資料－5　フィールドレポート

PREPARATORY SURVEY
ON
THE PROJECT FOR
IMPROVEMENT OF QUEENSWAY SUBSTATION
IN
THE REPUBLIC OF UGANDA

FIELD REPORT

30th APRIL 2014

Prepared and Submitted by:

Mr. Kazunari Nogami
Chief Consultant
Preparatory Survey Team, JICA

Confirmed and Agreed by

Mr. Eriasi Kiyamba
Managing Director
Uganda Electricity Transmission Co. Ltd.

Confirmed and Agreed by

Mr. Joseph Katera
Managing Director
Uganda Electricity Distribution Co. Ltd.

JICA PREPARATORY SURVEY TEAM
Yachiyo Engineering Co.,Ltd.

A-5-1

Contents

1. Outline of the Project 1
1.1 Background of the Project 1
1.2 Framework for the Project 1
1.3 The Scope of the Japanese side on Minutes of Discussions on 16th April, 2014 2
1.4 Obligations/Undertakings of the Ugandan side for the Project 3
2. Technical requirements confirmed in the first field survey 5
2.1 Technical requirements for the substation of the Project 5
2.1.1 Technical requirements for the equipment of the substation of the Project 5
2.1.2 Technical requirements for the facilities of the substation of the Project 9
2.2 Technical requirements for Transmission Line 11
2.3 Procurement Plan of Spare Parts and Maintenance Tools 13
2.4 On-the-Job Training (OJT) 14
3. Tentative Implementation Schedule of the Project 14
4. Drawings 14

[Attachment]
Attachment – 1 Member List of the Study Team
Attachment – 2 Area for the Project
Attachment – 3 Location of the Existing Facilities, Materials and Equipment
Attachment – 4 Spare Parts List and Maintenance Tools of the Project
Attachment – 5 Tentative implementation schedule of the Project
Attachment – 6 Minutes of Discussions signed on 16th April, 2014

A-5-2

1. Outline of the Project

1.1 Background of the Project

In response to the request from the Government of the Republic of Uganda (Uganda), the Japan International Cooperation Agency (JICA), in consultation with the Government of Japan, decided to conduct a Preparatory Survey (the Survey) on the Project for Improvement of Queensway Substation (the Project).

JICA sent to Uganda the Preparatory Survey Team (the Team) headed by Dr. Hiroshi Sato, Director, Energy and Mining Division 2, Industrial Development and Public Policy Department, JICA, to conduct the first field survey and the Team is scheduled to stay in the country from 11th April to 14th May, 2014.

The Team continued discussions with the concerned officials of Uganda and the field survey in Uganda in consideration of mutual understandings made on the minuets of discussions signed between the Ministry of Energy and Mineral Development (MEMD), Ministry of Finance, Planning and Economic Development, (MoFPED), Uganda Electricity Transmission Company Limited (UETCL) and Uganda Electricity Distribution Company Limited (UEDCL) on 16th April, 2014.

UETCL, UEDCL and the Team had series of technical discussions to form mutual understandings about the contents, scope, preconditions for the Outline Design, basic specifications, general layouts, and so on of the Project in the first field survey. UETCL, UEDCL and the Team agreed to record the following issues described on this Field Report as a conclusion of the discussions.

Components of the Project and their priority will be further examined and may be modified through the consultation with the Japanese Ministry of Foreign Affairs and JICA headquarters. It is important for the Ugandan side to understand that the Preparatory Survey is not a commitment for the future implementation of the Project.

Particularly, in consideration of the schedule and procedures of Japan's Grant Aid projects, the Team explained that the outline design, planning of the implementation schedule, the cost estimation and so on of the Project will be carried out in accordance with the mutual understandings made on this Field Report immediately after the first field survey. UETCL and UEDCL expressed understanding about the schedule and procedures of Japan's Grant Aid projects. UETCL and UEDCL agreed for the Team to progress the further study, the outline design, planning of the implementation schedule, the cost estimation and so on of the Project in accordance with the mutual understandings made on this Field Report immediately after the first field survey.

1.2 Framework for the Project

The framework for the Project is shown as follows.

(1) The responsible ministry is the Ministry of Energy and Mineral Development (MEMD).
(2) The implementing agency is Uganda Electricity Transmission Company Limited (UETCL).
(3) The cooperating agency is Uganda Electricity Distribution Company Limited (UEDCL).

1.3 The Scope of the Japanese side on Minutes of Discussions on 16th April, 2014

The Scope of the Japanese side on Minutes of Discussions (M/D) on 16th April, 2014 is shown in Table 1.3-1 and Figure 1.3-1.

The Ugandan side and the Team discussed the final requested components of the Project and their priority in consideration of change of the conditions after submission of the application of the Japan's Grant Aid for the Project. The Team suggested three alternatives of the Project and priority of the components in each alternative in conformity with the current conditions surrounding the Project. The Ugandan side and the Team agreed the following alternative as the final requested components of the Project and their priority. The rating of the priority shown in the following table is higher in the following manner; A+, A-, and B.

Based on the discussion after M/D signed on 16th April, 2014, the number of 33 kV Indoor GIS to be procured and installed is agreed between the Ugandan and Japanese side as below.

Table 1.3-1 Final requested components of the Project and their priority

Components	Capacity	Priority
Procurement and Installation Work		
1. No.1 and No.2 transformation banks		
(1) 132/33 kV Transformer	40 MVA×2 units	A+
(2) 132 kV Outdoor GIS (Double Bus Type)	5 units	
(3) 33 kV Indoor GIS	9 units	
(4) 132 kV Transmission Line for incomings	0.5 km distance	
(5) SCADA Interface Marshalling Cubicle	1 unit	
2. Connection bay for No.3 transformation bank		
(1) 132 kV Outdoor GIS (Double Bus Type)	1 unit	A-
3. No.3 transformation bank		
(2) 132/33 kV Transformer	40 MVA×1 unit	B
(3) 33 kV Indoor GIS	5 units	
Procurement Work		
4. Maintenance Tools for the Equipment of the Project	1 lot	A+
5. Spare Parts for the Equipment of the Project	1 lot	
Construction Work		
6. Foundation for the Equipment of the Project (GISs, transformers and towers for 132 kV transmission line)	1 lot	A+
7. Building of Queensway Substation	1 building	

[Notes] GIS: Gas Insulated Switchgear
[Remark] Quantities shall be examined in the outline design.

Figure 1.3-1 Location of the Requested Components

1.4 Obligations/Undertakings of the Ugandan side for the Project

(1) Preconditions

- UETCL shall obtain an Environmental Permit (EP) from National Environment Management Authority (NEMA) until August, 2014 after submitting the Project Brief in timely manner.
- UETCL agreed to secure the land as shown in Attachment-2 for 132/33 kV Queensway Substation of the Project in accordance with agreement on M/D signed on 16th April, 2014 and submit to the Team a copy of the official document showing the land belonging to UETCL.
- UETCL agreed to secure the land for the entire 132 kV transmission line route of the Project and submit to the Team a copy of the official document showing the land belonging to UETCL.
- UETCL and UEDCL agreed for the cables of the incoming 132 kV transmission lines to the 132/33 kV Queensway Substation of the Project to be installed under the existing main road in the existing Queensway Substation with coordination with UMEME.
- UETCL agreed to obtain permission from related authorities for 132 kV transmission lines to go across Queensway Road and the small branch road before commencement of the installation work by the Japanese side (see DWG. No. T-01).
- UETCL agreed to provide a list showing signals to be transferred from 132/33 kV Queensway Substation of the Project to Lugogo Central Control Center before the Team complete the first field survey.

(2) Necessary Inputs by the Ugandan side

1) Prior to the Commencement of the Construction Work

- UETCL agreed to relocate the Country Trees within the above mentioned area for the Project as shown in Attachment-2 to outside of the area with coordination with Pan African Movement before commencement of the installation work of the Project by the Japanese side.
- UETCL agreed to relocate the existing ditch within the above mentioned area for the Project to the northern side of existing Queensway Substation along the existing fence with coordination with Pan African Movement before commencement of the installation work of the Project by the Japanese side (see DWG. No. A-02).
- UETCL and UEDCL agreed to expand and add, within existing Queensway Substation, trenches for cables from the 33 kV switchgears of the Project to 33/11 kV substations by themselves for proper installation and connection of 33 kV lines of the Project (see DWG. No. A-01).
- The Ugandan side agreed to prepare access holding dimensions and number enough for the 33 kV cables of the Project to the existing 33 kV switchgears installed by the previous Japan's Grant Aid project.

2) During the Construction Work

- UETCL and UEDCL agreed to schedule power outages required for installation work of the Project and carry out them in timely manner. UETCL and UEDCL shall also manage any issue concerning the power outages, including related procedures, and compensation to and grievances from customers.

  Especially, to install the towers for branching 132 kV transmission line to the 132/33 kV Queensway Substation of the Project, UETCL agreed for both two circuits of the existing 132 kV transmission lines between Lugogo and Mutundwe to be kept in condition of power-out during the installation work of these towers.
- UETCL agreed to control traffic properly and timely to carry out location of 132 kV incoming lines to 132/33 kV Queensway Substation of the Project during the work. UETCL also agreed to manage any issue concerning the traffic control, including related procedures, and compensation to and grievances from the public.
- The Ugandan side agreed to manage to secure the small branch road between Katwe road and Queensway road as the access to the existing main entrance of Queensway Substation with coordination with the related authorities.
- UETCL agreed to secure a temporary storage yard (Approx. 5,000 m^2) for the Project near the Project site.

- UETCL agreed to procure and supply to the Japanese side total 8 units (4 units for the main and 4 units for confirmation of accuracy of the main) of energy meters used for official transaction in Uganda.

- UETCL and UEDCL agreed to decommission and relocate the existing equipment, facilities, materials and so on (terminal poles, underground cable, pipes and so on) within the above mentioned area for the Project, as shown in Attachment-3, to outside of the area before commencement of the installation work by the Japanese side.

3) After the Commencement of Operation

- With applying the materials for the final connection work procured by the Japanese side, UETCL and UEDCL agreed to carry out the final connection work between 33 kV lines of the Project to the existing 33/11 kV substations at Queensway Substation.

- UETCL agreed to procure and install, by themselves, equipment such as remote terminal unit (RTU), multiplexer, optical fiber distribution frame (ODF) and so on in conformity with the requirements of the existing ABB SCADA system.

  The equipment shall be connected by UETCL to the SCADA interface marshalling cubicle of the Project which collect information analog or digital signals of the equipment of the Project after procurement and installation of such equipment as RTU, ODF, and so on by UETCL.

  The materials for this connection work shall be procured and installed by UETCL in accordance with their location at the first floor of the control building of the Project.

- UETCL shall provide the setting list of the protection relays to the Japanese side.

2. Technical requirements confirmed in the first field survey

2.1 Technical requirements for the substation of the Project

2.1.1 Technical requirements for the equipment of the substation of the Project

(1) Applicable Codes and Standards

The equipment of 132/33 kV Queensway Substation of the Project shall be designed in accordance with IEC, JEC standards and/or equivalent.

(2) Requirements for the equipment of the substations

The specifications of the equipment procured by the Japanese side are shown in Table 2.1.1-1. Single Line Diagram for the equipment is shown in DWG No. E-01 and E-02.

Table 2.1.1-1 Specification of Equipment to be supplied for 132/33 kV Queensway Substation by the Japanese side

No.	Description	Specifications	Q'ty
QS1	**132/33 kV Transformer**		2 sets
	➢ Standards	IEC, JEC or equivalent	
	➢ Capacity	40 MVA	
	➢ Primary voltage	132 kV	
	➢ Voltage regulating range	132 kV +/- 10%	
	➢ Steps (tape)	+/- 8 steps (17 steps)	
	➢ Secondary voltage	33 kV	
	➢ Cooling	ONAN/ONAI	
	➢ Vector group	YNyn0+d1	
	➢ % impedance	Approx. 13%	
	➢ Rated basic impulse withstand voltage	132 kV: 650 kV 33 kV: 170 kV	
	➢ Rated power frequency withstand voltage (1 min.)	132 kV: 275 kV 33 kV: 70 kV	
	➢ Bushing CT	132 kV line: 3 CTs 132 kV neutral: 1CT 33 kV line: 3 CTs 33 kV neutral: 1CT	
	➢ Neutral earthing	132 kV : Solidly earthing system 33 kV: Solidly earthing system	
	➢ Connection	132 kV side: Direct connection to GIS 33kV side: Cable connection (2 x 400 mm²/phase)	
	➢ Others	- Fire walls between transformers are necessary. - Future space for No.3 Transformer is considered.	
QS2	**132 kV Outdoor GIS**		1 lot
	➢ Standards	IEC, JEC or equivalent	
	➢ Busbar configuration	Double Busbar system	
	➢ Quantity	Feeder bays : 2 bays Transformer bays : 2 bays Bus Coupler bay : 1 bay VT/ES bay : 2 sets	
	➢ Rated voltage	132 kV	
	➢ Rated current	Busbar: more than 2,000 A Bus coupler: more than 2,000 A Feeder: more than 2,000 A Transformer: more than 1,250 A	
	➢ Rated interrupting current	31.5 kA	
	➢ Rated short-time withstand current (short time)	31.5 kA (1 sec.)	
	➢ Rated basic impulse withstand voltage	650 kV	
	➢ Rated power frequency withstand voltage (1 min.)	275 kV	
	➢ Circuit Breaker - Auto-reclosing - Operating sequence	 Not Available O-0.3 sec-CO-3 min-CO (Three phase)	
	➢ Current Transformer - Feeder bays - Transformer bays - Coupler bay - Secondary current	 3 CTs None 2 CTs 1 A	
	➢ Voltage Transformer	132/√3 kV/110/√3 V	
	➢ Others -Future bays for 132 kV feeders	 - Future space for 1 x spare transformer feeder bay is considered.	

No.	Description	Specifications	Q'ty
QS3	**132 kV Control and Relay Panels**		**1 lot**
	➢ Type of Control and Protection panel	Duplex type panel	
	➢ Panel arrangement	Front of panel: 132 kV Switchgear Control and 40 MVA Transformer voltage regulating control with mimic bus, control switches, meters, alarms and other control devices Rear of panel: 132 kV Protection relays	
	➢ Standard Protection system (recommended)		
	- 132 kV Transmission line protection	Main: Current Differential Relay (standard type in Uganda) Back-up: Directional Ground Fault Relay, 1st Stage: Teleprotection 2nd Stage: Inverse Definite Minimum Time Over Current Relay	
	- 132/33 kV Transformer protection	Transformer Differential Relay Overcurrent Relay * Each relay shall have dedicated Device	
	- 132 kV Busbar protection	Current Differential Relay * Breaker Failure Protection shall be applied.	
QS4	**33 kV Indoor GIS**		**9 panels**
	➢ Standards	IEC, JEC or equivalent	
	➢ Busbar configuration	Single Busbar system	
	➢ Quantity	Following bays are provided. Control, metering and protection relays are mounted on the respective Switchgear. - 2 x 40 MVA Transformer bays - 4 x 33 kV Feeder bays - 1 x Bus Section bays - 2 x Station Transformer bays	
	➢ Rated voltage	36 kV	
	➢ Rated current	Busbar: 2,000 A Bus Section: 2,000 A Feeder: 1,250 A 132/33 kV Transformer: 2,000 A	
	➢ Rated interrupting current	20 kA	
	➢ Rated short-time withstand current (short time)	20 kA (1 sec.)	
	➢ Rated basic impulse withstand voltage	170 kV	
	➢ Rated power frequency withstand voltage (1 min.)	70 kV	
	➢ Circuit Breaker		
	- Auto-reclosing	Not Available	
	- Operating sequence	O-0.3 sec.-CO-3 min.-CO (Three phase)	
	➢ Current Transformer		
	- Secondary current	1 A	
	➢ Voltage Transformer	33/√3 kV/110/√3 V	
	➢ Protection relays	Numerical relays should be applied.	
	➢ Standard Protection system		
	- 33 kV Incomer (132/33 kV Transformer) protection	50/51/51N	
	- 33 kV Feeder Protection	50/51/51N/87 * A dedicated CT and devise is required for 87.	
	- 33 kV Bus Coupler Protection	50/51/51N	
	- 33/0.415 kV Aux. Transformer Protection	50/51/51N	
QS5	**Others**		
-1	SCADA Interface Marshalling Cubicle	Interface terminals for Digital I/O, Analogue I/O and Pulse signals are provided by Japanese side. RTU, Multiplexer and ODF shall be provided by the Ugandan side.	1 panel
-2	Energy Meter Panel	The Panel shall be provided by the Japanese side. However, total 8 units (4 units for the main and 4 units for confirmation of accuracy of the main) of energy meters shall be provided by the Ugandan side.	1 panel
-3	DC Power Supply System		1 lot
	➢ DC Voltage	110 V DC	
	➢ Battery Capacity	250 Ah/10hr (Black out time: 2 hours)	
	➢ Battery type	Lead acid type (Maintenance free type) * Batteries will be installed inside the DC panel of the Project.	
-4	AC Power Supply System		1 lot
	➢ AC Voltage	415/240 V AC (Three phases and four wires)	
	➢ Station Service Transformer	Capacity: 200 kVA (Tentative) (2 sets) Final capacity will be informed later. AC distribution panel (1 panel) is included.	
-5	Diesel Engine Generator	45 kVA, 415/240 V AC (Three phases and four wires) Fuel tank capacity: 48 hours continuous operation	1 unit
-6	Substation Earthing		1 lot
	➢ Earthing Resistance	Less than 1 ohm	
	➢ Materials	Earthing conductors (copper wire) and terminals	

(3) Interface of SCADA system

UETCL shall procure and install, by themselves, equipment such as RTU, multiplexer, ODF and so on in conformity with the requirements of the existing ABB SCADA system.

The equipment shall be connected by UETCL to the SCADA interface marshalling cubicle of the Project which collect information analog or digital signals of the equipment of the Project after procurement and installation of such equipment as RTU, ODF, and so on by UETCL, as shown in Fig. 2.1.1-3.

The equipment after the SCADA interface marshalling cubicle up to the splicing box as shown in Fig. 2.1.1-3 shall be provided by UETCL. However, an optical fiber cable with 24 cores shall be procured and installed beside the 132 kV incoming underground cables of the Project by the Japanese side. The connection work of the optical fiber cable to the splicing box and ODF shall be carried out by UETCL.

UETCL explained to the Team that the existing splicing box is located on No. 20 Tower and the optical fiber cable will be connected to the system at the splicing box by UETCL.

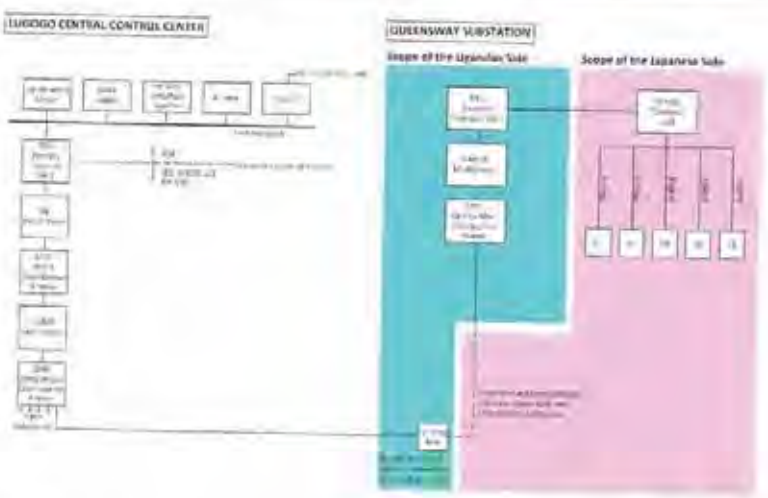


Fig. 2.1.1-3 Work demarcation between the Ugandan side and Japanese side regarding SCADA

2.1.2 Technical requirements for the facilities of the substation of the Project

(1) Design Conditions for the Substation Facilities

The design conditions for the substation facilities are shown in the following Table 2.1.2-1.

Table 2.1.2-1 Basic Conditions for the Facility Design of the Project

Items		Values
Altitude		1190 m
Ambient Temperature	Maximum	35 Degrees Centigrade
	Minimum	10 Degrees Centigrade
	Mean	25 Degrees Centigrade
Maximum Wind Velocity		34 m/s
Annual Rain Fall		1,128 mm/year
Seismic Force		Horizontal 0.15 G
Soil Bearing Capacity		10 t/m^2 (more on survey)

(2) Requirements for the Substation Facilities

Design ground level should be raised up by 1.5 m from existing ground level 65cm higher to the existing Queensway Substation to avoid flood. So retaining wall around the project site would be constructed.

1) Outline of Control Building

The Outline of Control Building is shown in Table 2.1.2-2 (See DWG. No. A-02 and A-03).

Ground floor level should be +1.0 m from the design ground level to secure the height of

Cable Culvert and Cable Pit.

Table 2.1.2-2 Outline of the Control Building

Items	Contents	Details
Structure	Reinforced Concrete Ruhmen Structure	
Height of story	3 stories BFL-GFL=2.65 m GFL-1FL=4.0 m 1FL-RFL=4.0 m	BF: Cable Maintenance Pit, Water Tank 4ton, Pump unit, Submersible pump GF: Office, Switchgear Room, Entrance, Generator Room, Battery Room, Toilet, Shower, Pantry, Corridor, Stair Case 1F: Control Room, Corridor, Stair Case, Roof Balcony: 2 units of 200 kVA transformer, Emergency Balcony: Evacuation and Air-conditioning Units
Total Floor Area	Approx. 680 m^2	-
Building Area	Approx. 280 m^2	-
Exterior	Wall Finishing	Concrete with Urethane Exterior Paint Concrete Louver with Urethane Exterior Paint
	Roof Finishing	Concrete Plate t=80 wire-mesh @200 Urethane joint @2000 each Insulation t=50 Asphalt Membrane 3 Layer Water Proofing
Interior	Wall Finishing	Paint on Mortar iron trowel
	Floor Finishing	Free Access Floor h=300 mm Ceramic Tile 300 x 300
	Ceiling	System Ceiling with Gypsum Board t=12 mm Paint Finishing

2) Foundation of 132/33 kV 40MVA Transformers

The Outline of the Foundation of 132/33 kV transformers is shown in Table 2.1.2-3 (See DWG. No. A-02 and A-03).

Ground floor level should be +0.5 m from the design ground level.

Table 2.1.2-3 Outline of the Foundations of 132/33 kV transformers

Items	Contents	Details
Structure	Reinforced Concrete Mat Foundation	-
Height of story	1 story	GF: 2 units of 40 MVA transformer and future space [Note] For the equipment to avoid submerging to water on heavy rainy days, the floor level of the foundations shall be 0.5 m raised from the design ground level. Fire Wall: Concrete wall H=7.5 m, L=9.0 m, t=250 Total number 3 Oil pit: Around Transformer Foundation D=1.5 m filled with gravel, overflow piping connected to the oil-water separator set west-beside the foundation Cable Culvert (4) 500mm x 900mm
Total Floor Area	Approx. 132 m^2	-
Building Area	Approx. 132 m^2	-

3) Foundations of GISs

The Outline of the foundations of GISs is shown in Table 2.1.2-4 (See DWG. No. A-02

and A-03).

Ground floor level should be +0.5 m from the design ground level.

Table 2.1.2-4 Outline of the Foundations of GISs

Items	Contents	Details
Structure	Reinforced Concrete Wall Structure and Mat Foundation	-
Height of story	1 story	BF: Cable Pit for 132 kV cable (6) GF: GIS and Future Space Fire wall: H=5.0m L=8.0m t=200 [Note] For the equipment to avoid submerging to water on heavy rainy days, the floor level of the foundations shall be 0.5 m raised from the design ground level.
Total Floor Area	Approx. 180m^2	-
Building Area	Approx. 180m^2	-

4) Cable Culvert

The Outline of the Cable Culvert is shown in Table 2.1.2-5 (See DWG. No. A-02 and A-03).

Table 2.1.2-5 Outline of the foundations of GISs

Items	Contents
Cable Culvert (1) from 40 MVA transformers to Cable Culvert (2)	Reinforced Concrete Box Culvert Approx. 26 m^2 (W=1.7 m, H=2.0m with Cable Rack)
Cable Culvert (2) from Cable Culvert (1) to Control Building	Reinforced Concrete Box Culvert Approx. 26 m^2 (W=2.5 m, H=1.4m with Cable Rack)
Cable Culvert (3): from Control Building to Existing Facilities	Reinforced Concrete Box Culvert Approx. 15 m^2 (W=2.5 m, H=1.4 m with Cable Rack)

The function of each cable culvert is as follows. Cable Culvert (1) is for smooth cable installation from each transformer. Cable Culvert (2) is for connection to Control Building. Culvert (3) is for smooth cabling from new building to existing facilities.

5) Foundations for Towers of 132 kV transmission lines

The Outline of the foundations for Towers 132 kV transmission lines is shown in Table 2.1.2-3.

Table 2.1.2-3 Outline of the Foundations of 132/33 kV transformers

Items	Contents	Details
Structure	Reinforced Concrete Foundation	Tower H=Approx. 30 m, 2 Units

2.2 Technical requirements for Transmission Line

132 kV transmission line to new 132/33 kV Queensway Substation shall be installed as shown in DWG. No. T-01, the branch point is the existing transmission lines (between the existing No.19 and No.20 Towers).

The requirements for the transmission lines shall be as follows:

1) 132 kV overhead power lines between the new towers of Tower No. QW1 and QW2 (Double circuits).

2) 132 kV underground power lines between Tower No. QW2 tower and new 132/33 kV Queensway Substation (Double circuits). The underground cables are direct-buried type, however they shall be protected by warning tape and concrete cover. The laying depth shall be 1.4 m from the ground level.

3) The overhead grounding wires between the new towers of Tower No. QW1 and Tower No. QW2 (Double circuits).

4) The optical fiber cable from the tower of Tower No.20 to 132/33 kV Queensway Substation of the Project shall be procured and installed by the Japanese side. The optical fiber cable shall be connected to the existing splicing box at the tower of Tower No. 20 by UETCL.

(1) Design Conditions for 132 kV Transmission Line

The electrical conditions are shown in Table 2.2-1.

