Bank in Liberia	図書/ Book	ソフトコピー/ Soft Copy	The World Bank	NA
19	Fuel Consumption of Diesel Engine Generator	文書/ Doumentc	ソフトコピー/ Soft Copy	Liberia Electricity Corporation	2011
20	Environmental & Social Management Framework Energy & Electricity Distribution in Liberia	文書/ Document	ソフトコピー/ Soft Copy	Government of Liberia	2010
21	P ID Bushrod	文書/ Document	ソフトコピー/ Soft Copy	Liberia Electricity Corporation	2010
22	P ID Kru Town	文書/ Document	ソフトコピー/ Soft Copy	Liberia Electricity Corporation	2010
23	Power Plant Single Line Diagram	文書/ Document	ソフトコピー/ Soft Copy	Liberia Electricity Corporation	2010
24	Liberia Site Drawing with Ground Grid	文書/ Document	ソフトコピー/ Soft Copy	Liberia Electricity Corporation	2010

図 面 集

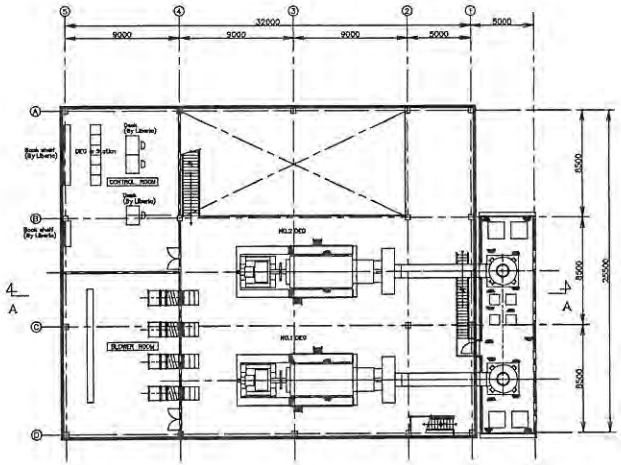


1:1500
(Only if A3)

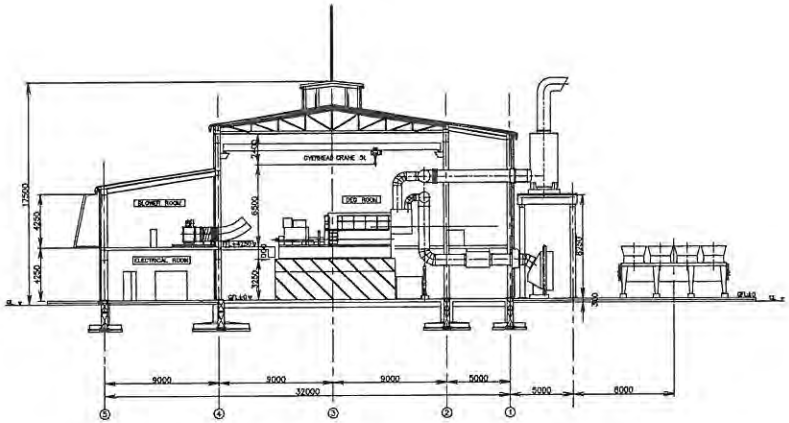
全体配置図
GENERAL LAYOUT IN BUSHROD POWER STATION G-01



GROUND FLOOR PLAN



FIRST FLOOR PLAN

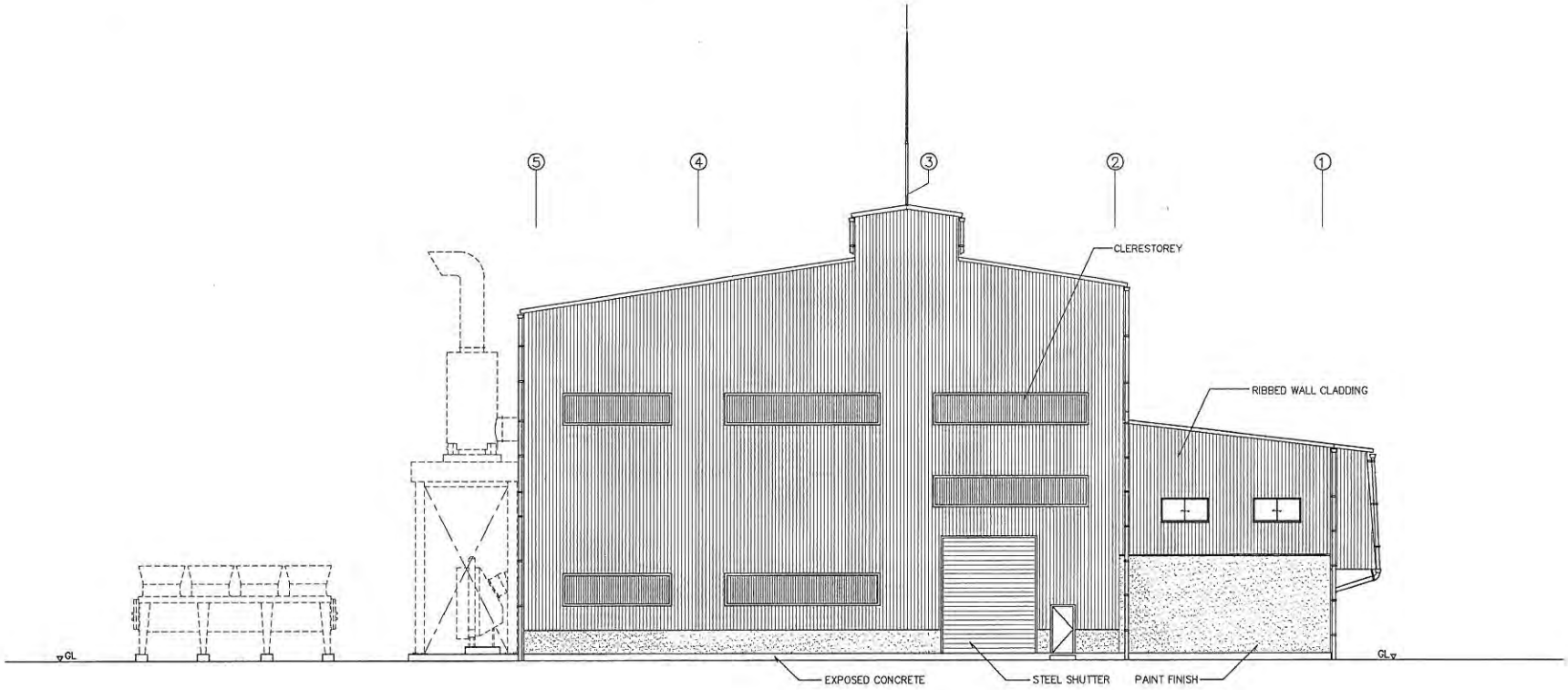


A–A SECTION

1:400
(Only if A3)

