APPENDIX 7

STUDY ON VOLTAGE DROP

Basic Design Study
For
The Rural Electrification Project in the Republic of Uganda

Examination of Voltage Drop

1. Examination Criteria

1.1 Transmission Network

Transmission line routes from the existing 33 kV transmission network to local areas are as indicated in Attached Figure 1

1.2 Voltage, Frequency and Load Power Factor

Voltage and frequency shall be set at 33 kV three-phase three-wire and 50 Hz respectively.

Concerning the load power factor, this shall be set at 0.95, since it is considered that load in consumer areas will mainly be generated by fluorescent lamps and electric heaters.

1.3 Load Criteria

(1) Load Along the Route from the Power Source to the Project Area

The estimated load of substations in 2004, that exist between the power source substations (132/33 kV) and the Project areas are as indicated below.

Area	Substation	Projected Load (MVA)
Area A1	Njeru Substation	10.4
Area A2	Kamli Substation	1.2
Area B	Kawanda Substation	2.6
	Bombo Substation	5.2
	Nakasongola Substation	0.85
Area C	Mityana Substation	2.27
	Busunju Substation	0.58
	Hoima Substation	1.08
	Masindi Substation	1.08
	Kinyala Substation	0.12

(2) Load in the Project Area

The projected power demand in the Project area for 2004 as calculated by the above procedure is as indicated in Attached Table 1, and the arrangement of distribution transformers is as indicated in Attached Figure 2.

1.4 Transmission Method

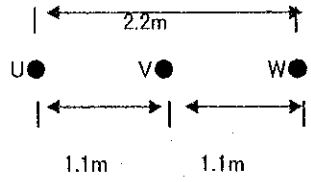
Overhead power lines with bare conductors shall be adopted.

1.5 Line Constant

The line constant of existing lines and new lines has been set in the manner described below. Incidentally, the type of transmission line used in the Project shall be AAAC, 95 mm2.

Power Line Radius　　Equivalent Phase Segregation

①HAL100mm^2(r=13.0/2mm.　S=$\sqrt[3]{}$(1.1x1.1x2.2)=1.386m)



L=0.05+0.4605 $\log_{10}$ s/r （mH/km)

=1.122mH/km　　(50Hz)

X=0.352Ω/km
R=0.284Ω/km

②ACSR75mm^2(r=12.0/2mm.　S=$\sqrt[3]{}$(1.1x1.1x2.2)=1.386m)

L=1.138 mH/km

X=0.358Ω/km
R=0.380Ω/km

③ACSR92.4mm^2(r=13.2/2mm.　S=$\sqrt[3]{}$(1.1x1.1x2.2)=1.386m)

L=1.119 mH/km

X=0.352Ω/km
R=0.315Ω/km

④HDC100mm^2(r=13.0/2mm.　S=$\sqrt[3]{}$(1.1x1.1x2.2)=1.386m)

L=1.122 mH/km

X=0.352Ω/km
R=0.178Ω/km

⑤HDC50mm^2(r=9.0/2mm.　S=$\sqrt[3]{}$(1.1x1.1x2.2)=1.386m)

L=1.196 mH/km

X=0.376Ω/km
R=0.376Ω/km

⑥AAAC95mm^2(r=12.6/2mm.　S=$\sqrt[3]{}$(1.1x1.1x2.2)=1.386m)

L=1.171 mH/km

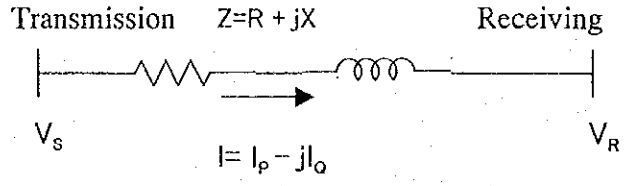
X=0.368Ω/km
R=0.295Ω/km

1.6 Voltage Drop Calculation Methodology

(1) Calculation Technique

- Treat the line constant (R + jX) and load current (I_p - jI_c) as complex numbers.
- Voltage drop is calculated using the following formula:

$$\Delta V=(I_P \cdot R+I_Q \cdot X)+j(I_P \cdot X-I_Q \cdot R)$$



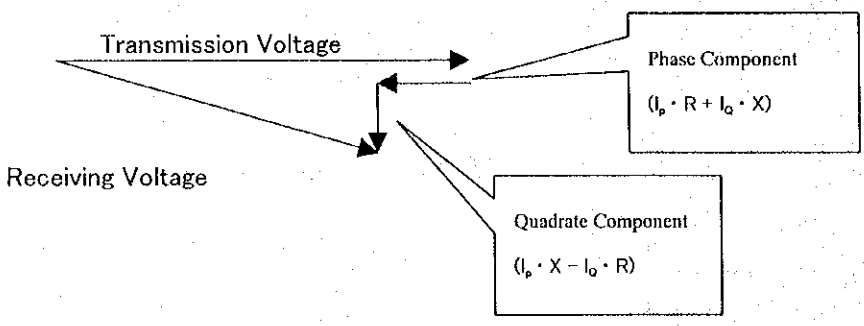
(Lagging Power to be treated as —)

$V_R = V_S - I \times Z$ $\quad \Delta V = I \times Z$(Voltage Drop)

$$\Delta V = (I_P - jI_Q) \times (R + jX)$$
$$= I_P \cdot R + I_P \cdot jX - jI_Q \cdot R - jI_Q \cdot jX \qquad j^2 = -1$$
$$= (I_P \cdot R + I_Q \cdot X) + j(I_P \cdot X - I_Q \cdot R)$$

Phase Component Quadrate Component

- Because the second item in the above formula is the quadrate component regarding the power voltage and this has a minimal effect, therefore this shall be ignored.



- Accordingly, voltage drop in a three-phase three-wire transmission line shall be sought as $\Delta V=\sqrt{3}(I_P \cdot R + I_Q \cdot X)$.

(2) Treatment of Uniform Distributed Load

- The terminal voltage drop in the case where load is uniformly distributed along a distribution line of the same type shall be assumed to be equivalent to the voltage

drop in the case where all load is concentrated in the center of the distribution line.

2. Results of Examination

Attached Table 3 shows the results of the examination of voltage drop for each system.

3. Consideration

3.1 Area A1

The terminal voltage is 30.6 kV and the voltage drop factor is 7.9%, which falls within the allowable range of voltage fluctuation (±10%) and is not a problem.

However, since it is thought that voltage drop countermeasures will be required in the future when the load increases, steps that can be considered are the establishment of a power condenser at Kayunga substation, installation of a voltage regulator along the line, and so on.

3.2 Area A2

The terminal voltage is 31.9 kV and the voltage drop factor is 3.5%, which falls within the allowable range of voltage fluctuation and is not a problem.

3.3 Area B

According to the calculation results, since the terminal voltage is 28.3 kV and the voltage drop factor is 16.4%, which exceeds the allowable range of voltage fluctuation, it will be necessary to take voltage drop countermeasures.

One way of dealing with the voltage drop in this system is to modify voltage to a more appropriate value (33 kV) by installing a voltage regulator between the Project area and Bombo substation (the power supply source for the Project area). In consideration of the composition of the existing system and the site selection, the voltage regulator shall be installed at the junction (Wabigalo area) of the existing 33 kV transmission line where it leads to the Project area and Nakasongola substation. Since the examination of voltage drop in the Project target year arrived at a projected terminal voltage in the Project area of 28.3 kV (representing a voltage drop of 14.1% from the rated voltage of 33 kV), it will be necessary to select a voltage regulator that enables voltage to be regulated over a range of 15%.

3.4 Area C

According to the calculation results, since the terminal voltage is 26.8 kV and the

voltage drop factor is 23.0%, which exceeds the allowable range of voltage fluctuation, it will be necessary to take voltage drop countermeasures.

In the C System, since the transmission line between the Project area and Mutòndwe substation (the power supply source for the Project area) covers a long distance of approximately 100 km, voltage drop problems are already occurring on the existing 33 kV line. UEB installed a voltage regulator in the existing Hoima substation in 1996 to deal with this problem, however, because this is a used regulator (made in 1990) already showing signs of deterioration and has a limited voltage regulating range of 12.5%, it is unable to deal with the voltage drop presently arising in the target area. Therefore, in consideration of demand in the Project area and demand on the existing Hoima substation, the said voltage regulator shall be replaced with a new regulator that is capable of handling the projected voltage drop in the Project target year. Moreover, since it is forecast that terminal voltage in the Project area will be 26.8 kV (representing a voltage drop of 18.7% from the rated voltage of 33 kV), it will be necessary to select a voltage regulator that enables voltage to be regulated over a range of 20%.

