8. 潮流解析の基礎データ

系統データ

(1) 発電機

Location	Unit	Type	Rated				Impedance Rated capacity MVA Base
			(MW)	(kV)	(MVA)	PF (%)	Xd" (p.u.)
Akosombo	Akosombo G1	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G2	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G3	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G4	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G5	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G6	Hydro	170.5	14.4	179.50	95	0.210
Aboadze T1	TAPCo GT1	Gas Turbine	120.4	13.8	141.70	85	0.214
	TAPCo GT2	Gas Turbine	120.4	13.8	141.70	85	0.214
	TAPCo HRSG	Steam Turbine	123.5	13.8	145.30	85	0.220
Aboadze T2	TICo GT1	Gas Turbine	120.4	13.8	141.70	85	0.214
	TICo GT2	Gas Turbine	120.4	13.8	141.70	85	0.214
Aboaze T3	T1-G1	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G2	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G3	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G4	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G5 (HRSG)	Steam Turbine	31.0	13.8	38.75	80	0.217
Kpong	Kpong G1	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G2	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G3	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G4	Hydro	45.9	13.8	51.00	90	0.270
Sunon Asogli	Asogri(1) GT1	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(1) GT2	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(1) HRSG	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) GT1	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) GT2	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) HRSG	Steam Turbine	29.0	11.0	36.29	80	0.148
Tema TT1PP	TT1PP GT1	Gas Turbine	113.4	14.4	141.70	80	0.179
	CENIT GT	Gas Turbine	113.4	14.4	141.70	80	0.179
Tema MRP	MRP GT1	Gas Turbine	47.3	11.5	52.50	90	0.171
	MRP GT2	Gas Turbine	20.0	11.5	22.25	90	0.171
	MRP HRSG	Steam Turbine	15.0	11.5	16.70	90	0.171
TT2PP	TT2PP GT1	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT2	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT3	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT5	Gas Turbine	12.9	11.0	13.10	80	0.244
	TT2PP HRSG	Steam Turbine	12.9	11.0	13.10	80	0.244
Bui	Bui1	Hydro	133.0	13.8	147.80	90	0.270
	Bui2	Hydro	133.0	13.8	147.80	90	0.270
	Bui3	Hydro	133.0	13.8	147.80	90	0.270

(2) 送電線

Location		Line No.	Voltage	Length	Conductor			Impedance(pu)			Thermal rating	
From	To		(kV)	(km)	Type	Code	Size (mm^2)	R	X	Y	(A)	(MVA)
Akosombo	Old Kpong	A1H(1)	161	16.1	AAC	LILAC	403	0.00510	0.02450	0.01220	764	213
		A4V(1)	161	16.1	AAC	LILAC	403	0.00510	0.02450	0.01220	764	213
	Volta	A2V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A3V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A5V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A6V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
	Kpong	Z10A	161	24.6	AAC	LILAC	403	0.00770	0.03810	0.01830	764	213
	Tafo	A7F	161	61.2	AAC	MISTLETOE	282	2.70000	9.70000	2.20000	610	170
		A11F	161	61.2	ACSR	TOUCAN	182 x 2	1.60000	6.80000	3.10000	653 x 2 bundles	182 x 2bundle
	Asiekpe	A9L	161	54.7	AAC	DAFFODIL	177	0.03940	0.08890	0.03870	459	128
	Aflao	A8L	161	124.8	AAC	DAFFODIL	177	0.08837	0.20254	0.08827	459	128
Old Kpong	Volta	A4V(2)	161	51.5	AAC	LILAC	403	0.01620	0.07840	0.03905	764	213
	Achimota	A1H(2)	161	77.2	AAC	LILAC	403	0.02434	0.11751	0.05856	764	213
Achimota	Mallam	H3M	161	12.0	AAC	MISTLETOE	282	0.70000	2.40000	0.60000	610	170
		H4M	161	12.0	AAC	MISTLETOE	282	0.70000	2.40000	0.60000	610	170
Mallam	Cape Coast	C1M	161	119.9	AAC	MISTLETOE	282	0.05336	0.18728	0.08801	610	170
	Winneba	W2M	161	42.9	AAC	MISTLETOE	282	0.02045	0.07182	0.03377	610	170
T3	Winneba	TT1W	161	131.8	AAC	MISTLETOE	282	0.04217	0.16248	0.07654	610	170
	Cape Coast	TT2C	161	57.8	AAC	MISTLETOE	282	0.02356	0.09065	0.04263	610	170

Location		Line No.	Voltage	Length	Conductor			Impedance(pu)			Thermal rating	
From	To		(kV)	(km)	Type	Code	Size (mm^2)	R	X	Y	(A)	(MVA)
Volta	Kpong	Z18V	161	63.2	AAC	HAWTHORN	604	0.01140	0.08430	0.03890	979	273
	New Tema	V9E	161	3.2	AAC	TOUCAN	265 x2	0.00085	0.00358	0.00324	653 x 2bundle	182 x 2bundle
		V10E	161	3.2	AAC	TOUCAN	265 x2	0.00085	0.00358	0.00324	653 x 2bundle	182 x 2bundle
	Smelter Two	V11S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V12S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V13S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V14S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V15S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V16S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
	A3BSP (Accra East)	V7AE	161	15.0	AAC	LILAC	403	0.00470	0.02290	0.01137	764	213
	Achimota	V8H	161	25.7	AAC	LILAC	403	0.00810	0.03980	0.01950	764	213
		V19H	161	25.7	AAC	LILAC	403	0.00810	0.03980	0.01950	764	213
	Aboadze	TT21V	330	219.5	ACSR	TERN	430 x2	0.90000	5.67000	46.35000	500 x 2bundle	875 x 2bundle
A3BSP (Accra East)	Achimota	AE4H	161	10.7	AAC	LILAC	403	0.00340	0.01630	0.00811	764	213
Aboadze Plant	T3	TT6TT	161	0.1	ACSR	uncoded	400 x2	0.00003	0.00015	0.00007	875 x 2bundle	244 x 2bundle
		TT7TT	161	0.1	ACSR	uncoded	400 x2	0.00003	0.00015	0.00007	875 x 2bundle	244 x 2bundle
	Takoradi	TT3T	161	15.0	AAC	MISTLETOE	282	0.00610	0.02350	0.01100	610	170
		TT4T	161	15.0	AAC	MISTLETOE	282	0.00610	0.02350	0.01100	610	170
	Prestea	TT5T	161	83.0	ACSR	TOUCAN	265 x2	0.01953	0.08532	0.07726	653 x 2bundle	182 x 2bundle

(3) 変圧器

Location			Rating			Impedance (%) Rating Power MVA Base	Vector Grope	Load Tap Changer
			Voltage (%)		Power (MVA)			
	From	To	Prim.	Sec.				
Achimota	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.71	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.38	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
Mallam	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.38	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.34	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.06	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.06	YNd11	On-Load
A3BSP	A3BSP 161kV	A3BSP 34.5kV	161	34.5	66	11.51	YNd11	On-Load
	A3BSP 161kV	A3BSP 34.5kV	161	34.5	66	10.19	YNd11	On-Load
Akosombo	Akosombo G1	Akosombo 161kV	14.4	161	200	13.39	YNd1	Off-Load
	Akosombo G2	Akosombo 161kV	14.4	161	200	13.29	YNd1	Off-Load
	Akosombo G3	Akosombo 161kV	14.4	161	180	13.00	YNd1	Off-Load
	Akosombo G4	Akosombo 161kV	14.4	161	200	13.35	YNd1	Off-Load
	Akosombo G5	Akosombo 161kV	14.4	161	200	13.35	YNd1	Off-Load
	Akosombo G6	Akosombo 161kV	14.4	161	180	13.30	YNd1	Off-Load
Aboadze T1	TAPCo GT1	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
	TAPCo GT2	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
	TAPCo HRSG	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
Aboadze T2	TICo GT1	Aboadze 161kV	13.8	161	141	11.45	YNd1	Off-Load
	TICo GT2	Aboadze 161kV	13.8	161	141	11.45	YNd1	Off-Load
Aboadze T3	T1-G12	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
	T1-G34	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
	T1-G5 (HRSG)	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
Kpong G.S.	Kpong G1	Kpong G.S. 161kV	13.8	169	51	10.60	YNd1	Off-Load
	Kpong G2	Kpong G.S. 161kV	13.8	169	51	10.50	YNd1	Off-Load
	Kpong G3	Kpong G.S. 161kV	13.8	169	51	10.40	YNd1	Off-Load
	Kpong G4	Kpong G.S. 161kV	13.8	169	51	10.60	YNd1	Off-Load
Sunon Asogli	G1 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G2 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G3 (HRSG)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G4 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G5 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load