発電設備配置図
POWER HOUSE LAYOUT

G-02



NORTH ELEVATION 1/200

1/200

発電建屋立面図
POWERHOUSE ELEVATION

A-01

GENERAL

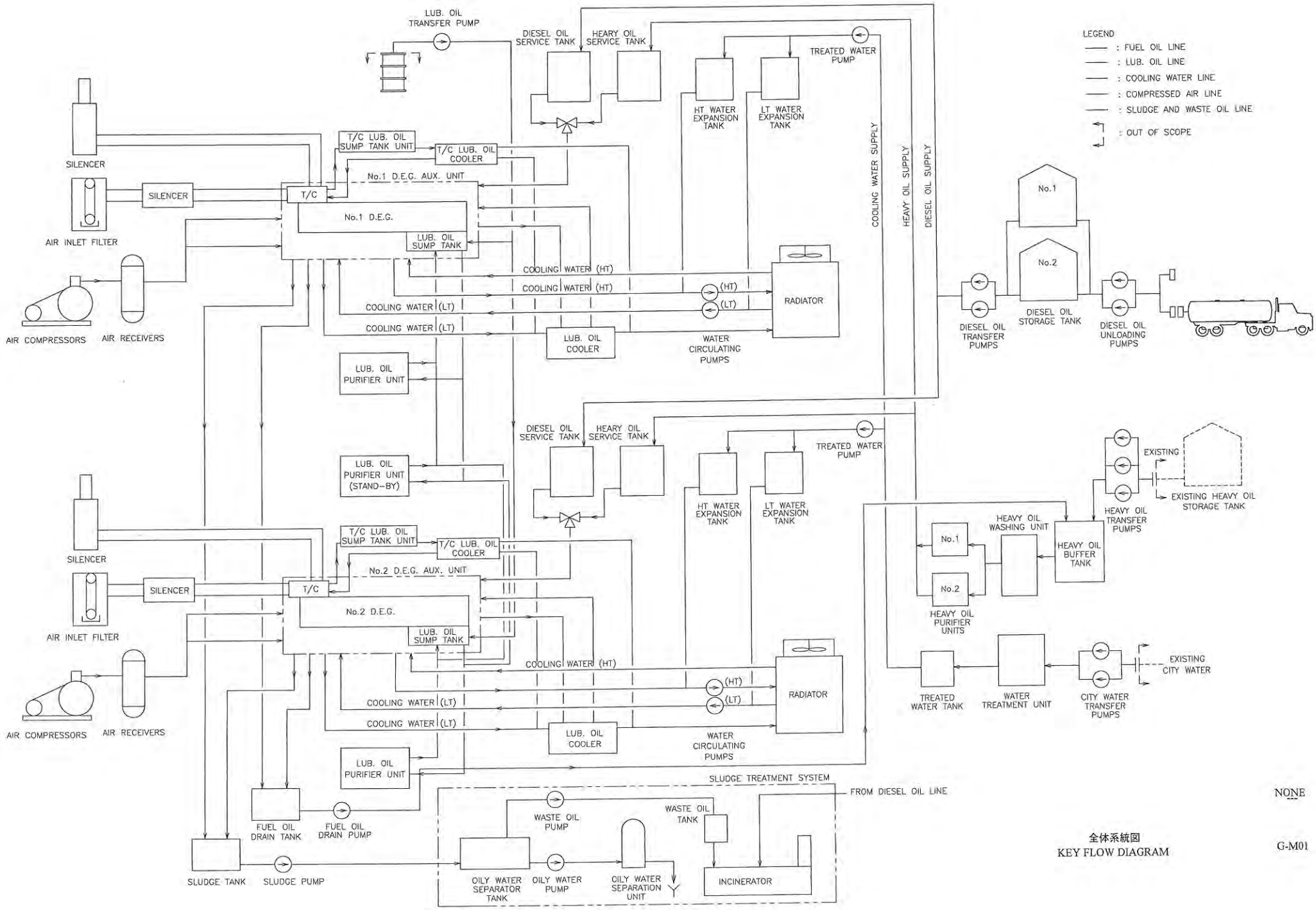
BUILDING AREA	867m2
TOTAL FLOOR AREA	1,581m2
UNDER GROUND STRUCTURE	REINFORCED CONCRETE CONSTRUCTION
UPPER GROUND STRUCTURE	STEEL STRUCTURE (hot dip galvanizing)

EXTERIOR FINISHING SCHEDULE

LOCATION	SPECIFICATION
ROOF	FLUORIDE RESIN PAINTING GAL BARIUM STEEL SHEET 0.8THK RIBBED METAL ROOF H=170 WITH INSULATION : URETHANE TYPEt=4
WALL	FLUORIDE RESIN PAINTING GAL BARIUM CLAD STEEL SHEET 0.6THK RIBBED WALL CLADDING D=38 (ELECTRICAL ROOM) PAINT FINISH (E.P) ON 150THK CONCRETE BLOCK WITH MORTAR
CLERESTOREY	1.5 THK FIBER REINFORCED PLASTIC TRANSLUCENT SHEET D=38
WAINSCOT	(DEG ROOM) PAINT FINISH(E.P) ON 100THK CONCRETE BLOCK WITH MORTAR
BASEBOARD	EXPOSED CONCRETE