Table 2.2-1 Electrical Conditions

Items	Design Values
Minimum clearance of conductor	-
Phase to ground	1,200 mm
Phase to phase	1,500 mm
Minimum creepage distance of insulator	16 mm/kV
Equivalent salt deposit density	N/A

(2) Requirements for 132 kV Transmission Line

The specifications for 132 kV Transmission Line are shown in Table 2.2-2.

Table 2.2-2 Specifications for 132 kV Transmission Line

No.	Items	Specifications		Q'ty
TL1	➢ Tower	Style of tower:	Steel lattice type	
		Configuration of tower:	Wide base square type	
		Type of tower:	Tension type (Angle: 0-20 degree), Dead end type mounted cable termination and arrestor (Angle: 0-20 degree)	1 tower 1 tower
		Safety factor:	1.2 for tension towers	
		Earthing resistance:	less than 10 ohms.	
		[Note]	Broken wire condition shall be two ACSR conductors or one conductor and one overhead grounding wire.	
TL2	➢ Overhead Line (Conductor)	Type:	ACSR	400 m
		Size	420 (Aluminum: 385 mm^2, total: 420 mm^2) BS	
		Sagging stress at 20 °C:	50 N /mm	
TL3	➢ Insulator	Standards:	IEC60383-1 or equivalent	1 lot
		Size:	254 mm suspension insulators	

No.	Items	Specifications	Q'ty
		Creepage distance: 320 mm Material: Porcelain Color: Brown Electro-mechanical falling load: 120 kN Number of insulators shall be 11 units/phase	
TL4	➢ 132 kV Underground Cable	Type: XLPE Size: 800mm^2 Conductor: Copper Number of core: Single Core Type of sheath: PVC with anti-termite protection Color of sheath: Black Armor: Aluminum armor or lead metallic sheath for direct buried in the ground	2.31 km (0.35 km x 3 phases x 1 / phase x 2 circuits = 110%)
TL5	➢ 132 kV Underground cable termination	For Outdoor: Single core porcelain type For GIS: Single core	6 pcs 6 pcs
TL6	➢ Overhead Grounding Wire	Type: 50 mm^2 Steel wire strand The shielding angle: less than 15 degree. Sagging stress at 20°C: 120 N /mm	50 m
	➢ Fiber Optical Cable	Number of Core: 24 cores Type of optical fiber cable: Type ITU-T G655 or equivalent Mode: Single Wave length: 1550 nm Others: *Optical fiber cables shall be provided by the Japanese side. However the existing fiber optical line splice and termination of materials for the work shall be done by the Ugandan side. *The laying of the optical cable with the laying of 132 kV underground cable to the new 132/33 kV Queensway substation shall be carried out by the Japanese side.	500 m
TL7	➢ 132kV Outdoor Lightning Arrestor	Standards: IEC 60099-4 IEC line discharge class: class 2 Type: Porcelain Outdoor Zinc Oxide type Maximum System Voltage (kVrms): 145 kV Normal Discharge Current (kA crest): 10 kA Accessories: Surge counter with leakage current mA meter	6 pcs

2.3 Procurement Plan of Spare Parts and Maintenance Tools

Capability of sustainable operation and maintenance for the equipment of the Project by the Recipient is one of conditions for the Japan's Grant Aid. The Ugandan side shall keep operation and maintenance for the equipment of the Project properly by himself, including procurement of spare parts. On the other hand, the warranty period for the Project is 1 year after issuance of the completion certificate in case of the Japan's Grant Aid. To secure operation and maintenance for the equipment of the Project for the warranty period, the spare parts required for the period shall be provided as the scope of the Japanese side.

Possession of maintenance tools for proper operation and maintenance for the equipment of the Project by the Recipient is one of conditions for the Japan's Grant Aid. However, the special tools required for operation and maintenance of the equipment of the Project shall be provided as the scope of the Japanese side.

Outline of the spare parts and maintenance tools of the Project is shown in Attachment-4. More detailed parts, tools, test equipment and the quantity will be explained with the Draft Final Report.

2.4 On-the-Job Training (OJT)

An On-the-job training (OJT) will be carried out during the construction period. Through the OJT, maintenance and operation for the equipment of the Project will be carried out by Japanese skilled engineer of the manufacturers of the equipment of the Project at the project site.

3. Tentative Implementation Schedule of the Project

The tentative implementation schedule is shown as Attachment-5. In case that the Project is adapted by the Japanese Government, the Project will proceed as follows in the earliest scenario. The installation work of the Project will start in June, 2015. It is important for both sides to understand that the Preparatory Survey is not a commitment for the future implementation of the Project.

- ➢ The Exchange of Notes between the Ugandan and Japanese Government will be signed in November, 2014.
- ➢ The Tender Opening will be held in May, 2015.
- ➢ Installation work of the Project will start in June, 2015.
- ➢ Commissioning of the Project will be in March, 2017.

4. Drawings

Part 1 Substation

E-01: Single Line Diagram for Queensway Substation
E-02: Single Line Diagram for Queensway Substation (LV AC AND DC CIRCUIT)

Part 2 Transmission Lines

T-01: 132 kV Transmission Line and Underground Cable Route Map to Queensway Substation
T-02: Improvement of Queensway Substation
T-03: Type of Steel Tower [T]
T-04: Dead End Type Steel Tower Cable Termination
T-05: 132 kV Underground Cable Section (General)

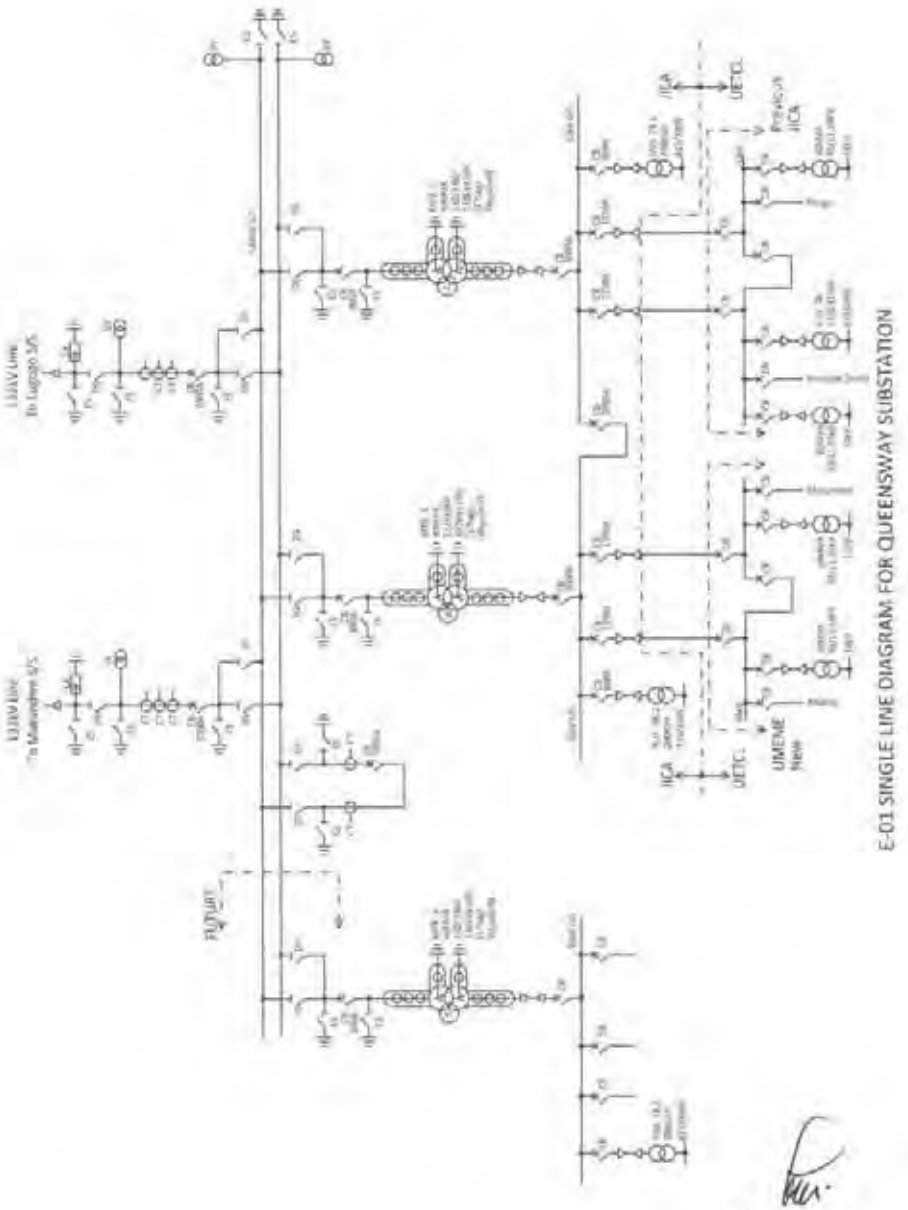
T-06: 132 kV Underground Cable Section (For Road)

Part 3 Architectural

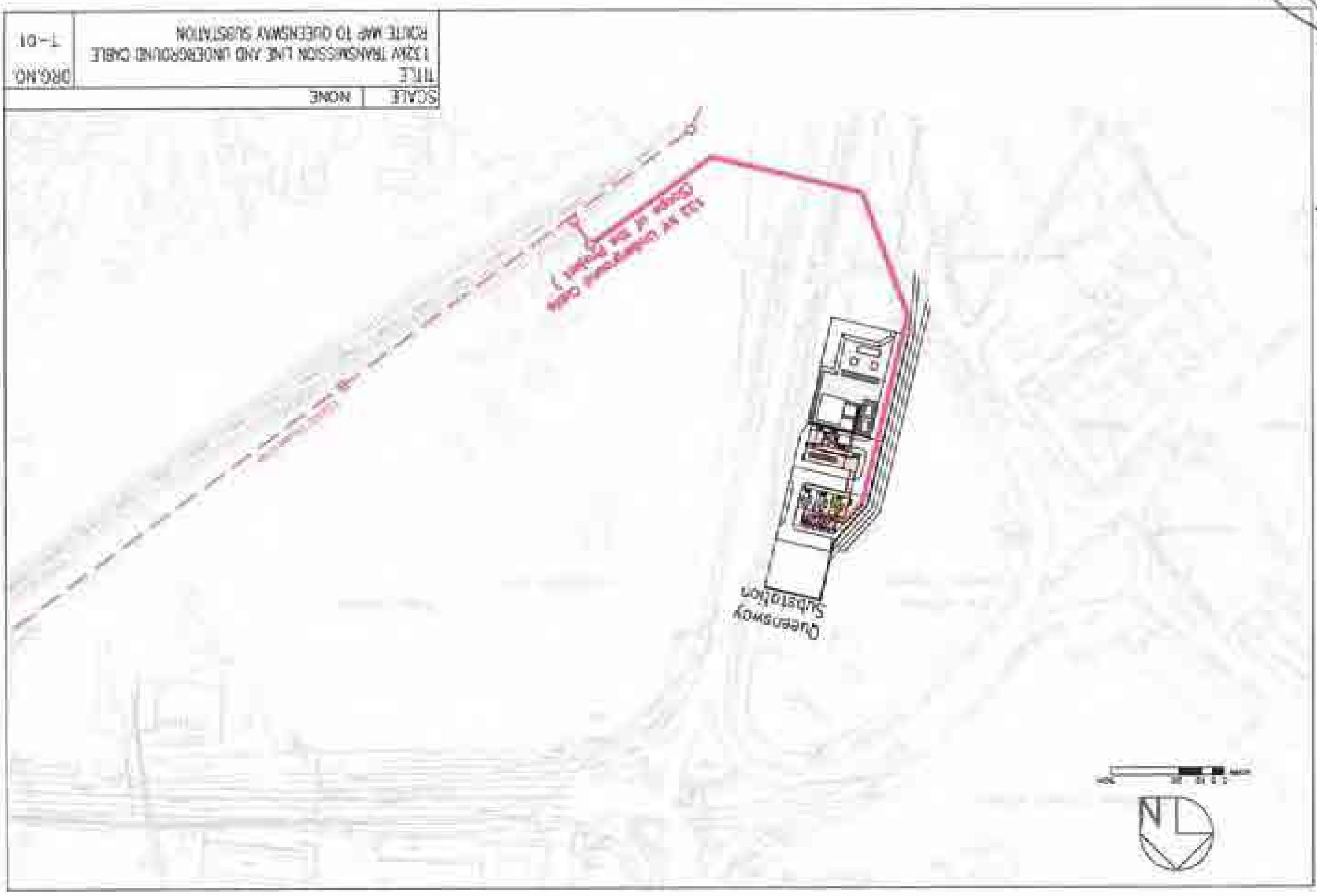
A-01: Site Layout of Queensway Substation