	G6 (HRSG)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
Location			Rating			Impedance (%) Rating Power MVA Base	Vector Grope	Load Tap Changer
			Voltage (%)		Power (MVA)			
	From	To	Prim.	Sec.				
Tema TT1PP	TT1PP GT1	TT1PP 161kV	14.4	161	145	14.85	YNd1	Off-Load
	CENIT GT	TT1PP 161kV	14.4	161	145	14.85	YNd1	Off-Load
Tema MRP	MRP Generator	Tema MRP 161kV	11.5	161	165	13.10	YNd1	Off-Load
Tema TT2PP	TT2PP Generator	Tema TT2PP 161kV	11.0	161	75	9.08	YNd1	Off-Load
Bui	Bui G1	Bui 161kV	14.4	161	160	13.13	YNd1	Off-Load
	Bui G2	Bui 161kV	14.4	161	160	13.00	YNd1	Off-Load
	Bui G3	Bui 161kV	14.4	161	160	13.08	YNd1	Off-Load
Aboadze	Aboaze 330kV	Aboadze 161kV	330	161	200 x2	10.00	YNd11	-
Volta	Volta 330kV	Volta 161kV	330	161	200 x2	10.00	YNd11	-

(4) キャパシタ

Substation	Voltage (kV)	Bank No.	Rating/bank (Mvar)	Total rating (Mvar)
Achimota	34.5	5	21.8	109.0
New Tema	34.5	2	10.8	21.6
Winneba	34.5	2	21.6	43.2
Cape Coast	34.5	2	10.8	21.2
Accra East	34.5	2	21.6	43.2
Mallam	34.5	2	21.6	43.2

(5) 既設および計画中の発電所一覧

発電所	発電機	種類	運開年 ( )は運開予定	定格容量
アコソンボ	Akosombo G1	水力	1965	170.525 MW
	Akosombo G2	水力	1965	170.525 MW
	Akosombo G3	水力	1965	170.525 MW
	Akosombo G4	水力	1965	170.525 MW
	Akosombo G5	水力	1972	170.525 MW
	Akosombo G6	水力	1972	170.525 MW
アボアゼ T1	TAPCo GT1	ガスタービン	1998	120.4 MW
	TAPCo GT2	ガスタービン	1998	120.4 MW
	TAPCo HRSG	蒸気タービン	1998	123.5 MW
アボアゼ T2	TICo GT1	ガスタービン	2001	120.4 MW
	TICo GT2	ガスタービン	2001	120.4 MW
	TICo HRSG	蒸気タービン	(2015)	123.5 MW
アボアゼ T3	T1-G1	ガスタービン	2013	31 MW
	T1-G2	ガスタービン	2013	31 MW
	T1-G3	ガスタービン	2013	31 MW
	T1-G4	ガスタービン	2013	31 MW
	T1-G5 (HRSG)	蒸気タービン	2013	31 MW
アボアゼ T3 拡張	T2-G	ガスタービン	(2015)	120 MW
	T2-HRSG	蒸気タービン	(2015)	60 MW
アボアゼ T4	T4-G1	ガスタービン	(2018)	133.3 MW
	T4-G2	ガスタービン	(2018)	133.3 MW
	T4-HRSG	蒸気タービン	(2018)	133.3 MW
クポン	Kpong G1	水力	1982	45.9 MW
	Kpong G2	水力	1982	45.9 MW
	Kpong G3	水力	1982	45.9 MW
	Kpong G4	水力	1982	45.9 MW
ポネ	Kpone GT1	ガスタービン	(2014)	120.5 MW
	Kpone GT2	ガスタービン	(2014)	120.5 MW
	Kpone HRSG	蒸気タービン	(2016)	123.5 MW
アソグリ	Asogri(1) GT1	ガスタービン	2010	29.0 MW
	Asogri(1) GT2	ガスタービン	2010	29.0 MW
	Asogri(1) HRSG	蒸気タービン	2010	29.0 MW
	Asogri(2) GT1	ガスタービン	2010	29.0 MW
	Asogri(2) GT2	ガスタービン	2010	29.0 MW
	Asogri(2) HRSG	蒸気タービン	2010	29.0 MW
	Asogri(3) GT1	ガスタービン	(2016)	60 MW
	Asogri(3) GT2	ガスタービン	(2016)	60 MW
	Asogri(3) HRSG	蒸気タービン	(2016)	60 MW
	Asogri(4) GT1	ガスタービン	(2016)	60 MW
	Asogri(4) GT2	ガスタービン	(2016)	60 MW
	Asogri(4) HRSG	蒸気タービン	(2016)	60 MW
テマ TT1PP	TT1PP GT1	ガスタービン	2009	113.4 MW
	CENIT GT	ガスタービン	2012	113.4 MW
	TT1PP HRSG	蒸気タービン	(2017)	113.4 MW
テマ MRP	MRP GT1	ガスタービン	2007	47.3 MW
	MRP GT2	ガスタービン	2007	20 MW
	MRP HRSG	蒸気タービン	2007	15 MW
テマ TT2PP	TT2PP GT1	ガスタービン	2010	7.8 MW
	TT2PP GT2	ガスタービン	2010	7.8 MW
	TT2PP GT3	ガスタービン	2010	7.8 MW
	TT2PP GT5	ガスタービン	2010	13.1 MW
	TT2PP HRSG	蒸気タービン	2010	13.1 MW
ボニョレ 1	GT1	ガスタービン	(2016)	150 MW
	GT2	ガスタービン	(2016)	150 MW
	HRSG	蒸気タービン	(2016)	150 MW
ボニョレ 2	GT1	ガスタービン	(2017)	150 MW
	GT2	ガスタービン	(2017)	150 MW
	HRSG	蒸気タービン	(2017)	150 MW
ブイ	Bui1	水力	2013	133 MW
	Bui2	水力	2013	133 MW
	Bui3	水力	2013	133 MW
ワルグ	Pwalugu 1	水力	(2026)	24 MW
	Pwalugu 2	水力	(2026)	24 MW
ヘマン	Heman 1	水力	(2020)	46.5 MW
	Heman 2	水力	(2020)	46.5 MW
ジュアル	Juale 1	水力	(2020)	41.5 MW
	Juale 2	水力	(2020)	41.5 MW

(6) 33kV 準送電線

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
E (Graphic Road)	H (Achimota)	existing	33	11.2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	AD (Adabraka)	existing	33	2.4	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	G (Makola)	existing	33	2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	2	2x(3x 240 CU PILC)	Cable	0.0983 2 bundles	0.1100 2 bundles	397 2 bundles
	F (Kokomlemle)	2017	33	2.9	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	2.9	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	D (Avenor)	existing	33	2.6	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	2.6	AAC 265	Overhead	0.1128	0.3254	810
	AW (Awudome)	2017	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2017	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	B (Korle-Bu)	existing	33	7	3x(1x 240 CU XLPE)	Cable	0.0928	0.1100	480
		existing	33	7	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	R (Ridge)	2017	33	9.5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2017	33	9.5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
K (Switchback Road)	R (Ridge)	existing	33	3.2	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
		2016	33	3.2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	X (Osu)	existing	33	2.7	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	L (Burma Camp)	existing	33	3.1	2x(3x 240 CU PILC)	Cable	0.0983 2 bundles	0.1100 2 bundles	397 2 bundles
		2016	33	3.1	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		2016	33	3.1	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	AU (Cantonments)	existing	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
AU (Cantonments)	L (Burma Camp)	existing	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
M (Legon)	Ogbodzo	2016	33	3.8	AAC 265	Overhead	0.1128	0.3254	810
		2016	33	3.8	AAC 265	Overhead	0.1128	0.3254	810