Attachments

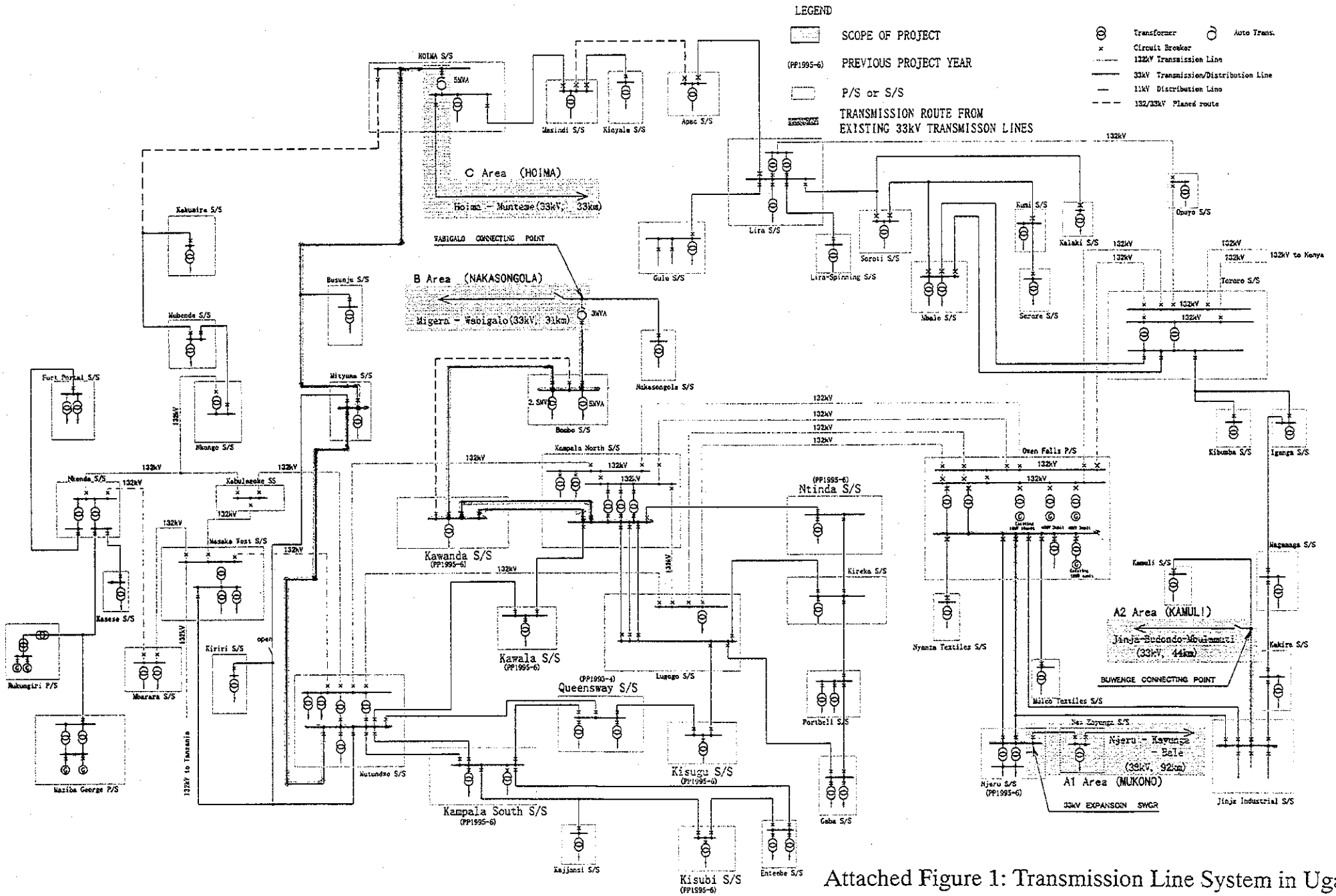
Attached Table 1:	Projected Load and Number of Distribution Transformers in the Project Area
Attached Figure 1:	Transmission Line System in Uganda
Attached Figure 2:	Arrangement of Distribution Transformers
Attached Figure 3:	Voltage Drop Calculation Results

Attached Table 1: Projected Load and Number of Distribution Transformers in project Area (1/2)

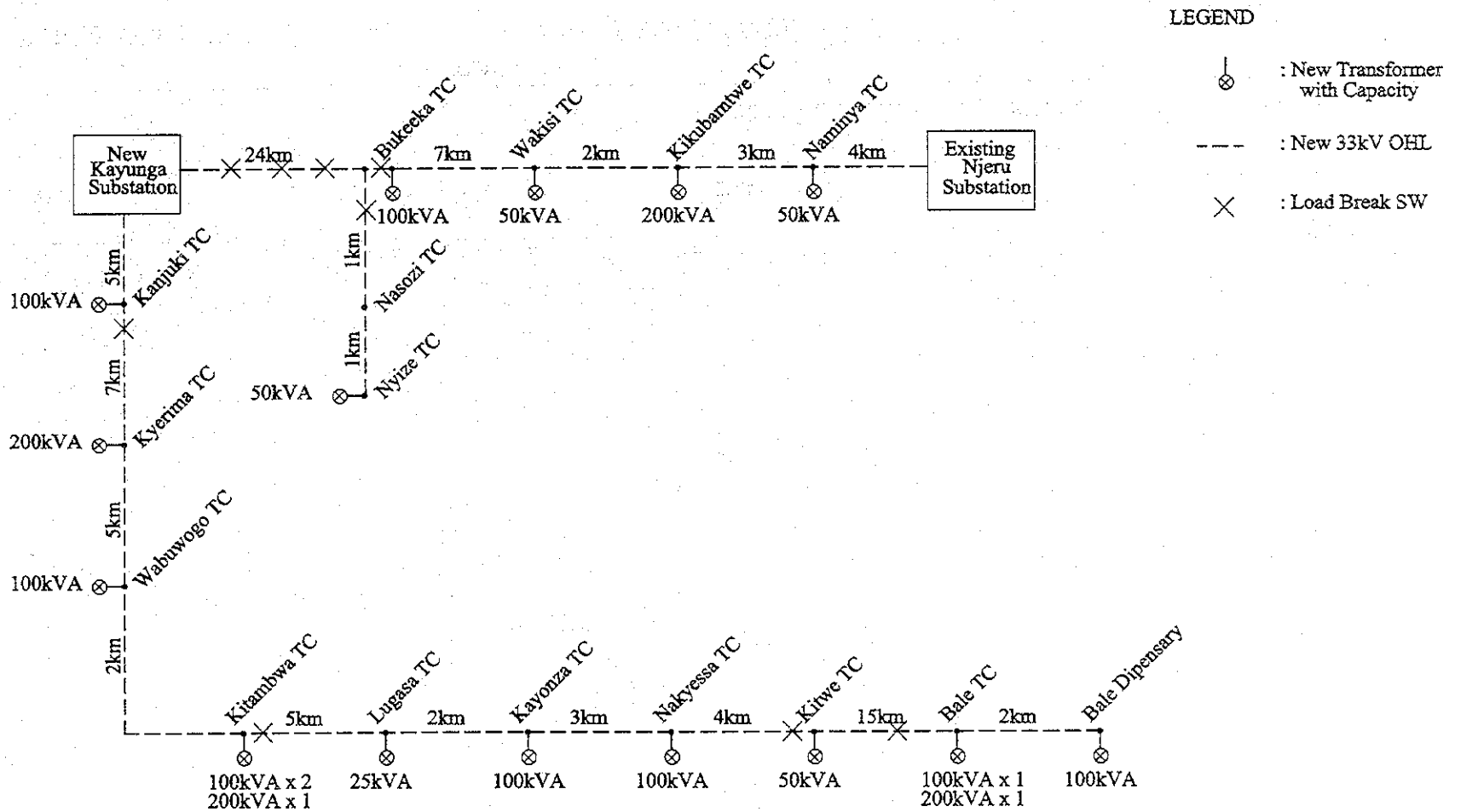
Name	Demand (kW)	Capacity (kVA)	No. of Transf. (Set/Sets)	Capacity of Transf. (KVA)	Remarks
Area A1					
Kanjuki	92.24	97.09	1	100	
Kyerima	187.77	197.66	1	200	
Wabwogo	55.11	58.01	1	100	
Kitimbwa	368.43	387.82	1	200	
			2	100	
Kayonza	64.76	68.17	1	100	
Nakyesa	89.71	94.43	1	100	
Kitwe	44.85	47.21	1	50	
Bale	308.20	324.42	1	200	
			2	100	
Bukeeka	73.73	77.61	1	100	
Nyize	46.64	49.10	1	50	
Wakisi	34.08	35.88	1	50	
Kikubamutwe	115.32	121.39	1	200	
Naminya	43.15	45.42	1	50	
Lugasa	4.43	4.66	1	25	
Total	***1528.42***	***1608.87***	***18***	***1925***	
Area A2					
Buwenda	18.82	19.81	1	50	To include (a*)
Bujagali	29.69	31.25			(a*)
Ivunamba	68.59	72.20	1	100	
Namize	24.60	25.90	1	50	
Budondo S/C	13.29	86.10	2	50	
Budondo TC	69.17				
Buyala	171.65	180.69	1	200	
Kabowa	18.45	19.42	1	25	
Nakanyonyi	48.38	50.92	1	50	
Namagera	157.52	165.81	1	200	
Butagaya	22.94	24.15	1	50	
Lubani	65.92	69.38	1	100	
Budima	65.92	69.38	1	100	
Nankandulo	175.32	184.55	1	200	
Kisozi	161.95	170.47	1	200	
Namaganda	28.17	29.65	1	50	
Kiyunga	118.23	124.45	1	200	
Muwange	0.30	0.32			(b*)
Namwenda	12.81	13.49	1	25	To include (b*)
Total	***1265.70***	***1332.31***	***17***	***1700***	

Attached Table 1: Projected Load and Number of Distribution Transformers in project Area (2/2)

Name	*Demand* (kW)	*Capacity* (kVA)	*No. of Transf.* (Set/Sets)	*Capacity of Transf.* (KVA)	*Remarks*
Area B					
Wabigalo	164.92	173.60	2	100	
Sasira	99.45	104.68	1	100	
Namasa	68.38	71.98	1	100	
Migera	247.83	260.87	1	200	
			1	100	
Total	***580.57***	***611.13***	***6***	***700***	
Area C					
Buswekera	87.83	92.45	1	100	
Buhimba	176.40	185.68	1	200	
Kikube	100.83	106.14	1	100	
Munteme	190.18	200.19	2	100	
Total	***555.24***	***584.47***	***5***	***600***	
Grand Total	***3929.94***	***4136.78***	***46***	***4925***	