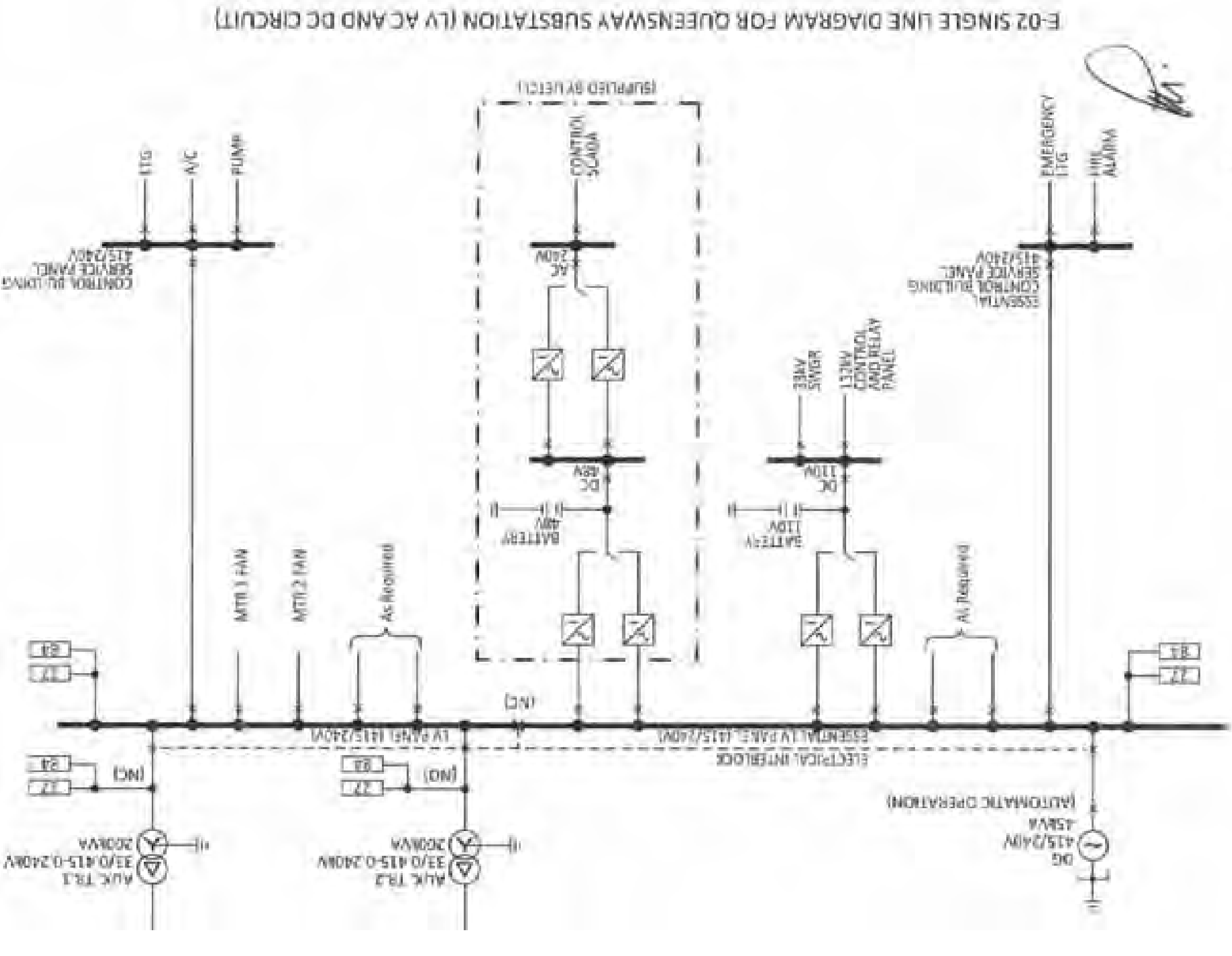
A-02: Section of Queensway Substation

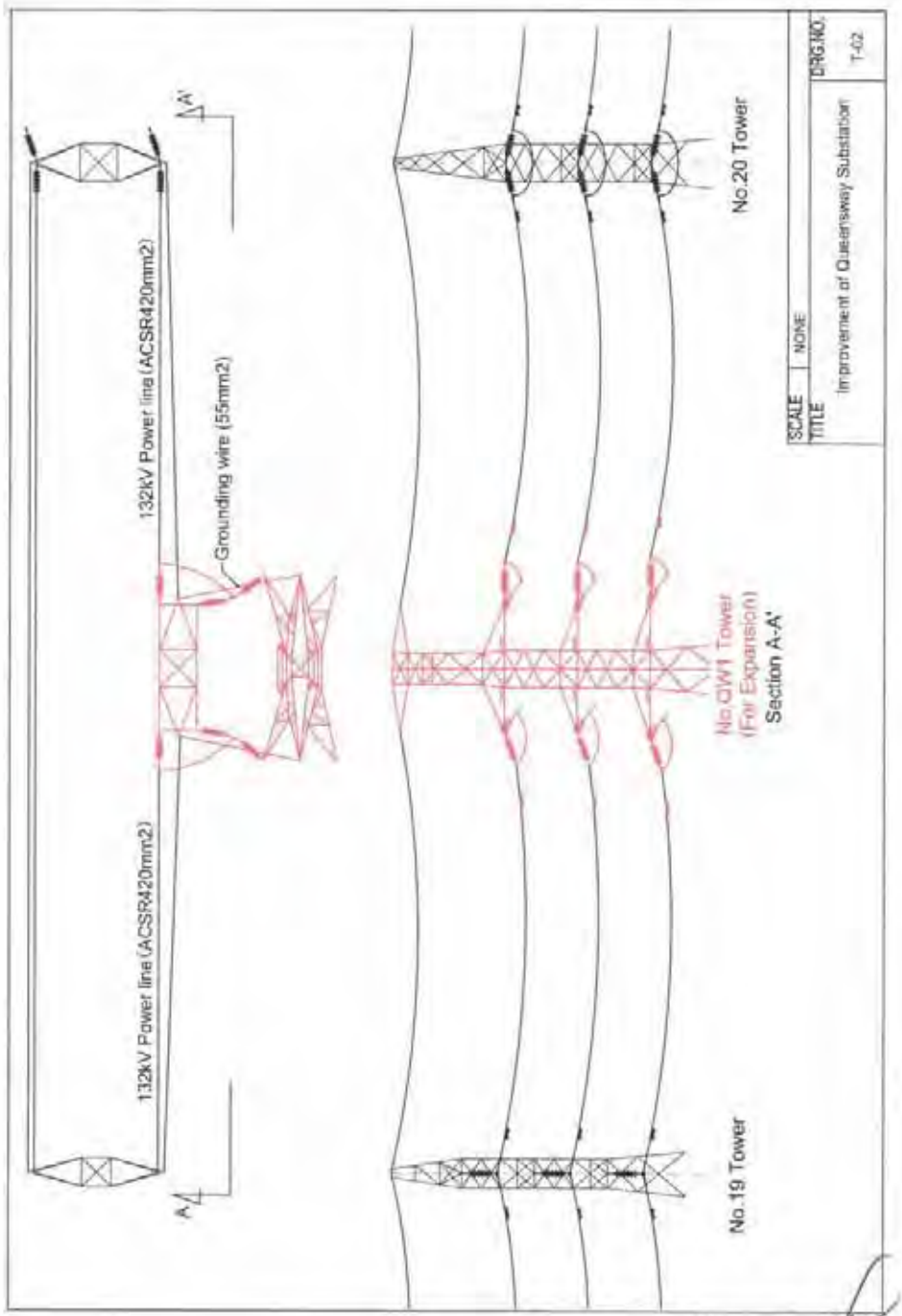
A-03: Layout of Electrical Equipment

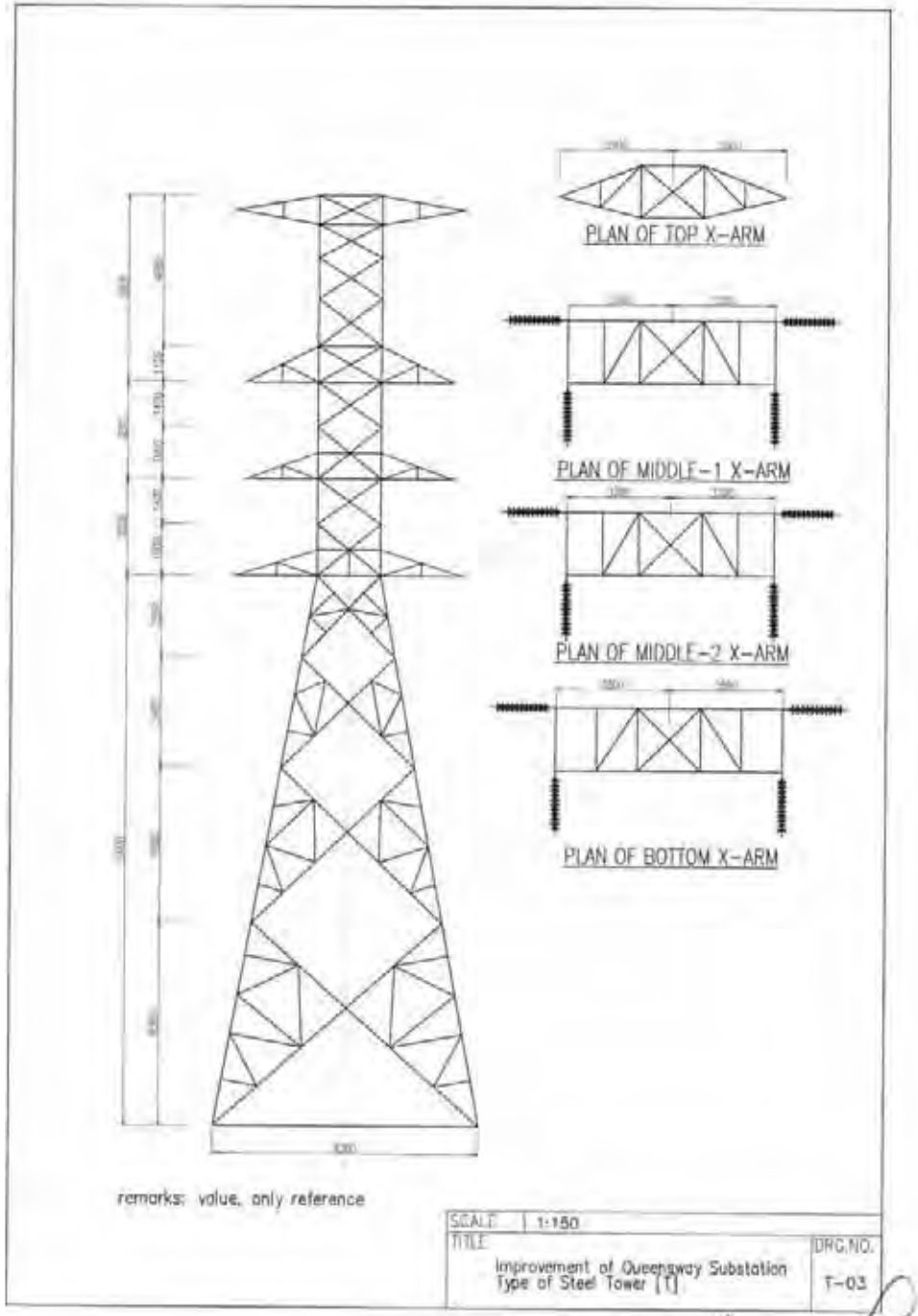


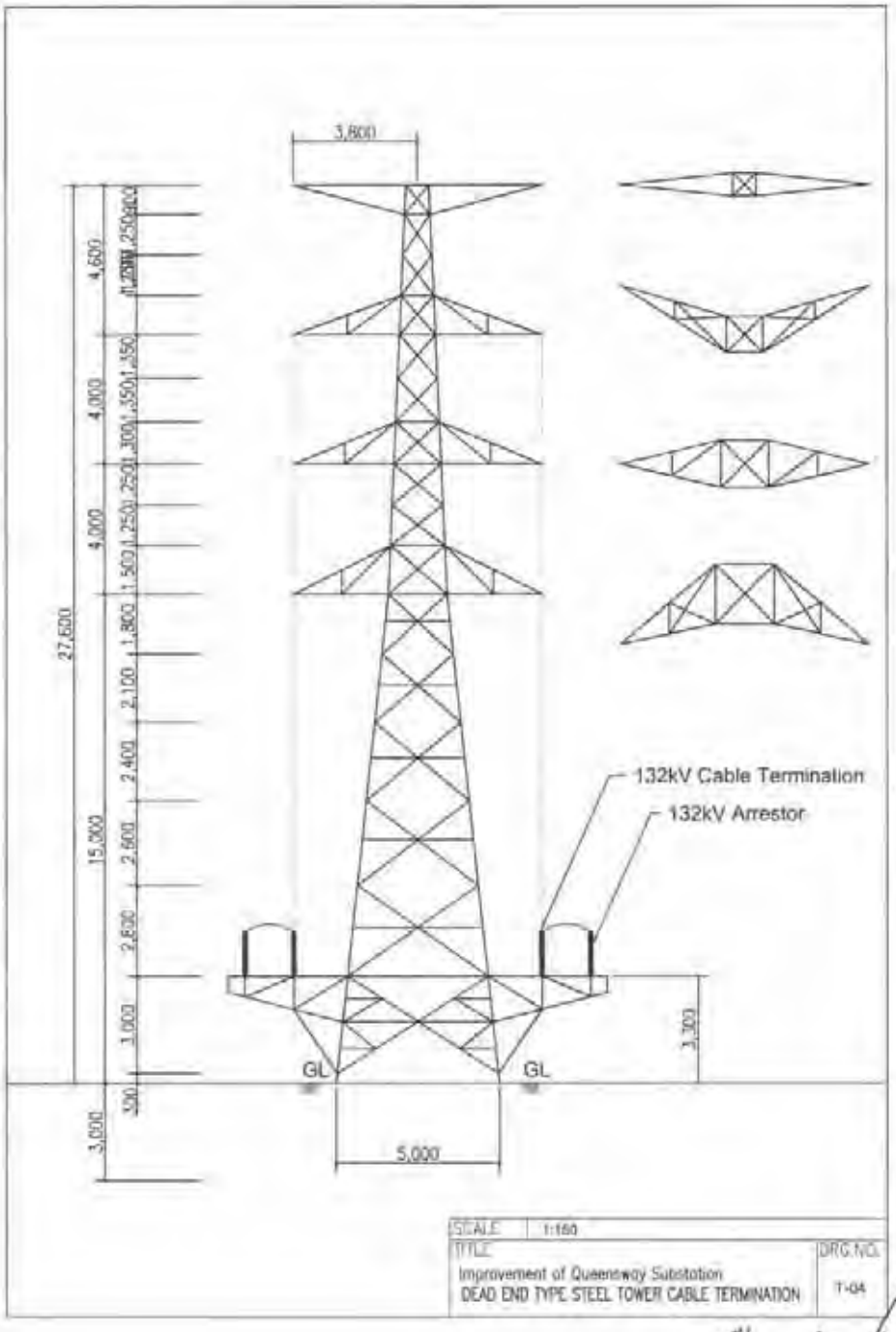
E-01 SINGLE LINE DIAGRAM FOR QUEENSWAY SUBSTATION

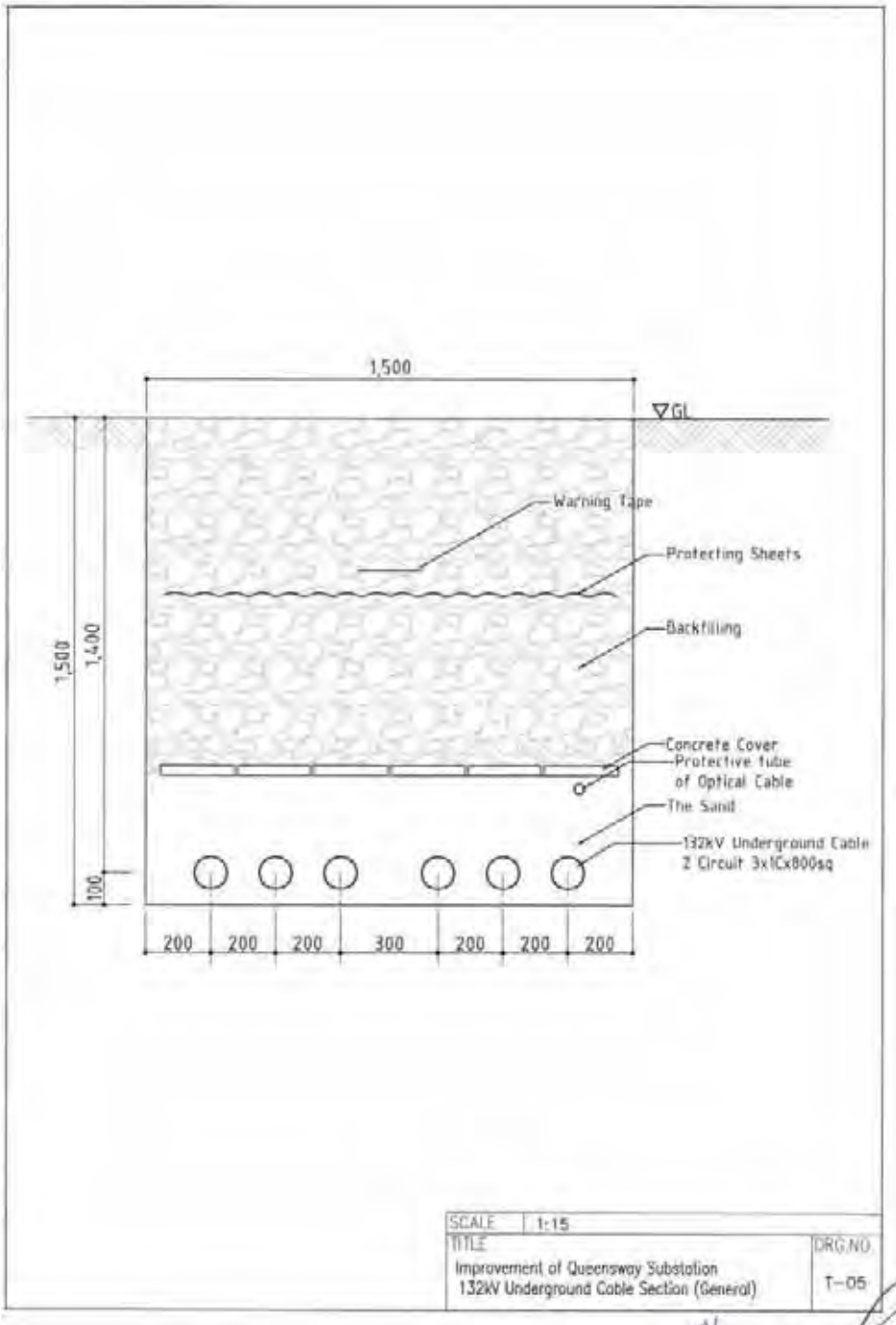

SCALE
NONE
TITLE
132kV TRANSMISSION LINE AND UNDERGROUND CABLE
ROUTE MAP TO QUEENSWAY SUBSTATION
DRG.NO.
T-01
132 kV Underground Cable (Scope of the Project)
Queensway Substation

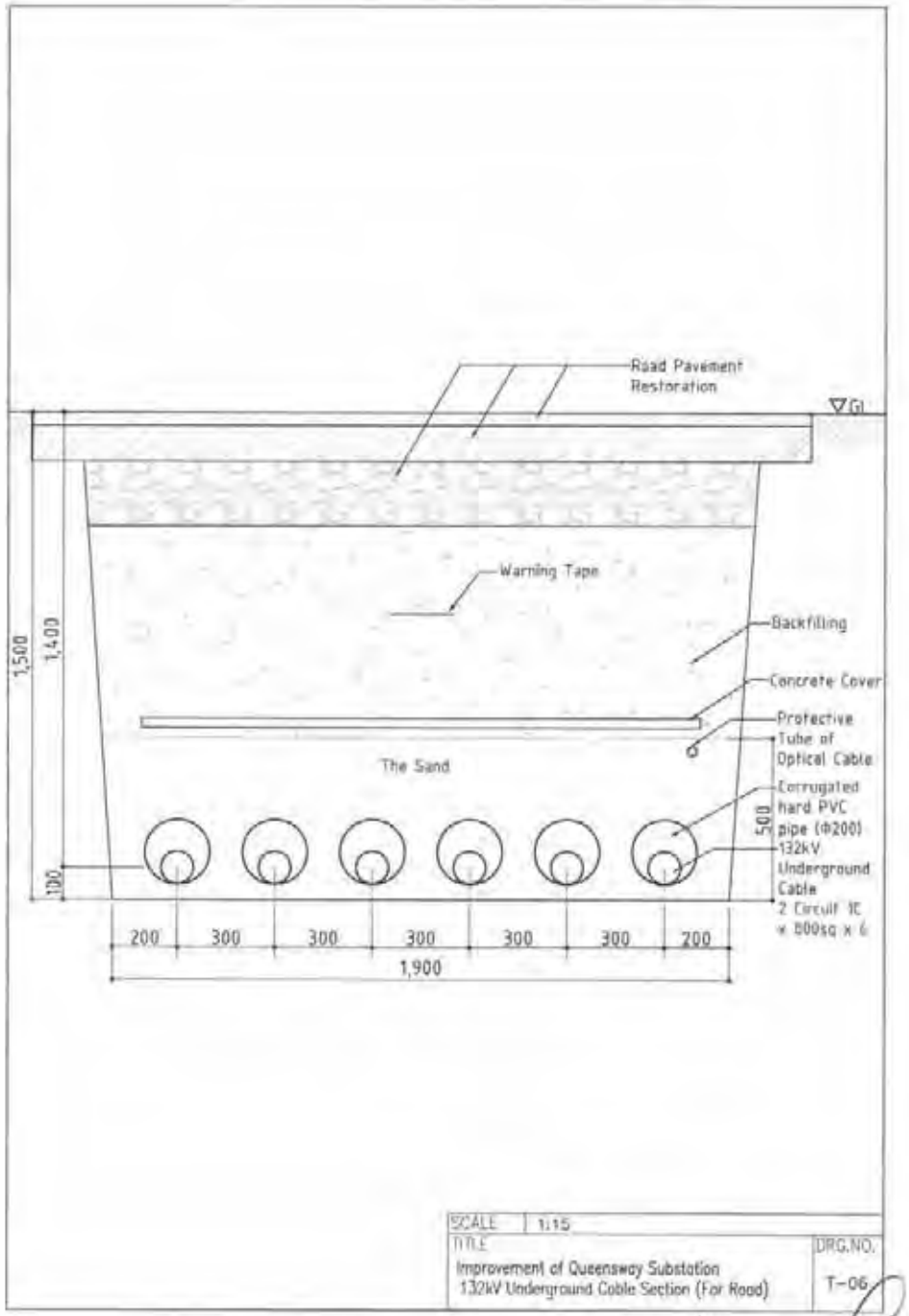

E-02 SINGLE LINE DIAGRAM FOR QUEENSWAY SUBSTATION (LV AC AND DC CIRCUIT)
(SUPPLIED BY LIETCL)
CONTROL SCADA
AC 240V
DC 48V
BATTERY 48V
DC 110V
BATTERY 110V
33kV SWGR
132kV CONTROL AND RELAY PANEL
EMERGENCY LTG
FIRE ALARM
ESSENTIAL CONTROL BUILDING SERVICE PANEL 415/240V
CONTROL BUILDING SERVICE PANEL 415/240V
LTG
A/C
PUMP
MTR 1 FAN
MTR 2 FAN
As Required
LV PANEL (415/240V)
ESSENTIAL LV PANEL (415/240V)
ELECTRICAL INTERLOCK
(NC)
(NO)
AUX. TR.1 33/0.415-0.240kV 200kVA
AUX. TR.2 33/0.415-0.240kV 200kVA
DG 415/240V 45kVA
(AUTOMATIC OPERATION)

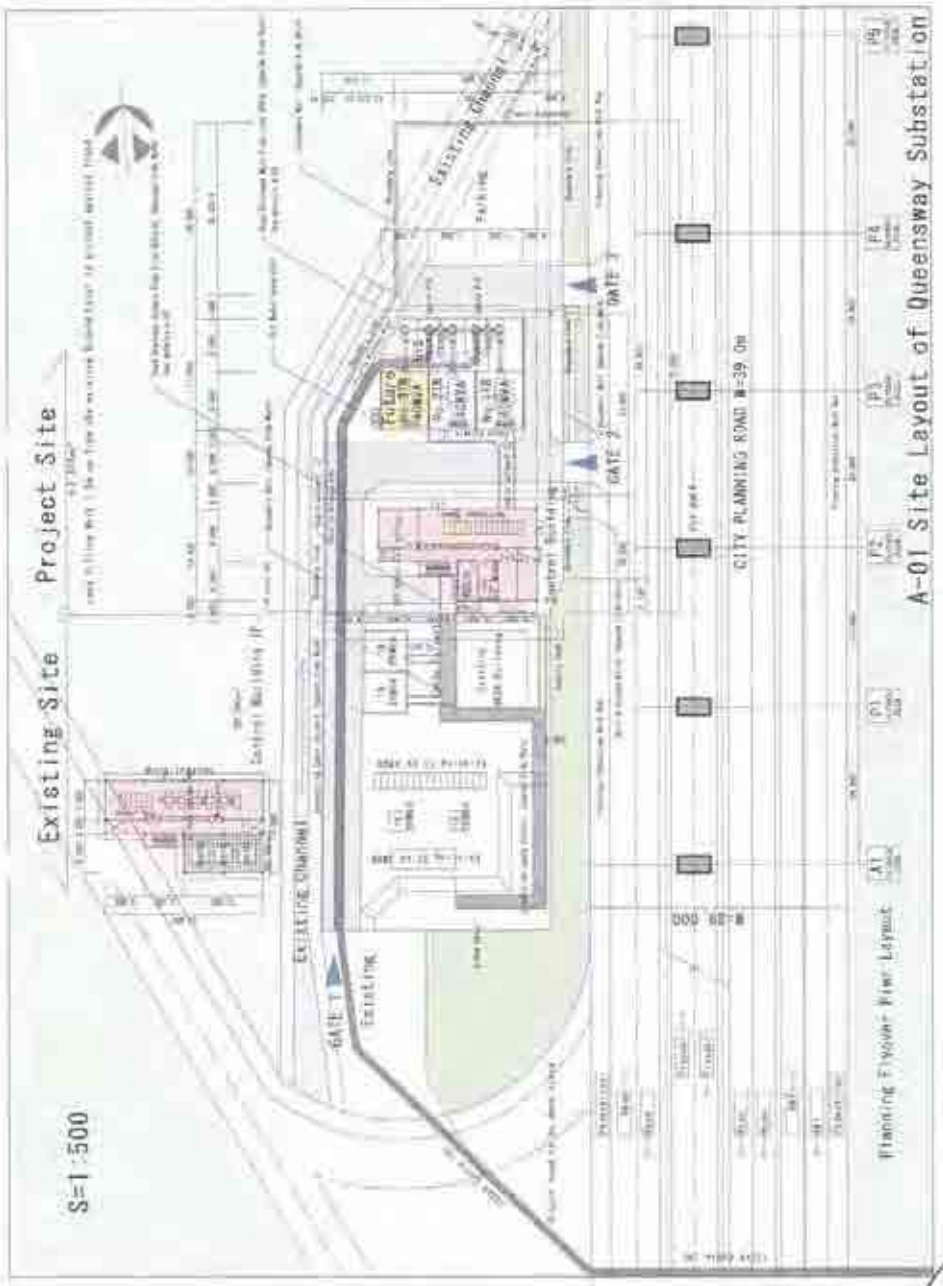

A'
A
132kV Power line (ACSR420mm2)
Grounding wire (55mm2)
132kV Power line (ACSR420mm2)
No.20 Tower
No.GW1 Tower
(For Expansion)
Section A-A'
No.19 Tower
SCALE NONE
TITLE Improvement of Queensway Substation
DRG.NO. T-02

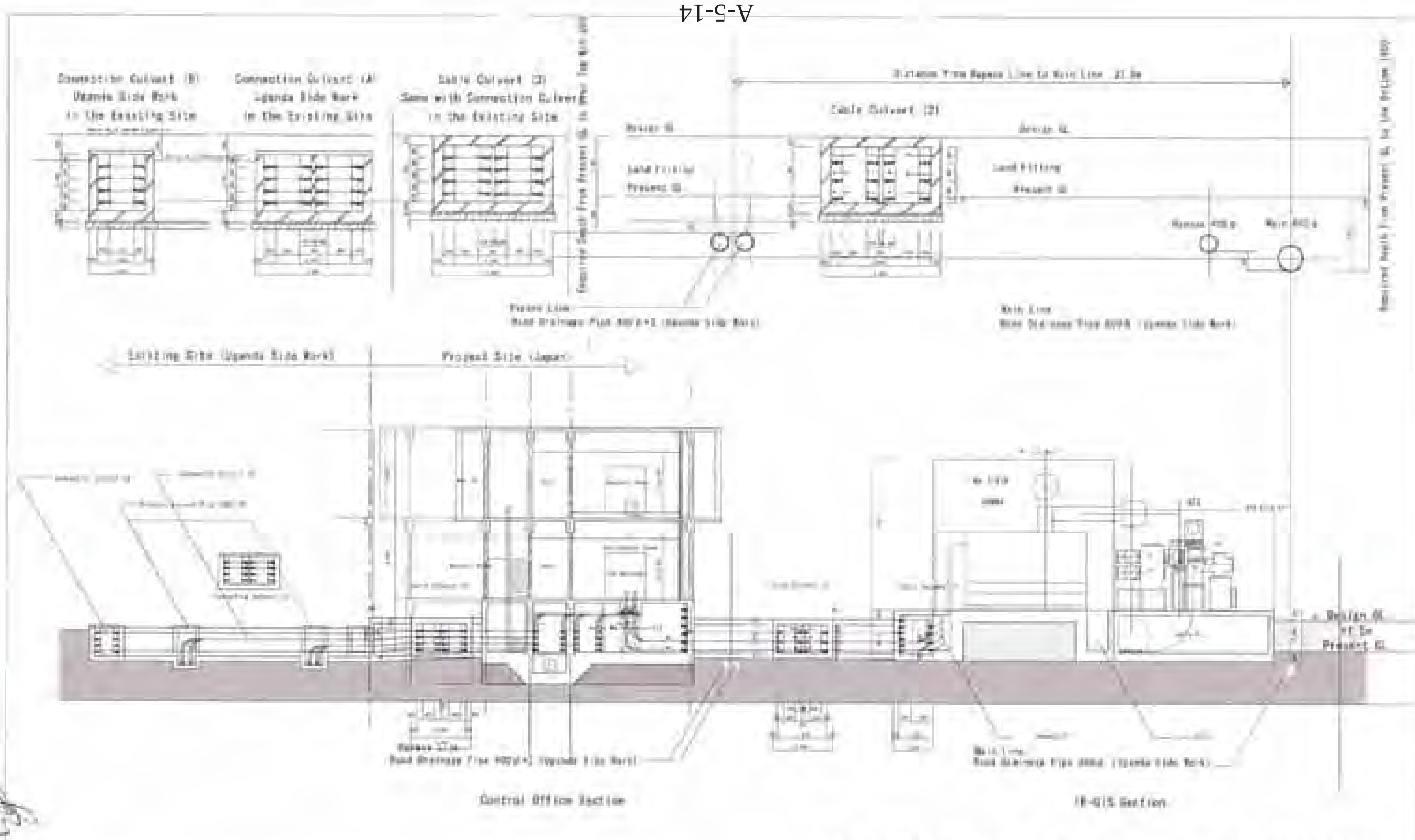

PLAN OF TOP X-ARM
PLAN OF MIDDLE-1 X-ARM
PLAN OF MIDDLE-2 X-ARM
PLAN OF BOTTOM X-ARM
remarks: value, only reference
SCALE 1:150
TITLE Improvement of Queensway Substation
Type of Steel Tower (T)
DRG.NO. T-03


3,800
4,600
4,000
4,000
15,000
2,100
2,400
2,600
2,800
3,000
27,600
1,800
1,500
1,250
1,250
1,300
1,350
1,350
900
300
3,000
132kV Cable Termination
132kV Arrestor
3,300
GL
GL
5,000
SCALE 1:150
TITLE
Improvement of Queensway Substation
DEAD END TYPE STEEL TOWER CABLE TERMINATION
DRG.NO.
T-04

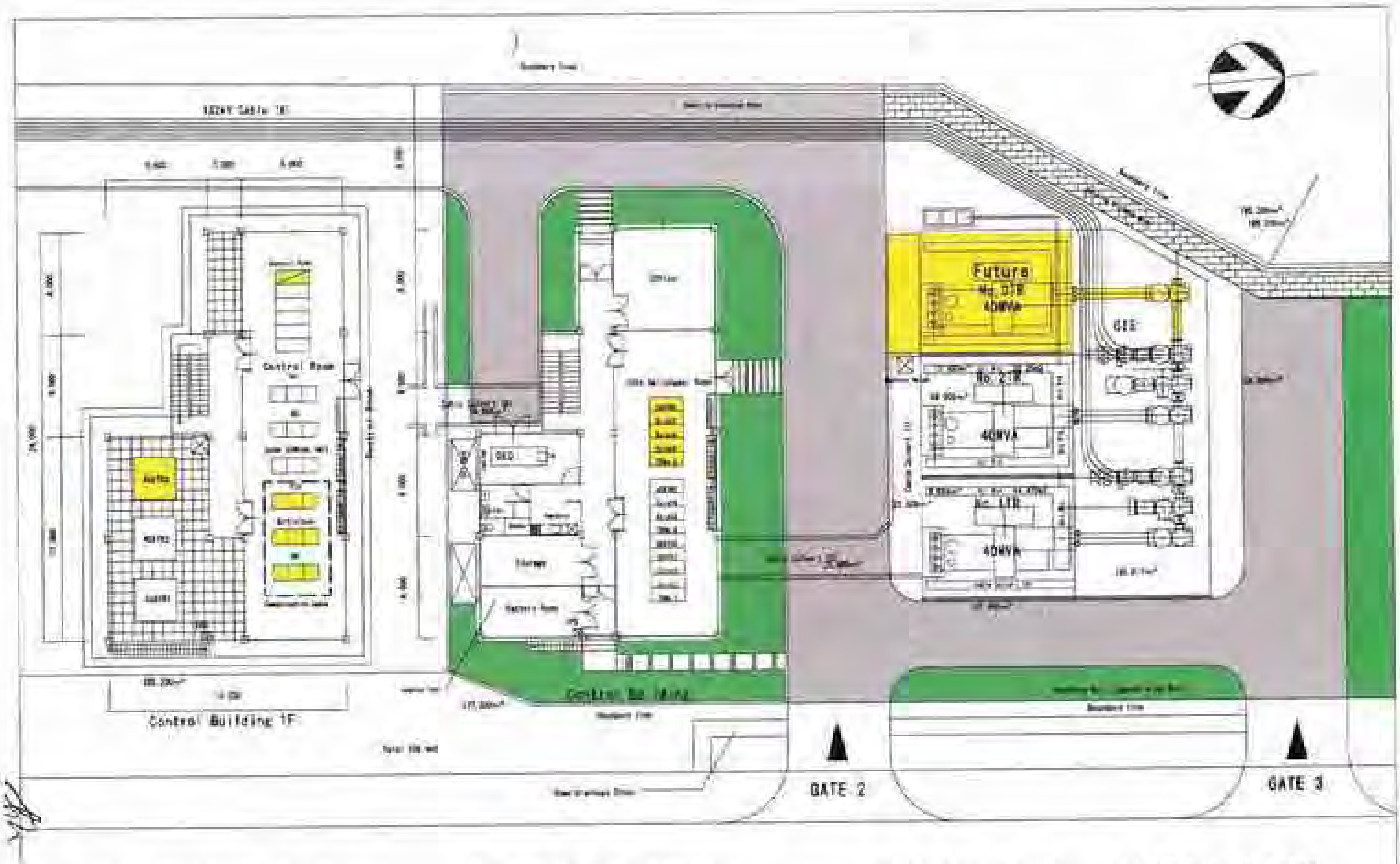

1,500
GL
Warning Tape
Protecting Sheets
Backfilling
1,500
1,400
100
Concrete Cover
Protective tube
of Optical Cable
The Sand
132kV Underground Cable
2 Circuit 3x1Cx800sq
200
200
200
300
200
200
200
SCALE 1:15
TITLE
Improvement of Queensway Substation
132kV Underground Cable Section (General)
DRG.NO.
T-05


Road Pavement Restoration
GL
Warning Tape
Backfilling
Concrete Cover
Protective Tube of Optical Cable
The Sand
Corrugated hard PVC pipe (Φ200)
132kV Underground Cable
2 Circuit 1C x 800sq x 6
1,500
1,400
100
500
200
300
300
300
300
300
200
1,900
SCALE 1:15
TITLE
Improvement of Queensway Substation
132kV Underground Cable Section (For Road)
DRG.NO.
T-06


A-01 Site Layout of Queensway Substation
Existing Site
Project Site
S=1:500
CITY PLANNING ROAD
GATE 1
GATE 2
GATE 3
Existing
Future
Planning Flyover Near Layout



A-02 Section of Queensway Substation



Control 1F Plan S=1/200 Control GF Plan S=1/200 TR GF Plan S=1/200 GIS GF Plan S=1/200

A-03 Layout of Electrical Equipment

資料－6　技術協議録

9th May, 2014

Technical Memorandum
on the Preparatory Survey on the Project for Improvement of Queensway Substation

UETCL, UEDCL, MEMD, MoFPED and the Preparatory Survey Team ("the Team") of JICA agreed and signed on the Minuets of Discussions for the results of the first field survey for the captioned Project ("the Project"). In addition, UETCL, UEDCL and the Team also agreed and signed on the Field Report for the Outline Design of the Project. This Technical Memorandum is prepared to agree some additional technical issues for the Outline Design of the Project.