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
ND (Nami Djorn)	T (Adenta)	2016	33	18	AAC 400	Overhead	0.0789	0.315	1066
		2016	33	18	AAC 400	Overhead	0.0789	0.315	1066
	Ogbodzo	2016	33	5.4	AAC 400	Overhead	0.0789	0.315	1066
		2016	33	5.4	AAC 400	Overhead	0.0789	0.315	1066
A3BSP (Accra East)	Ogbodzo	2016	33	5.3	AAC 400	Overhead	0.0789	0.315	1066
		2016	33	5.3	AAC 400	Overhead	0.0789	0.315	1066
	Shiashi	2014	33	8.8	AAC 400	Overhead	0.0789	0.315	1066
		2014	33	8.8	AAC 400	Overhead	0.0789	0.315	1066
	Y (Batsonaa)	2014	33	3	AAC 400	Overhead	0.0789	0.315	1066
		2014	33	3	AAC 400	Overhead	0.0789	0.315	1066
	Adjei Kojo	existing	33	6.7	AAC 400	Overhead	0.0789	0.315	1066
		existing	33	6.7	AAC 400	Overhead	0.0789	0.315	1066
H (Achimota)	Kotobabi	2016	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2016	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	Kisseman	existing	33	5	AAC 400	Overhead	0.0789	0.315	1066
		existing	33	5	AAC 400	Overhead	0.0789	0.315	1066
	M (Legon)	existing	33	7.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	7.5	AAC 265	Overhead	0.1128	0.3254	810
	T (Adenta)	existing	33	8.3	AAC 265	Overhead	0.1128	0.3254	810
		2014	33	8.3	AAC 265	Overhead	0.1128	0.3254	810
	AC (Airport City)	existing	33	4.2 3	AAC 265 3x(1x 500 CU XLPE)	Overhead Cable	0.1128 0.0236	0.3254 0.0772	810 831
	L (Burma Camp)	existing	33	8.5	3x(1x 500 CU XLPE)	Cable	0.0236	0.04715	831
		existing	33	4.2 1.5	AAC 265 3x(1x 500 CU XLPE)	Overhead Cable	0.1128 0.0236	0.3254 0.0772	810 831
	K (Switchback Road)	existing	33	4.7	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles

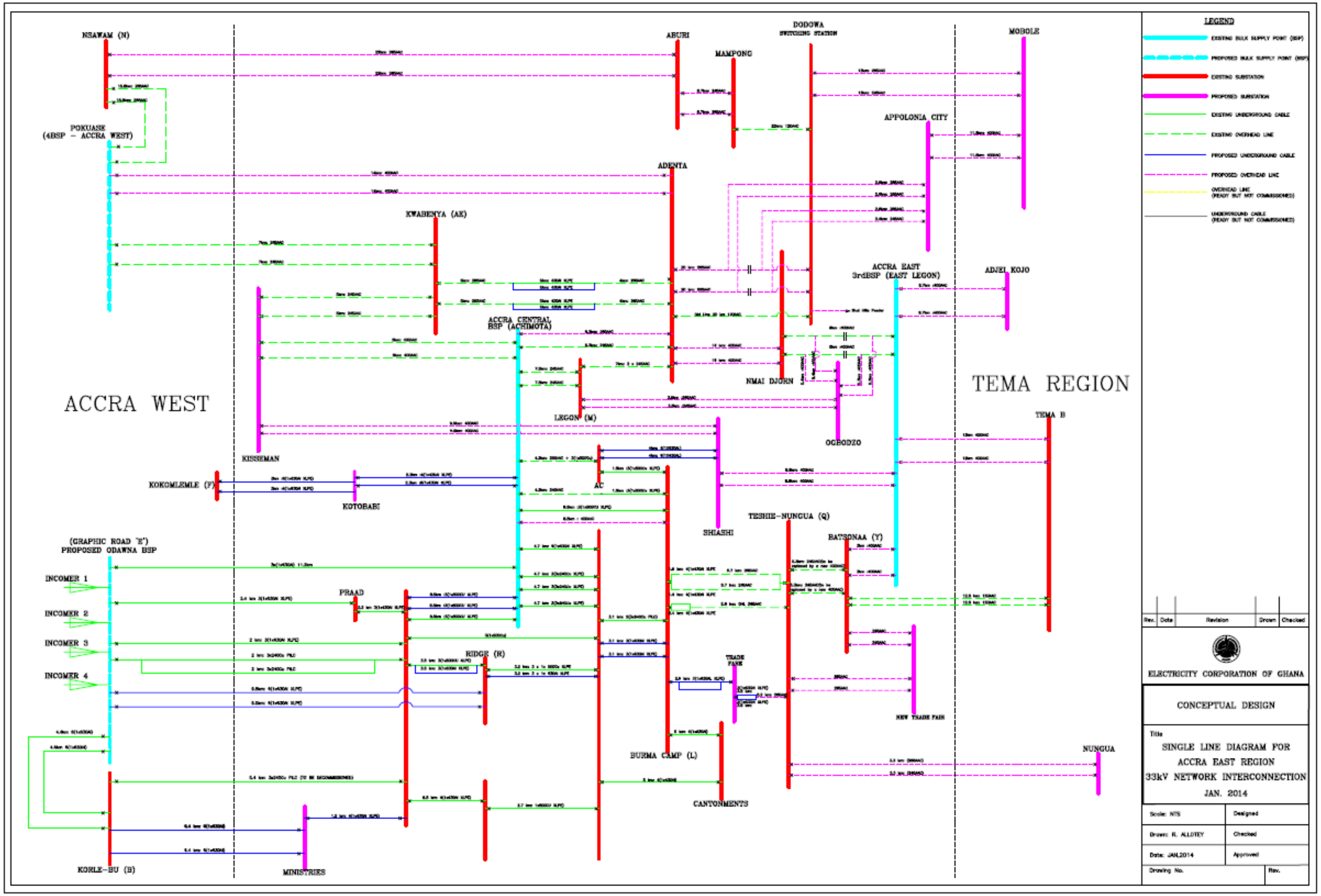
Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
H (Achimota)	K (Switchback Road)	existing	33	4.7	3x(1x 240 CU XLPE)	Cable	0.0983	0.1230	440
		existing	33	4.7	3x(1x 240 CU XLPE)	Cable	0.0983	0.1230	440
		existing	33	4.7	3x(1x 240 CU XLPE)	Cable	0.0983	0.1230	440
	C (Achimota Village)	existing	33	3.9	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	3.9	AAC 265 x 2	Overhead	0.1128 2 bundles	0.3254 2 bundles	810 2 bundles
		existing	33	8.5	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
AC (Airport City)	L (Burma Camp)	existing	33	1.5	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	Shiashi	2014	33	4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2014	33	4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
L (Burma Camp)	Q (Teshie-Nungua)	existing	33	1.6 5.7	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
		existing	33	1.6 5.7	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
		existing	33	2.4 5.8	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
	Trade Fare	existing	33	2.9	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
Q (Teshie-Nungua)	Trade Fare	existing	33	3.8 5.2	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
	New Trade Fair	existing	33	5.3	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	5.3	ACC 265	Overhead	0.1128	0.3254	810
Kisseman	AE (Kwabenya)	existing	33	5	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	5	ACC 265	Overhead	0.1128	0.3254	810
	Shiashi	2014	33	9.9	AAC 400	Overhead	0.2743	0.3568	455
		2014	33	9.9	AAC 400	Overhead	0.2743	0.3568	455
T (Adenta)	M (Legon)	existing	33	7	ACC 265	Overhead	0.1128	0.3254	810
	U (Dodowa)	existing	33	20	AAC 120	Overhead	0.2743	0.3568	455
		2014	33	20	ACC 265	Overhead	0.1128	0.3254	810