INTERIOR FINISHING SCHEDULE

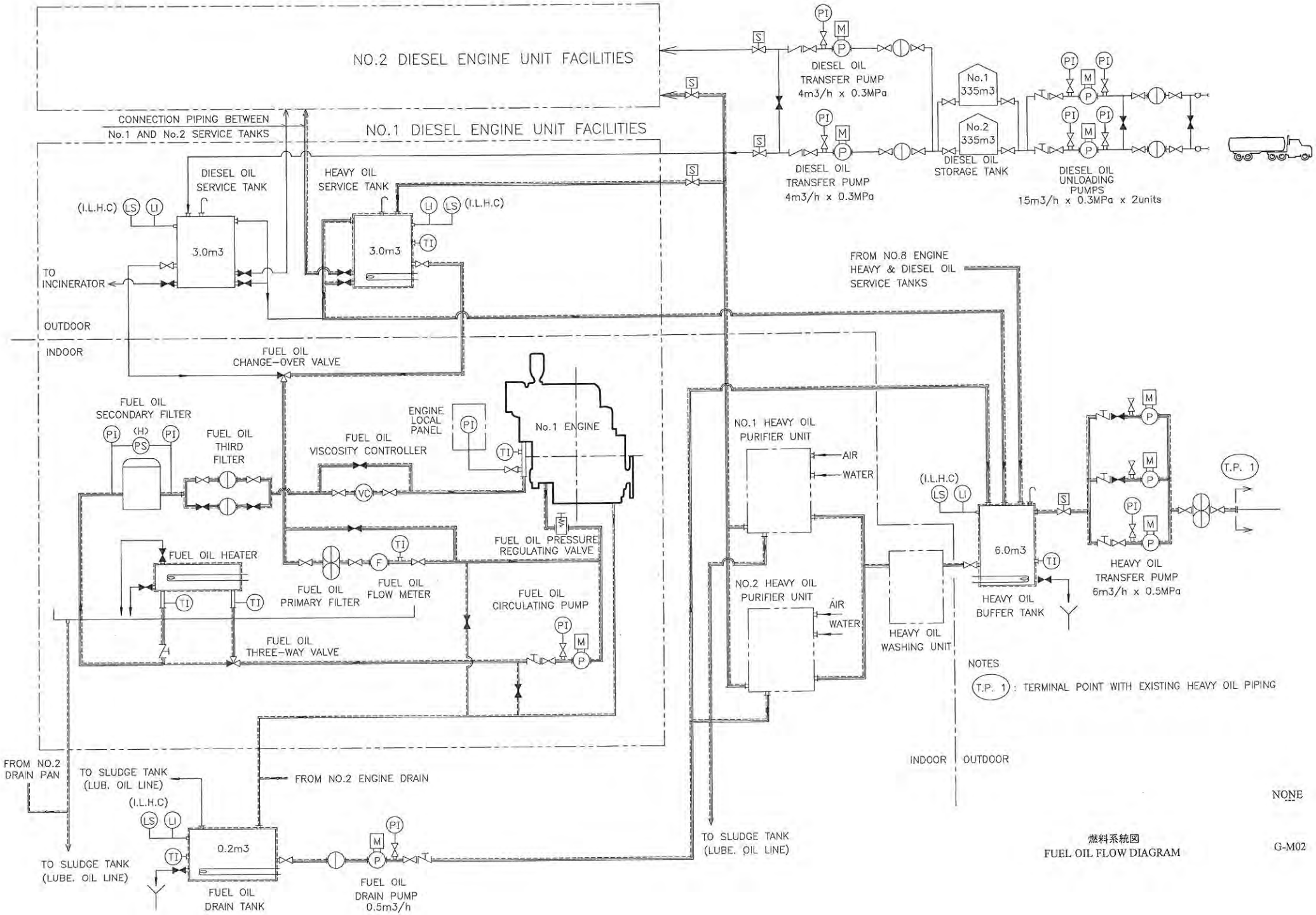
ROOM NAME	FLOOR	BASEBOARD	WALL	CEILING	REMARKS
ELECTRICAL ROOM	CONCRETE STEEL TROWEL DUSTPROOF PAINT FINISH	MORTAR FINISH H=100	PAINT FINISH(E.P) ON MORTAR	EXPOSED GALVANIZED STEEL DECK PLATE	AIR-CONDITINOR,VENTILATION FAN CABLE PIT
DEG ROOM LOWER FLOOR	CONCRETE STEEL TROWEL DUSTPROOF PAINT FINISH	MORTAR FINISH H=100	EXPOSED STEEL STRUCTURE & EXPOSED CLADDING CONCRETE BLOCK WITH MORTAR	EXPOSED GALVANIZED STEEL DECK PLATE	
DEG ROOM UPPER FLOOR	CONCRETE STEEL TROWEL OILPROOF PAINT FINISH	VINYL TILE H=60 LINE 2 ONLY	EXPOSED STEEL STRUCTURE & EXPOSED CLADDING 8THK PERFORATED FIBER-REINFORCED SILICON DIOXIDE CALCIUM BOARD WITH PAINT(EP) FINISH	EXPOSED STEEL STRUCTURE & EXPOSED ROOFING	ANTI BIRD BED MESH WIRE(STAINLESS)
CONTROL ROOM	FREE ACCESS FLOOR H=300 CHARGING WITH ELECTRICITY PREVENTION VINYL TILE	VINYL TILE H=60	8THK PERFORATED FIBER-REINFORCED SILICON DIOXIDE CALCIUM BOARD WITH PAINT(EP) FINISH LIGHT IRON WALL FRAME	MAKEUP PLASTERBOARD t=9.5 LIGHT IRON SUSPENDED FRAME CEILING SYSTEM CH=3000	AIR-CONDITINOR,VENTILATION FAN 50THK WALL AND CEILING GLASSWOOL INSULATION
BLOWER ROOM	CONCRETE STEEL TROWEL FINISH	VINYL TILE H=60	8THK PERFORATED FIBER-REINFORCED SILICON DIOXIDE CALCIUM BOARD WITH PAINT(EP) FINISH	EXPOSED STEEL STRUCTURE & EXPOSED ROOFING	ANTI BIRD BED MESH WIRE(STAINLESS)