1. **UETCL agreed to secure the area for the towers of the Project and complete the required procedures in timely manner before commencement of installation work by the Japanese side, as shown in Annex-1 and Annex-2 of this Technical Memorandum.**

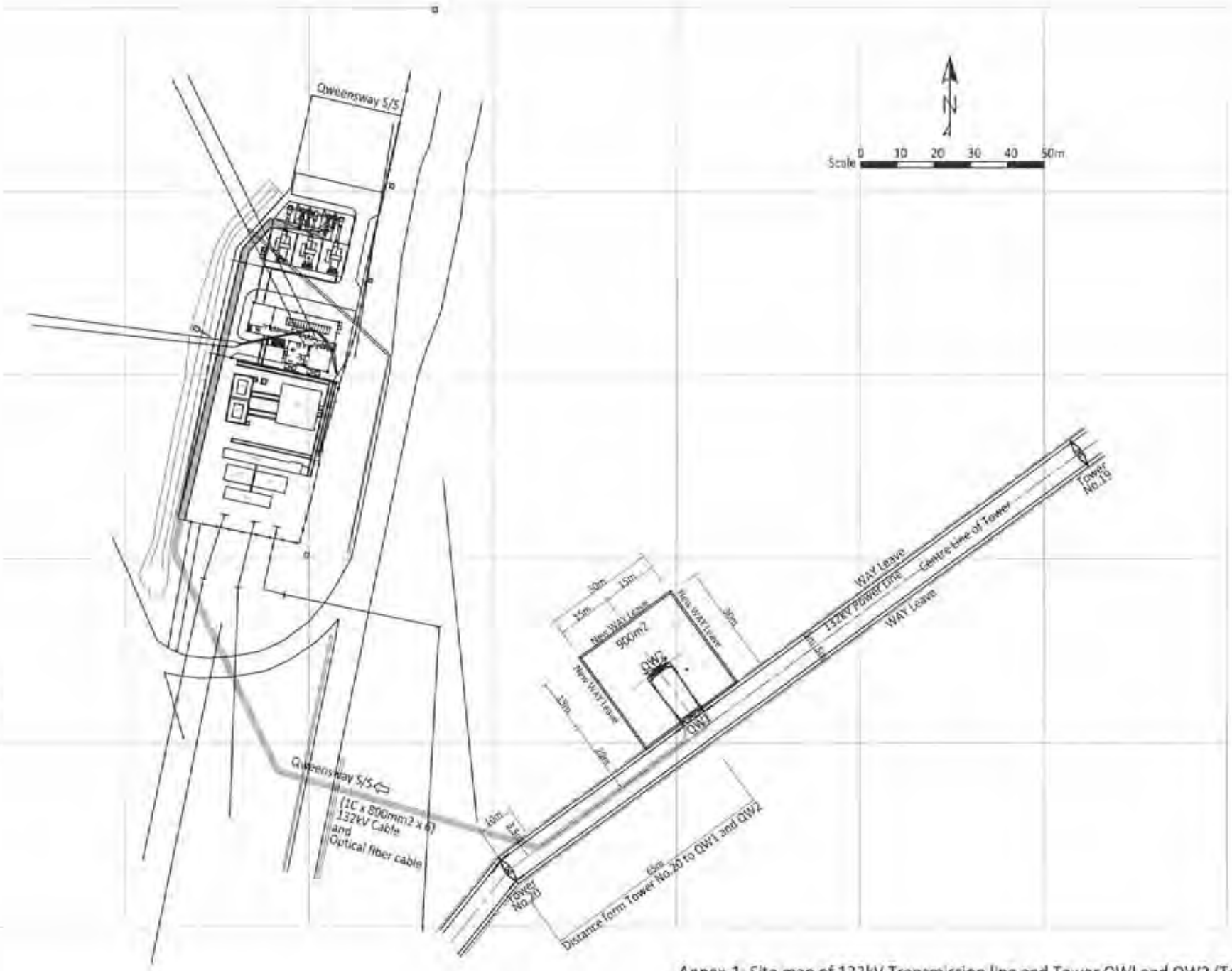
2. **The existing empty conduits for the cables of the Project to connect between the 33 kV switchgears of the Project and the existing 33 kV switchgears procured and installed in the previous JICA project have not been secured. UEDCL agreed to prepare a new cable trench by breaking the foundations of the existing switchgears in coordination with UMEME before commencement of installation work by the Japanese side in consideration of the number and size of the cables of the Project, as shown in Annex-3 of this Technical Memorandum.**

3. **UETCL and the Team confirmed that the existing splicing box for the optical fiber cables of the Project to be connected is not located at the Tower No.20 as described in the Field Report, but located at the Tower No.16. UETCL requested to the Team to procure the new splicing box. The Team agreed to do so. UETCL agreed to install the new splicing box at the location of the Tower No.20 and connect the optical fiber cables to the splicing box by himself, including procurement and installation of materials required for the connection work.**

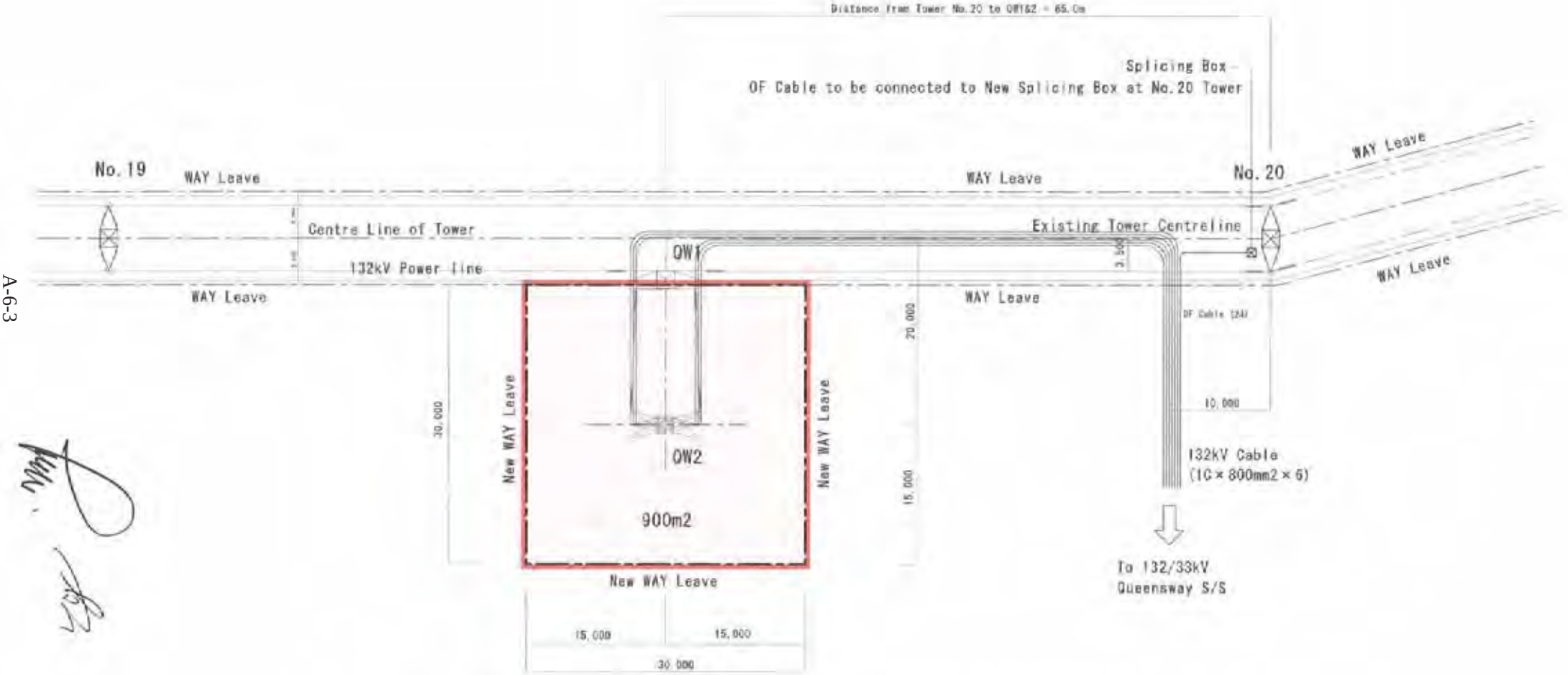
Annex

Annex-1: **Site map of 132 kV Transmission line and Tower QW1 and QW2 (Tentative)**
Annex-2: **Area to be obtained by UETCL for Installation of the Towers of the Project**
Annex-3: **New cable trench for 33 kV switchgear**

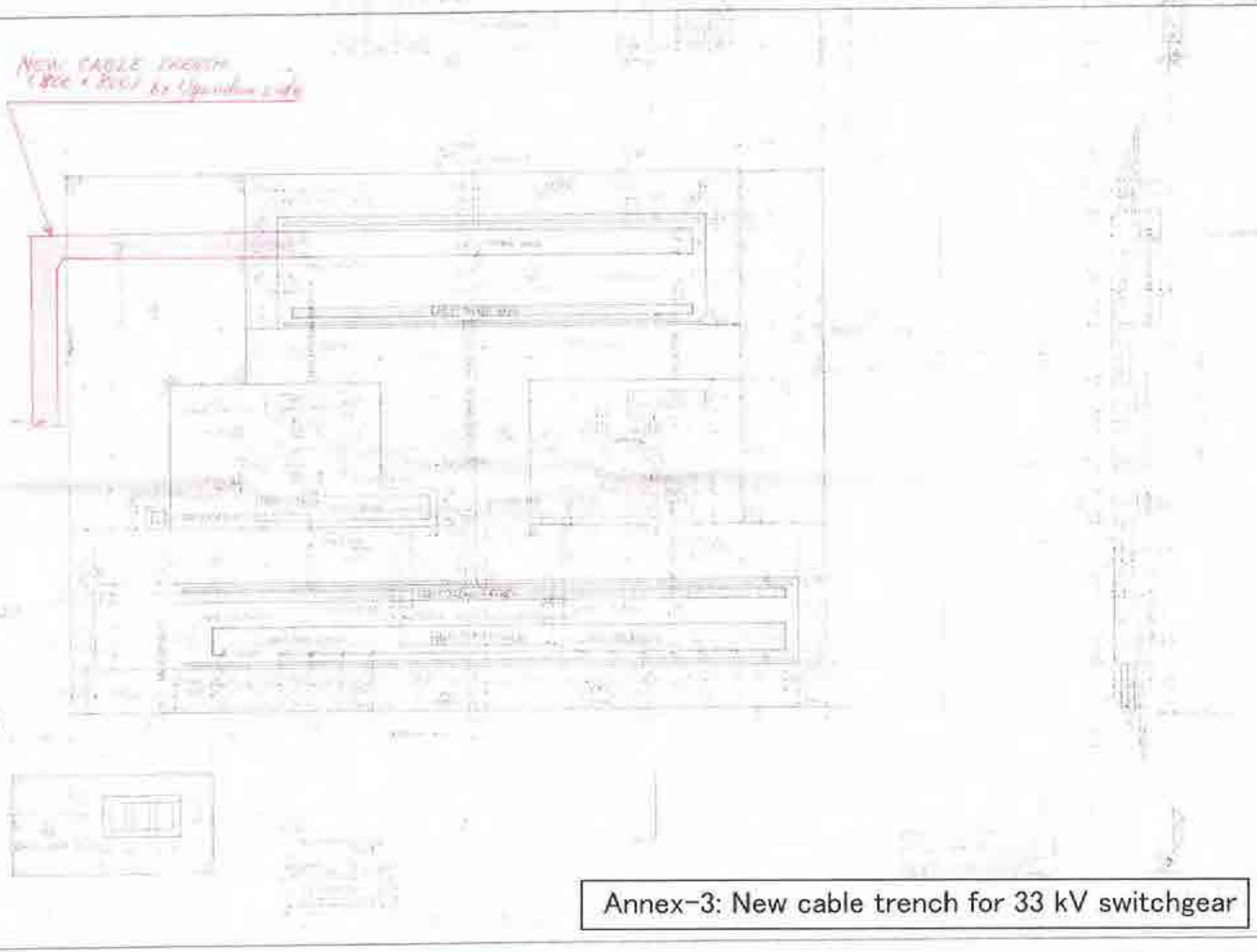
Mr. Kazunari Nogami Chief Consultant Preparatory Survey Team, JICA	Mr. Eriasi Kiyemba Managing Director Uganda Electricity Transmission Company Limited	Mr. Joseph Katera Managing Director Uganda Electricity Distribution Company Limited



Annex-1: Site map of 132kV Transmission line and Tower QWI and QW2 (Tentative)



ANNEX-2 Area to be obtained by UETCL for Instalation of the Towers of the Project



Annex-3: New cable trench for 33 kV switchgear

資料－7　潮流解析

ウガンダ国　需要想定の分布一覧

		Bus No.	2013		2014		2015		2016		2017前		2017後		2018		2019		2020		2021		2022		2023		2024		2025		2026		2027	
			PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL
全国			**483**	**158**	**516**	**170**	**551**	**177**	**588**	**193**	**627**	**206**	**627**	**206**	**670**	**220**	**715**	**235**	**763**	**251**	**814**	**268**	**869**	**286**	**928**	**305**	**991**	**326**	**1058**	**348**	**1129**	**371**	**1205**	**396**
1.中央地域			**353**	**116**	**377**	**124**	**401**	**132**	**430**	**141**	**458**	**151**	**458**	**151**	**490**	**161**	**522**	**172**	**557**	**183**	**594**	**195**	**635**	**209**	**677**	**223**	**723**	**238**	**773**	**254**	**824**	**271**	**880**	**289**
(1)首都圏			**317**	**104**	**338**	**111**	**358**	**118**	**384**	**126**	**408**	**134**	**408**	**134**	**435**	**143**	**462**	**152**	**492**	**162**	**524**	**172**	**559**	**184**	**594**	**195**	**633**	**208**	**675**	**222**	**718**	**236**	**765**	**251**
①	ルゴゴ変電所	3125	56	18	60	20	63	21	68	22	72	24	56	18	60	20	53	17	56	18	81	27	86	28	85	28	90	30	92	30	98	32	104	34
②		3325	41	13	44	14	47	15	51	17	55	18	56	18	60	20	53	17	57	19	81	27	86	28	85	28	91	30	92	30	98	32	104	34
③	カンパラ北変電所	3124	56	18	60	20	63	21	68	22	72	24	56	18	60	20	53	17	56	18	53	17	57	19	57	19	60	20	62	20	65	21	70	23
④		3324	41	13	44	14	48	16	51	17	55	18	56	18	60	20	53	17	57	19	53	17	58	19	57	19	61	20	92	30	98	32	104	34
⑤	ムトゥンドゥエ変電所	3129	29	10	30	10	32	11	34	11	36	12	29	10	30	10	79	26	84	28	81	27	86	28	85	28	90	30	92	30	98	32	104	34
⑥		3329	55	18	59	19	62	20	67	22	71	23	57	19	60	20	79	26	84	28	81	27	86	28	85	28	91	30	92	30	98	32	104	34
⑦	カワラ変電所	3120	11	4	12	4	13	4	14	5	15	5	14	5	15	5	13	4	14	5	13	4	14	5	55	18	60	20	61	20	65	21	71	23
⑧	クイーンズウェイ変電所	3301	28	9	29	10	30	10	31	10	32	11	84	28	90	30	79	26	84	28	81	27	86	28	85	28	90	30	92	30	98	32	104	34
(2)首都圏外周部			**36**	**12**	**39**	**13**	**43**	**14**	**46**	**15**	**50**	**16**	**50**	**16**	**55**	**18**	**60**	**20**	**65**	**21**	**70**	**23**	**76**	**25**	**83**	**27**	**90**	**30**	**98**	**32**	**106**	**35**	**115**	**38**
①	カワンダ	3321	17	6	17	6	18	6	18	6	19	6	19	6	19	6	20	7	20	7	21	7	21	7	22	7	23	8	23	8	24	8	24	8
②	ナマンベ	3333	19	6	22	7	25	8	8	3	3	1	3	1	5	2	6	2	8	3	9	3	12	4	13	4	14	5	17	6	19	6	21	7
③	ナマンベ南	3427							8	3	9	3	9	3	10	3	11	4	12	4	13	4	14	5	16	5	18	6	20	7	22	7	25	8
④	ルジラ	3428							4	1	5	2	5	2	6	2	7	2	8	3	9	3	10	3	11	4	12	4	13	4	14	5	15	5
⑤	ムコノ	3426							8	3	9	3	9	3	10	3	11	4	12	4	13	4	14	5	16	5	18	6	20	7	22	7	25	8
⑥	エンテベ	3312									5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2
2.西部地域			**43**	**14**	**46**	**15**	**50**	**15**	**53**	**17**	**56**	**18**	**56**	**18**	**60**	**20**	**64**	**21**	**69**	**23**	**73**	**24**	**78**	**26**	**84**	**28**	**89**	**29**	**95**	**31**	**102**	**34**	**108**	**35**
①	マサカ	3387	13	4	14	5	14	5	13	4	11	4	11	4	9	3	10	3	10	3	11	4	10	3	12	4	12	4	15	5	18	6	21	7
②	ヌコンゲ	3351	4	1	4	1	5	2	4	1	4	1	4	1	5	2	5	2	5	2	5	2	5	2	6	2	6	2	6	2	6	2	6	2
③	ヌケンダ	3389	13	4	14	5	15	5	15	5	15	5	15	5	16	5	16	5	17	6	17	6	18	6	18	6	19	6	19	6	20	7	20	7
④	ムパララ	1301	13	4	14	5	13	4	12	4	11	4	11	4	13	4	14	5	15	5	16	5	17	6	18	6	19	6	20	7	21	7	22	7
⑤	フォートポータル	3313							3	1	4	1	4	1	5	2	6	2	7	2	8	3	9	3	10	3	11	4	12	4	13	4	14	5
⑥	ホイマ	3314							3	1	4	1	4	1	5	2	6	2	7	2	8	3	9	3	10	3	11	4	12	4	13	4	14	5
⑦	キボガ	3409									2	1	2	1	2	1	2	1	2	1	2	1	3	1	3	1	3	1	3	1	3	1	3	1
⑧	ミラマ	3414					3		3	1	3	1	3	1	3	1	3	1	4	1	4	1	4	1	4	1	5	2	5	2	5	2	5	2
⑨	カバレ	3317									2	1	2	1	2	1	2	1	2	1	2	1	3	1	3	1	3	1	3	1	3	1	3	1
3.東部地域			**63**	**21**	**67**	**22**	**72**	**21**	**76**	**25**	**82**	**27**	**82**	**27**	**87**	**29**	**93**	**31**	**99**	**33**	**106**	**35**	**113**	**37**	**121**	**40**	**129**	**42**	**137**	**45**	**147**	**48**	**157**	**52**
①	ナルバレ	3357	35	12	39	13	34	11	28	9	23	8	23	8	23	8	24	8	25	8	26	9	28	9	30	10	32	11	34	11	38	12	42	14
②	ルガジ	3156	8	3	8	3	9	3	9	3	15	5	15	5	16	5	17	6	18	6	19	6	20	7	21	7	22	7	23	8	24	8	25	8
③	トロロ	3362	20	7	20	7	21	7	21	7	25	8	25	8	28	9	31	10	34	11	37	12	40	13	43	14	46	15	49	16	52	17	55	18
④	イガンガ	3429							10	3	10	3	10	3	11	4	11	4	12	4	12	4	13	4	14	5	15	5	16	5	17	6	18	6
⑤	ムバレ	3399					8		8	3	9	3	9	3	9	3	10	3	10	3	12	4	12	4	13	4	14	5	15	5	16	5	17	6
4.北部地域			**24**	**8**	**26**	**9**	**28**	**9**	**29**	**10**	**31**	**10**	**31**	**10**	**33**	**11**	**36**	**12**	**38**	**12**	**41**	**13**	**43**	**14**	**46**	**15**	**50**	**16**	**53**	**17**	**56**	**18**	**60**	**20**
①	オプヨ	3361	7	2	8	3	9	3	9	3	9	3	9	3	8	3	9	3	9	3	8	3	10	3	11	4	11	4	12	4	12	4	12	4
②	リラ	3364	17	6	18	6	19	6	20	7	16	5	16	5	10	3	12	4	14	5	14	5	14	5	16	5	16	5	18	6	20	7	20	7
③	モロト	3365									6	2	6	2	6	2	6	2	6	2	7	2	7	2	7	2	8	3	8	3	9	3	10	3
④	グル	3394													5	2	5	2	5	2	6	2	6	2	6	2	7	2	7	2	7	2	8	3
⑤	オルウィヨ	3366													2	1	2	1	2	1	3	1	3	1	3	1	4	1	4	1	4	1	5	2
⑥	アルア	3396													2	1	2	1	2	1	3	1	3	1	3	1	4	1	4	1	4	1	5	2
5.国際連系			**12**	**4**	**13**	**4**	**50**	**16**	**60**	**20**	**70**	**23**	**70**	**23**	**150**	**49**	**230**	**76**	**260**	**85**	**280**	**92**	**300**	**99**	**320**	**105**	**340**	**112**	**340**	**112**	**315**	**104**	**315**	**104**
①	ケニア（レソス）	2199					20	7	20	7	30	10	30	10	50	16	100	33	100	33	100	33	100	33	100	33	100	33	100	33	100	33	100	33
②	タンザニア（MTKU）	6199	12	4	13	4	20	7	20	7	20	7	20	7	20	7	50	16	50	16	70	23	80	26	100	33	120	39	120	39	120	39	120	39
③	ルワンダ（）	3293					10	3	20	7	20	7	20	7	50	16	50	16	50	16	50	16	50	16	50	16	50	16	50	16	25	8	25	8
④	コンゴ（ムポンドゥエ）	3290					0	0	0	0	0	0	0	0	30	10	30	10	40	13	40	13	50	16	50	16	50	16	50	16	50	16	50	16
⑤	スーダン（ニムレ）	3486															0	0	20	7	20	7	20	7	20	7	20	7	20	7	20	7	20	7
総需要			**495**	**162**	**529**	**174**	**601**	**194**	**648**	**213**	**697**	**229**	**697**	**229**	**820**	**270**	**945**	**311**	**1023**	**336**	**1094**	**360**	**1169**	**384**	**1248**	**410**	**1331**	**437**	**1398**	**460**	**1444**	**475**	**1520**	**500**

PL：有効電力負荷[MW]
QL：無効電力負荷[Mvar]

ウガンダ国潮流解析　需給バランス

年	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
キイラーナルバレ	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
ブジャガリ	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
カルマ						200	300	400	400	450	500	600	600	600	600
イシンバ					50	150	150	150	150	150	180	180	180	180	180
アヤゴ								100	100	100	100	300	300	500	500
カルマB															
オリアング															
マーチソン															
アチャワ					40	80	80	80	80	80	80	80	80	80	80
大規模水力	450	450	450	450	540	880	980	1180	1180	1230	1310	1610	1610	1810	1810
小規模水力	39	39	56	80	131	133	133	133	133	133	133	133	133	134	134
水力発電	489	489	506	530	671	1013	1113	1313	1313	1363	1443	1743	1743	1944	1944
火力発電	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
その他＋不明	24	37	37	37	37	37	37	37	37	37	37	37	37	37	37
総発電容量	513	526	543	567	708	1050	1150	1350	1350	1400	1480	1780	1780	1981	1981
国内需要	483	516	551	588	627	670	715	763	814	869	928	991	1058	1129	1205
予備力	48	52	55	59	63	67	72	76	81	87	93	99	106	113	121
国内需要	531	568	606	647	690	737	787	839	895	956	1021	1090	1164	1242	1326
ケニア			20	20	30	50	100	100	100	100	100	100	100	100	100
タンザニア	12	13	20	20	20	20	50	50	70	80	100	120	120	120	120
ルワンダ			10	20	20	50	50	50	50	50	50	50	50	25	25
コンゴ			0	0	0	30	30	40	40	50	50	50	50	50	50
スーダン						0	0	20	20	20	20	20	20	20	20
海外需要	12	13	50	60	70	150	230	260	280	300	320	340	340	315	315
総需要	543	581	656	707	760	887	1017	1099	1175	1256	1341	1430	1504	1557	1641
国内バランス	−18	−41	−64	−80	18	313	363	511	454	444	459	690	616	739	655
総合バランス	−30	−54	−114	−140	−52	163	133	251	174	144	139	350	276	424	340
大規模水力依存率	88%	85%	83%	79%	76%	84%	85%	87%	87%	88%	89%	90%	90%	91%	91%
国内ー国外比	2%	2%	8%	9%	10%	20%	29%	31%	31%	31%	31%	31%	29%	25%	24%

6.7%															
	516	551	588	628	669	715	763	814	869	928	991	1058	1129	1205	

ウガンダ国　発電設備計画（潮流解析におけるPSS/Eデータ上の設備）

		定格容量	定格出力	2013			2014			2015			2016			2017			2018			2019			2020			2021			2022			2023			2024			2025			2026			2027		
		MVA	MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW	出力 MW	台数	総出力量 MW
	キイラーナルバレ		380.0	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95
	ブジャガリ		250.0	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250
	カルマ		600.0																100	2	200	100	3	300	100	4	400	100	4	400	100	4.5	450	100	5	500	100	6	600	100	6	600	100	6	600	100	6	600
	イシンバ		200.0													50	1	50	50	3	150	50	3	150	50	3	150	50	3	150	50	3	150						180			180						180		
	アヤゴ		600.0																						100	1	100	100	1	100	100	1	100	100	1	100	100	3	300	100	3	300	125	4	500	125	4	500
	カルマB		250.0																																													
	オリアング		400.0																																													
	マーチソン		600.0																																													
	アチャワ		80.0													40	1	40	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80
大規模水力：合計						450			450			450			450			540			880			980			1180			1180			1230			1310			1610			1610			1810			1810
	KML	2.8	2.5	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0
	KCCL	3.6	3.2	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0
	Maziba	1.0	1.0																																												
	ISHSHA	3.6	3.2	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0
	Nyagak 3	4.0	3.6							2.1	0	0.0	2.1	0	0.0	2.1	0	0.0	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1
	Kikagati	17.9	16.0							11.0	0	0.0	11.0	0	0.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0
	BUGY0	14.8	13.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0
	Waaki	5.6	5.0							2.0	0	0.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0
	MUZZ	30.2	27.0							16.0	0	0.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0
	MPANGA	6.7	6.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0
	Kyambura	9.3	8.3	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0
	Busurukai(HMAX)	10.1	9.0	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4
	Nyamambwa	15.7	14.0							8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4
	Muyembe	11.2	10.0							6.0	0	0.0	6.0	0	0.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0
	Siti I	5.6	5.0							4.0	0	0.0	4.0	0	0.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0
	Siti 2	18.4	16.5							8.9	0	0.0	8.9	0	0.0	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9
	Lubilia	6.0	5.5							3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2
	Pwimi	6.2	5.5							3.3	0	0.0	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3
	NENGO Bridge	11.2	10.0							4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5
	Nsongezi	39.0	35.0													21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0
	KAKA	8.0	7.2							3.0	0	0.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0
小規模水力：合計						39.4			39.4			55.5			79.8			130.7			132.8			132.8			132.8			132.8			132.8			132.8			132.8			132.8			133.8			133.8
水力：合計						489.4			489.4			505.5			529.8			670.7			1012.8			1112.8			1312.8			1312.8			1362.8			1442.8			1742.8			1742.8			1943.8			1943.8
	Namanve	–	50.0																																												
	Invespro,Nalubaale	–	50.0																																												
	Electromaxx	–	50.0																																											
	Mputa-Kabale(Test crude)	–	57.0																																											
	Mputa-Kabale(Gas&Oil)	–	250.0																																												
	Albatros	–	230.0																																											
	Kabaale Peat	–	33.0																																												
	Sesame	–	33.0																																											
	Geothemal	–	100.0																																											
	Namugoga Solar	–	50.0																																												
火力：合計						0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0
	Kinyara Sugar Works	–	5.0	1.5	1	1.5	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0
	Kakira Sugar Works	–	40.0	22.0	1	22.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0
	SCOUL,Lugazi	–	6.0																																												
コジェネレーション：合計						23.5			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0
発電合計容量						512.9			526.4			542.5			566.8			707.7			1049.8			1149.8			1349.8			1349.8			1399.8			1479.8			1779.8			1779.8			1980.8			1980.8