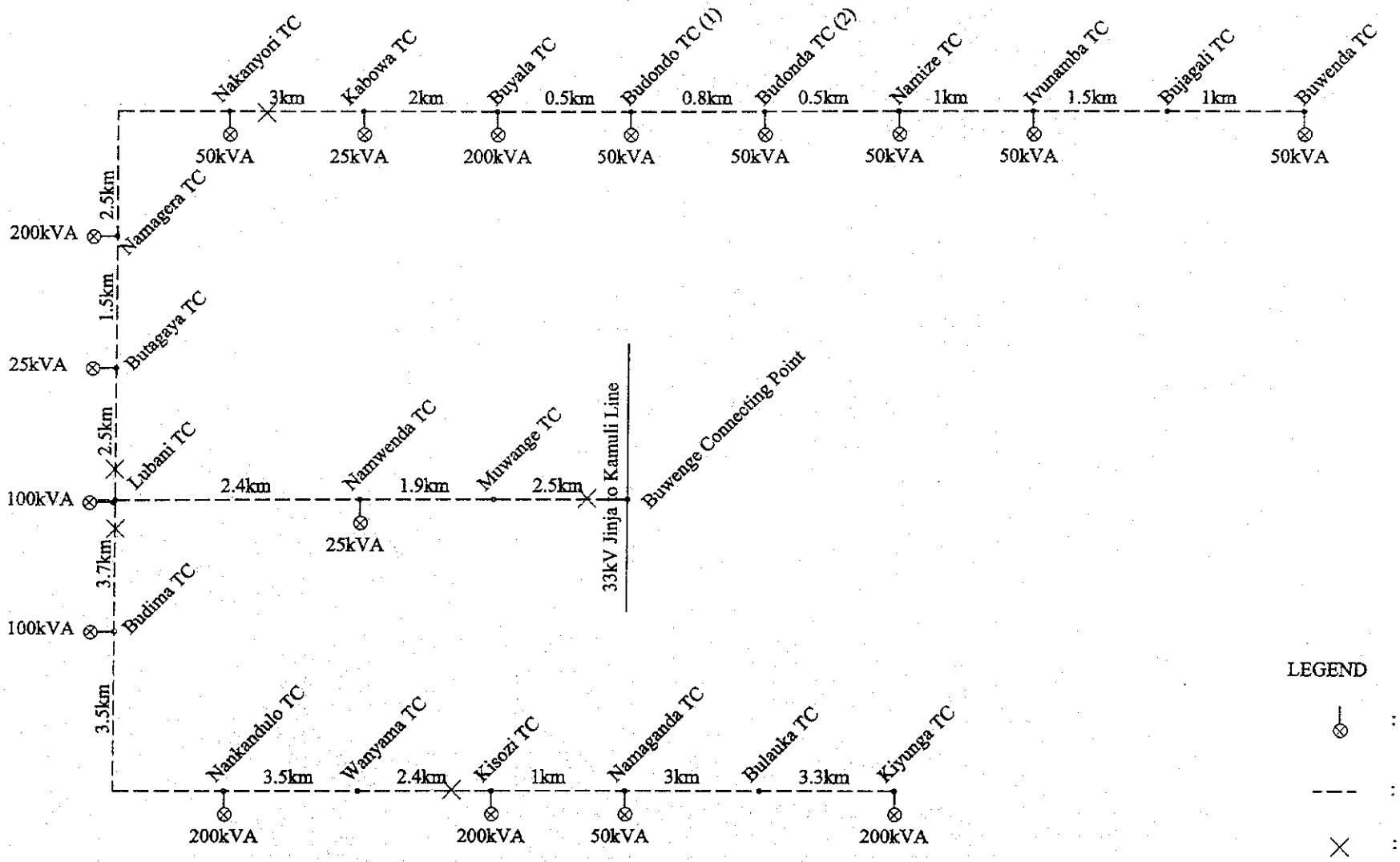


Attached Figure 1: Transmission Line System in Uganda



Attached Figure 2: Arrangement of Distribution Transformer (1/4)

- Project Name -	- Project Compartment -	- District Area -
THE RURAL ELECTRIFICATION PROJECT IN REPUBLIC OF UGANDA	TRANSFORMER PLOTTING OF 33kV DISTRIBUTION NETWORK	AREA No. A1 (Njeru to Bale route)
		- Sheet No. - GS-11 Rev. 3



Attached Figure 2: Arrangement of Distribution Transformer (2/4)

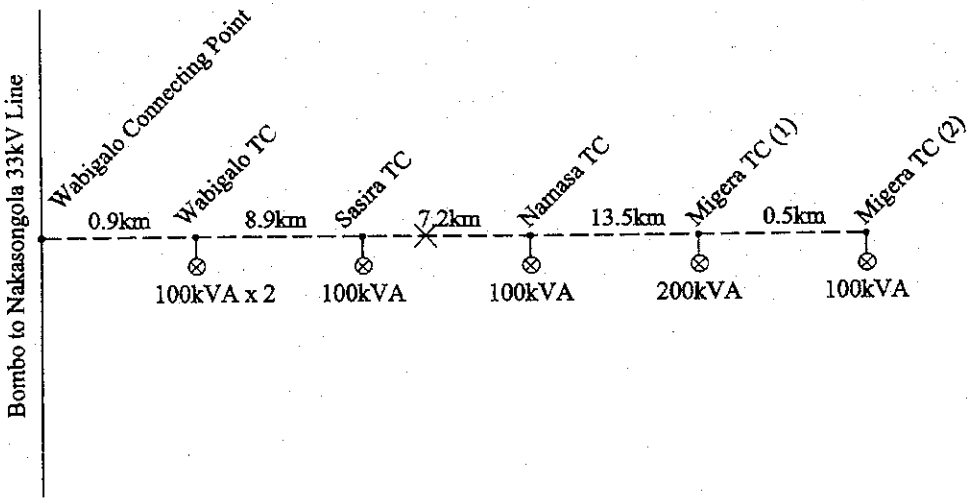
- Project Name -	- Project Compartment -	- District Area -
THE RUERAL ELECTRIFICATION PROJECT IN THE REPUBLIC OF UGANDA	TRANSFORMER PLOTTING OF 33kV DISTRIBUTION NETWORK	AREA No. A2 (Buwenge to Jinja and Kiyunga route)
		- Sheet No. - GS-12 Rev. 3

LEGEND

: New Transformer with Capacity

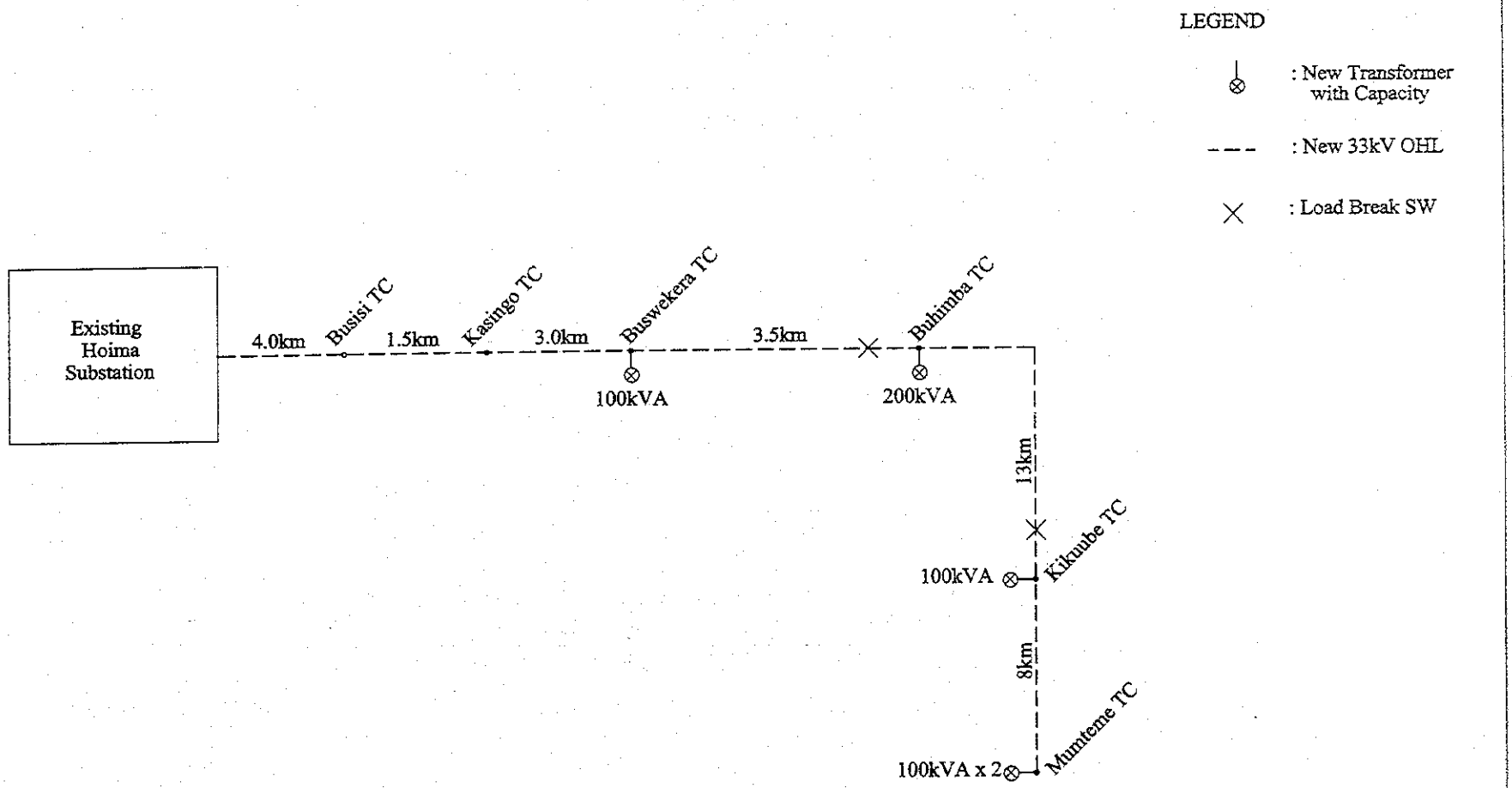
: New 33kV OHL

: Load Break SW



Attached Figure 2: Arrangement of Distribution Transformer (3/4)