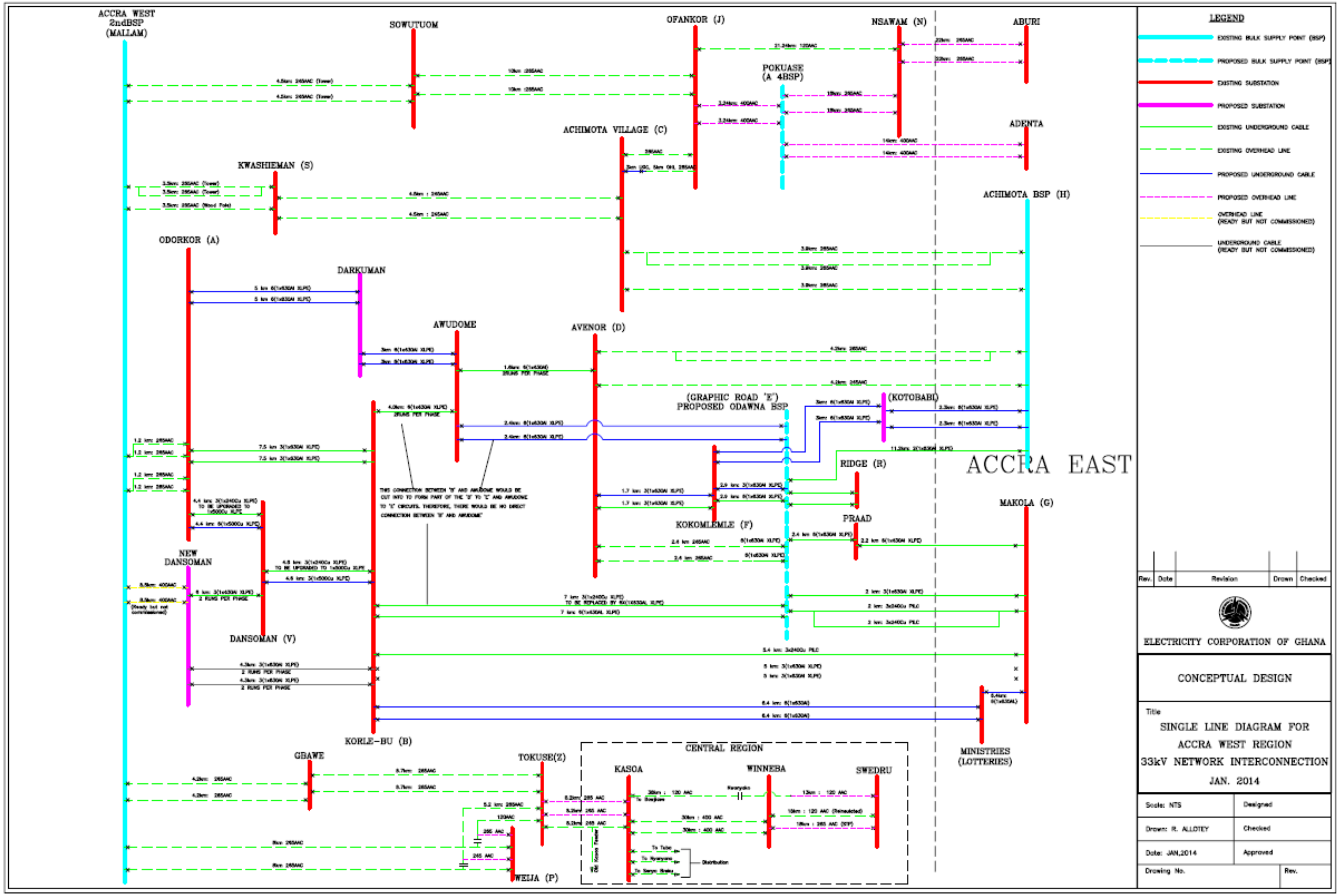
Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
		2014	33	20	ACC 265	Overhead	0.1128	0.3254	810
U (Dodowa)	W (Mampong)	existing	33	22	AAC 120	Overhead	0.2743	0.3568	455
W (Mampong)	Aburi	2014	33	8.7	ACC 265	Overhead	0.1128	0.3254	810
		2014	33	8.7	ACC 265	Overhead	0.1128	0.3254	810
Aburi	N (Nsawam)	2014	33	22	ACC 265	Overhead	0.1128	0.3254	810
		2014	33	22	ACC 265	Overhead	0.1128	0.3254	810
N (Naswam)	J (Ofankor)	existing	33	21.2	AAC 400	Overhead	0.2743	0.3568	455
J (Ofankor)	SW (Sowutuom)	existing	33	10	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	10	ACC 265	Overhead	0.1128	0.3254	810
	C (Achimota Village)	existing	33	8	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	8	ACC 265	Overhead	0.1128	0.3254	810
A4BSP (Pokuase)	T (Adenta)	2020	33	14	AAC 400	Overhead	0.0789	0.315	1066
		2020	33	14	AAC 400	Overhead	0.0789	0.315	1066
	N (Nsawam)	existing	33	18	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	18	ACC 265	Overhead	0.1128	0.3254	810
	J (Ofankor)	existing	33	3.2	AAC 400	Overhead	0.0789	0.315	1066
		existing	33	3.2	AAC 400	Overhead	0.0789	0.315	1066
	AE (Kwabenya)	existing	33	7	ACC 265	Overhead	0.1128	0.3254	810
	AE (Kwabenya)	existing	33	7	ACC 265	Overhead	0.1128	0.3254	810
G (Makola)	AD (Adabraka)	existing	33	2.2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	R (Ridge)	existing	33	3.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		2016	33	3.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	K (Switchback Road)	existing	33	7.0	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	X (Osu)	existing	33	8.5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	Ministries	2014	33	1.2	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
Ministries	B (Korle-Bu)	2014	33	6.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
Ministries	B (Korle-Bu)	2014	33	6.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	X (Osu)	2014	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
B (Korle-Bu)	AW (Awudome)	existing	33	4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	A (Odorkor)	existing	33	7.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	7.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	V (Dansoman)	2014	33	4.6	3x(1x 630 AL XLPE) x2	Cable	0.0236	0.0472	831
		2014	33	4.6	3x(1x 630 AL XLPE) x2	Cable	0.0236	0.0472	831
	New Dansoman	existing	33	4.3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		existing	33	4.3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
V (Dansoman)	A (Odorkor)	2016	33	4.4	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
		2016	33	4.4	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	New Dansoman	existing	33	6	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
D (Avenor)	H (Achimota)	existing	33	4.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.2	AAC 265 x 2	Overhead	0.1128 2 bundles	0.3254 2 bundles	810 2 bundles
	F (Kokomlemle)	2017	33	1.7	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	1.7	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	AW (Awudome)	existing	33	1.6	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
Darkuman	AW (Awudome)	2014	33	3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2014	33	3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	A (Odorkor)	2014	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2014	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
C (Achimota Village)	S (Kwashieman)	existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810
	SW (Sowutuom)	existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
Mallam		existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810
Mallam	S (Kwashieman)	existing	33	3.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	3.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	3.5	AAC 265	Overhead	0.1128	0.3254	810
	A (Odorkor)	existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
	New Dansoman	2014	33	8.5	AAC 400	Overhead	0.0789	0.315	1066
		2014	33	8.5	AAC 400	Overhead	0.0789	0.315	1066
	Gbawe	existing	33	4.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.2	AAC 265	Overhead	0.1128	0.3254	810
	p (Weija)	existing	33	8	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	8	AAC 265	Overhead	0.1128	0.3254	810
p (Weija)	Z (Tokuse)	2015	33	5.2	AAC 265	Overhead	0.1128	0.3254	810
		2015	33	5.2	AAC 265	Overhead	0.1128	0.3254	810
AE (Kwabenya)	T (Adenta)	existing	33	9 5	AAC 265 3x(1x 630 AL XLPE)	Overhead Cable	0.1128 0.03712	0.3254 0.044	810 755
		existing	33	9 5	AAC 265 3x(1x 630 AL XLPE)	Overhead Cable	0.1128 0.03712	0.3254 0.044	810 755

(7) 33 kV 配電ネットワーク




ACCRA WEST 2ndBSP (MALLAM)
SOWUTUOM
OFANKOR (J)
NSAWAM (N)
ABURI
POKUASE (A 4BSP)
ADENTA
ACHIMOTA VILLAGE (C)
KWASHIEMAN (S)
ACHIMOTA BSP (H)
ODORKOR (A)
DARKUMAN
AWUDOME
AVENOR (D)
(GRAPHIC ROAD 'E') PROPOSED ODAWNA BSP
(KOTOBABI)
RIDGE (R)
ACCRA EAST
MAKOLA (G)
KOKOMLEMLE (F)
PRAAD
NEW DANSOMAN
DANSOMAN (V)
KORLE-BU (B)
MINISTRIES (LOTTERIES)
GBAWE
TOKUSE(Z)
CENTRAL REGION
KASOA
WINNEBA
SWEDRU
WEIJA (P)
LEGEND
EXISTING BULK SUPPLY POINT (BSP)
PROPOSED BULK SUPPLY POINT (BSP)
EXISTING SUBSTATION
PROPOSED SUBSTATION
EXISTING UNDERGROUND CABLE
EXISTING OVERHEAD LINE
PROPOSED UNDERGROUND CABLE
PROPOSED OVERHEAD LINE
OVERHEAD LINE (READY BUT NOT COMMISSIONED)
UNDERGROUND CABLE (READY BUT NOT COMMISSIONED)
Rev. Date Revision Drawn Checked
ELECTRICITY CORPORATION OF GHANA
CONCEPTUAL DESIGN
Title
SINGLE LINE DIAGRAM FOR ACCRA WEST REGION 33kV NETWORK INTERCONNECTION
JAN. 2014
Scale: NTS
Designed
Drawn: R. ALLOTEY
Checked
Date: JAN,2014
Approved
Drawing No.
Rev.