ウガンダ国　送電設備計画（潮流解析におけるPSS/Eデータ上の設備）

番号	送電線	kV	cct	状況	2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
2013年 既設送電設備	カブラソケ-マサカ西	132	1	既設	●															
	カブラソケ-ヌコンゲ	132	1	既設	●															
	ルゴゴ-カンパラ北	132	2	既設	●															
	ルゴゴ-ムトゥンドゥエ	132	2	既設	●															
	マサカ西-MTKU（タンザニア）	132	1	既設	●															
	マサカ西-ムバララ北	132	1	既設	●															
	ヌコンゲ-(カフンギェ)-ヌケンダ	132	1	既設	●															
	ナルバレ-(T-MUKONO)-(T-NMVE STH)-ナマンベ	132	1	既設	●															
	ナマンベ-カンパラ北	132	1	既設	●															
	ナルバレ-ルガジ	66	1	既設	●															
	ナルバレ-ルゴゴ	132	2	既設	●															
	オブヨ-リラ	132	1	既設	●															
	トロロ-レソス（ケニア）	132	2	既設	●															
	トロロ-オプヨ	132	1	既設	●															
	ブジャガリ-トロロ	132	2	既設	●			中間(イガンガ建設)												
	ブジャガリ-カワンダ	132	2	既設→増強	●(132kV)		●(220kV)													
	ナルバレ-ブジャガリ	132	2	既設	●															
	ムトゥンドゥエ-カワンダ	132	2	既設	●															
	カンパラ北-(カワラ)-ムトゥンドゥエ	132	2	既設	●															
	ムトゥンドゥエ-カブラソケ	132	1	既設→増強	●	●														
首都圏， 首都圏外周部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	ナマンベ南-ルジラ	132	1	建設				●												
	ムコノ(ナルバレ-ナマンベ)T分岐	132	1	建設				●												
	ナマンベ-ナマンベ南	132	1	建設				●												
	ナルバレ-ブジャガリ	132	2	建設（増強）					●											
	オーウェンフォールズ（ナルバレ）-ナマンベ-カンパラ北	132	1	建設（増強）					●											
	ブジャガリ-イシンバ	132	2	建設					●											
	ナルバレ-ルガジ	132	2	建設					●											
	ムトゥンドゥエ-エンテベ	132	2	建設					●											
	カワンダ-ボンボ	132	2	建設							●									
	カンパラ北-ムトゥンドゥエ	132	1	建設（増強）							●									
首都圏⇔西部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	カワンダ-マサカ	220	2	建設					●											
	ムトゥンドゥエ-カブラソケ-ヌケンダ	220	2	建設									●							
首都圏⇔北部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	カルマ-カワンダ	400	2	建設							●									
西部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	ヌケンダ-フォートポータル-カバーレ-ホイマ	220	2	建設				●												
	ムバララ-ヌケンダ	132	2	建設					●											
	ミラマ-カバレ	132	2	建設					●											
	カブラソケ-キガンダ-キボガ	132	1	建設					●											
	ミラマ-キカガティ-ヌソンゲジ	132	2	建設					●											
	マサカ-ムバララ	220	2	建設							●									
	ムバララ-ヌケンダ	220	2	2027																●
東部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	イガンガ（ブジャガリ-トロロ）	132	2	建設				●												
	オブヨ-モロト	132	2	建設					●											
	ムバレ-ブランブリ	132	2	建設					●											
北部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	ホイマ-カフ	220	2	建設					●											
	グル-アチョワ(アガゴ)	132	1	建設					●											
	カルマ-リラ	132	2	建設					●											
	リラ-グル	132	1	建設					●											
	グル-キトゥグム	132	2	建設							●									
	グル-オルウィヨ-ネピ-アルア	132	2	建設							●									
	カルマ-オルウィヨ	400	2	建設									●							
	アヤゴ-オルウィヨ	400	2	建設									●							
北部⇔東部					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	トロロ-ムバレ-オブヨ-リラ	132	2	建設			●													
	カルマ-トロロ	400	2	建設										●						
国際連系					2013	2014	2015	2016	2017前	2017後	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	ブジャガリ-トロロ-レソス（ケニア）	220	2	建設			●													
	ムバララ-ミラマ-ビレンボ（ルワンダ）	220	2	建設			●													
	ヌケンダ-ムボンドェ（コンゴ）	220	2	建設							●									
	マサカ-ムワンザ（タンザニア）	220	2	建設							●									
	オルウィヨ-ニムレ（南スーダン）	400	2	建設									●							

ウガンダ国　変電設備計画（潮流解析におけるPSS/Eデータ上の設備）

		電圧階級	既設	2013		2014		2015		2016		2017前		2017後		2018		2019		2020		2021		2022		2023		2014		2025		2026		2027	
1.中央地域（1）首都圏																																	
	ルゴゴ	132/11	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	廃止											
		132/11	増強																			2	120	2	120	2	120	2	120	2	120	2	120	2	120
		132/33	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	廃止											
		132/33	増強																			2	120	2	120	2	120	2	120	2	120	2	120	2	120
	カンパラ北	132/11	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		132/33	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		132/33	増強																									1	40	1	40	1	40
	ムトゥンドゥエ	132/11	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	廃止																	
		132/11	増強															2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
		132/33	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	廃止																	
		132/33	増強															2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
		220/132	建設																	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	カワラ	132/11	●	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	廃止									
		132/11	増強							1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	廃止									
		132/11	増強																							2	80	2	80	2	80	2	80	2	80
	クイーンズウェイ	132/33	増強											3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120
1.中央地域（2）首都圏外周部																																	
	カワンダ	132/33	●	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		132/33	増強							1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		220/132	建設					2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500
		400/220	建設													2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200
	ナマンベ	132/33	●	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120
	ナマンベ南	132/33	建設							3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180
	ルジラ	132/33	建設							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	ムコノ	132/33	建設							3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180
	エンテベ	132/33	建設									2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140
	ボンボ	132/33	建設													2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
2.西部地域																																	
	マサカ西	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		220/132	建設									2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	ヌコンゲ	132/33	●	1	7.5	1	7.5	1	7.5	1	7.5	廃止																					
		132/33	増強									1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	ヌケンダ	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		132/33	増強									1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
		220/132	建設							2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
	ムパララ北	132/33	●	1	20	1	20	1	20	1	20	廃止																					
		132/33	●	1	15	1	15	1	15	1	15	廃止																					
		132/33	増強									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		220/132/33	建設					1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60
	フォートポータル	132/33	建設							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		220/132	建設							2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
	ホイマ	132/33	建設							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		220/132	建設							2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
	キボガ	132/22	建設									2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	ミラマ	220/132/33	建設					1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60
	カバレ	132/33	建設									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	カフンギェ	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	カプラソケ	220/132	建設																	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	キニャラ	220/132	建設									1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45
	カバーレ	220/33	建設							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
3.東部地域																																	
	ナルバレ	66/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	ルガジ	66/11	●	2	28	2	28	2	28	2	28	廃止																					
		132/11	建設									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	トロロ	132/33	●	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
		132/33	●	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		132/33	増強									1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		220/132	建設					2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300
		400/220	建設																			2	400	2	400	2	400	2	400	2	400	2	400	2	400
	イガンガ	132/33	建設							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	ムバレ	132/33	建設					2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	ブジャガリ	220/132/33	建設					2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500
4.北部地域																																	
	オブヨ	132/33	●	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10
		132/33	増強							1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	リラ	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		132/33	増強									1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	モロト	132/33	建設									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	グル	132/33	建設									2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	オルウィヨ	132/33	建設													2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		400/132	建設																	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	アルア	132/33	建設													1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	カルマ	400/132	建設													1	273	1	273	1	273	1	273	1	273	1	273	1	273	1	273	1	273	1	273
	ネッビ	132/33	建設													2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	カフ	220/132	建設									2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
		400/220	建設													2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500

ウガンダ国　調相設備（潮流解析におけるPSS/Eデータ上の設備）

	地域	電圧階級 [kV]	段数	設備容量 [Mvar]	2013 投入量 [Mvar]	2014 投入量 [Mvar]	2015 投入量 [Mvar]	2016 投入量 [Mvar]	2017B 投入量 [Mvar]	2017A 投入量 [Mvar]	2018 投入量 [Mvar]	2019 投入量 [Mvar]	2020 投入量 [Mvar]	2021 投入量 [Mvar]	2022 投入量 [Mvar]	2023 投入量 [Mvar]	2024 投入量 [Mvar]	2025 投入量 [Mvar]	2026 投入量 [Mvar]	2027 投入量 [Mvar]
1.中央地域 (1)首都圏	ルゴゴ	33	1	10			10	10	10	10	10	10	10	10	10	10	10	10	10	10
	カンパラ北	33	1	10					10	10	10	10	10	10	10	10	10	10	10	10
	ムトゥンドゥエ	33	1	10																
	カンパラ北	132	5	40												40	120	160	200	200
	ルゴゴ	132	1	40																40
1.中央地域 (2)首都圏外周部	ナマンベ	33	3	16		48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
	ナマンベ南	33	3	10				30	30	30	30	30	30	30	30	30	30	30	30	30
	ルジラ	33	3	10																
	ムコノ	33	3	15																
	エンテベ	33	1	20																
	ナマンベ	132	1	40																
	エンテベ	132	2	10																
	カワンダ	400	2	−35							−70	−70	−70	−70	−70	−70	−70	−70	−70	−70
2.西部地域	マサカ西	33	1	10	10	10	10	10												
	ヌケンダ	33	1	10	0	10	10	10												
	ヌケンダ	132	2	20																
	ムバララ	33	3	4	4	4	4	4												
	ニュームバララ	33	2	−10					−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
	ミラマ	33	1	−10					−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
3.東部地域	ナルバレ	33	2	10																
	ルガジ	132	3	10																
	トロロ	33	4	−10																
	トロロ	132	1	20																
	イガンガ	33	2	10																
4.北部地域	オプヨ	33	1	−10							−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
	リラ	33	1	−10							−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
5.国際連系	レソス	132	3	20																
	タンザニア(MTKU)	132	1	10								10	10	10	10	10	10	10	10	10

資料－8　地形測量結果報告書

QUEENSWAY SUBSTATION IMPROVEMENT: TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

A-8-1

VOLUME I: TOPOGRAPHIC SURVEY REPORT

MAY 2014

Prepared by Consultant : NEWPLAN Limited

For : Yachiyo Engineering Company Ltd

newplan

Prepared:	AA
Checked:	RK
Approved:	EK

newplan

TABLE OF CONTENTS

1. INTRODUCTION 1
1.1 General 1
1.2 Location and access to the site 1
1.3 Project Description, Duration, Staffing and Equipment 2
2. TOPOGRAPHIC SURVEYS 3
2.1 General 3
2.2 Extension of Control 3
2.3 Topographic Detail Points Measurement/ Field Observations 4
2.4 Measurement of Elevations of Transmission Line Wires 4
2.5 Computations and Topographic Mapping 6
3. CHALLENGES 7
4. RECOMMENDATIONS AND CONCLUSION 7
APPENDIX 1: SELECTED PHOTOGRAPHS OF PROJECT AREA 8
APPENDIX 2: TOPOGRAPHIC SURVEY MAP 12

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume I: Topographic Survey Report

1. INTRODUCTION

1.1 General

The surveys are required to facilitate the design of the various components of the expansion and upgrading of Queensway substation. The resultant data and maps can also be used for preparation of the Resettlement Action Plan (RAP) for the project.

1.2 Location and access to the site

The project is located along Queensway on Entebbe road, in the Central Business District of Kampala. The project site is located adjacent to the existing Queensway substation, opposite USAFI market in the Pan-African Freedom square as shown in the image below.

1.3 Project Description, Duration, Staffing and Equipment

The Consultant subcontracted NEWPLAN to carry out a topographic survey of the site covering the existing substation site, the proposed extension site, T-off tower sites, and the cable alignment for the proposed connection into the Substation.

The main product of the survey would be a topographic map covering the entire area to facilitate the design of the Substation. The survey has to be supported by a set of control points, well measured to enable the topographic survey to be as accurate as possible. The control points will also be used for setting out the scheme during construction.

Part of NEWPLAN's survey team together with the representatives of Yachiyo Engineering Company Ltd carried out a reconnaissance site visit on 22nd April 2014, to get a clear understanding of the client's requirements for the survey.

In general, fieldwork for the topographic survey was carried out in the first two days after the reconnaissance visit. On 5th May 2014, a final site visit was carried out to measure the elevations of the six cables on the Transmission line at the point where the T-off connection to the substation will be made.

The survey team comprised of: two Field Surveyors, each with two Chainmen.

The Equipment used included; GPS (CHC X90), and a Leica TCR 700 Series Total station, and their accessories.

The computations and drawings were processed using a computer and relevant software.

2. TOPOGRAPHIC SURVEYS

2.1 General

A reconnaissance site visit was carried out with the client for the purpose of understanding the site requirements for the survey and enable making decisions on a way to approach the exercise.

During the entire exercise, the consultant carried out the following activities:

1. Extended control to the site in order to be able to carry out the topographic survey.
2. Measured coordinate (XYZ) details of feature points for preparation of a topographic map for the site.

2.2 Extension of Control

National grid control had to be extended from known point(s) 71Y125, an RTS close to the site at the Mukwano Round about. Details of this control point are as follows.

Point	Descr.	East	North	Height
71Y125	RTS	454808.454	35074.665	1150.081

(RTS: Rigorous Traverse Station)

Connection to the National Grid

The control point RTS 71Y125 is a reliable control point used in the Kampala area and is already connected to the national grid.

The National Grid is based on the following:

Reference Ellipsoid: Clarke 1880 with the following parameters

- Semi-major axis: 6378249.145m
- Inverse flattening: 293.465

Datum: Arc 1960

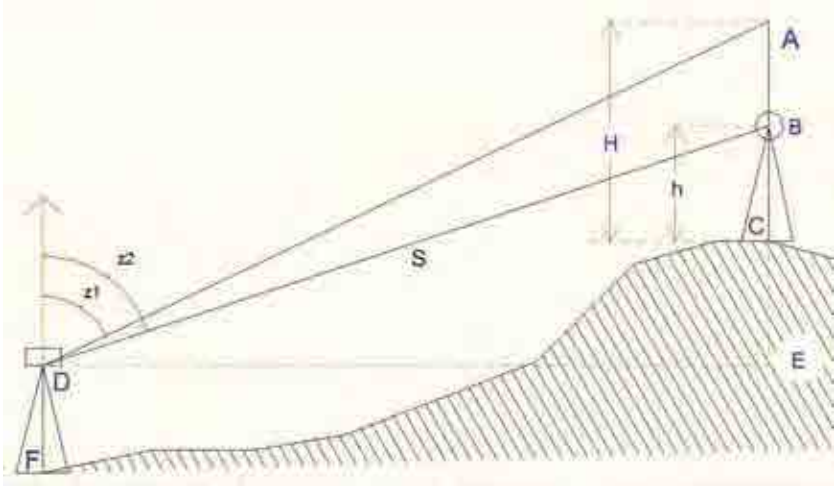
Projection Type: Transverse Mercator Zone: UTM Zone 36N (the project was in the northern hemisphere) Zone parameters: Central Meridian (CM): 33°E Scale factor at CM: 0.9996 Longitude of Grid Origin: 0.0°E Latitude of Grid Origin: 0.0°N False Northing: 0.0m False Easting: 500000.0m Scale Factor: 0.9996 Uses orthometric heights.

2.3 Topographic Detail Points Measurement/ Field Observations

After extension of control to the site, all other topographic detail points were measured; with 'Change Points' made at convenient points in and around the site to enable faster measurement. Point spot heights were measured using Total station and RTK GPS. More details about staffing and equipment for this exercise can be found in section 1.3 above.

2.4 Measurement of Elevations of Transmission Line Wires

The REM method (Wei and Cheng, 2006) was used to find the height above ground of the wires of the transmission at the location of the proposed T-off tower. It is best explained in the figure below.



And the height of the wires above the ground was calculated using the formula;

$$H = S \sin Z_2 \cot Z_1 - S \cos Z_2 + h$$

Where: H is the height of the inaccessible point above the ground

S is the slope distance to a measured target of known height

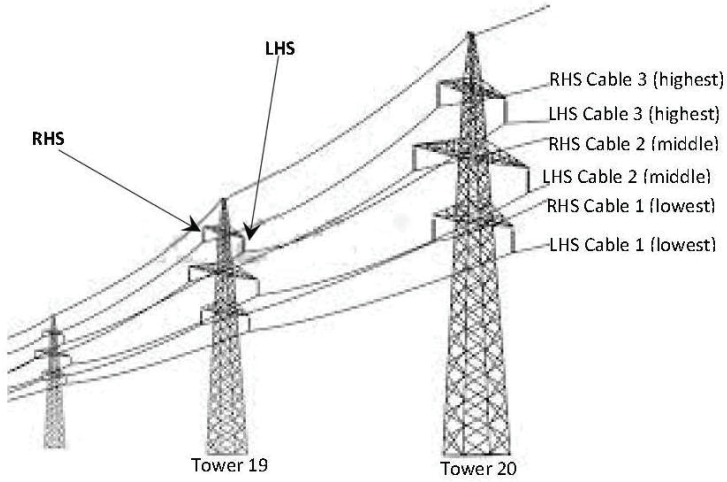
h is the height of the target

Z_1 is the vertical angle to the inaccessible point

Z_2 is the vertical angle to the measured target of known height

The measured target of known height above the ground has to be placed directly below the inaccessible point (electric wire) in the plumb position.

The above parameters were measured and recorded for all the six wires on either side of the towers 19 and 20, with the LHS (Left hand side) and RHS (Right hand side) defined moving from Tower 19 towards Tower 20, as illustrated in the drawing below:



The measurement results are summarized in the table below:

	Cables	Elevation	Height above ground
LHS	Cable1 (Lowest)	1174.264m	13.103m
	Cable2 (Middle)	1178.341m	17.180m
	Cable3 (Highest)	1182.537m	21.376m
RHS	Cable1 (Lowest)	1174.060m	13.557m
	Cable2 (Middle)	1178.031m	17.528m
	Cable3 (Highest)	1182.367m	21.864m

2.5 Computations and Topographic Mapping

Spread sheets were used to reorganise the Total Station measured detail points. These were saved as excel files in comma separated values (csv) format with the following descriptions.

- 're' road edge
- 'hse' for house/structure corner
- 'sh' spot height
- 'fe' fence
- 'tree' tree
- 'drain' drain
- 'c top' for channel top
- 'c bottom' channel bottom
- 'mh' man hole

Etc.

The points were imported into CAD software in which the drawing was processed.

Topographical Maps

The maps were formatted to A1 and A3 paper print size in AutoCAD layouts and in pdf and are submitted as attachments to this report. A softcopy file in AutoCAD format will be submitted as well.

Autodesk Civil 3D 2012 was used to prepare the topographic map drawing with the following details.

Area Covered

2D surface area = 15588.02 sq.m

3D surface area = 16337.82 sq.m

Scale

The scale of the drawing in the model is 1:1000 m

The scale of the drawing on the ready for print layouts is 1:5000 m on A3 paper size.

Contour Intervals

Major Contour Interval (Brown colour) = 2m

Minor Contour Interval (Grey colour) = 0.5m

Grid Interval

The grid interval in the map is 50m

3. CHALLENGES

Some artificial features especially underground ones like electric cables, sewer lines, water pipes were not easy to identify and therefore difficult to accurately measure and show on the map.

On-going construction works on the site made it difficult to measure and show all the existing features on ground as ground conditions were changing on a daily basis.

Sewerage flowing in the drainage channel made the measurements therein very unpleasant.

During the measurement of Transmission wire elevations above the ground, it difficult to get the plumb position of the wires on the ground.

4. RECOMMENDATIONS AND CONCLUSION

The survey was done within acceptable limits of accuracy and connected to the National Grid and therefore sufficient to be used for execution of the project for the design as well as for the Resettlement Action Plan (RAP) surveys.

APPENDIX 1: SELECTED PHOTOGRAPHS OF PROJECT AREA

Drainage Channel

Pan-African Freedom Square

Existing Substation

33kV line to Existing Substation

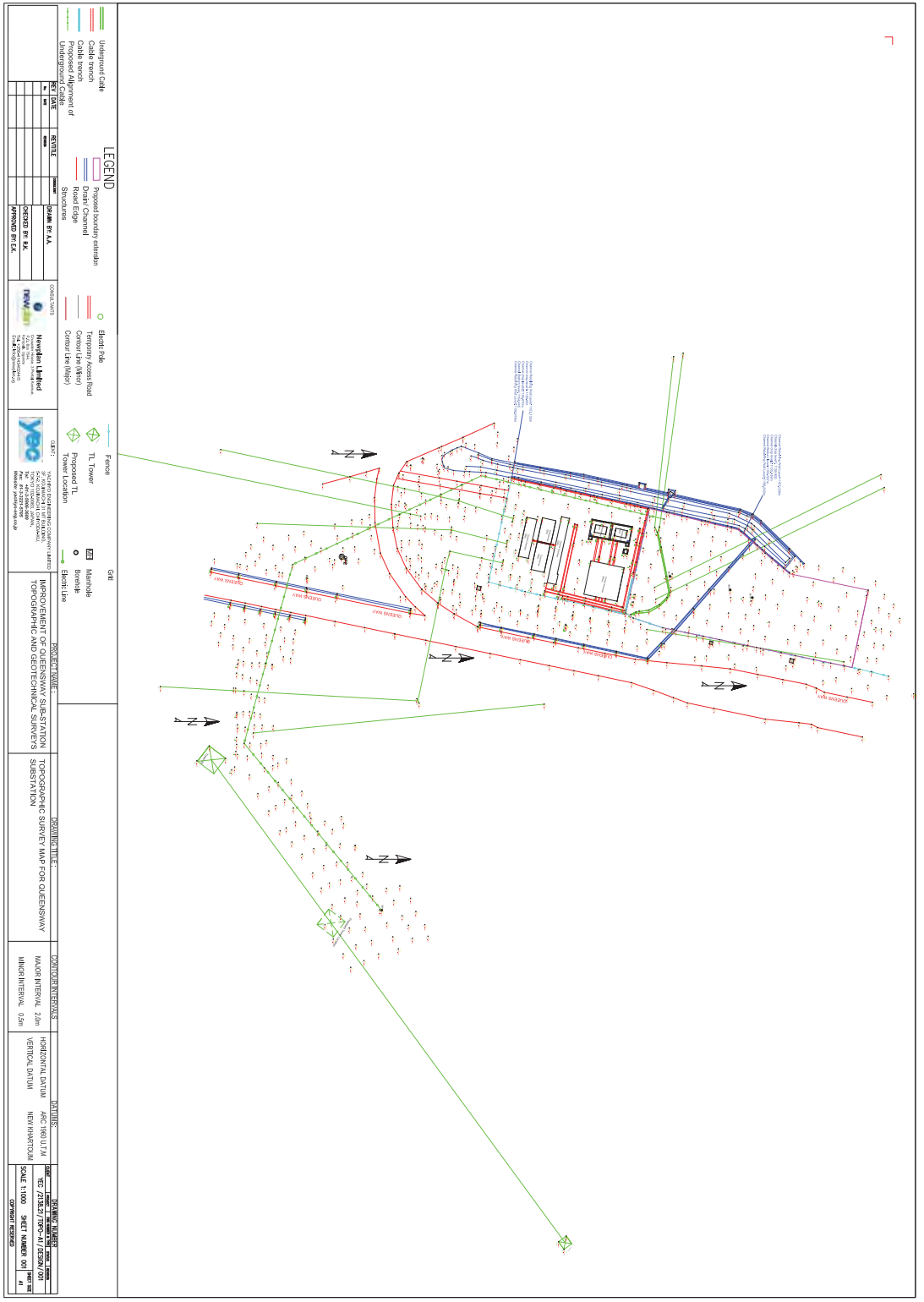
LHS: Existing Queensway Substation
CENTRE: Sidewalk with drainage channel
RHS: Queensway

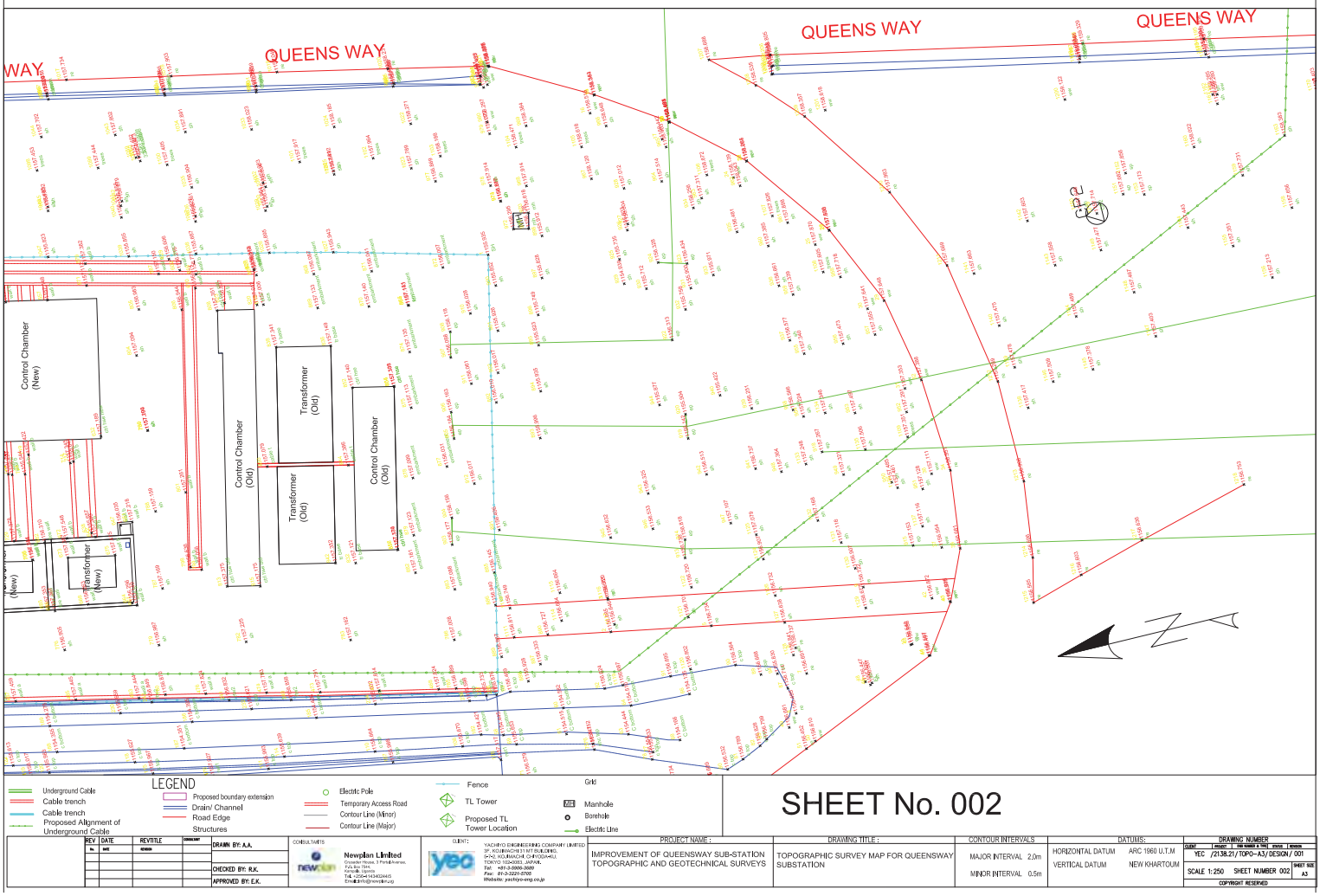
FOREGROUND: Queensway
BACKGROUND: Pan-African Freedom Square

Drainage channel over-grown with weeds at the planned site of the substation extension

APPENDIX 2: TOPOGRAPHIC SURVEY MAP

[See subsequent pages]





LEGEND

- Underground Cable
- Cable trench
- Cable trench
- Proposed Alignment of Underground Cable
- Proposed boundary extension
- Drain/ Channel
- Road Edge
- Structures
- Electric Pole
- Temporary Access Road
- Contour Line (Minor)
- Contour Line (Major)
- Fence
- TL Tower
- Proposed TL Tower Location
- Grid
- Manhole
- Borehole
- Electric Line

SHEET No. 002

REV	DATE	REVITILE	CONSULTANT

DRAWN BY: A.A.
CHECKED BY: R.K.
APPROVED BY: E.K.