- Project Name -	- Project Compartment -	- District Area -
THE RURAL ELECTRIFICATION PROJECT IN REPUBLIC OF UGANDA	TRANSFORMER PLOTTING OF 33kV DISTRIBUTION NETWORK	AREA No. B (Wabigalo to Migera route)
		- Sheet No. - GS-13 Rev. 3

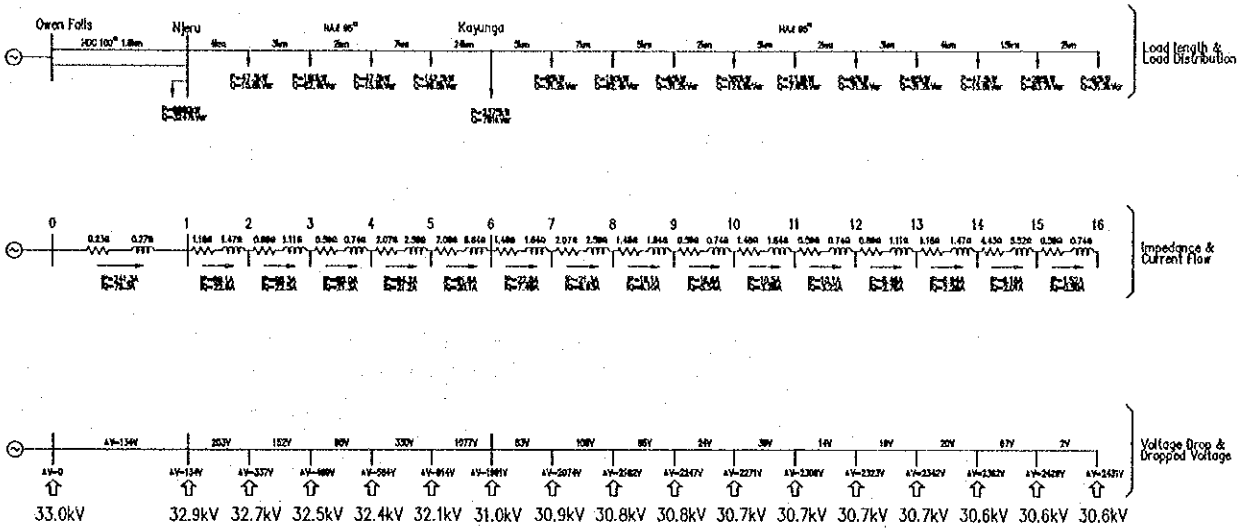


Attached Figure 2: Arrangement of Distribution Transformer (4/4)

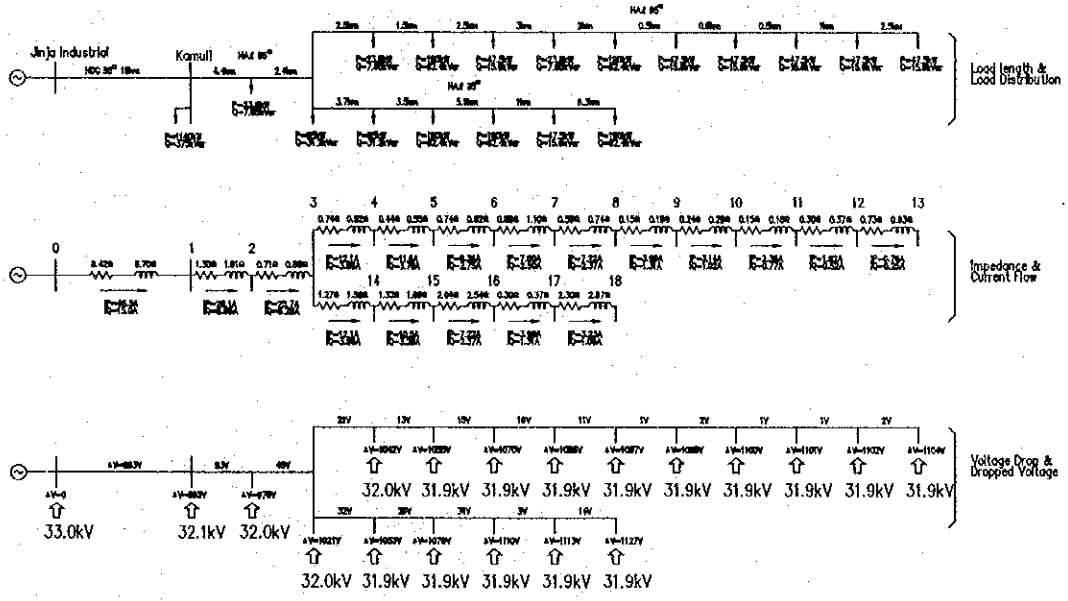
- Project Name -	- Project Compartment -	- District Area -
THE RURAL ELECTRIFICATION PROJECT IN REPUBLIC OF UGANDA	TRANSFORMER PLOTTING OF 33kV DISTRIBUTION NETWORK	AREA No. C (Hoima to Mumteme route)
		- Sheet No. - GS-14 Rev. 3

Attached Figure 3 : Voltage Drop Calculation Result (1/2)

AREA A1

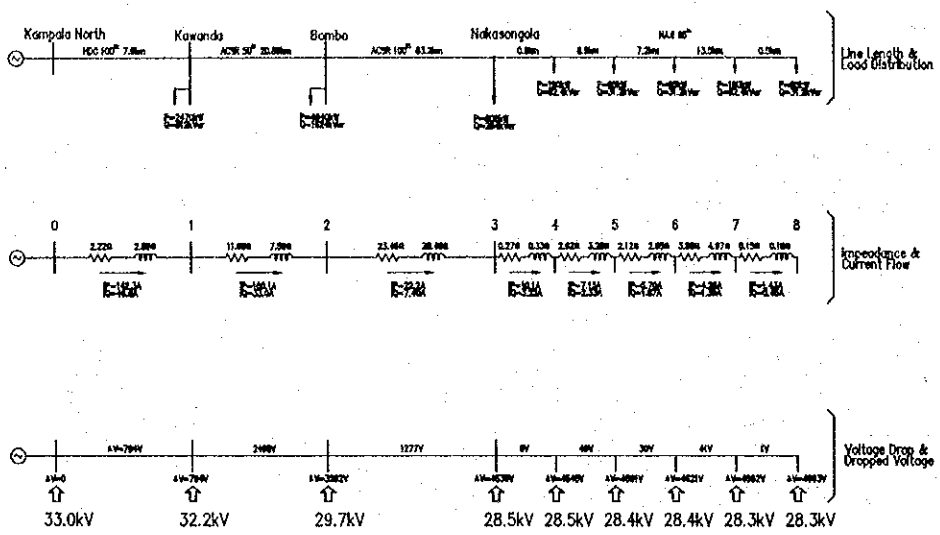


AREA A2

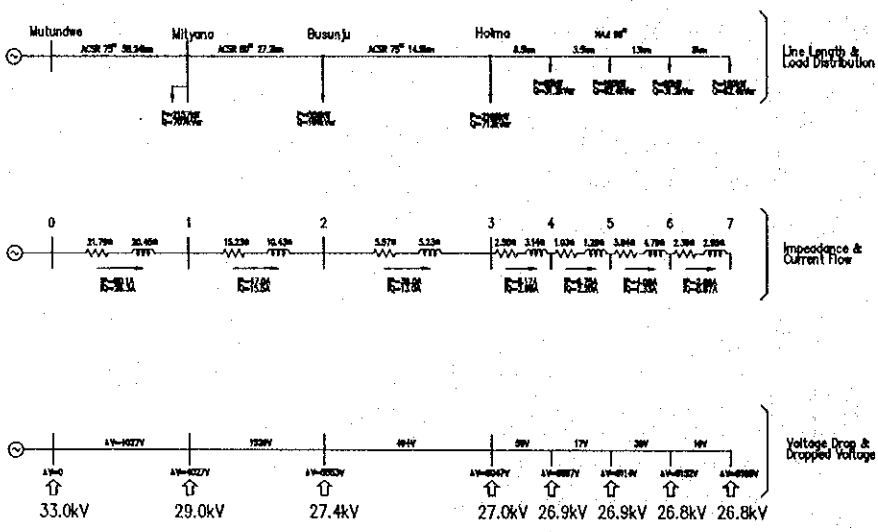


Attached Figure 3 : Voltage Drop Calculation Result (2/2)

AREA B



AREA C



APPENDIX 8

SOIL EXPLORATION TEST REPORT

GOVERNMENT OF UGANDA

RURAL ELECTRIFICATION PROJECT

GEOTECHNICAL INVESTIGATION FOR THE PROPOSED NEW POWER SUBSTATION AT KAYUNGA

CONDUCTED BY
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OCTOBER 1998

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List of Abbreviations

BH	-	Borehole.
BS	-	British Standard.
CH	-	Inorganic Clays of High Plasticity.
CI	-	Inorganic Clays of Intermediate Plasticity.
CL	-	Inorganic Clays of Low Plasticity.
SC	-	Clayey Sands.
D-35	-	Position of Disturbed Samples.
U-100	-	Position of Undisturbed Samples.
M	-	Meters.
SPT	-	Standard Penetration Test.
N-value	-	SPT Blows for 300 mm penetration.
NM	-	Natural Moisture Content.
SA	-	Sieve Analysis.
LL	-	Liquid Limit.
PL	-	Plastic Limit.
PI	-	Plasticity Index.
USCS	-	Unified Soil Classification System.
ρ	-	Bulk Density.
C_u	-	Shear Strength Value.
G_s	-	Specific Gravity.
q_u	-	Ultimate Compressive Strength.