需要データ

(1) 2013 年~2020 年（本計画なし）

Supply BSP	Code Name	Location	Voltage	Status		Capacity	Number	Total	Power Factor	Forecast of Demand															
										2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
			kV			MVA	Units	MVA		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Achimota BSP		Capacity	MVA						0.87	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
		Demand	MW						0.87	288	245	259	274	291	309	328	348	197	209	222	236	250	266	282	299
		Demand	MVA					660	0.87	331	281	297	315	335	355	377	400	227	241	255	271	288	305	324	344
	C	Achimota Village	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	B	Korle Bu	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	D	Avenor	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	E	Graphic Road	33/11	Existing		20	3	60	0.87	26.15	22.25	23.51	24.94	26.47	28.10	29.82	31.66								
	F	Kokomlemle	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	G	Power House	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	H	Achimota	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	K	Switchback	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	R	Ridge	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	X	Osu	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	AC	Airport City	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	AD	Archives	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	AW	Awudome	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
		Ministries	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
		Apenkwa	33/11	Proposed	2016	20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
		Kotobabi	33/11	Proposed	2016	20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
Mallam BSP		Capacity	MVA						0.87	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	230	196	207	219	233	247	262	279	158	167	178	189	200	213	226	240
		Demand	MVA					530	0.87	264	225	238	252	268	284	302	320	181	192	204	217	230	244	259	275
	A	Odorkor	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	J	Ofankor	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	N	Nsawam	33/11	Existing		20	1	20	0.87	8.68	7.39	7.81	8.28	8.79	9.33	9.90	10.51								
	P	Weija	33/11	Existing		5	2	10	0.87	4.34	3.69	3.90	4.14	4.40	4.67	4.95	5.26								
	S	Kwashieman	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	V	Dansoman	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	W	Mampong	33/11	Existing		20	2	40.0	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	Z	Tokuse	33/11	Existing		10	2	20	0.87	8.68	7.39	7.81	8.28	8.79	9.33	9.90	10.51								
	AE	Kwabenya	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Sowutuom	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Darkuman	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Mataheko	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Gbawe Janman	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		New Dansoma	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Aburi	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
A3 BSP		Capacity	MVA						0.87	132	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	115	196	207	219	233	247	262	279	158	167	178	189	200	213	226	240
		Demand	MVA					560	0.87	132	225	238	252	268	284	302	320	181	192	204	217	230	244	259	275
	L	Burma Camp	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	M	Legon	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	Q	Teshie Nunqua	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	T	Adenta	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	Y	Baatsonaa	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	AU	Cantonments	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Nungua	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	ND	Ngmai Jorn	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Trade Fare	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Adjei Kojo	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Kabekuro	33/11	Proposed	2016	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Kisseman	33/11	Proposed	2016	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Shiashi	33/11	Committed	2014	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Ogbodzo	33/11	Proposed	2016	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								

(2) 2017 年~2019 年（本計画あり）

Supply BSP	Code Name	Location	Voltage	Status		Capacity	Number	Total	Power Factor	Forecast of Demand															
										2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
			kV			MVA	Units	MVA		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Achimota BSP		Capacity	MVA						0.87	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
		Demand	MW						0.87	288	245	259	274	203	215	228	186	197	209	222	236	250	266	282	299
		Demand	MVA					440	0.87	331	281	297	315	233	247	262	214	227	241	255	271	288	305	324	344
	C	Achimota Village	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	H	Achimota	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	K	Switchback	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	M	Legon	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	S	Kwashieman	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	AC	Airport City	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
		Shiashi	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Darkuman	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Kotobabi	33/11	Proposed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Apenkwa	33/11	Proposed	2016	20	2	40	0.87					18.42	19.55	20.75									
		Kisseman	33/11	Proposed	2016	20	2	40	0.87					18.42	19.55	20.75									
Mallam BSP		Capacity	MVA						0.87	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	230	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					370	0.87	264	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	A	Odorkor	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	J	Ofankor	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	N	Nsawam	33/11	Existing		20	1	20	0.87					8.76	9.30	9.87									
	P	Weija	33/11	Existing		5	2	10	0.87					4.38	4.65	4.94									
	V	Dansoman	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	W	Mampong	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	Z	Tokuse	33/11	Existing		10	2	20	0.87					8.76	9.30	9.87									
	AE	Kwabenya	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
		Sowutuom	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
		Gbawe Janman	33/11	Committed	2014	20	2	40	0.87					17.53	18.60	19.74									
		Aburi	33/11	Committed	2014	20	2	40	0.87					17.53	18.60	19.74									
Accra Central BSP		Capacity	MVA						0.87					375	375	375	375	375	375	375	375	375	375	375	375
		Demand	MW						0.87					230	244	259	211	224	238	253	268	284	302	321	340
		Demand	MVA					500	0.87					265	281	298	243	258	273	290	308	327	347	368	391
	B	Korle Bu	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	D	Avenor	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	E	Graphic Road	33/11	Existing		20	3	60	0.87					27.63	29.33	31.13									
	F	Kokomlemle	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	G	Power House	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	R	Ridge	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	X	Osu	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	AD	Archives	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	AW	Awudome	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
		Ministries	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
		New Dansoma	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Mataheko	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
A3 BSP		Capacity	MVA						0.87	132	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	115	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					440	0.87	132	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	L	Burma Camp	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	Q	Teshie Nunqua	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	T	Adenta	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	Y	Baatsonaa	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	AU	Cantonments	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Nungua	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	ND	Ngmai Jorn	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Trade Fare	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Adjei Kojo	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Kabekuro	33/11	Proposed	2016	20	2	40	0.87					14.74	15.64	16.60									
		Ogbodzo	33/11	Proposed	2016	20	2	40	0.87					14.74	15.64	16.60									

(3) 2020 年~2028 年（本計画あり）

Supply BSP	Name	Location	Voltage	Status		Capacity	Number	Total	Power Factor		Forecast of Demand														
										2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
			kV			MVA	Units	MVA		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Achimota BSP		Capacity	MVA						0.87	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
		Demand	MW						0.87	288	245	259	274	203	215	228	186	197	209	222	236	250	266	282	299
		Demand	MVA					360	0.87	331	281	297	315	233	247	262	214	227	241	255	271	288	305	324	344
	C	Achimota Village	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	H	Achimota	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	K	Switchback	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	S	Kwashieman	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	AC	Airport City	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Darkuman	33/11	Committed	2014	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Kotobabi	33/11	Proposed	2016	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Kisseman	33/11	Proposed	2016	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Apenkwa	33/11	Proposed	2016	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
A4 BSP		Capacity	MVA						0.87								375	375	375	375	375	375	375	375	375
		Demand	MW						0.87								211	224	238	253	268	284	302	321	340
		Demand	MVA					420	0.87								243	258	273	290	308	327	347	368	391
	J	Ofankor	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	M	Legon	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	N	Nsawam	33/11	Existing		20	1	20	0.87								10.05	10.67	11.33	12.02	12.76	13.55	14.38	15.26	16.20
	W	Mampong	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	T	Adenta	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	AE	Kwabenya	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	ND	Ngmai Jorn	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Adjei Kojo	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Kabekuro	33/11	Proposed	2016	20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Ogbodzo	33/11	Proposed	2016	20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Aburi	33/11	Committed	2014	20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
Mallam BSP		Capacity	MVA						0.87	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	230	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					270	0.87	264	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	A	Odorkor	33/11	Existing		20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
	P	Weija	33/11	Existing		5	2	10	0.87								5.51	5.84	6.20	6.58	6.99	7.42	7.87	8.36	8.87
	V	Dansoman	33/11	Existing		20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
	Z	Tokuse	33/11	Existing		10	2	20	0.87								11.01	11.69	12.41	13.17	13.98	14.84	15.75	16.71	17.74
		Sowutuom	33/11	Existing		20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
		Gbawe Janman	33/11	Committed	2014	20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
		New Dansoma	33/11	Committed	2014	20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
		Mataheko	33/11	Committed	2014	20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
Accra Central BSP		Capacity	MVA						0.87						375	375	375	375	375	375	375	375	375	375	375
		Demand	MW						0.87						244	259	211	224	238	253	268	284	302	321	340
		Demand	MVA					420	0.87						281	298	243	258	273	290	308	327	347	368	391
	B	Korle Bu	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	D	Avenor	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	E	Graphic Road	33/11	Existing		20	3	60	0.87								30.16	32.02	33.98	36.07	38.29	40.64	43.14	45.79	48.61
	F	Kokomlemle	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	G	Power House	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	R	Ridge	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	X	Osu	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	AD	Archives	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	AW	Awudome	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Ministries	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
A3 BSP		Capacity	MVA						0.87	132	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	115	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					280	0.87	132	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	L	Burma Camp	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
	Q	Teshie Nunqua	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
	Y	Baatsonaa	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
	AU	Cantonments	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
		Nungua	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
		Trade Fare	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
		Shiashi	33/11	Committed	2014	20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22