CONSULTANTS: Newplan Limited, Crocodile House, 3 Portal Avenue, P.O.Box 7844, Kampala, Uganda, Tel: +256-414-342444/5, Email:info@newplan.ug

CLIENT: YACHIYO ENGINEERING COMPANY LIMITED, 3F, KOUMACHI 31 MT BUILDING, 5-7-2, KOUMACHI, CHIYODA-KU, TOKYO 102-0083, JAPAN, Tel: +81-3-3221-0705, Fax: 81-3-3221-0705, Website: yachiyo-eng.co.jp

PROJECT NAME: IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

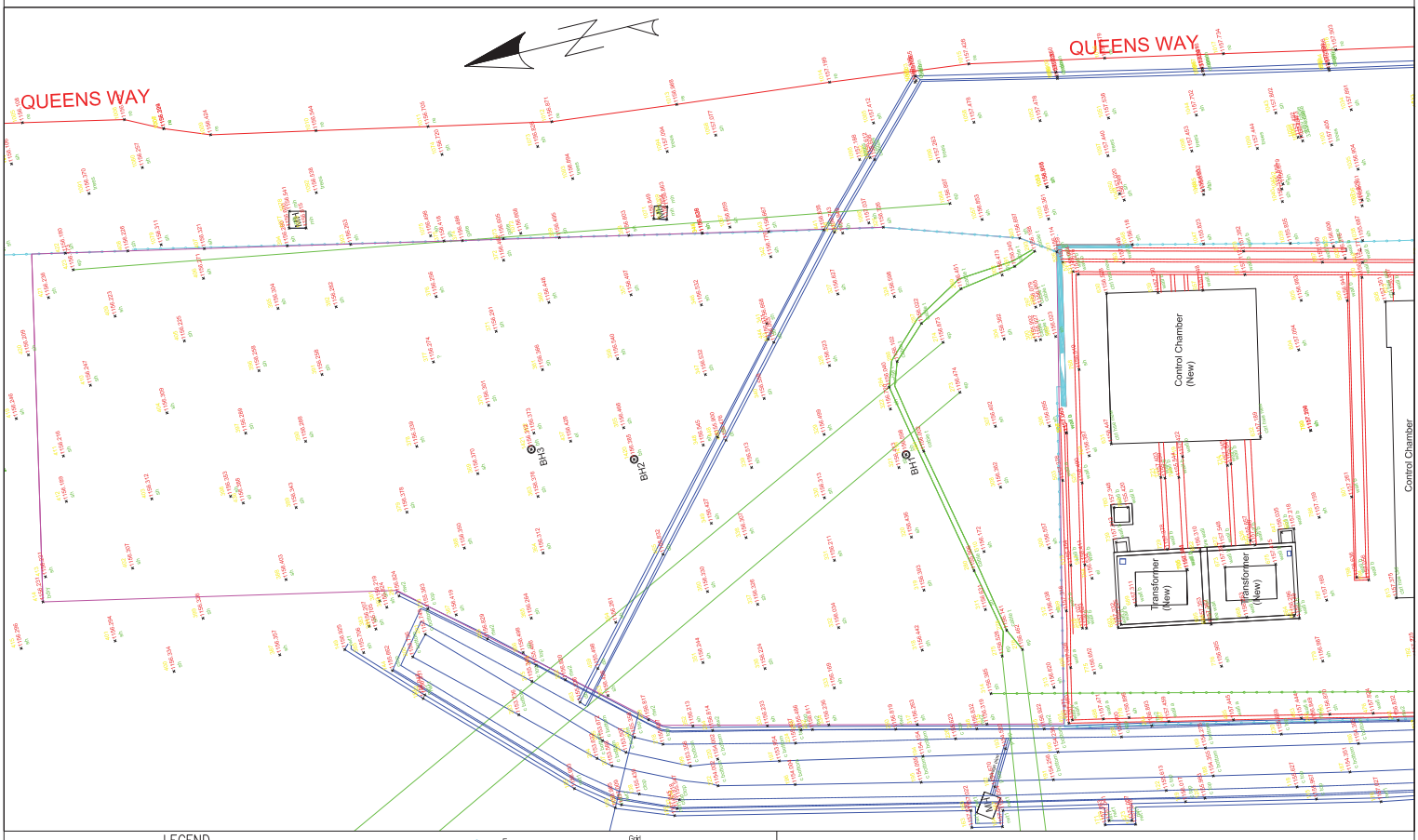
DRAWING TITLE: TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION

CONTOUR INTERVALS: MAJOR INTERVAL 2.0m; MINOR INTERVAL 0.5m

DATUMS: HORIZONTAL DATUM ARC 1960 U.T.M; VERTICAL DATUM NEW KHARTOUM

DRAWING NUMBER: CLIENT | PROJECT | SUB NUMBER & TYPE | STATUS | REVISION: YEC /2138.21/ TOPO–A3/ DESIGN/ 001

SCALE 1:250 SHEET NUMBER 002 SHEET SIZE A3



LEGEND

- Underground Cable
- Cable trench
- Cable trench
- Proposed Alignment of Underground Cable
- Proposed boundary extension
- Drain/ Channel
- Road Edge
- Structures
- Electric Pole
- Temporary Access Road
- Contour Line (Minor)
- Contour Line (Major)
- Fence
- TL Tower
- Proposed TL Tower Location
- Grid
- Manhole
- Borehole
- Electric Line

SHEET No. 001

REV	DATE	REVITILE	CONSULTANT

DRAWN BY: A.A.
CHECKED BY: R.K.
APPROVED BY: E.K.

CONSULTANTS: Newplan Limited, Crocodile House, 3 Portal Avenue, P.O.Box 7844, Kampala, Uganda, Tel: +256-414-342444/5, Email:info@newplan.ug

CLIENT: YACHIYO ENGINEERING COMPANY LIMITED, 3F, KOUMACHI 31 MT BUILDING, 5-7-2, KOUMACHI, CHIYODA-KU, TOKYO 102-0083, JAPAN, Tel: +81-3-3221-0705, Fax: 81-3-3221-0705, Website: yachiyo-eng.co.jp

PROJECT NAME: IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

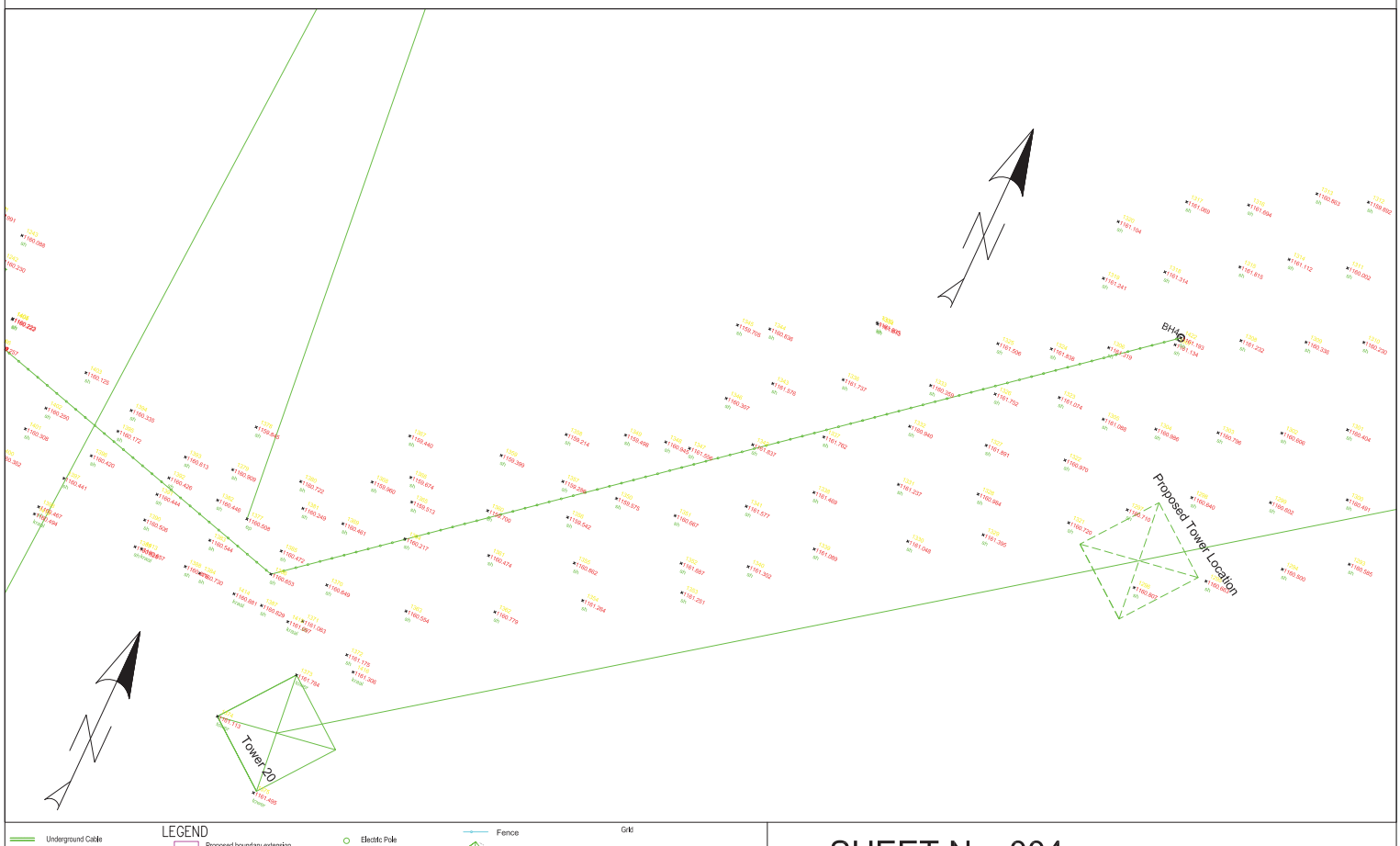
DRAWING TITLE: TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION

CONTOUR INTERVALS: MAJOR INTERVAL 2.0m; MINOR INTERVAL 0.5m

DATUMS: HORIZONTAL DATUM ARC 1960 U.T.M; VERTICAL DATUM NEW KHARTOUM

DRAWING NUMBER: CLIENT | PROJECT | SUB NUMBER & TYPE | STATUS | REVISION: YEC /2138.21/ TOPO–A3/ DESIGN/ 001

SCALE 1:250 SHEET NUMBER 001 SHEET SIZE A3



LEGEND

- Underground Cable
- Cable trench
- Cable trench
- Proposed Alignment of Underground Cable
- Proposed boundary extension
- Drain/ Channel
- Road Edge
- Structures
- Electric Pole
- Temporary Access Road
- Contour Line (Minor)
- Contour Line (Major)
- Fence
- TL Tower
- Proposed TL Tower Location
- Grid
- Manhole
- Borehole
- Electric Line

SHEET No. 004

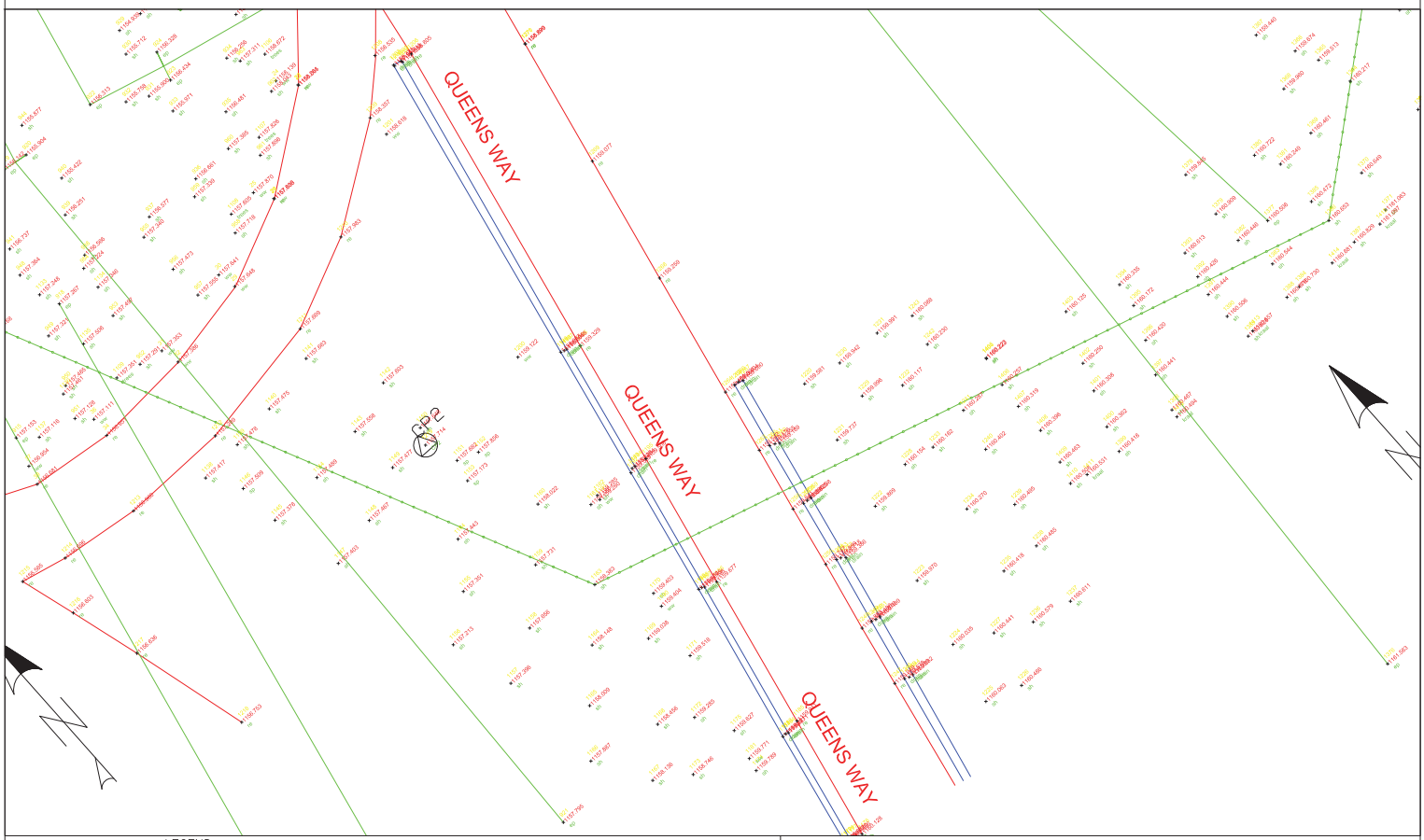
REV	DATE	REVITILE	CONSULTANT

DRAWN BY: A.A.
CHECKED BY: R.K
APPROVED BY: E.K.

CONSULTANTS: Newplan Limited
Chisamba House, 3 Portal Avenue, P.O.Box 7844, Kampala, Uganda
Tel: +256-414-342644/5
Email:info@newplan.ug

CLIENT: YACHIYO ENGINEERING COMPANY LIMITED
3F, KOUMACHI 31 MT BUILDING, 5-7-2, KOUMACHI, CHIYODA-KU, TOKYO 102-0083, JAPAN.
Tel: +81-3-3222-0705
Fax: 81-3-3221-0705
Website: yachiyo-eng.co.jp

PROJECT NAME:	DRAWING TITLE:	CONTOUR INTERVALS	DATUMS:	DRAWING NUMBER
IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS	TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION	MAJOR INTERVAL 2.0m MINOR INTERVAL 0.5m	HORIZONTAL DATUM ARC 1960 U.T.M VERTICAL DATUM NEW KHARTOUM	CLIENT / PROJECT / SUB NUMBER & TYPE / STATUS / REVISION: YEC / 21.38.21 / TOPO–A3 / DESIGN / 001 SCALE 1:250 SHEET NUMBER 004 SHEET SIZE A3



LEGEND

- Underground Cable
- Cable trench
- Cable trench
- Proposed Alignment of Underground Cable
- Proposed boundary extension
- Drain/ Channel
- Road Edge
- Structures
- Electric Pole
- Temporary Access Road
- Contour Line (Minor)
- Contour Line (Major)
- Fence
- TL Tower
- Proposed TL Tower Location
- Grid
- Manhole
- Borehole
- Electric Line

SHEET No. 003

REV	DATE	REVITILE	CONSULTANT

DRAWN BY: A.A.
CHECKED BY: R.K
APPROVED BY: E.K.

CONSULTANTS: Newplan Limited
Chisamba House, 3 Portal Avenue, P.O.Box 7844, Kampala, Uganda
Tel: +256-414-342644/5
Email:info@newplan.ug

CLIENT: YACHIYO ENGINEERING COMPANY LIMITED
3F, KOUMACHI 31 MT BUILDING, 5-7-2, KOUMACHI, CHIYODA-KU, TOKYO 102-0083, JAPAN.
Tel: +81-3-3222-0705
Fax: 81-3-3221-0705
Website: yachiyo-eng.co.jp

PROJECT NAME:	DRAWING TITLE:	CONTOUR INTERVALS	DATUMS:	DRAWING NUMBER
IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS	TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION	MAJOR INTERVAL 2.0m MINOR INTERVAL 0.5m	HORIZONTAL DATUM ARC 1960 U.T.M VERTICAL DATUM NEW KHARTOUM	CLIENT / PROJECT / SUB NUMBER & TYPE / STATUS / REVISION: YEC / 21.38.21 / TOPO–A3 / DESIGN / 001 SCALE 1:250 SHEET NUMBER 003 SHEET SIZE A3

資料－9　地質測量結果報告書

QUEENSWAY SUBSTATION IMPROVEMENT: TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

VOLUME II: GEOTECHNICAL SURVEY REPORT

MAY 2014

Prepared by Consultant : NEWPLAN Limited

For : Yachiyo Engineering Company Ltd

A-9-1

TABLE OF CONTENTS

1 BACKGROUND 4
2 METHODOLOGY 4
2.1 Drilling 4
2.2 SPT tests 4
3 FIELD ACTIVITIES 5
3.1 Borehole BH1 5
3.2 Borehole BH2 8
3.3 Borehole BH3 10
3.4 Borehole BH4 12
4 LABORATORY REPORT 15
4.1 Scope of Work 15
4.2 Laboratory Testing Procedure 15
4.2.1 Classification tests 15
4.2.2 Strength 16
4.2.3 Consolidation test 17
4.2.4 Unconfined compression strength test (UCS) on soils samples 17
4.2.5 Unconfined compression strength test (UCS) on soils samples 17
5 CONCLUSIONS AND RECOMMENDATIONS 18
BIBLIOGRAPHY 19
APPENDICES: DETAILS OF LABORATORY RESULTS AND BOREHOLE LOGS 20
APPENDIX 1: CLASSIFICATION TEST RESULTS 21
APPENDIX 2: SHEAR BOX TEST RESULTS 24
APPENDIX 3: CONSOLIDATION TEST RESULTS 48
APPENDIX 4: UNCONFINED COMPRESSION STRENGTH TEST ON SOIL SAMPLES 50
APPENDIX 5: UNCONFINED COMPRESSION STRENGTH TEST ON ROCK CORES 53
APPENDIX 6: BOREHOLE LOGS 55

LIST OF FIGURES

Figure 3-1: Core box for borehole BH1 box 1 of 3 6

Figure 3-2: Core box for borehole BH1 box 2 of 3 6

Figure 3-3: Core box for borehole BH1 box 3 of 3 7

Figure 3-4: SPT cores from BH1 8

Figure 3-5: Core box for borehole BH2 box 1 of 2 8

Figure 3-6: Core box for borehole BH2 box 2 of 2 9

Figure 3-7: SPT cores from BH2 10

Figure 3-8: Core box for borehole BH3 box 1 of 2 10

Figure 3-9: Core box for borehole BH3 box 2 of 2 11

Figure 3-10: SPT cores from BH3 12

Figure 3-11: Core box for borehole BH4 box 1 of 3 12

Figure 3-12: Core box for borehole BH4 box 2 of 3 13

Figure 3-13: Core box for borehole BH4 box 3 of 3 13

Figure 3-14: SPT cores from BH4 14

LIST OF TABLES

Table 3-1: N-number for SPT Tests at BH1 7

Table 3-2: N-number for SPT Tests at BH2 9

Table 3-3: N-number for SPT Tests at BH3 11

Table 3-4: N-number for SPT Tests at BH4 14

Table 4-1: Tests carried out 15

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

LIST OF SYMBOLS

BS	-	British Standard
C	-	Cohesion
CL	-	Sandy lean clay
CL^-	-	Chlorides
D	-	Depth
kN/m^3	-	Kilo Newton per cubic meter
LL	-	Liquid Limit
m	-	Linear meters
mm	-	Millimeters
ML	-	Sandy silt
NMC	-	Natural Moisture Content
NP	-	Non-plastic
PI	-	Plasticity Index
PL	-	Plastic Limit
SM	-	Clayey sand with gravel
SO^{3-}	-	Sulphates
TP	-	Test Pit
U	-	Position of Undisturbed sample
USCS	-	Unified Soil Classification System
Φ	-	Internal angle of friction
%	-	Percentage

1 BACKGROUND

NEWPLAN Limited was contracted by Yachiyo Engineering Company Limited to carry out a geotechnical survey involving soil investigations at the construction site for the planned improvements for the substation and electrical transmission lines area at Queensway substation.

Following drilling, the soil samples were transferred to the Central Materials Laboratory for testing.

2 METHODOLOGY

2.1 Drilling

Drilling was carried out in line with BS 4049-4: 1993 standard using the HGY 200 series drilling machine. In order to ensure maximum sample recovery rotary drilling without water circulation was implemented using the NX casings with a drilling bit, up to such a depth where cores failed to be recovered in the casing. After the failure a triple core tube with a smaller diameter was also used without water circulation to further recover cores as much as possible. Water was then circulated with a standard NXW drilling bit since at this level the ground consisted of cobbles and boulders making highly weathered rock before fresh bedrock.

2.2 SPT tests

SPT tests were done in line with BS 1377-9: 1990. The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. The test uses a thick-walled sample tube, with an outside diameter of 50 mm and an inside diameter of 35 mm, and a length of around 650 mm. This was driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5 kg falling through a distance of 760 mm. The blow count (n-value) provides an indication of the density of the ground.

3 FIELD ACTIVITIES

The consultancy implementation activities were to be in line with the terms of reference and are described as follows.

a) Preparation of work implementation schedule

b) No confirmation of location was done since this would have required to dig a pit up to the maximum depth of 20 meters.

c) Transportation, assembling, and disassembling of all the drilling equipment

d) Installation of a ladder and other safety measures during the execution of the works

e) Implementation of miscellaneous work related to penetrating and sampling, field test and laboratory test

f) Execution of field test

g) Sampling and transportation of sampled soil

h) Report on geological aspect based on laboratory tests and field tests

i) Submission of geological samples for inspection

j) Presentation of test results and necessary calculations in report form

k) Backfilling of borehole

Coordinates of for each drilling site were collected using a GPS set to ellipsoid WGS 84

3.1 Borehole BH1

This borehole was drilled at coordinates 36N 452901E, 34116N to 13.1 meter depth. Drilling was stopped in bedrock. The borehole drilling included a 0.7m rock core extraction at the bottom of borehole. Groundwater was intercepted at 0.8 meter depth. The following pictures show the core boxes into which samples were collected.

Figure 3-1: Core box for borehole BH1 box 1 of 3

Figure 3-2: Core box for borehole BH1 box 2 of 3

Figure 3-3: Core box for borehole BH1 box 3 of 3

The log for borehole 1 was prepared as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH1.