1. INTRODUCTION:

M/S YACHIYO ENGINEERING CO. LTD contracted HYDROTECH Consultants to conduct a geotechnical investigation at the proposed new power substation at Kayunga.

The Investigation followed an agreed scope of work aimed at the following;

i) Confirming the location of the test holes and determination of the exact boring location.

ii) Measurement of height above mean sea level based on authorized temporary bench mark.

iii) Establishing the thickness and composition of the underlying soil profile down to a depth of 5.0 meters;

iv) Establishing the depth of the water table;

v) Evaluating the consistency of the in-situ soils using SPTs;

vi) Establishing engineering properties of the in-situ material through laboratory tests.

vii) Evaluating the soil bearing capacity and recommend the foundation system; and

viii) Compiling a technical report.

ix) Backfilling of boreholes.

The geotechnical investigation was conducted by drilling two boreholes to a maximum depth of 5.5M at the proposed test points. Disturbed and undisturbed samples were retrieved from the boreholes for laboratory testing. The field investigation was conducted between Monday October 6 and October 8, 1998.

2. THE SITE

2.1 Site Location (See Appendices)

The site is located about 75 km on Mukono – Kayunga Road. It is within one of the tributaries of the Sezibwa River which flows in to L. Kyoga (see attached map).

2.2 Site Condition

At the time of the investigation, the site was dry having been filled with murram during previous old construction activities of the Bugerere Dairy Co-operative Society Limited plant within the vicinity. The site was easily accessible to the drilling equipment.

2.3 Geology of the Site (see attached map).

Geological Maps sheets N.A. 36-14 AND North A 36/4-II Bombo indicate granitoid rocks are the parent material forming the predominant geology underlying the site. These are mainly foliated and unfoliated gneisses and granites. Geological mapping revealed topical isolated and thin laterites. The valley has alluvial deposits, mainly of sands, silts, clays and peat.

2.4 Tectonics

There are no major faulting in the area. Tremors due to earth movements, though common in Uganda, are not significant in the investigated area. The site is not associated with volcanism and is free from land slides owing to its rather flat topography.

3.0 FIELD TESTS

3.1 General

The fieldwork was conducted in accordance with BS 5930 198: "Code of Practice for Site Investigations"

The fieldwork consisted of rotary boring, conducting SPT test, recovery of disturbed and undisturbed soil samples.

3.2 Boring with Standard Penetration Tests

Two boreholes were sunk to a maximum depth of 5.5m using a rotary drilling rig mobile model 47. The rig was mounted with 100mm or 200mm diameter flight augers. Standard penetration tests were performed in boreholes using a standard split spoon sampler over a total depth of 450mm. The number of blows required to drive the spoon through the last 300mm penetration was recorded as the N-value. A logging of the soil type, and condition was prepared (see drill logs in appendices).

3.3 Disturbed and Undisturbed Soil Samples.

A total of 10 disturbed samples resulting from SPTs were collected for subsequent laboratory testing. Also using the Shelby and sampling tubes, undisturbed samples were collected at pre-identified depth and were subsequently taken for laboratory testing. A summary of test results is given in Tables 1a-b in the Appendices.

3.4 Ground Water Table

Ground water was encountered in both boreholes at a depth of 1.5m below ground level but being in the R. Sezibwa valley flooding is expected and common.

4. LABORATORY TESTING

Laboratory testing was conducted by the Central Materials Laboratory in accordance to BS 1377: 990 "Methods of Test of Soils for Engineering Purposes".

Individual tests were conducted according to the following test procedures;

Natural moisture content	Part 2: 3.2
Sieve analysis	Part 2: 9.2
Liquid Limit	Part 2: 4.3
Plastic Limit	Part 2: 5.3
Plasticity index	Part 2: 5.4
Specific gravity	Part 2: 8.3
Unconfined compression	Part 7: 7.2

5. FIELD AND LABORATORY TEST RESULTS.

5.1 Field Test Results

The soil profile at both test points in general have a thin fill/top of a thick grey clayey silty sand Gravel. The above soil rests on gray red/brown silty clay before grading into a weathered rock. In BH1 a layer of silty clay was identified between 0.3 – 1.5m. The silty clays below 3.5m depth probably a product of weathering of the in-situ rocks. The thickness of the top soil/fill averaged to 0.5m while for the silty sandy Gravel 2.5m.

The consistency of the silty clay material was ranged from stiff to very stiff while for silty sandy gravel the relative density was from dense to medium dense.

The in-situ moisture regime was predominantly found below liquid limits in all tested samples and in for BH1 depth 1.5 – 3.5m where the natural moisture was below the plastic limit. The uncorrected SPT value of 11 was obtained in BH1 for the silty clay while for the silty sandy Gravel 22.

5.2 Laboratory Test Results.

5.2.1 Soil classification

The soil directly below the existing fill are silty clays with intermediate plasticity indices in BH1. Then a rather thick silty sandy gravel in both BH1 and BH2. Then silty clays of intermediate to high plasticity were identified below 3.5m depth.

According to the unified Soil Classification System, the silty clay soils can be classified as either CI or CH while for the clayey silty sandy (GC).

The soils proposed to directly support the loads (clayey silty sandy gravel) have the following average composition.

- Gravel 42%
- Sand 24%
- Silty and Clay 32%

5.2.2 Shear Strength

Unconfined strength test was only possible for the silty clays and the compressive strength qu ranged from 230 kN/m^2 to 500 kN/m^2 . The shear strength Cu thus, vary from 115 kN/m^2 to 250 kN/m^2. The average bulk density was 19kN/m^3.

6. EVALUATION OF THE BEARING CAPACITY

6.1 General

In absence of information regarding the foundation type, size and depth, an accurate bearing capacity evaluation for in-situ soils cannot be made. The evaluation presented here is based on assumptions in order to guide the design engineer.

6.2 Assumptions

The following assumptions have been made;

i) Two alternative foundation types may be used:

- Strip continuos foundation of minimum width of 1.0m and
- Single square footings of 2.0

ii) The foundation depth will not exceed 1.5m

iii) Below 1.5m the soil profile to be affected by the proposed construction is the silty sandy gravel and generally the relevant SPT value are those to a depth of from 1.5m-3.5m. The minimum SPT value in this range was 22.

For N = 22; $\varnothing^{o} = 34^{o}$ from Charts
b = 20.7 kN/m^3

iv) Terzaghi's bearing capacity equations and the theory on which they are based are valid.

v) The most likely failure mechanism is by general shear.

vi) The allowable bearing capacity safety factor is 3.

6.3 Allowable Bearing Capacity

Based on the laboratory test results and assumptions outlined in 6.2, the following allowable bearing values were determined;

FOUNDATION TYPE	BEARING CAPACITY (kNm^2)
A 1.0M wide strip footing at 1.5M depth	375
A single square footing 2.0M wide placed at 1.5M depth.	422

From the above table a load of about 8MN can be supported by 2x2 single square footing at 1.5m depths.

7. CONCLUSIONS

i) The proposed site for construction of the proposed New Power Substation at Kayunga was investigated using two boreholes drilled down to a depth 5.5 meters.

ii) The site generally has top soil/fill on top of thick clayey silty sandy gravels. Top soil/fill averaging 0.5m thick. This will need to be stripped to spoil in the preparation for a founding system.

iii) The top silty clay and the clayey sandy gravel on alluvial products resulting from erosional deposition materials is product within the land system. It was evident from the logs that residual soils from weathering in in-situ rocks start at a depth of about 3.5m.

iv) The in-situ moistures are significantly below liquid limit and the proposed 1.5m deep excavations are expected to be wet due to a high water level. The use of pumping or any dewatering system is not ruled out.

v) The silty clay material was found with a substantial fraction passing Bs sieve 0.063mm (between 54% - 92%). Within the recommended construction depth of 2.0m the predominant material shall be clayey silty sandy gravels with average passing Bs sieve 0.063mm of 32%.

vi) The liquid limit was found to range from 34% to 53% while the minimum plasticity index was 14%. These values are high and the soils are likely to be sticky. However, at the construction depth, considerable volume changes are not expected.

vii) The shear parameters recommended for bearing capacity evaluation Cu = $\varnothing kNm^2$ and $\varnothing=34^0$ for a general shear failure mechanism. This was got from the minimum SPT value of 22.

viii) The bearing capacity was evaluated to be 375 kNm^2 for 1.0m wide strip footing and 422 kNm^2 for 2.0m square footing at a depth of 1.5m, a load up to 8MN shall be supported on a 2m x 2m square footing.

ix) Ground water level was encountered at 1.5m in the investigated depth and is likely to be permanent as water level measurements taken after 25 hours was 0.5m below ground surface. Although the investigations were conducted during the dry season the site is susceptible to seasonal flooding and the foundations engineer must take this into account. If the substation is very sensitive to water, rock fill should be considered. The idea is to raise sensitive parts out of reach of flood levels.

x) The site is free of any geological structural discontinuity like faults and is tectonically stable. No land slides are expected.

xi) The information provided in this report about the site soil conditions is considered adequate for foundation design and analysis.