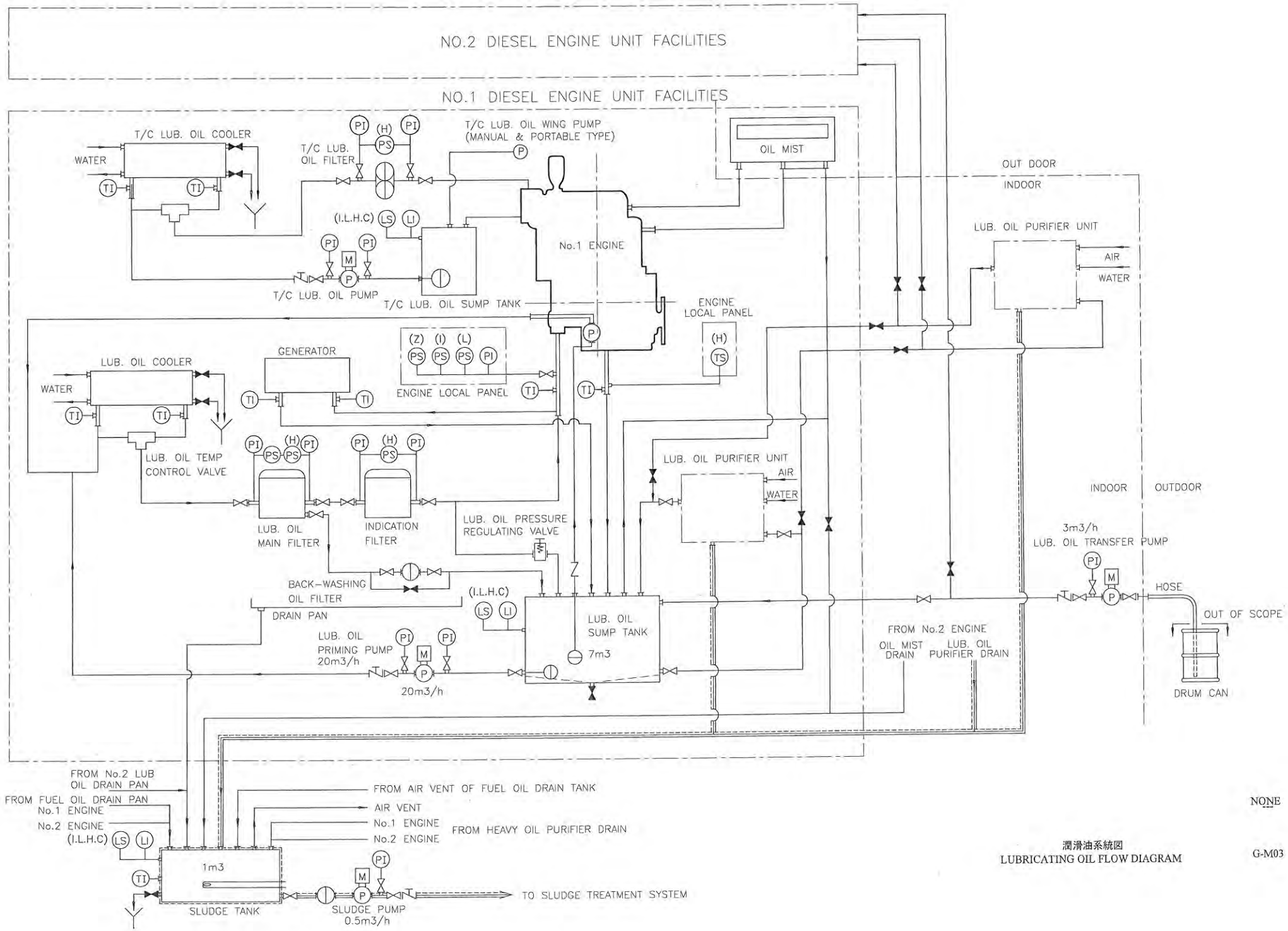


NONE

全体系統図
KEY FLOW DIAGRAM

G-M01

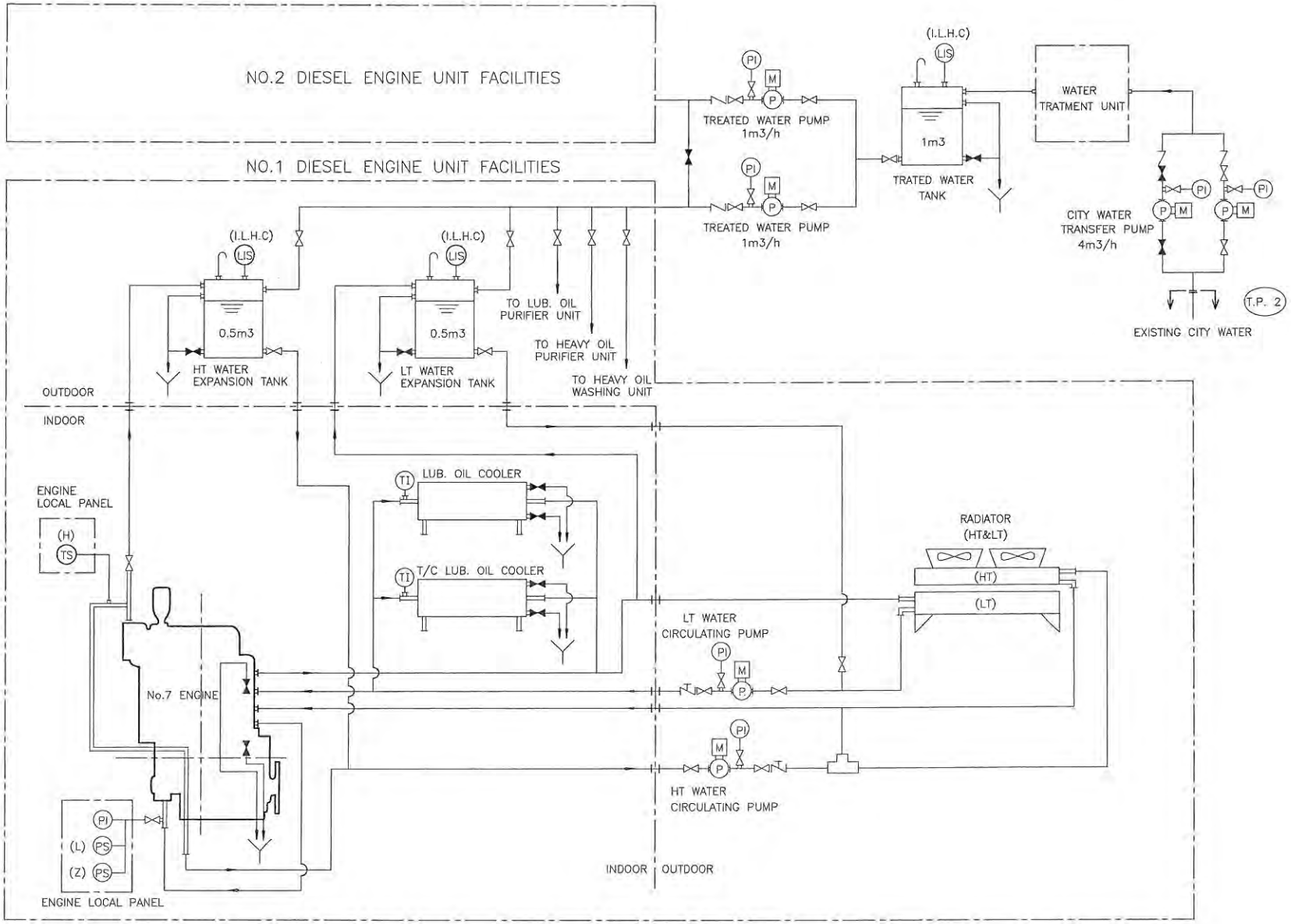

NO.2 DIESEL ENGINE UNIT FACILITIES
NO.1 DIESEL ENGINE UNIT FACILITIES
CONNECTION PIPING BETWEEN No.1 AND No.2 SERVICE TANKS
DIESEL OIL TRANSFER PUMP 4m3/h x 0.3MPa
DIESEL OIL TRANSFER PUMP 4m3/h x 0.3MPa
No.1 335m3
No.2 335m3
DIESEL OIL STORAGE TANK
DIESEL OIL UNLOADING PUMPS 15m3/h x 0.3MPa x 2units
DIESEL OIL SERVICE TANK
HEAVY OIL SERVICE TANK
3.0m3
3.0m3
TO INCINERATOR
FROM NO.8 ENGINE HEAVY & DIESEL OIL SERVICE TANKS
OUTDOOR
INDOOR
FUEL OIL CHANGE-OVER VALVE
FUEL OIL SECONDARY FILTER
FUEL OIL THIRD FILTER
FUEL OIL VISCOSITY CONTROLLER