Table 3-1: N-number for SPT Tests at BH1

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	25
2.0 to 2.5	3
3.0 to 3.5	11 (no sample recovered)
3.5 to 4.0	23
5.0 to 5.5	48
6.5 to 7.0	56
7.5 to 8.0	55
9.0 to 9.5	24
10.0 to 10.5	102
11.5 to 12.0	78
12.5 to 13.0	Refusal

The photograph below shows the SPT cores collected from borehole BH1:

Figure 3-4: SPT cores from BH1

3.2 Borehole BH2

This borehole was drilled at 18.5m north of BH1 coordinates 36N 452906E, 34133N to 9.0 meter depth. Drilling was stopped in bedrock. The borehole drilling included a 0.6m rock core extraction at the bottom of borehole. Groundwater was intercepted at 0.7 meter depth. The following pictures show the core boxes where samples were collected into.

Figure 3-5: Core box for borehole BH2 box 1 of 2

Figure 3-6: Core box for borehole BH2 box 2 of 2

The log for borehole 2 was prepared as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH2.

Table 3-2: N-number for SPT Tests at BH2

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	12
2.0 to 2.5	5
3.0 to 3.5	12
4.0 to 4.5	24
5.0 to 5.5	18
6.0 to 6.5	123
7.0 to 7.5	>102
8.0 to 8.5	26

The photograph below shows the SPT cores collected from borehole BH2:

Figure 3-7: SPT cores from BH2

Attempts to collect SPT samples resulted into unsuccessful hammering giving empty core barrels beyond 8.5 meters

3.3 Borehole BH3

This borehole was drilled at coordinates 36N 452905E, 34140N to 10.0 meter depth. Drilling was stopped before encountering fresh bedrock. Groundwater was intercepted at 0.8 meter depth. The following pictures show the core boxes where samples were collected into.

Figure 3-8: Core box for borehole BH3 box 1 of 2

Figure 3-9: Core box for borehole BH3 box 2 of 2

The log for borehole 3 was prepared by the sub consultant as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH3.

Table 3-3: N-number for SPT Tests at BH3

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	7
2.0 to 2.5	7
3.0 to 3.5	15
4.0 to 4.5	19
5.0 to 5.5	47
6.0 to 6.5	>100
7.0 to 7.5	48
8.0 to 8.5	42

The photograph below shows the SPT cores collected from borehole BH3

Figure 3-10: SPT cores from BH3

3.4 Borehole BH4

This borehole was drilled at coordinates 36N 452906E, 34133N to 12.0 meter depth. Drilling was stopped before reaching bedrock. Groundwater was intercepted at 5.2 meter depth. The following pictures show the core boxes where samples were collected into.

Figure 3-11: Core box for borehole BH4 box 1 of 3

Figure 3-12: Core box for borehole BH4 box 2 of 3

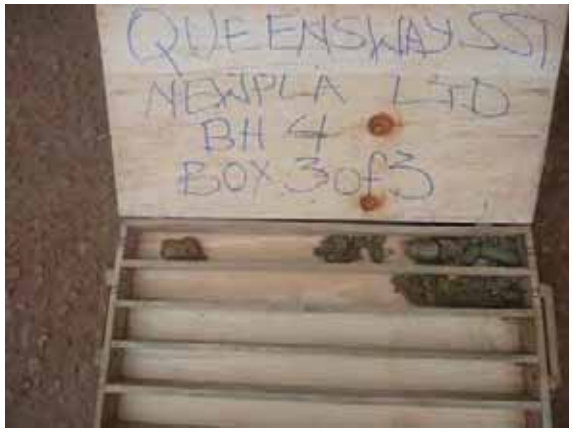


Figure 3-13: Core box for borehole BH4 box 3 of 3

The log for borehole 4 was prepared by the sub consultant as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH4.

Table 3-4: N-number for SPT Tests at BH4

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	52
2.0 to 2.5	15
3.0 to 3.5	25
4.0 to 4.5	29
5.0 to 5.5	42
6.0 to 6.5	33
7.0 to 7.5	56
8.0 to 8.5	27
9.0 to 9.5	29
10.0 to 10.5	25
11.0 to 11.5	45
12.0 to 12.5	44

The photograph below shows the SPT cores collected from borehole BH 4

Figure 3-14: SPT cores from BH4

4 LABORATORY REPORT

4.1 Scope of Work

The scope of work involved conducting tests on disturbed and undisturbed soil samples as in the Table 4-1 below:

Table 4-1: Tests carried out

Test	Standard
Sieve Analysis	BS1377 or equivalent International Standard
Liquid Limits	
Plastic Limits	
Water Natural Content	
Specific Gravity	
Unconfined compression Test	
Triaxial Compression Test (UU) *Test machine was faulty so Shear box test was instead carried out on all samples.* *****	
Consolidation Test (One sample was tested)	

***** The materials engineer who was assigned to implement the analysis for the project at the lab informed the lead investigator that the test machine for the triaxial compression test was faulty, however, this information was not relayed on time to the consultant as an omission. It was discussed at the time that shear box tests be carried out instead of the triaxial compression test in order to obtain some results on the bearing capacity.

4.2 Laboratory Testing Procedure

Laboratory testing was carried out on disturbed and undisturbed samples to identify the physical properties of the soils and establish parameters for predicting their strength characteristics. The tests were conducted according to the standard methods.

4.2.1 Classification tests

- **Natural Moisture Content**

This test was carried out in accordance with BS 1377: Part 2: 1990. Representative specimens were obtained from the samples and their net weights taken. The specimens were oven dried at temperatures between 105°C and 110°C for 24 hours and their dry weights were taken. The ratio of moisture loss (wet mass – dry mass) to the mass of the dried soil expressed as a percentage was taken as the moisture content of the respective specimen. See results in Appendix 1

- **Sieve Analysis**

The standard method of wet sieving which conforms to BS 1377: Part 2: 1990 was adopted. Representative specimens were taken from the samples and oven dried at temperatures between 105ºC and 110ºC for 24 hours. The dried soils were washed through a 0.075mm BS test sieve in accordance with the test method. The retained fractions were again oven-dried for 24 hours at the same temperature and then sieved through a nest of sieves in a descending order of aperture sizes, using a mechanical shaker. The fractions retained on each sieve were weighed and the proportions of the original sample passing given sieves were determined. See results in Appendix 1

- **Liquid Limit (LL)**

Liquid limit test was carried out using the British Standard (BS) cone penetrometer in accordance with BS 1377: Part 2: 1990. A British Standard (BS) cone penetrometer fitted with an automatic timing device that ensures 5 second penetration under an 80gm load was used. Oven-dried representative samples were pounded and sieved through a 0.425mm BS test sieve. 200gm of each sample passing the 0.425 mm BS test sieve was mixed thoroughly with distilled water and the water allowed to permeate it overnight in an air tight container. Each of the dried soils samples were then remixed the following day with sufficient water to achieve two penetrations in the range between 15mm and 25mm. After each penetration the soils paste moisture content were taken. The results are attached in Appendix 1.

- **Plastic Limit**

Plastic limit test was carried out in accordance with BS 1377: Part 2: 1990. The samples used for the tests were prepared in the same manner as those for the liquid limit tests. The test consisted of rolling a ball of soil paste between the hands and then into threads between the palm and a glass plate. The plastic limit was the moisture content at which the threads develop transverse cracks when they were about 3mm diameter. The results are attached in Appendix 1.

- **Plasticity Index**

The plasticity Index was determined in conformity with BS 1377: Part 2: 1990. The plasticity index (PI) is the numerical difference between the Liquid Limit (LL) and Plastic Limit (PL).

$$PI = LL - PL$$

A summary of the results of the soil index properties is attached in Appendix 1.

4.2.2 Strength

- **Direct Shear test**

This was performed on the undisturbed samples in conformity with BS: 1377: Part 7: 1990. For each of the samples, three specimens of sizes 60x60x20mm were prepared. The first specimen was given a fixed normal stress close to the respective overburden pressure and was sheared along its horizontal plane through its mid-depth to failure.

Thereafter the same was done on the other two specimens but this time the fixed normal stresses were successively increased. The failure points were noted. A plot was made between the normal stress of the absicca and the shear stress as the ordinate. The slope of the graph was the angle of internal friction Ø and the intercept was the cohesion C_u. Detailed results are as indicated in Appendix 2.

4.2.3 Consolidation test

This was performed in accordance with BS 1377: Part 5:1990. A specimen of **76mm** diameter and **20mm** height was cut from the undisturbed sample and placed in the floating ring of the odometer cell. Soaking of the sample was done after which the sample was loaded. Readings of compression were noted at regular time intervals of **0 min, 1/2, 1, 2, 4, 8, 15, 30 1hr.....24hr**. Successively higher loads were applied each after 24hours until 7 cycles were completed. In the meantime the specific gravity of the same sample was determined. A plot was made between the cell pressure and the void ratio from which the coefficient of volume compressibility (**mv**) and the pre-consolidation pressure (**Pc)** were determined. Results are presented in Appendix 3.

4.2.4 Unconfined compression strength test (UCS) on soils samples

This test was conducted in conformity with test requirements and methods in BS 1377: Part 7 1992. The test specimens were trimmed with a spatula from the intact portions of SPT samples that were properly preserved at natural moisture content. The lengths of each specimen was twice the diameter. The mass of the prepared specimen was determined and likewise the bulk density calculated. The specimen was vertically put on to the loading machine and compressed to failure as prescribed in the above mentioned standard. The maximum load at failure was recorded and the compressive strength calculated in N/mm2 (Mpa). The results are showed in Appendix 4.

4.2.5 Unconfined compression strength test (UCS) on soils samples

This test was conducted in conformity with test requirements and methods in BS 1377: Part 7 1992.The surfaces of the two bearing discs were cleaned and the test specimen. Alignment was done carefully with the axis of specimen with the center of thrust of the spherical seat. A load was continuously applied at a constant stress rate within the limits of 0.5 MPa/s to 1.0 MPa/s. The maximum load on the specimen at failure in N within 1% accuracy was recorded. The water absorption of the specimens were determined. Two specimens were used for each section of rock core in the two boreholes. The results are showed in Appendix 5

5 CONCLUSIONS AND RECOMMENDATIONS

i. The soils generally comprised fat clay, lean clay, sandy fat clay and silty sand;

ii. Shear strength parameters for the samples indicate mixed soils that derive their strength more from friction than cohesion at the substation. At the 132Kv line the inter-particle friction is more important than the cohesion. The computed allowable bearing capacity values due to local shear failure ranged from 71kPa to 668kPa at all the four drilling points;

iii. The key index properties of the soil samples varied as follows: LL = 31 to 60%, PL = NP to 29% and PI = 0 to 38%.

iv. The specific gravity ranged from 2.38 to 2.60 g/cm^3.

v. The Natural Moisture Content ranged from 1 to 49%.

vi. The groundwater table was between 0.7 and 0.8 meters below ground level at the substation and 5.2 meter under the 132Kv line. The groundwater level under the 132kv was made deeper by the over three meters of material dumped at this site.

vii. The volume compressibility from the consolidation test ranged from 0.26 to 0.04 m^2/MN for the sample that was collected between 3 to 3.5m depth in borehole 2.

viii. The unconfined compressive strength varied from 0.024 to 0.948. It is noteworthy to observe that the highest unconfined compressive strengths were obtained between 7.5 and 7.8 m depth borehole 1, 4.5 to 4.7 m depth in borehole 2, 4.8 to 5.2 m depth in borehole 3 and the values were generally much higher for borehole 4 compared to the rest of the boreholes drilled at the substation.

ix. The rock samples for boreholes 1 and 2 were tested for their compressive strength and water absorption. The tests yielded unconfined compressive strength of 10.6 to 43.1 Mpa and water absorption of 0.3 to 1.5.

x. Based on all the observations and results above a recommended excavation depth of 6 meters is desired at the substation and for the 132 Kv line, the depth should be 8 meters for stable founding conditions. This implies the need for deep foundations, piles would be suitable. The optimum size and depth could not be determined at this stage due to lack of design loadings from the structures

BIBLIOGRAPHY

Bowles, Joseph, E; (1977); Foundation Analysis and Design, Second Edition, McGraw Hill Kogukusha Ltd. Tokyo

Bryen, G; Evertt, J. P. and Schwartz, K. (11985); A Guide to Practical Geotechnical Engineering in Southern Africa, Frankipile SA, Third Edition.

British Standards Institution (1995); BS 1377; Methods of Test for Soils for Civil Engineering Purposes, London.

British Standards Institution (1981); BS 5930; Code of Practice for Site Investigations, London.

Head, K.H (1994); Manual of Soil Laboratory Testing, Second Edition, John Wiley & Sons, Inc. New York .

Kaniraj, Shenbaga, R. (1995); Design Aids in Soil Mechanics and Foundations Engineering; Tata McGraw Publishing Co. Ltd. New Delhi.

McCarthy, David, F. (1997); Essentials of Soil Mechanics and Foundations; Basic Geotechnics, Fifth Edition, Prentice Hall, USA.

M.Sc. Thesis, Institute of Solid Earth Physics, University of Bergen, Bergen, Norway, p.80 (Unpublished).

Vickers, Brain (1978); Laboratory work in Civil Engineering Soil Mechanics; Granada Publishers, London.

APPENDICES: DETAILS OF LABORATORY RESULTS AND BOREHOLE LOGS

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

APPENDIX 1: CLASSIFICATION TEST RESULTS

CENTRAL MATERIALS LABORATORY

PROJECT IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT M/S CaCL CONSULTING LTD
DATE MAY 2014

SUMMARY OF SOIL CLASSIFICATION RESULTS TESTED IN ACCORDANCE WITH BS 1377: 1990

SAMPLE IDENTIFICATION		GRADING % PASSING											ATTEBERG LIMITS			NMC	GS	USCS	REMARKS
BH No.	DEPTH m	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.150 mm	0.075 mm	LL %	PL %	PI %	%			
1	1.0 – 1.5		100	96	95	91	90	87	86	86	85	83	52	14	38	38	2.59	CH	Fat Clay
	3.5 – 4.0					100	98	84	80	79	78	76	46	17	29	26	2.57	CL	Lean Clay
	6.5 – 7.0				100	97	81	74	70	66	63	59	45	12	33	48	2.54	CL	Lean Clay
	9.0 – 9.5					100	78	62	37	21	14	10	31	NP	-	22	2.37	SW-SM	Well graded sand with silt
	11.5 – 12.0				100	88	63	51	44	36	30	24	32	NP	-	13	2.40	SM	Silty Sand
2	1.0 – 1.5				100	95	89	86	85	83	80	74	51	21	30	28	2.58	CH	Fat Clay with sand
	3.0 – 3.5				100	99	96	95	94	94	93	91	58	22	36	24	2.60	CH	Fat Clay
	5.0 – 5.5				100	97	80	75	72	69	67	63	52	16	36	21	2.55	CH	Sandy Fat Clay
	7.0 – 7.5		100	97	95	84	51	41	37	32	29	27	28	NP	-	8	2.41	SM	Silty Sand

CENTRAL MATERIALS LABORATORY

PROJECT IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT M/S CaCL CONSULTING LTD
DATE MAY 2014

SUMMARY OF SOIL CLASSIFICATION RESULTS TESTED IN ACCORDANCE WITH BS 1377: 1990

SAMPLE IDENTIFICATION		GRADING % PASSING											ATTEBERG LIMITS			NMC	GS	USCS	REMARKS
BH No.	DEPTH m	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.150 mm	0.075 mm	LL %	PL %	PI %	%			
3	1.0 – 1.5	100	98	97	95	89	84	83	82	82	81	80	48	19	29	4	2.59	CL	Lean Clay with sand
	3.0 – 3.5					100	93	88	86	83	80	78	49	17	32	22	2.58	CL	Lean Clay with sand
	5.0 – 5.5		100	96	92	77	58	47	43	39	35	31	38	13	25	11	2.52	SC-SM	Clayey sand with silt
	7.0 – 7.5		100	97	96	89	76	70	66	65	57	50	30	9	21	9	2.50	CL	Sandy Lean Clay
	9.0 – 9.5					100	74	53	46	33	25	16	28	NP	-	1	2.38	SM	Silty Sand
4	1.0 – 1.5	100	97	94	93	87	84	81	80	77	76	72	37	13	24	9	2.55	CL	Lean Clay with sand
	3.0 – 3.5		100	74	74	66	54	52	50	48	48	45	50	22	28	17	2.57	CH	Sandy Fat Clay
	5.0 – 5.5				100	99	93	91	90	88	85	82	45	16	29	23	2.60	CL	Lean Clay with sand
	7.0 – 7.5			100	98	95	86	83	81	78	71	68	45	17	28	23	2.54	CL	Sandy Fat Clay
	9.0 – 9.5				100	99	95	92	91	88	87	84	56	25	31	33	2.52	CH	Fat Clay with sand
	11.0 – 11.5				100	97	90	86	84	78	74	69	60	29	31	20	2.50	CH	Sandy Fat Clay

APPENDIX 2: SHEAR BOX TEST RESULTS

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEENS WAY ELECTRICITY SUBSTATION
CLIENT : M/S CeCI CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No:	DEPTH D (m)	WIDTH B (m)	BULK DENSITY, γ (kN/m³)	COHESION C (KPa)	COHESION C (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	Nγ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_a (KPa)
BH 01	1.2	1.0	17.16	13	9	27	18	13.1	5.3	2.1	220	3	73
BH 01	3.0	1.0	17.16	15	11	27	18	13.1	5.3	2.1	481	3	164
BH 01	5.0	1.0	17.03	21	14	33	23	19.1	9.1	4.9	1139	3	380
BH 01	7.2	1.0	20.14	32	21	35	25	20.7	10.7	6.8	2194	3	731
BH 01	9.3	1.0	20.35	17	11	38	27	23.9	13.2	9.3	2912	3	971

$q_{ult} = C'N_{cR} + q_o N_q + \frac{1}{2}\gamma B N_\gamma$

where $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan \phi)$

$C' = 0.67C$

$q_a = q_{ult}/F$

SHEAR BOX TEST OF SOILS

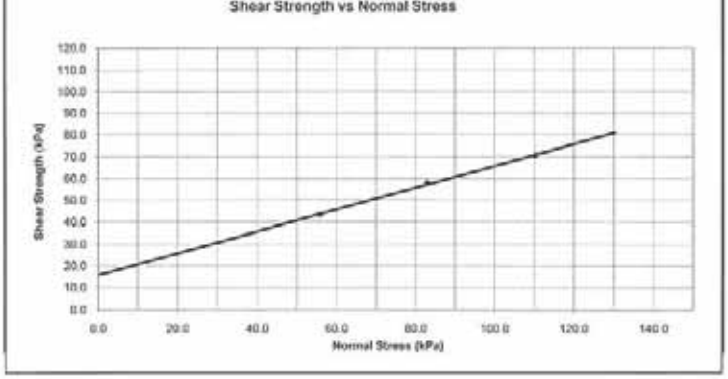
Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 01
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	1.25

Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.76	20.3	23.5	13	27
	47.6	37.1		
	74.8	50.8		

SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 01
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	3.25

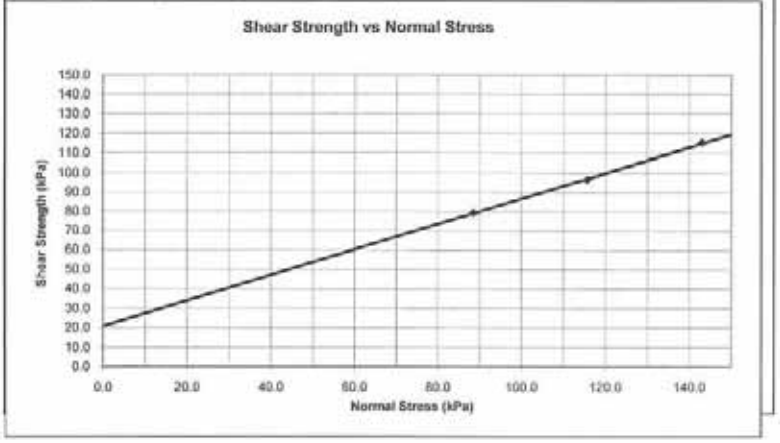
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.72	55.8	43.4	16	27
	83.0	57.9		
	110.3	70.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 01
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	5.25

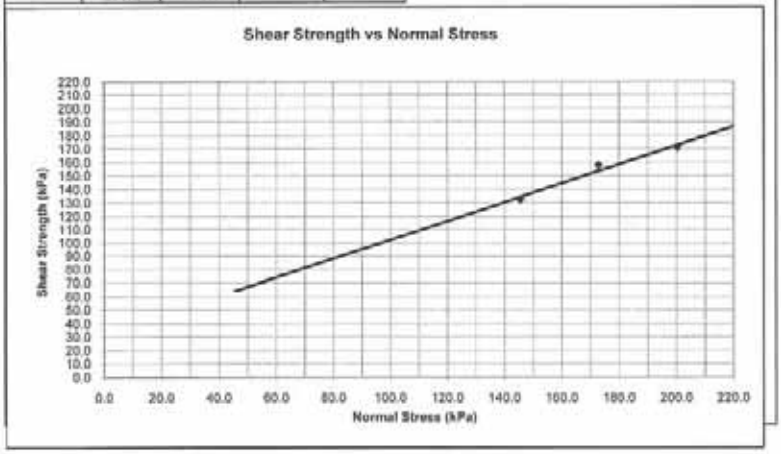
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.70	88.5	79.4	21	33
	115.7	96.4		
	143.0	115.3		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 01
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	7.25

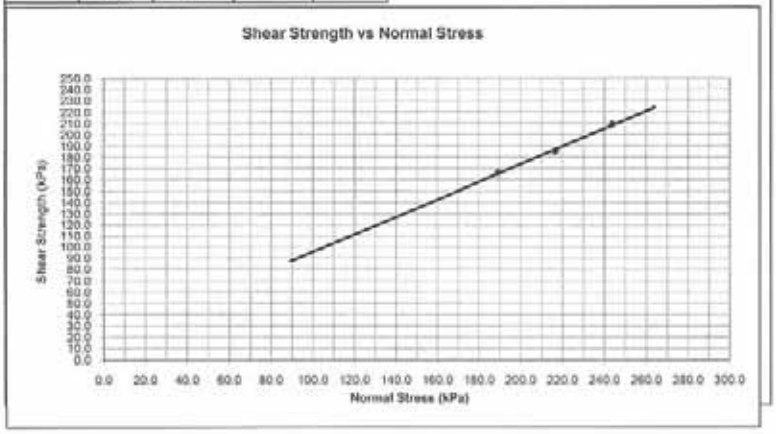
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.01	145.6	132.4	32	35
	172.9	157.6		
	200.2	170.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 01
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 9.25

Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.03	189.3	166.5	17	38
	216.5	185.4		
	243.8	209.3		



CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCl CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH D (m)	WIDTH B (m)	BULK DENSITY, γ kN/m^3	COHESION C (KPa)	COHESION C' (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	Nγ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
BH 01	1.25	1.0	20.83	11	7	23	15	11.0	3.9	1.2	212	3	71
BH 03	3.25	1.0	20.63	11	7	23	15	11.0	3.9	1.2	378	3	126
BH 02	5.25	1.0	19.63	16	11	28	19	13.9	5.8	2.6	770	3	260
BH 02	7.25	1.0	19.38	8	6	26	19	13.9	5.8	3.5	935	3	312

$q_{ult} = CN_c\alpha + q_oN_q + \frac{1}{2}\gamma BN_\gamma\alpha$

where $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan\phi)$

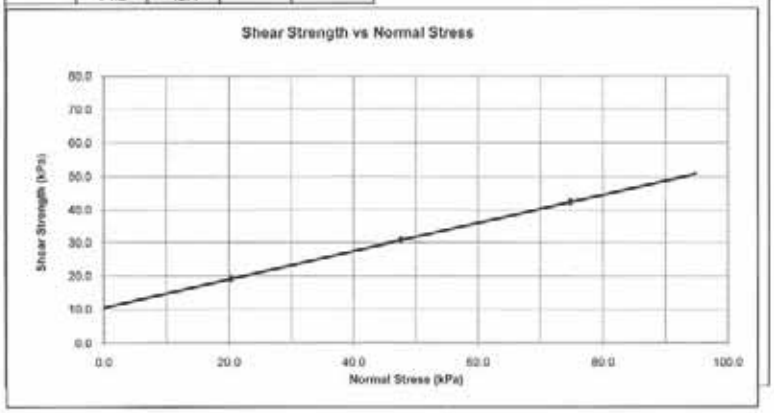
$C' = 0.67C$

$\gamma_w = 9.81$

SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 02
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	1.25

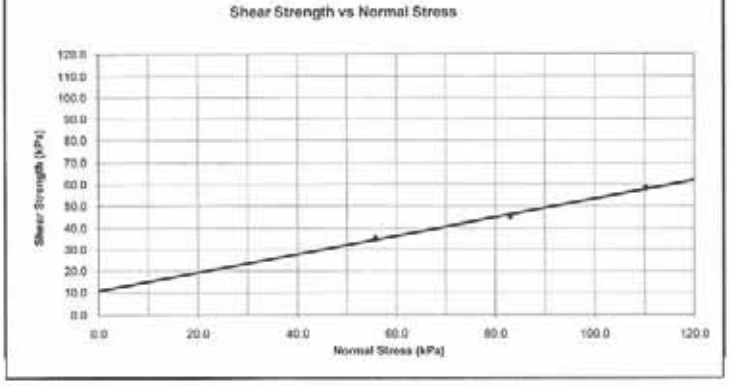
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.74	20.3	19.2	11	23
	47.6	30.8		
	74.8	42.4		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 02
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	3.25