BIBLIOGRAPHY

i) BRITISH STANDARDS INSTITUTION. British Standards 1377:1975 and British Standard 1377:1990. Methods of test for Soils for Civil Engineering Purposes London, 1990.

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v) JOSEPH E. BOWLES. Foundation Analysis and Design, Second edition, McGraw Hill Kogukusha Ltd. Tokyo, 1977.

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APPENDICES

HYDROTECH CONSULTANTS

LEVELLING BOOKING FORM

Date: 6th October, 98 **Observer:** KENNETH OTIM

Project: RURAL ELECTRIFICATION **Booker:** RICHARD ENEN

Location: KAYUNGA. **Staffman:** HERBERT

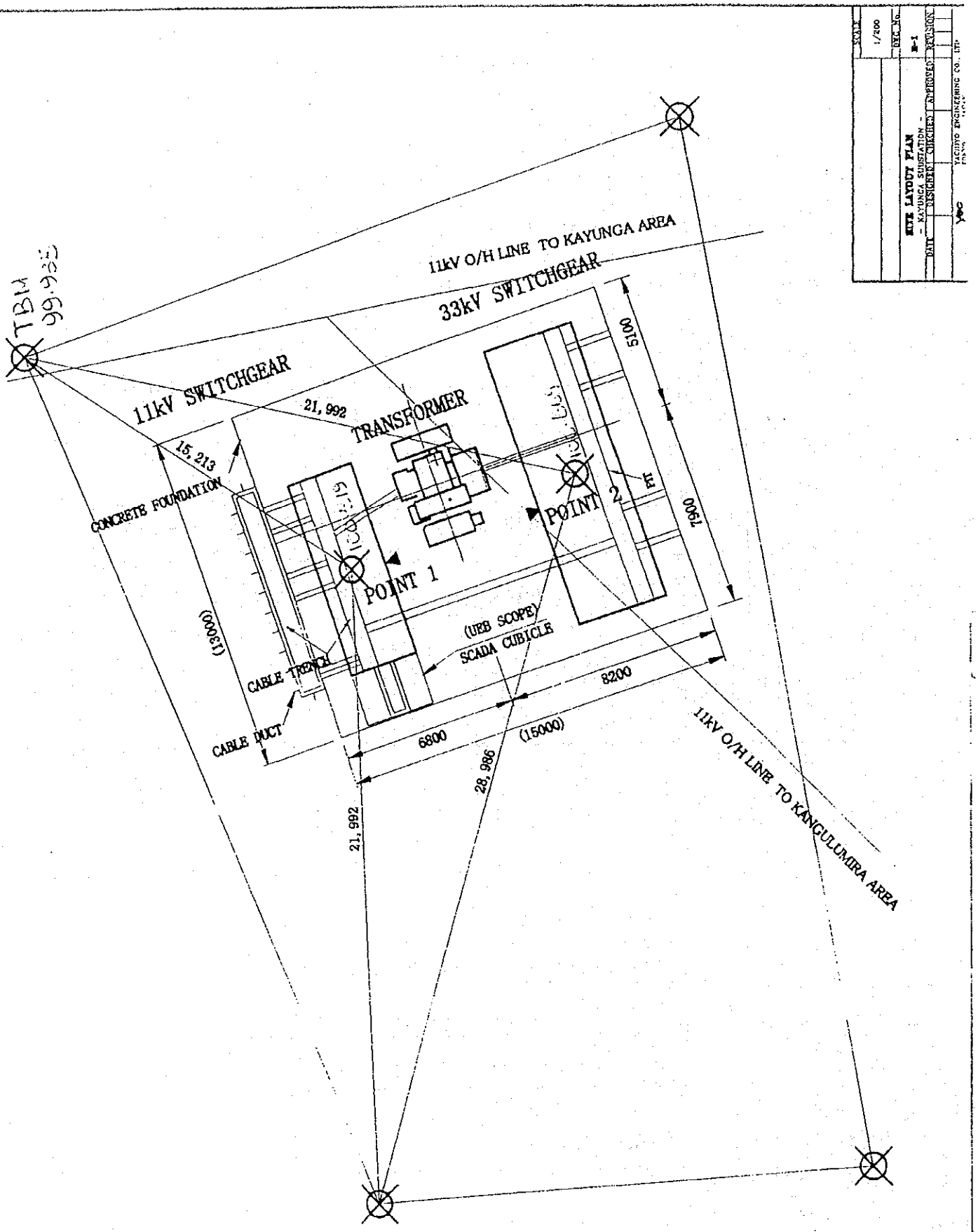
BS	IS	FS	RISE	FALL	REDUCED LEVEL	REMARKS
2.184					99.935	Sta. A. TBM
	1.600		0.584		100.519	Sta. B. Point 1
		1.450	0.150		100.669	Sta. C. Point 2
ΣBS = 2.184		ΣFS = 1.450				

CHECKS: ΣBS - ΣFS = RLL Point – RL TBM

∴ 2.184 - 1.450 = 0.734

and 100.669 - 99.935 = 0.734

CONCLUSION : No field error.


SCALE 1/200
DWG No. E-1
SITE LAYOUT PLAN
- KAYUNGA SUBSTATION -
YACHIYO ENGINEERING CO., LTD.
TBM 99.935
11kV O/H LINE TO KAYUNGA AREA
33kV SWITCHGEAR
11kV SWITCHGEAR
21, 992
TRANSFORMER
15, 213
CONCRETE FOUNDATION
POINT 1
POINT 2
5100
7900
(13000)
(URD SCOPE)
SCADA CUBICLE
CABLE TRENCH
CABLE DUCT
8200
6800
(15000)
28, 986
21, 992
11kV O/H LINE TO KANGULUMIRA AREA

HYDROTECH CONSULTANTS

SOIL FIELD TESTS

Project: Rural Electrification Project

Location: Kayunga

Ground Elevation: 100.519

Borehole No. B/H2

Size of Hole/Pit: 75 mm diameter

Drilling Equipment used: Mobile Drill F700

Date Started: 7.10.1995 Date completed: 7.10.1998

Depth of Water Table: 100.019M after 25 hours

SAMPLE				FIELD TESTS		DESCRI-PTION	GROUP SYMBOL	REMARKS
SAMPLE TUBE NO.	DEPTH	DISTUR BED	UNDIST-URBED	SPT	WATER TABLE	TOP SOIL		
	100.519 100.219							
	100.219 99.519				100.019	GREY BROWN SILTY SAND		
B/H1 1 – 1.45 D3	99.519 99.069	▮	UD	5 6 5(11)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H1 2 – 2.45 D3	98.519 98.069	▮		7 10 12(22)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H1 3-3.45 D3	97.519 97.069	▮		21 15 17(32)		GREY BROWN RED SILTY SAND	GM	DENSE
B/H1 4-4.45 D.3	96.519 96.069	▮		12 14 14(28)		GREY BROWN RED SILTY SAND	GM	VERY STIFF
B/H1 5-5.45 D3	95.519 95.069	▮		7 10 12(22)		WEATH-ERED ROCK	ML	MEDIUM DENSE

HYDROTECH CONSULTANTS

SOIL FIELD TESTS

Project: Rural Electrification Project

Location: Kayunga

Ground Elevation: 100.669

Borehole No. B/H2

Size of Hole/Pit: 75 mm diameter

Drilling Equipment used: Mobile Drill F700

Date Started: 7.10.1995 Date completed: 7.10.1998

Depth of Water Table: 100.169M after 25 hours

SAMPLE				FIELD TESTS		DESCRI-PTION	GROUP SYMBOL	REMARKS
SAMPLE TUBE NO.	DEPTH	DISTUR BED	UNDIST-URBED	SPT	WATER TABLE	TOP SOIL		
	100.669 100.269							
	100.269 99.669				100.169	GREY BROWN SILTY SAND		
B/H2 1 – 1.45 D3	99.669 99.219	▮		5 6 5(11)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H3 2 – 2.45 D3	98.669 98.219	▮		7 10 12(22)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H2 3-3.45 D3	97.669 97.219	▮		21 15 17(32)		GREY BROWN RED SILTY SAND	GM	DENSE
B/H2 4-4.45 D.3	96.669 96.219	▮		12 14 14(28)		GREY BROWN RED SILTY SAND	GM	VERY STIFF
B/H2 5-5.45 D3	95.669 95.219	▮		7 10 12(22)		WEATH-ERED ROCK	ML	MEDIUM DENSE