ENGINE LOCAL PANEL
No.1 ENGINE
FUEL OIL HEATER
FUEL OIL PRIMARY FILTER
FUEL OIL FLOW METER
FUEL OIL PRESSURE REGULATING VALVE
FUEL OIL CIRCULATING PUMP
FUEL OIL THREE-WAY VALVE
NO.1 HEAVY OIL PURIFIER UNIT
NO.2 HEAVY OIL PURIFIER UNIT
AIR
WATER
HEAVY OIL WASHING UNIT
6.0m3
HEAVY OIL BUFFER TANK
HEAVY OIL TRANSFER PUMP 6m3/h x 0.5MPa
T.P. 1
NOTES
T.P. 1 : TERMINAL POINT WITH EXISTING HEAVY OIL PIPING
INDOOR
OUTDOOR
FROM NO.2 DRAIN PAN
TO SLUDGE TANK (LUB. OIL LINE)
FROM NO.2 ENGINE DRAIN
0.2m3
FUEL OIL DRAIN TANK
FUEL OIL DRAIN PUMP 0.5m3/h
TO SLUDGE TANK (LUBE. OIL LINE)
TO SLUDGE TANK (LUBE. OIL LINE)
NONE
燃料系統図
FUEL OIL FLOW DIAGRAM
G-M02