潮流解析結果図

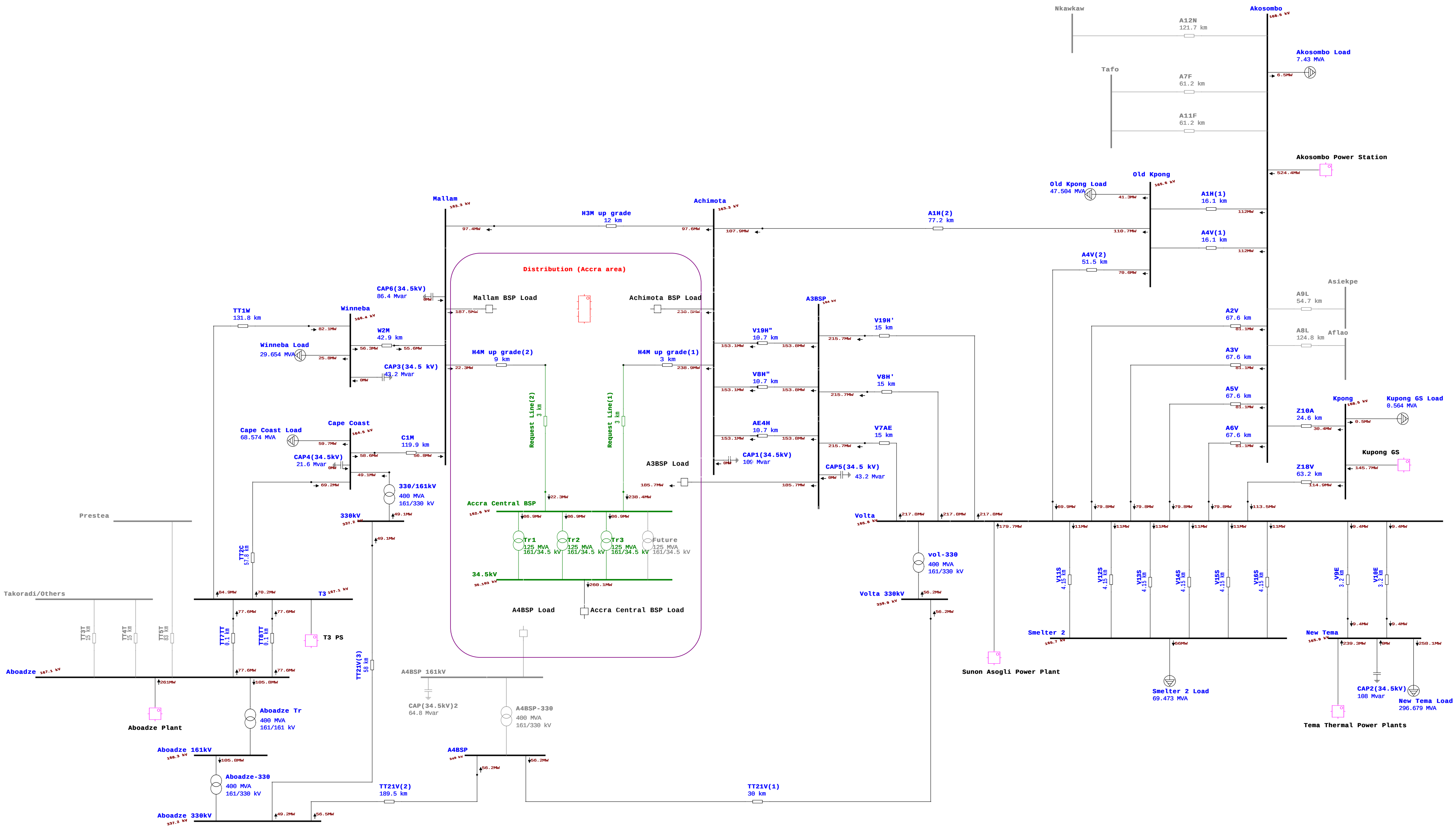


図５　ケース５（2019 年、本計画あり、A4 境界変電所なし、送電線増強なし）

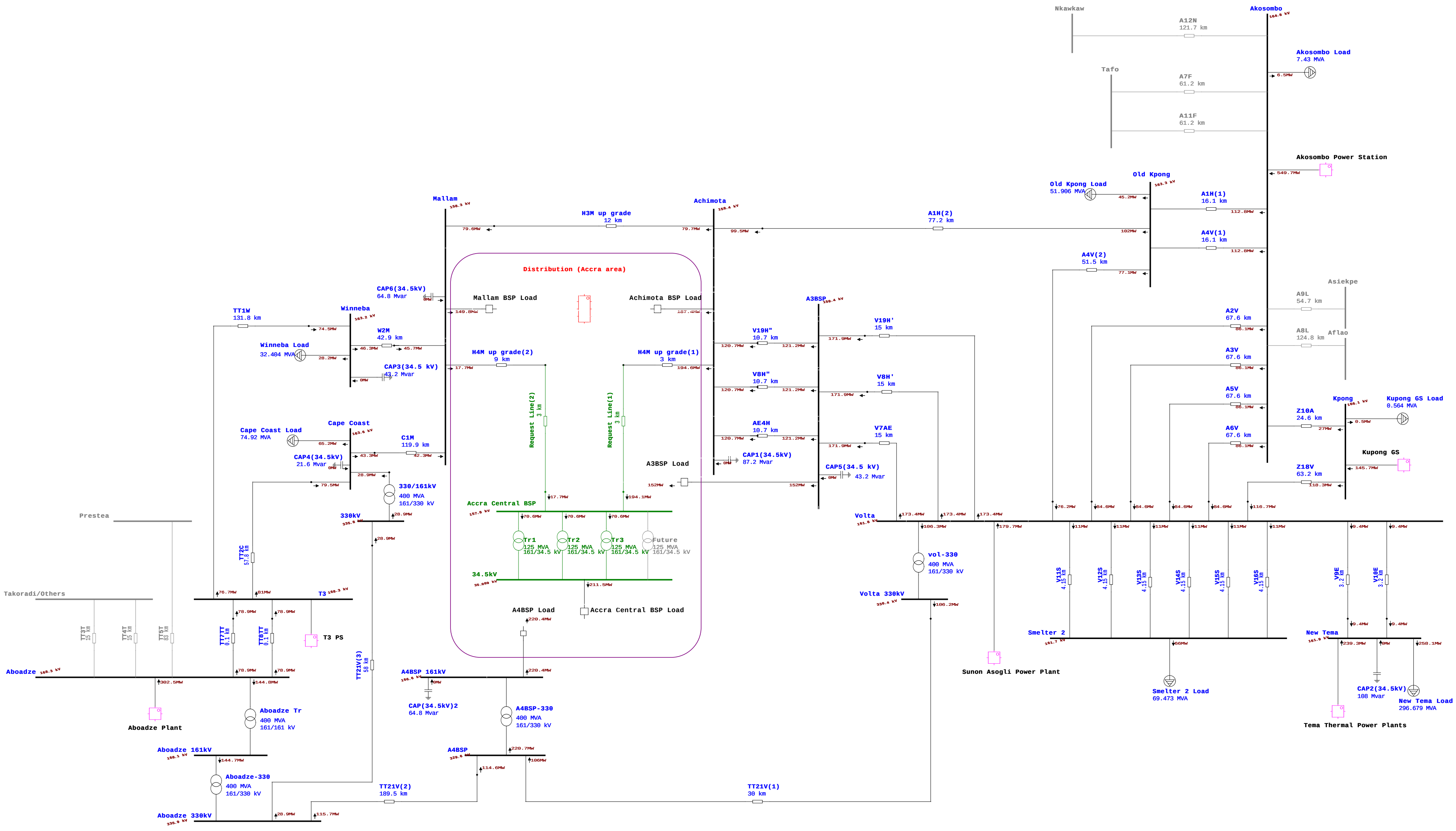


図６　ケース６（2020 年、本計画あり、A4 境界変電所あり、送電線増強なし）