CENTRAL MATERIALS LABORATORY

PROJECT : PROPOSED NEW POWER SUBSTATION AT KAYUNGA
CLIET : M/S HYDROTECH CONSULTANTS
DATE : 7/10 98

SUMMARY OF SOIL LABORARORY TESTS

DEPTH	FIELD SPT VALUE	N-VALUE	LOG	SOIL DESCRIPTION	N.M	ATTERBERG LIMITS			GRADING% PASSING										G_s	q_u	Remarks
					%	LL %	PL %	PI %	10.0 mm	6.3 mm	5.0 mm	2.0 µm	6.0 µm	0.425 µm	3.0 µm	0.212 µm	0.50 µm	0.63 µm		kPa	
0m00				Top soil (Fill)																	
1.00	3,3,8	11		Dark grey silty clay (stiff)u-100	17.1	43	16	27	100	98	97	94	84	79	72	67	61	54	2.69	230	Groundwater level 1.5m
2.00	34,24,18	42		Grey brown clayey silty sandy Gravel (dense) (D-35)	9.1	38	17	21	90	82	76	56	40	36	34	31	28	25	2.65		
3.00	24,30,18	48		Grey brown clayey silty sandy gravel(dense)(D-35)	10.1	34	20	14	90	79	73	59	44	40	37	35	32	28	2.64		
4.00	7,8,9	17		Grey brown very silty clay (very stiff) u-100)	25.0	46	23	23	96	88	87	81	79	78	77	76	74	69	2.68	350	
5.00	6,10,16	26		Weathered rock (medium dense) (D-35)	38.5	46	24	22		100	98	95	90	88	87	86	83	78	2.69		

BH NO. 1
FINAL DEPTHS AT 5.5m
SUMMARY FORM NO. 1a

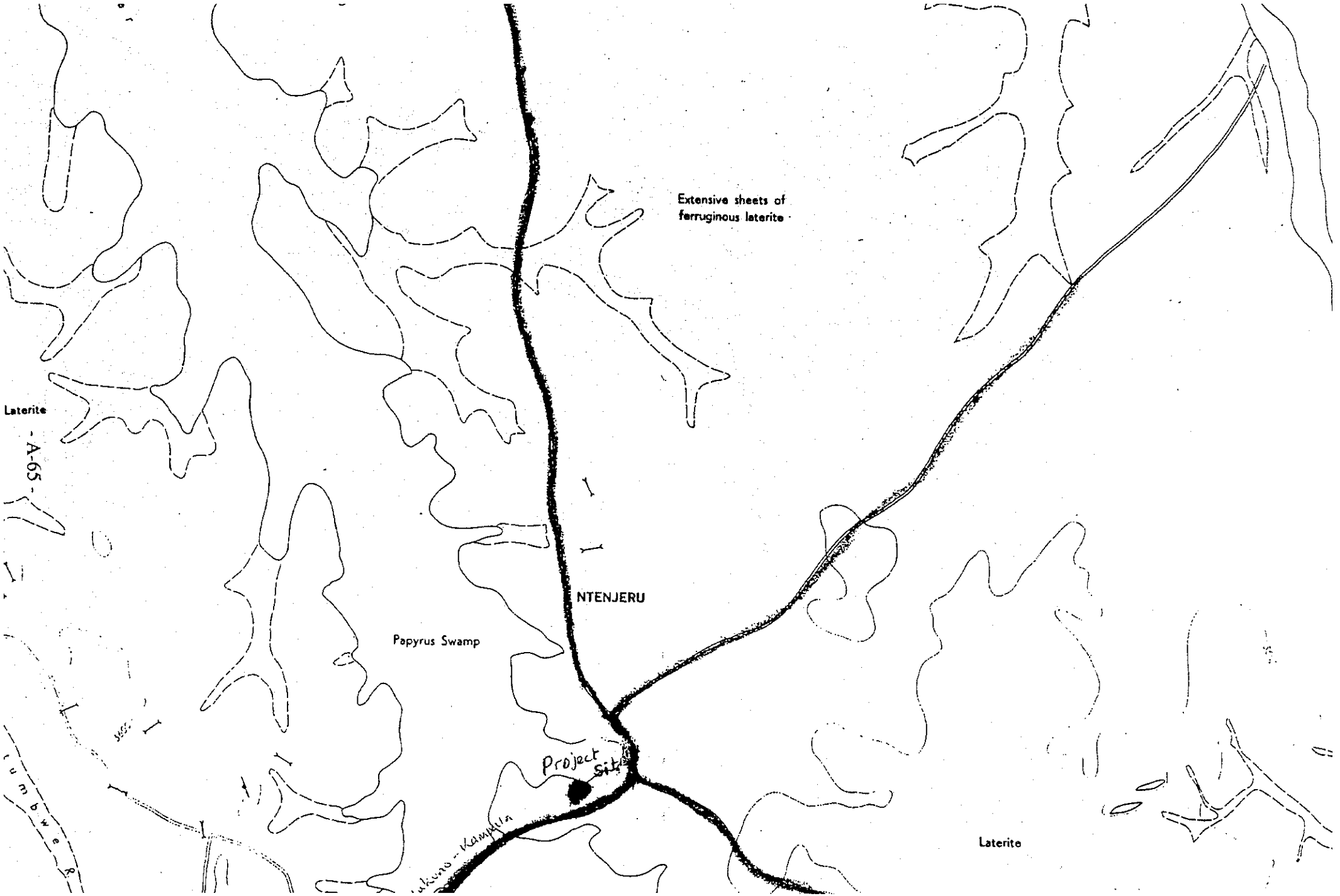
CENTRAL MATERIALS LABORATORY

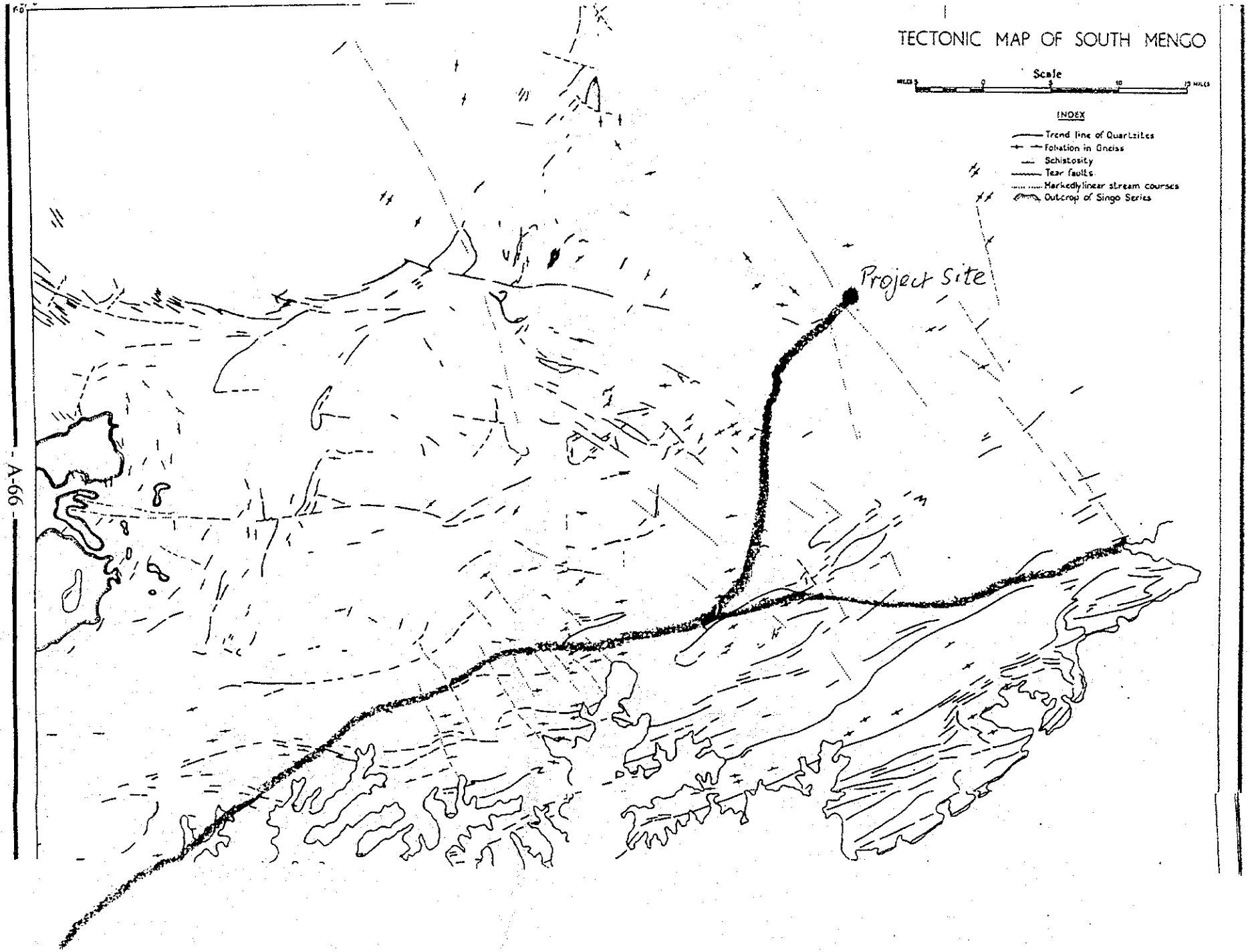
PROJECT : PROPOSED NEW POWER SUBSTATION AT KAYUNGA
CLIET : M/S HYDROTECH CONSULTANTS
DATE : 7/10 98