NONE

潤滑油系統図
LUBRICATING OIL FLOW DIAGRAM

G-M03



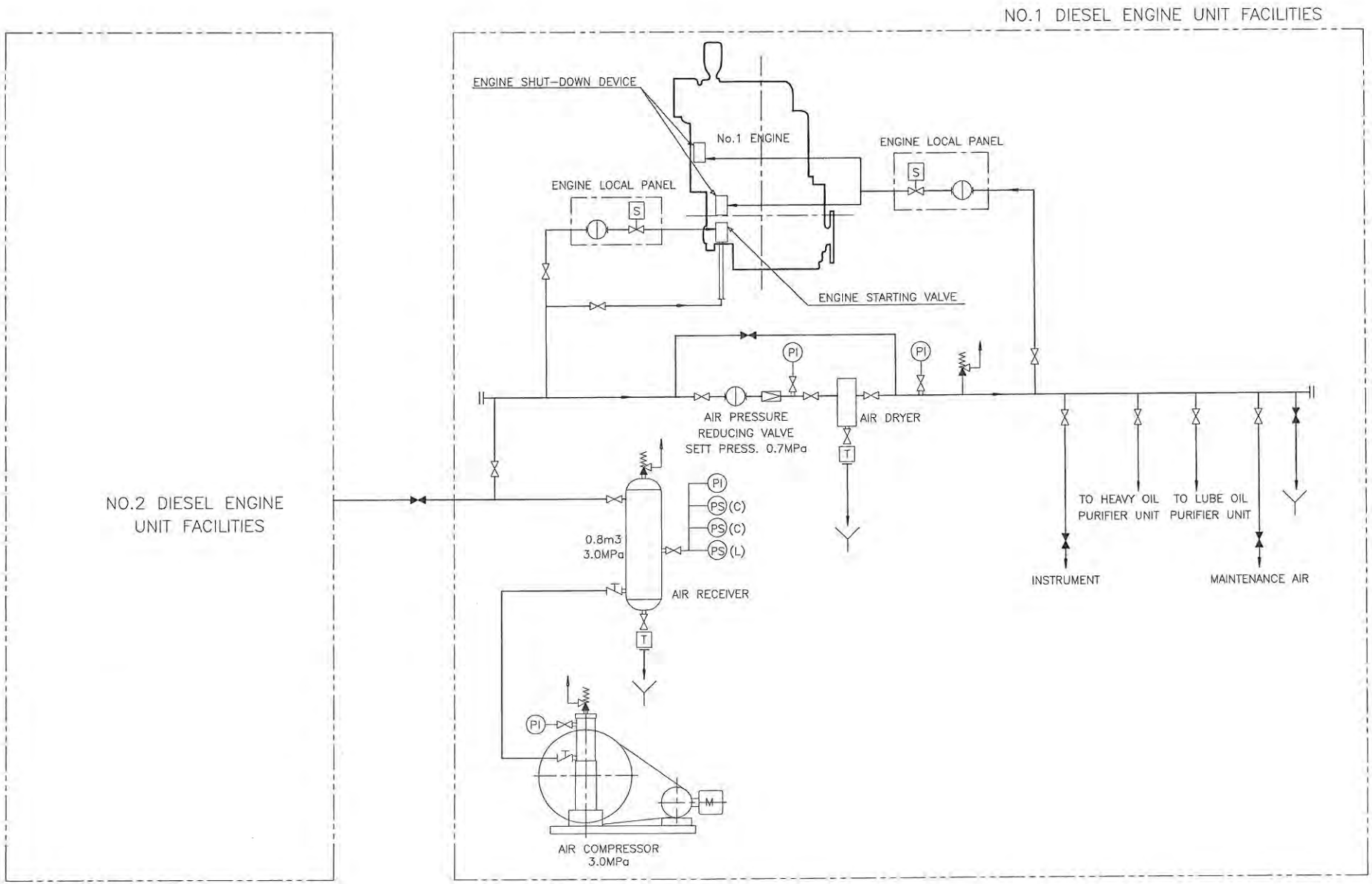
NOTE

(T.P. 2) : TERMINAL POINT WITH EXISTING CITY WATER PIPING

NONE

冷却水系統図
COOLING WATER FLOW DIAGRAM