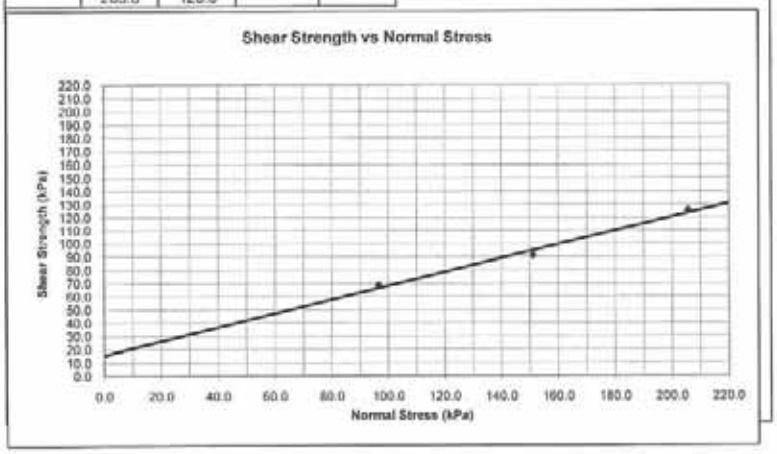
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.00	66.8	35.2	11	23
	83.0	45.2		
	110.3	58.5		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 02
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 5.25

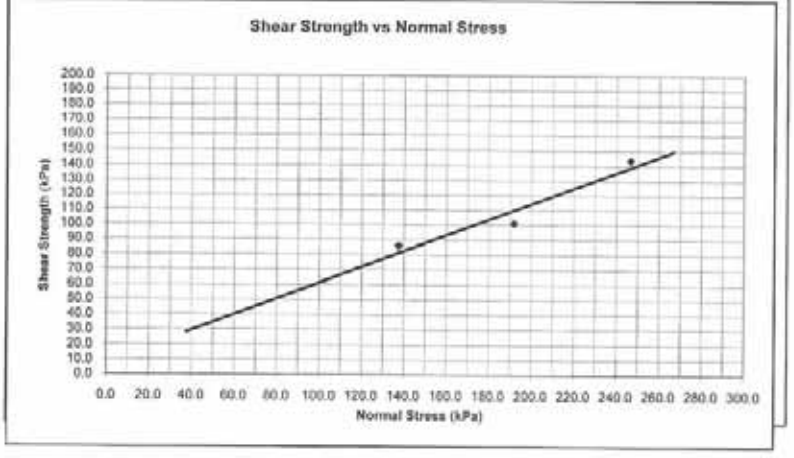
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.86	96.6	68.5	16	28
	151.1	91.1		
	205.6	125.6		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 02
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 7.25

Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.94	137.5	85.7	8	28
	192.0	101.2		
	246.5	143.5		



CENTRAL MATERIALS LABORATORY

PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCl CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH D (m)	WIDTH B (m)	BULK DENSITY, γ kN/m³	COHESION C (kPa)	COHESION C' (kPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	Nγ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
TP1 05	1.25	1.0	17.03	23	15	15	10	8.4	2.5	0.4	225	3	74
BH 03	3.25	1.0	17.03	14	10	25	17	12.3	4.5	1.7	430	3	143
BH 03	5.25	1.0	19.47	28	18	25	17	12.3	4.5	1.7	804	3	268
BH 03	7.25	1.0	20.05	56	28	29	18	13.1	5.3	2.1	1455	3	485
BH 03	9.25	1.0	20.61	73	32	32	22	16.9	7.8	4.1	2003	3	668

$q_{ult} = C'N_c + q_o N_q + \frac{1}{2}\gamma B N_\gamma$

where $q_o = \gamma D$

$\phi = \tan^{-1}(0.67 \tan \phi)$

$C' = 0.67C$

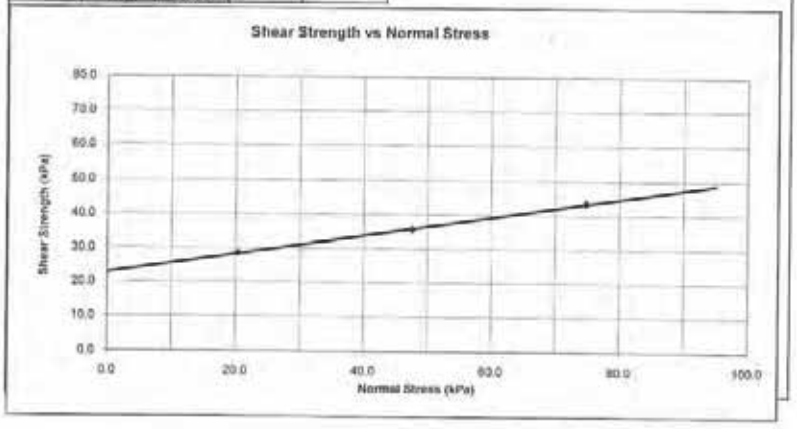
$q_{all} = q_{ult}/F$

for

SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION
Client : M/S CaCl CONSULTING LTD
Date : MAY 2014
LABEL BH 03
DEPTH (m): 1.25

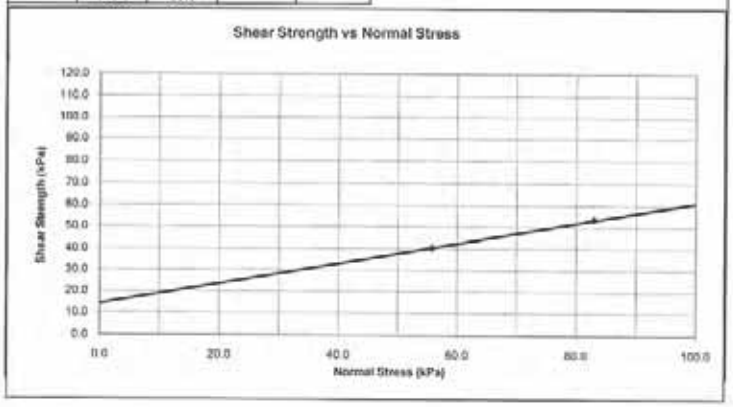
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.69	20.3	28.6	23	15
	47.6	35.6		
	74.6	43.5		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 03
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	3.25

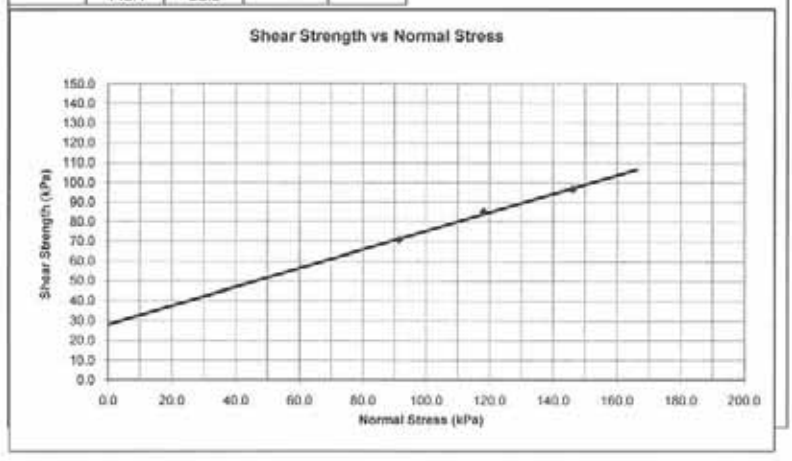
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.70	55.8	40.3	14	25
	83.0	53.6		
	110.3	65.9		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 03
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	5.25

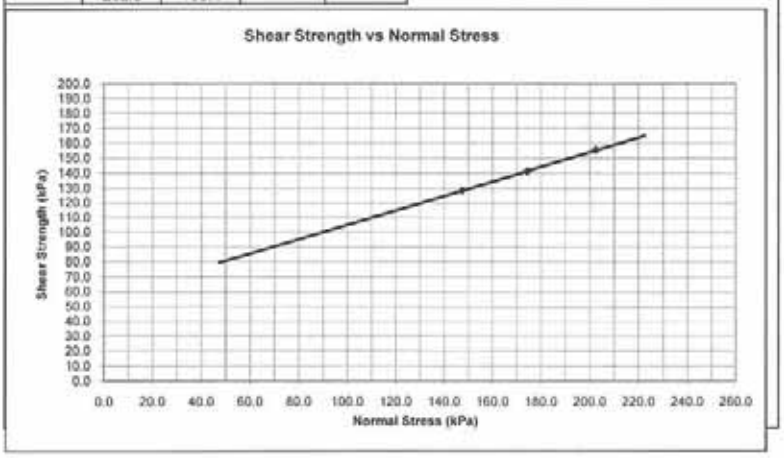
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.95	91.4	70.8	28	25
	118.2	85.3		
	146.1	96.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCI CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 7.25

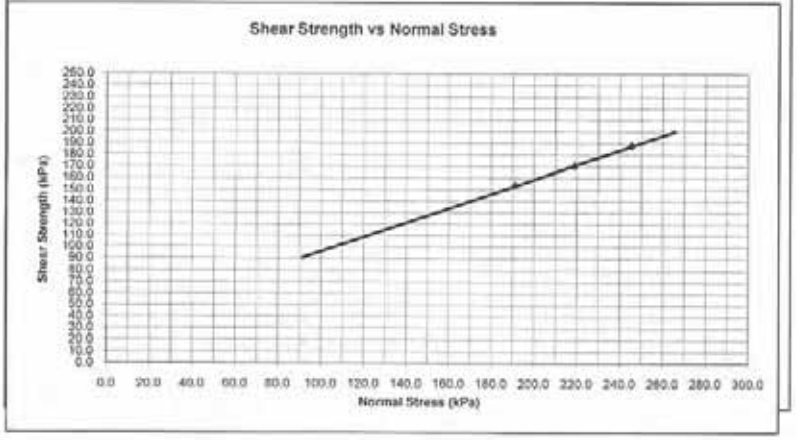
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.04	147.4	128.4	56	26
	174.3	141.3		
	202.5	155.4		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCI CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 9.25

Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.06	191.3	153.7	33	32
	219.0	170.3		
	245.5	187.9		



CENTRAL MATERIALS LABORATORY

PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCI CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH D (m)	WIDTH B (m)	BULK DENSITY γ kN/m^3	COHESION C (kPa)	COHESION C' (kPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS N_c	N_q	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
BH 04	1.25	1.0	18.78	19	13	18	12	9.8	3.0	0.8	228	3	76
BH 04	3.25	1.0	18.78	26	18	24	16	11.6	4.3	1.4	536	3	179
BH 04	5.25	1.0	19.89	57	38	31	14	10.4	3.6	1.0	992	3	237
BH 04	7.25	1.0	19.19	66	44	34	16	11.8	4.5	1.4	1268	3	423
BH 04	9.25	1.0	19.55	80	57	35	19	13.1	5.3	2.1	1857	3	538

$q_{ult} = C'N_{c(sc)} + q_o N_q + \frac{1}{2}\gamma B N_{\gamma(\gamma)}$

Where $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan \phi)$

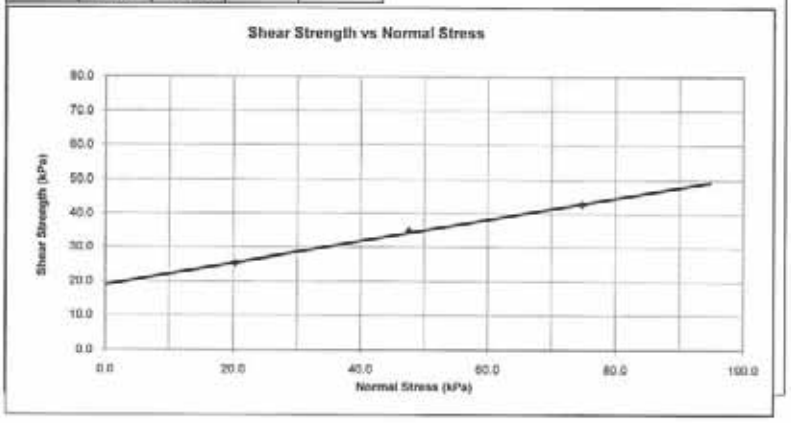
$C' = 0.67C$

$q_{all} = \frac{q_{ult}}{F}$

SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 04
Client : M/S CaCI CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 1.25

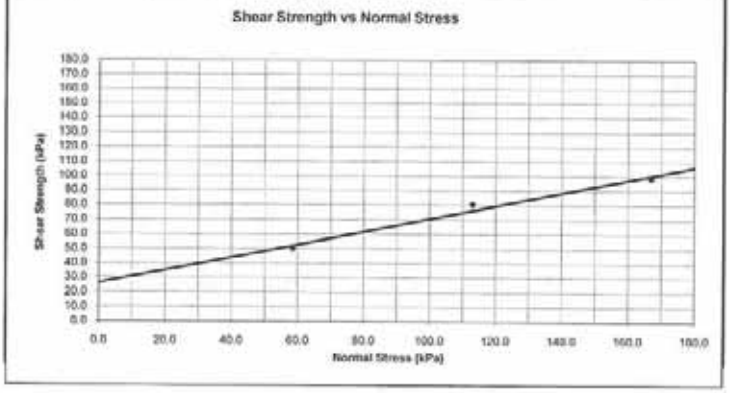
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.88	20.3	25.3	19	18
	47.6	34.8		
	74.0	42.0		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 04
Client : M/S CaCI CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	3.25

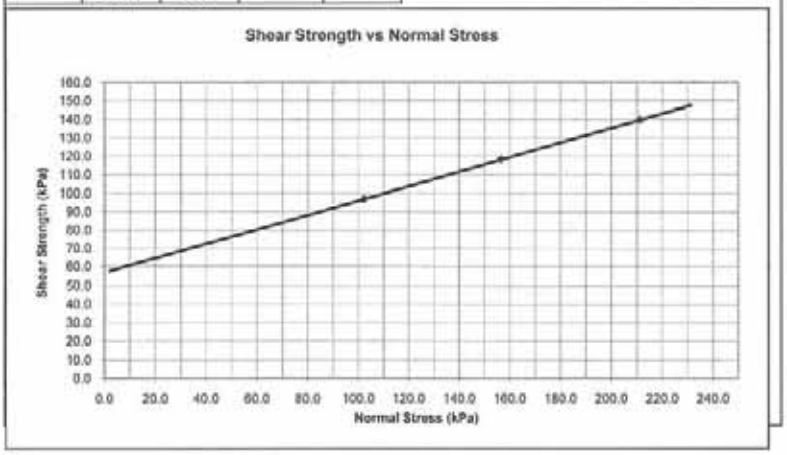
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_b kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.88	58.5	50.3	26	24
	113.0	80.4		
	167.0	98.5		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 04
Client : M/S CaCI CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	5.25

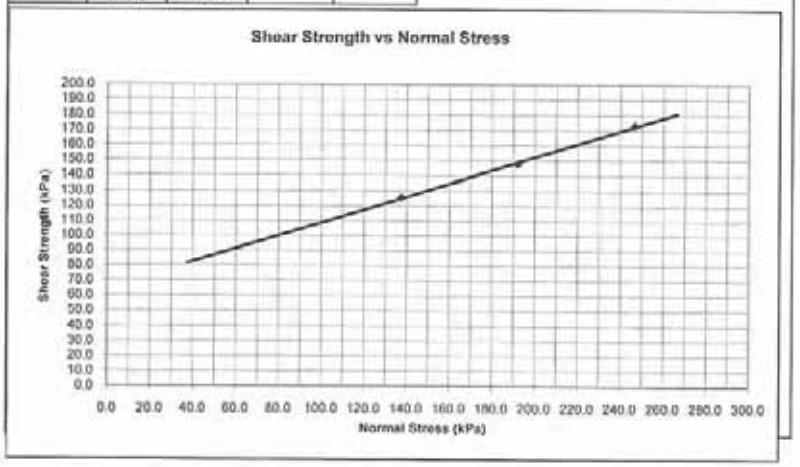
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_b kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.95	102.1	96.9	57	21
	156.6	118.4		
	211.1	139.7		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 04
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 7.25

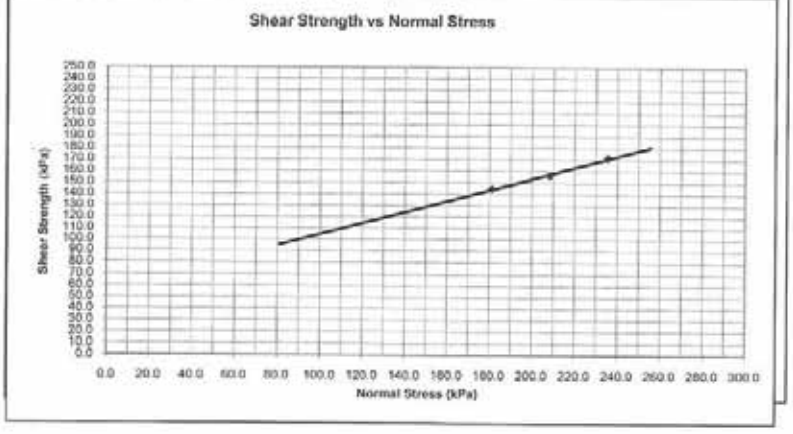
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.92	137.5	125.7	65	24
	192.0	147.6		
	246.5	173.1		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 04
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 9.25

Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.95	181.1	144.8	55	20
	208.4	156.3		
	235.8	171.5		



APPENDIX 3: CONSOLIDATION TEST RESULTS

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION

CLIENT: M/S CaCl CONSULTING LTD

DATE: MAY 2014

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF	BH 02	DEPTH	3.00 - 3.50m
DIAMETER OF SPECIMEN	0.075 m		THICKNESS ($2H_o$)	0.02 m
VOLUME OF SPECIMEN	0.0003884 m^3			
MC BEFORE TEST	24.3 %		BULK DENSITY	2.00 Mg/m^3
WT OF SAMPLE & RING	270.09 g		DRY DENSITY (γ_d)	1.684 Mg/m^3
WT OF EMPTY RING	85.07 g		SPECIFIC GRAVITY	2.61
WT OF WET SOIL	186.01 g		S_r	0.550
WT OF DRY SOIL	145.84 g			
			VOID RATIO FACTOR (F)	0.0775
RING CALIBRATION FACTOR	0.01			

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (Change in void ratio)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes: Void ratio	Pressure	$(+e_v)$	m_v m^2/MN
0	0.0				0.549881	0	0		
40	0.0	20.80	0.2080	0.015886	0.533995	0.01589	40.0	1.550	0.26
80	0.0	45.00	0.4500	0.034372	0.515509	0.01699	40.0	1.834	0.31
160	0.0	75.00	0.7500	0.058121	0.491761	0.02325	80.0	1.515	0.15
320	0.0	105.00	1.0500	0.083684	0.466198	0.02557	160.0	1.402	0.11
640	0.0	150.00	1.5000	0.118341	0.433642	0.03255	320.0	1.466	0.07
1280	0.0	193.00	1.9300	0.149954	0.400319	0.03332	640.0	1.434	0.04
Average									0.167

APPENDIX 4: UNCONFINED COMPRESSION STRENGTH TEST ON SOIL SAMPLES.

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

CENTRAL MATERIALS LABORATORY

CLIENT M/S CaCI CONSULTING LTD
PROJECT IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
DATE MAY 2014

SUMMARY OF UNCONFINED COMPRESSIVE STRENGTH RESULTS FOR SPT SOIL SAMPLES

Sample Identification		Dimensions		Mass	Bulk Density	Natural Moisture Content	Load	Un Unconfined Compressive Strength
BH No.	Depth (m)	Diameter (mm)	Length (mm)	(Kg)	(Kg/m³)	(%)	(kN)	(Mpa)
1	1.0 – 1.5	75	150	1.206	1820	26	0.194	0.044
	1.5 – 1.8	70	140	1.133	2103	26	0.370	0.096
	2.5 – 2.7	70	140	1.138	2112	26	0.387	0.101
	7.5 – 7.8	60	120	0.767	2261	12	0.699	0.307
	8.5 – 80	55	110	0.585	2238	12	0.520	0.219
2	3.1 – 3.4	75	150	1.216	1835	23	0.278	0.062
	3.5 – 4.0	75	150	1.158	1747	23	0.108	0.024
	4.5 – 4.7	75	150	1.369	2066	20	2.193	0.496
	7.0 – 7.3	55	110	0.445	1703	17	0.092	0.026

CENTRAL MATERIALS LABORATORY

CLIENT M/S CaCl CONSULTING LTD.
PROJECT IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
DATE MAY 2014

SUMMARY OF UNCONFINED COMPRESSIVE STRENGTH RESULTS FOR SPT SOIL SAMPLES

Sample Identification		Dimensions		Mass	Bulk Density	Natural Moisture Content	Load	Un Unconfined Compressive Strength
BH No.	Depth (m)	Diameter (mm)	Length (mm)	(Kg)	(Kg/m³)	(%)	(kN)	(Mpa)
3	1.6 – 2.0	75	150	1.183	1785	26	0.516	0.117
	2.5 – 2.8	75	150	1.245	1879	26	0.512	0.116
	4.8 – 5.0	75	150	1.365	2064	26	2.098	0.475
	6.5 – 6.7	75	150	1.402	2116	14	0.735	0.166
4	3.0 – 3.2	75	150	1.376	2076	20	4.180	0.948
	3.5 – 3.8	75	150	1.394	2104	20	1.634	0.370
	5.5 – 5.7	75	150	1.284	1938	15	1.359	0.308
	7.1 – 7.3	75	150	1.383	2087	15	1.183	0.268

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

APPENDIX 5: UNCONFINED COMPRESSION STRENGTH TEST ON ROCK CORES

CENTRAL MATERIALS LABORATORY

CLIENT — M/S CaCl CONSULTING LTD.
PROJECT — IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
DATE — MAY 2014

SUMMARY OF ROCK CORES TEST RESULTS:

Sample Identification			Dimensions		Mass	Density	Load	Unconfined Compressive Strength	Water Absorption
BH No.	Depth	Specimen	Diameter	Length					
	(m)	(No.)	(mm)	(mm)	(Kg)	(Kg/m^3)	(kN)	(Mpa)	(%)
1	12.0-13.1	1	60	120	0.931	2744	112	39.6	0.3
		2	60	120	0.938	2765	122	43.1	0.3
2	8.0-9.0	1	60	120	0.855	2520	32	11.3	1.5
		2	60	120	0.851	2508	30	10.6	1.2

APPENDIX 6: BOREHOLE LOGS

BOREHOLE No. 1

Equipment/Method
HGY 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses conventional drilling system.

Location No. 1
Location:
Queens Way substation

Carried out for
NewPlan Ltd

Ground Level

Coordinates:
36N 452901E, 34111W

Date: 26th to 27th April 2014

Description	Reduced Level	Legend	Depth (thick)	Sample/Tests: Depth	Sample: Type	Sample: No.	Test	No. of hammers (n-value)
Firm black CLAY with roots			0.1					
Firm black CLAY with COBBLES			0.37					
Very strong, light grey, fine grained fresh massive GRANITE				1-1.5	U			25
				2-2.5	U			29
Loose grey brown CLAY				3-3.5				11 (no sample recovered)
				3.5-4	U			23
			5.5	5-5.5	U			48
Loose brown CLAY with SILT				6.5-7	D			56
				7.5-8	U			55
			9.4	9-9.5	D			34
Loose, brown, Coarse grained, completely weathered GRANITE (COBBLES and SILT)				10-10.5	U			102
				11.5-12	D			78
Very strong, light grey brown, fresh GRANITE			12.2	13.5-13				Refusal

Remarks:
Hard rock intercepted at the bottom of the borehole was tested for compressive strength and water absorption

Logged by
CeCI Consulting Ltd

Scale
NTS

Fig.

BOREHOLE No. 2

Equipment/Method
HGY 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses conventional drilling system.

Location No.3
Location:
Queens Way substation

Carried out for
NewPlan Ltd

Ground Level

Coordinates
36N 452908E, 34133N

Date: 28th April 2014

Description	Reduced Level	Legend	Depth (thick)	Sample/Tests: Depth	Sample: Type	Sample: No.	Test	No. of hammers (n-value)
Firm black CLAY with COBBLES			0.1					
Firm brown CLAY			1.2	1-1.5	U			12
Loose grey CLAY				2-2.5	U			5
				3-3.5	U			12
				4-4.5	U			24
			4.9	5-5.5	U			16
Loose, brown, Coarse grained, completely weathered GRANITE (COBBLES and SILT)				6-6.5	U			123
				7-7.5	U			>102
				8-8.5	U			26
Very strong, light grey brown, fresh GRANITE			8.4					

Remarks:
Hard rock intercepted at the bottom of the borehole was tested for compressive strength and water absorption

Logged by
CeCI Consulting Ltd

Scale
NTS

Fig.

BOREHOLE No. 3

Equipment/Method
HGV 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses convetional drilling system.

Location No. 3

Location: Queens Way substation

Carried out for NewPlan Ltd

Ground Level | Coordinates 35N 452905E, 34140N | Date: 28th April 2014

Description	Reduced Level	Legend	Depth (thick)	Depth	Sample Type	Sample No.	Test	No. of hammers (n-value)
Firm black CLAY			0.2					
Firm brown CLAY with SILT			0.8					
Loose grey CLAY with SILT			4.7	1-1.5	U/D			7
				2-2.5	U			7
				3-3.5	U/D			15
				4-4.5	U			19
Loose brown SILT with CLAY and COBBLES				5-5.5	U/D			47
				5-6.5	U			>100
Loose, brown, Coarse grained, completely weathered GRANITE (COBBLES and SILT)			7.1	7-7.5	U/D			46
				8-8.5	U			42
					D			

Remarks:
No bed rock was intersepted

Logged by CeCi Consulting Ltd
Scale NTS
Fig.

BOREHOLE No. 4

Equipment/Method
HGV 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses convetional drilling system.

Location No. 4

Location: Under 132kv Line

Carried out for NewPlan Ltd

Ground Level | Coordinates 35N 452908E, 34133N | Date: 25th to 27th April 2014

Description	Reduced Level	Legend	Depth (thick)	Depth	Sample Type	Sample No.	Test	No. of hammers (n-value)
Firm brown grey CLAY, SILT and COBBLES. Tree roots material				1-1.5	U/D			52
				2-2.5	U			15
Firm brown CLAY with SILT			3	3-3.5	U/D			25
			3.5	4-4.5	U			29
				5-5.5	U/D			42
				6-6.5	U			33
Loose grey CLAY with SILT and COBBLES				7-7.5	U/D			56
			8.4	8-8.5	U			27
				9-9.5	U/D			29
Loose, brown grey, Coarse grained, moderately weathered GRANITE				10-10.5	U			35
				11-11.5	U/D			46
				12-12.5	U			44

Remarks:
No bed rock was intercepted

Logged by CeCi Consulting Ltd
Scale NTS
Fig.