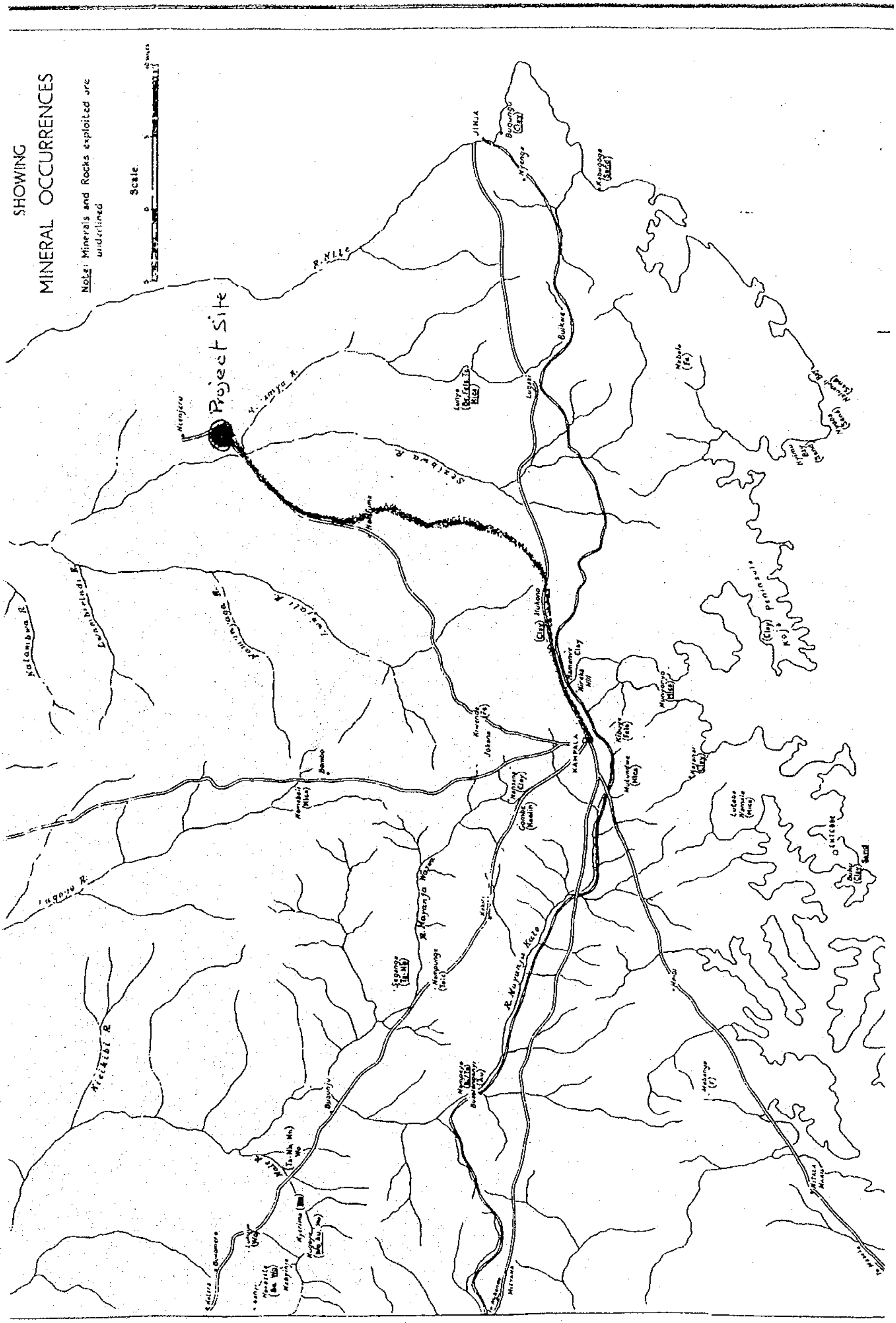
SUMMARY OF SOIL LABORARORY TESTS

DEPTH	FIELD SPT VALUE	N-VALUE	LOG	SOIL DESCRIPTION	N.M	ATTERBERG LIMITS			GRADING% PASSING										G_s	q_u	Remarks
					%	LL %	PL %	PI %	10.0 mm	6.3 mm	5.0 mm	2.0 µm	6.0 µm	0.425 µm	3.0 µm	0.212 µm	0.50 µm	0.63 µm		kPa	
0m00 0.4m				Top Soil (Fill)																	
1.00	5,6,5	11		Grey Brown silty sand (inedium dense)(D-35)	15.1	38	14	24	92	68	62	52	46	45	43	41	39	36	2.65		Groundwater level 1.5m
2.00	7,10,12	22		Grey brown clayey silty sandy Gravel (dense) (D-35)	16.3	44	16	28	81	65	60	50	45	45	44	43	42	38	2.65		
3.00	21,15,17	32		Grey red brown Red clayey silty sandy gravel (dense) (D-35)	16.4	38	16	22	91	86	78	69	58	56	54	53	51	47	2.67		
4.00	12,14,14	28		Grey -red brown very silty clay (verystiff) u-100	25.4	45	23	22		100	99	97	94	94	93	92	91	86	2.70	500	
5.00	7,10,12	22		Weathered rock (very stiff) (D-35)	32.2	53	26	27			100	99	98	98	97	97	95	92	2.72		

BH NO. 2
FINAL DEPTHS AT 5.5m
SUMMARY FORM NO. 1b


Extensive sheets of ferruginous laterite
Laterite
- A-65 -
NTENJERU
Papyrus Swamp
Project Site
Laterite


TECTONIC MAP OF SOUTH MENGO
Scale
INDEX
Trend line of Quartzites
Foliation in Gneiss
Schistosity
Tear faults
Markedly linear stream courses
Outcrop of Singo Series
Project Site



SHOWING
MINERAL OCCURRENCES
Note: Minerals and Rocks exploited are underlined
Scale
Project Site
R. Nile
Sezibwa R.
KAMPALA
JINJA
Kiira Hill
R. Mayanja Kato
R. Mayanja Waror
Lugogo R.
Kalambwa R.
Kitikibi R.
Busunju
Bombo
Mukono
Nalumino
Lunyo
Jokwa
Koja Peninsula

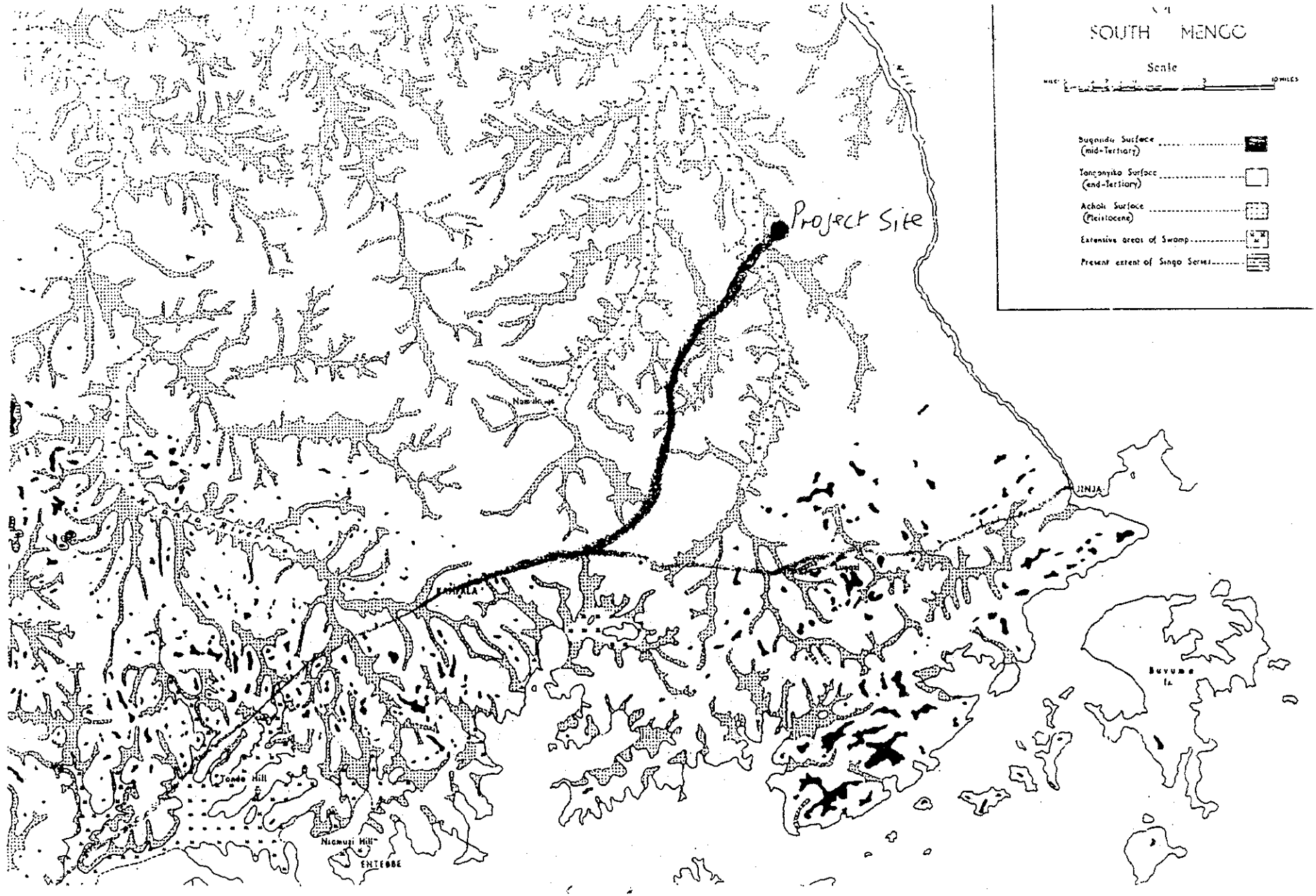

SOUTH MENGO
Scale
Buganda Surface (mid-Tertiary)
Tanganyika Surface (end-Tertiary)
Acholi Surface (Pleistocene)
Extensive areas of Swamp
Present extent of Singo Series
Project Site
JINJA
KAMPALA
Entebbe

Plate 1
Drilling in progress

Plate 2
Determining the GWT level after 25 hours

Plate 3
Laboratory Tests in progress at the Central Materials Laboratory, Kireka

Plate 4
Backfilling the holes