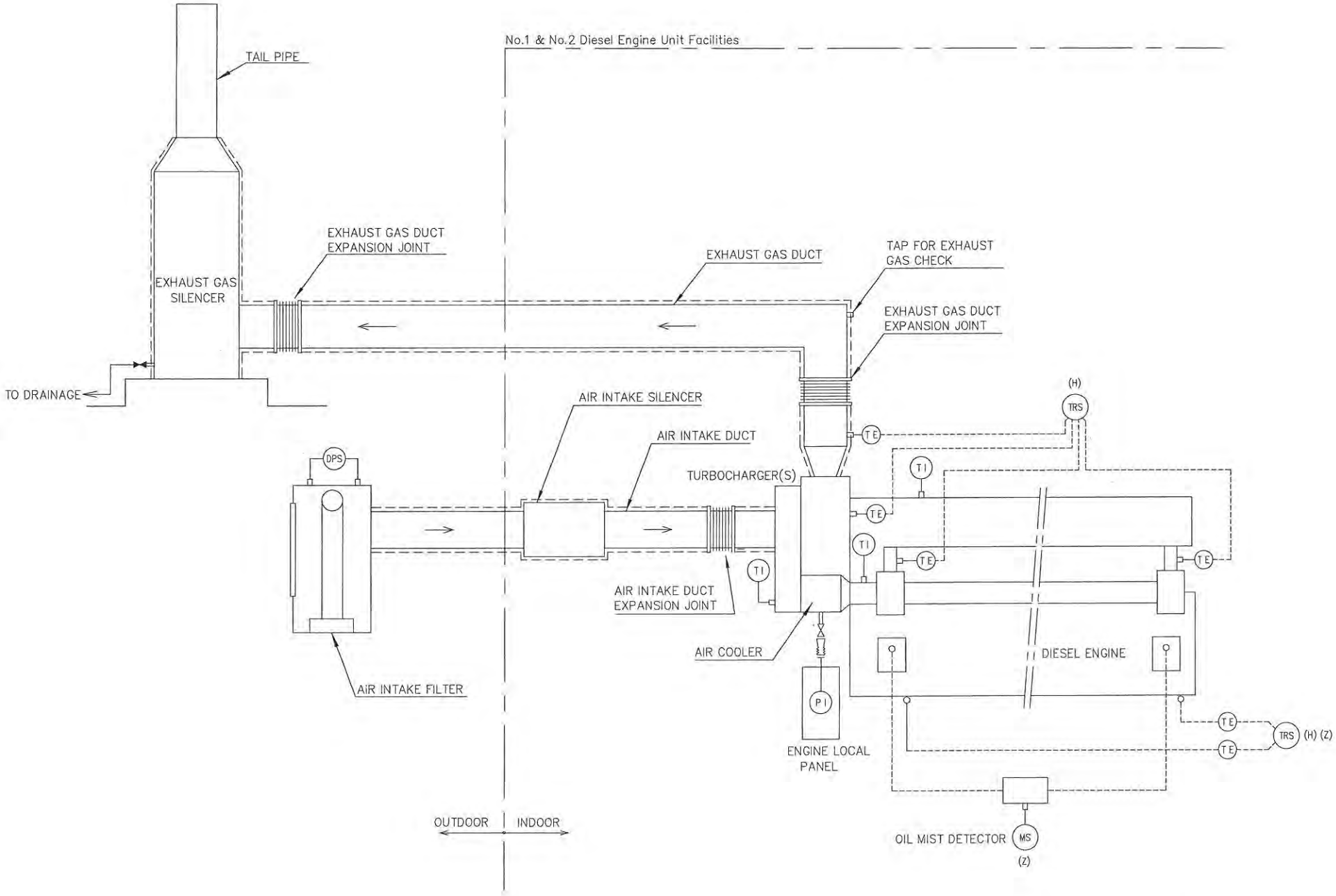
G-M04



NONE

圧縮空気系統図
COMPRESSED AIR FLOW DIAGRAM

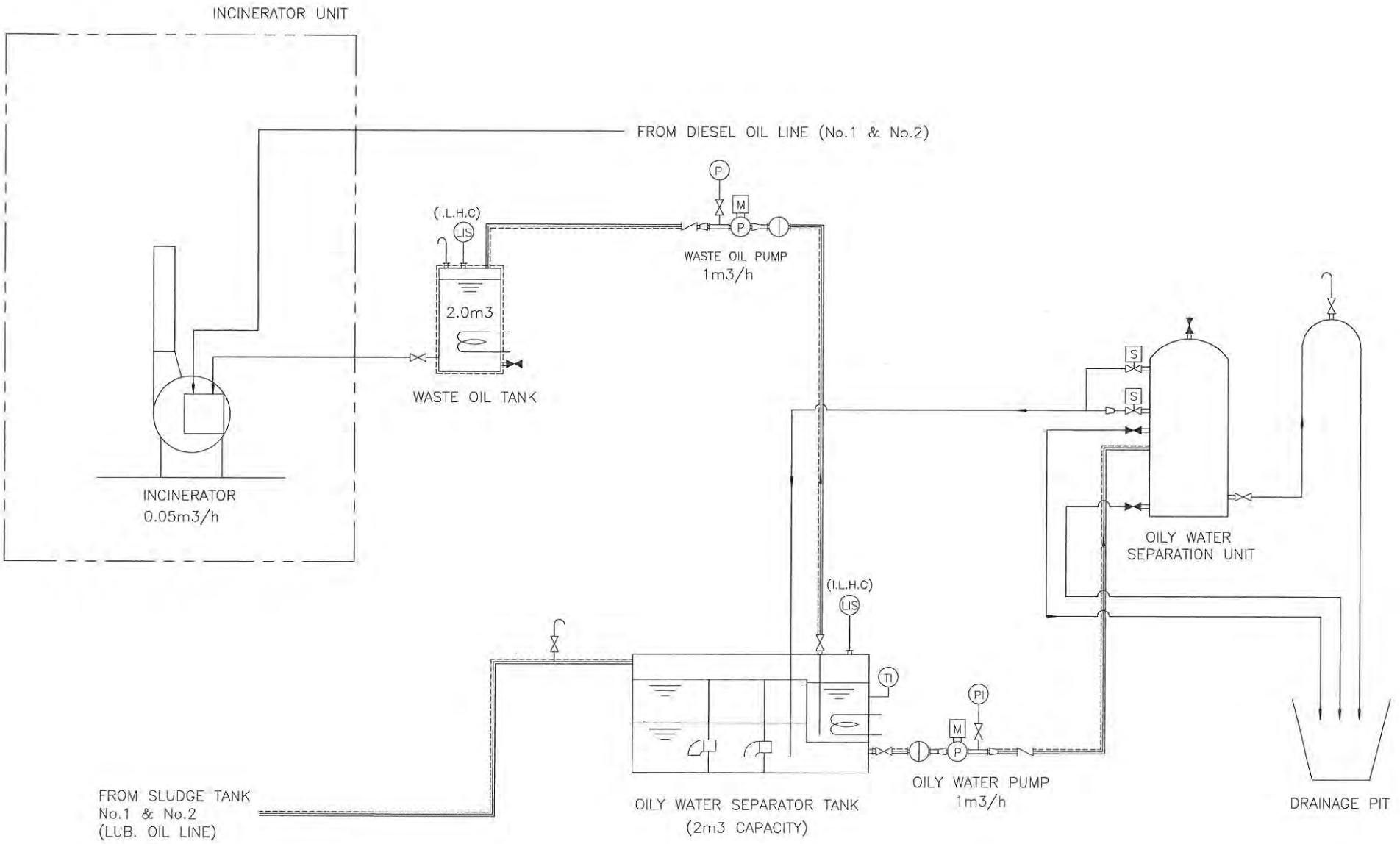
G-M05



NONE

吸気・排気系統図
AIR INTAKE AND EXHAUST GAS FLOW DIAGRAM

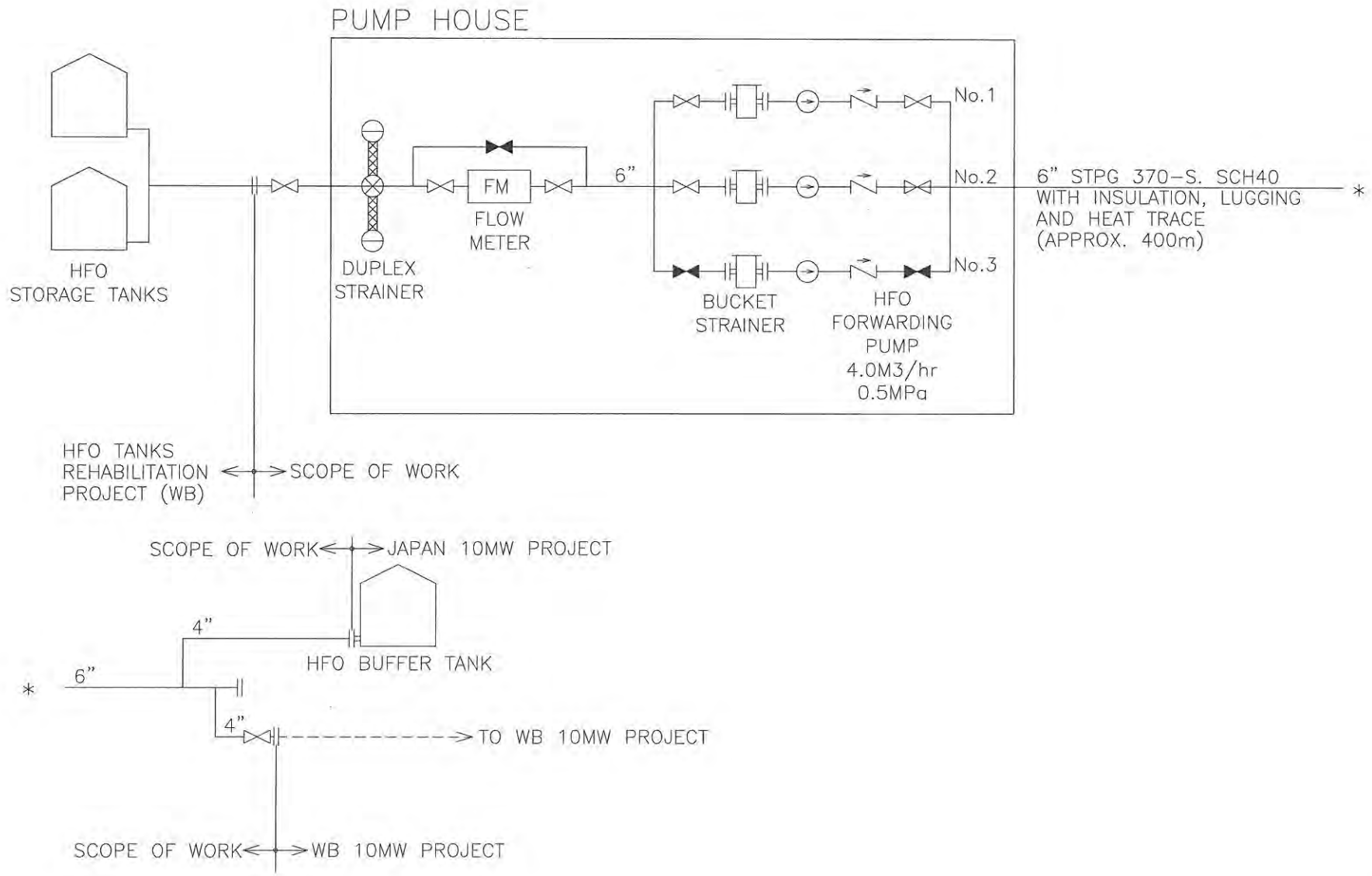