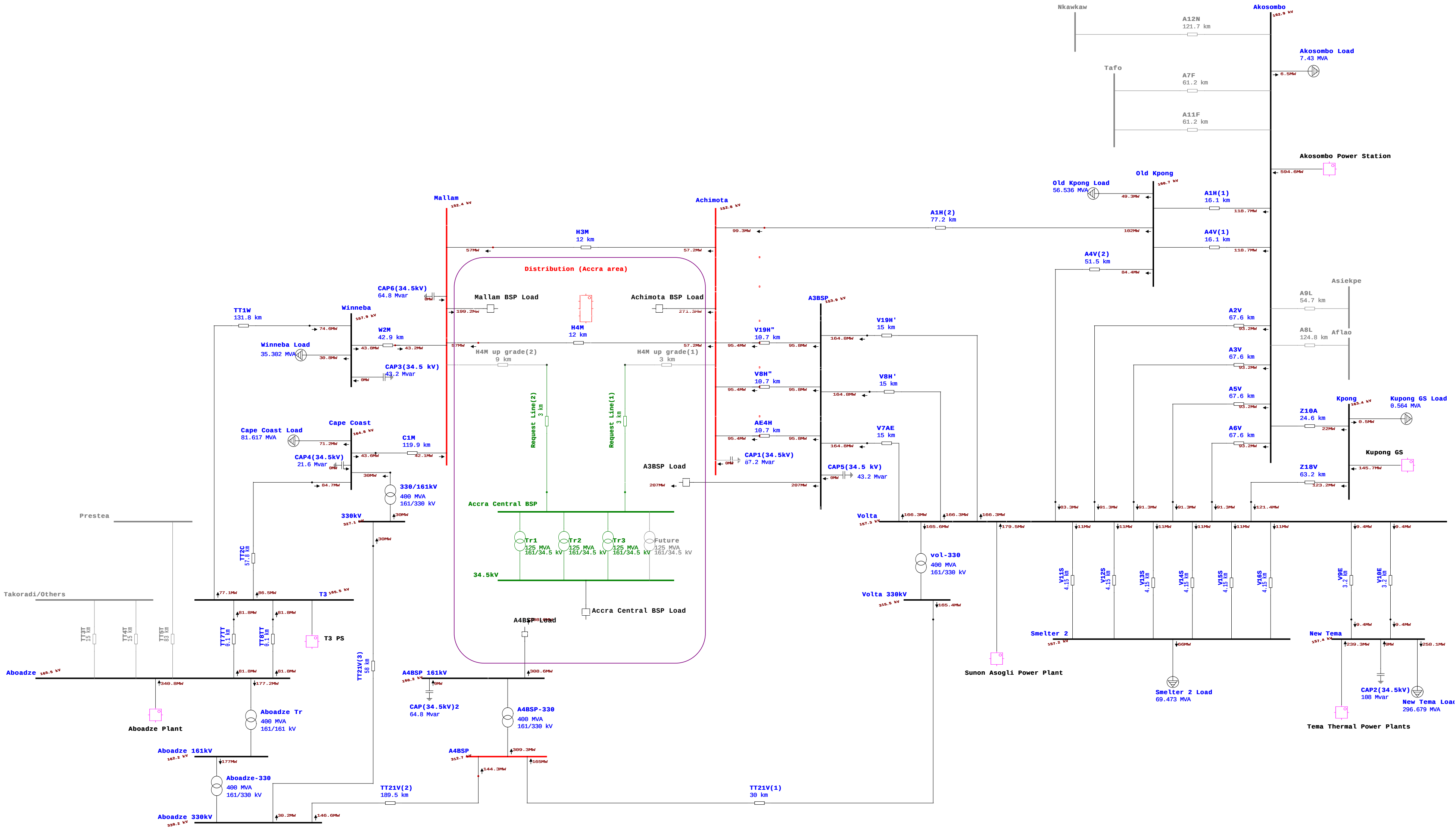


図 7　ケース 7（2021 年、本計画なし、A4 境界変電所あり、送電線増強なし）

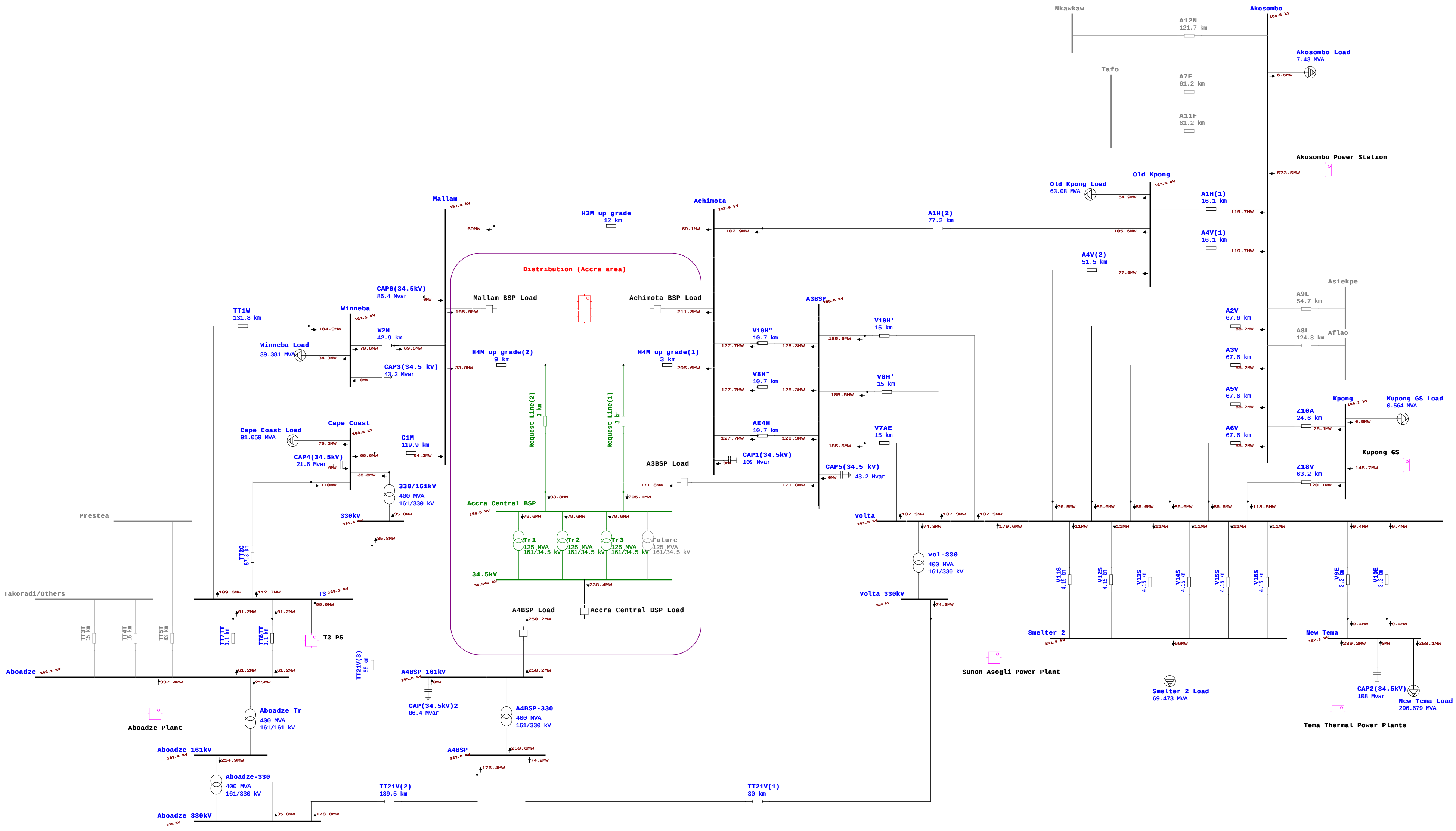


図９　ケース９（2022 年、本計画あり、A4 境界変電所あり、送電線増強なし）