G-M06



NONE

廃油処理系統図
SLUDGE TREATMENT FLOW DIAGRAM

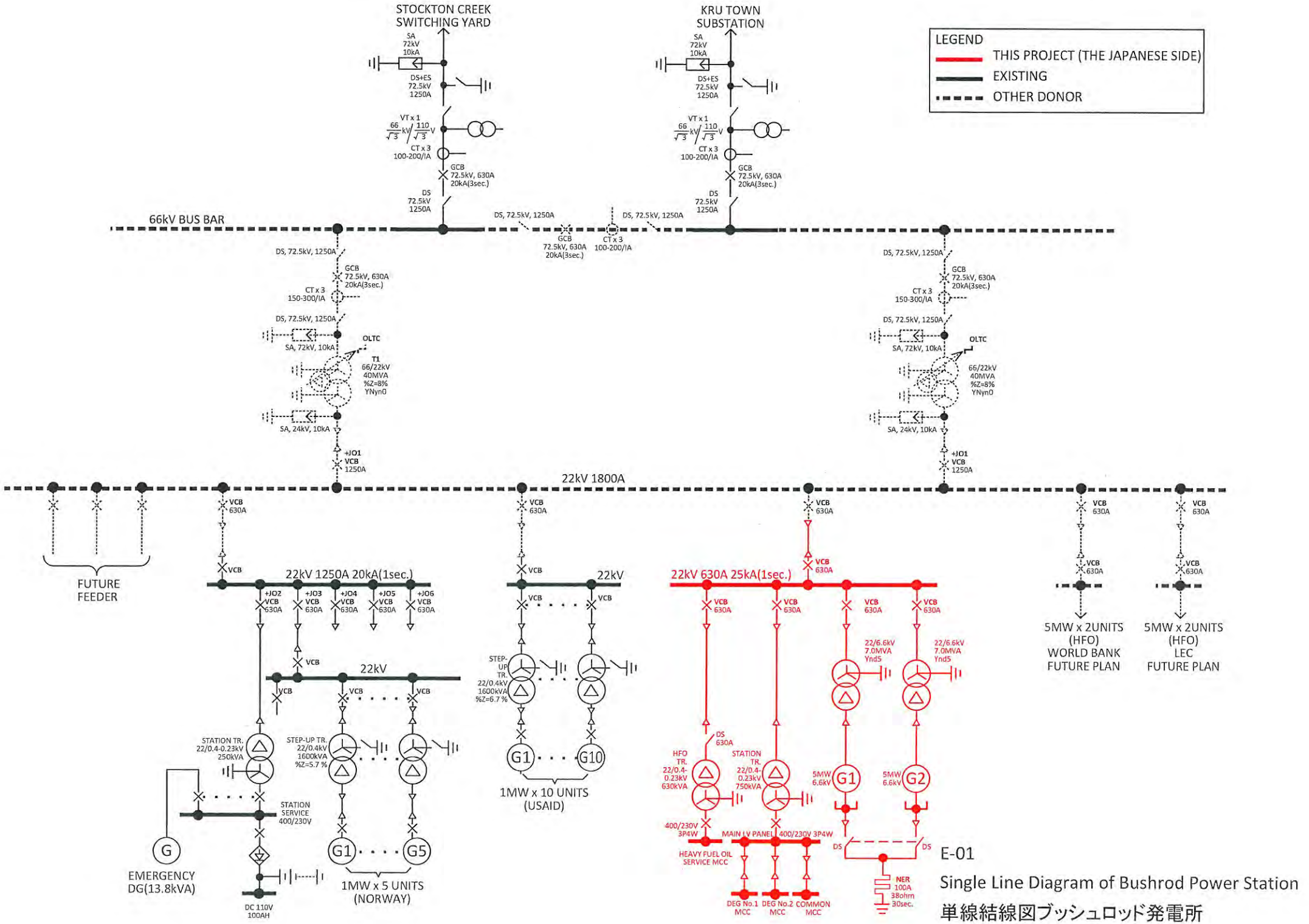
G-M07



NONE

重油供給系統図
HFO SUPPLY FLOW DIAGRAM

G-M08



E-01

Single Line Diagram of Bushrod Power Station

単線結線図ブッシュロッド発電所