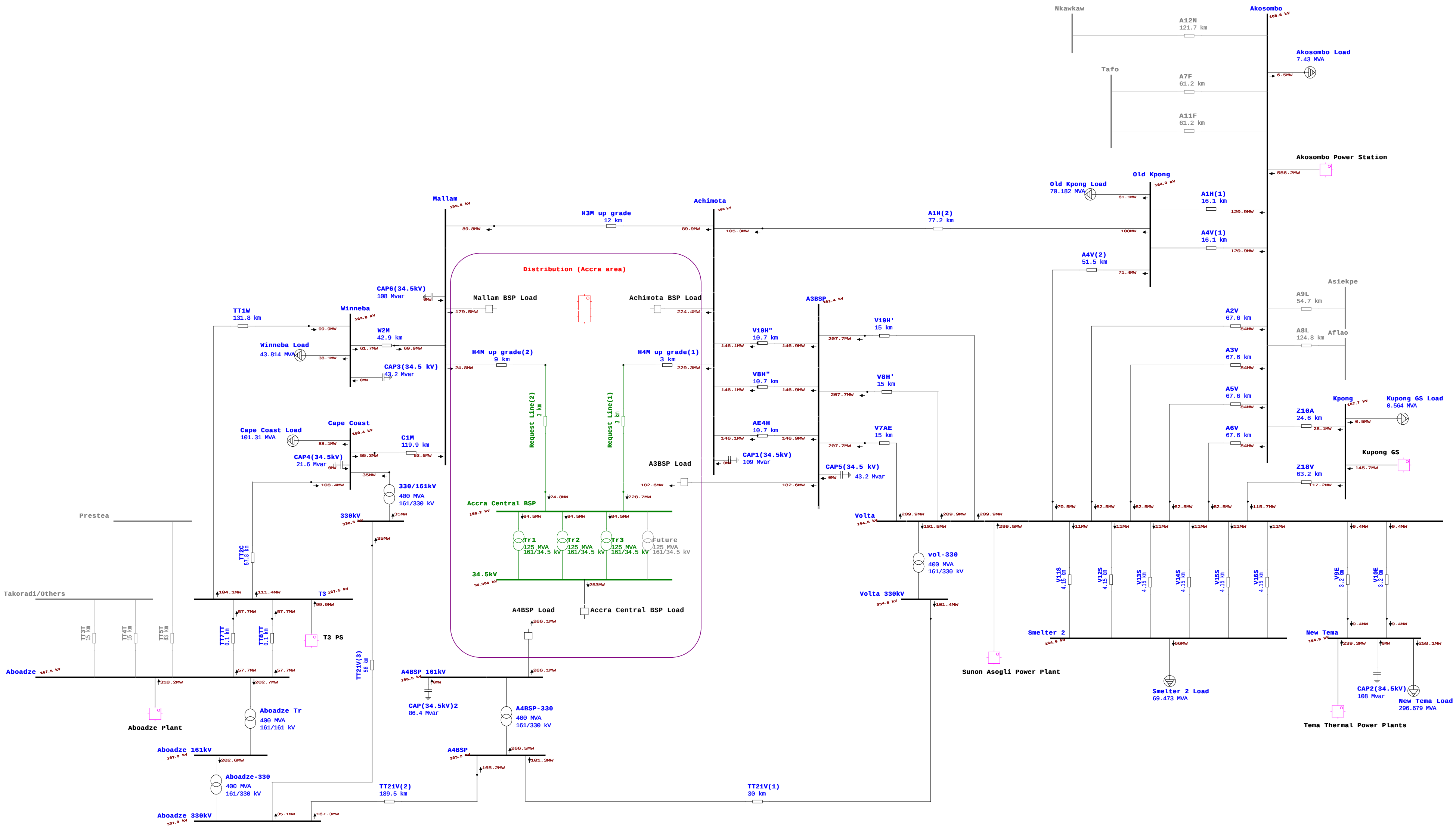


図１０　ケース 10（2023 年、本計画あり、A4 境界変電所あり、送電線増強なし）

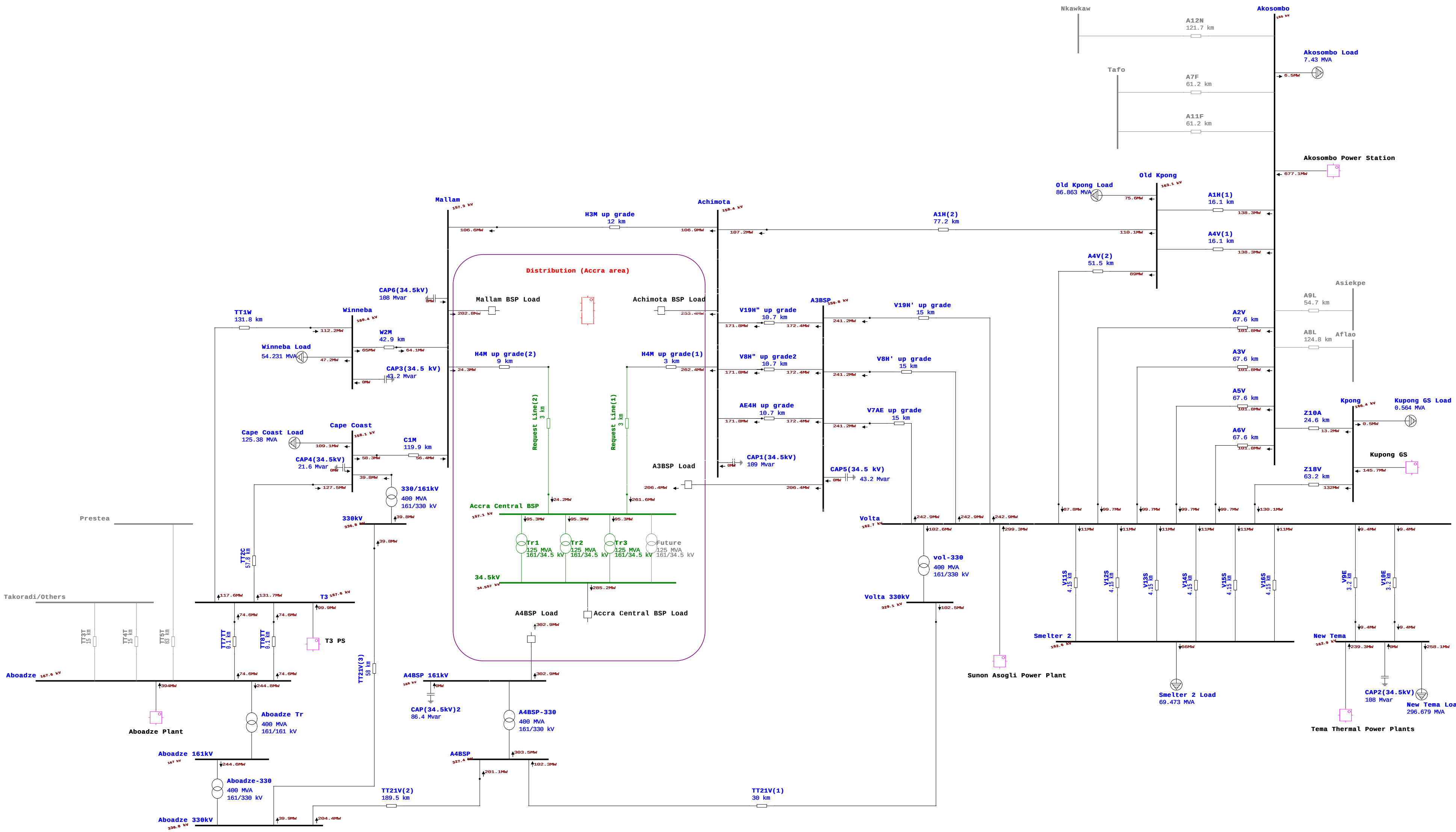


図１３　ケース 13（2025 年、本計画あり、A4 境界変電所あり、送電線増強あり）

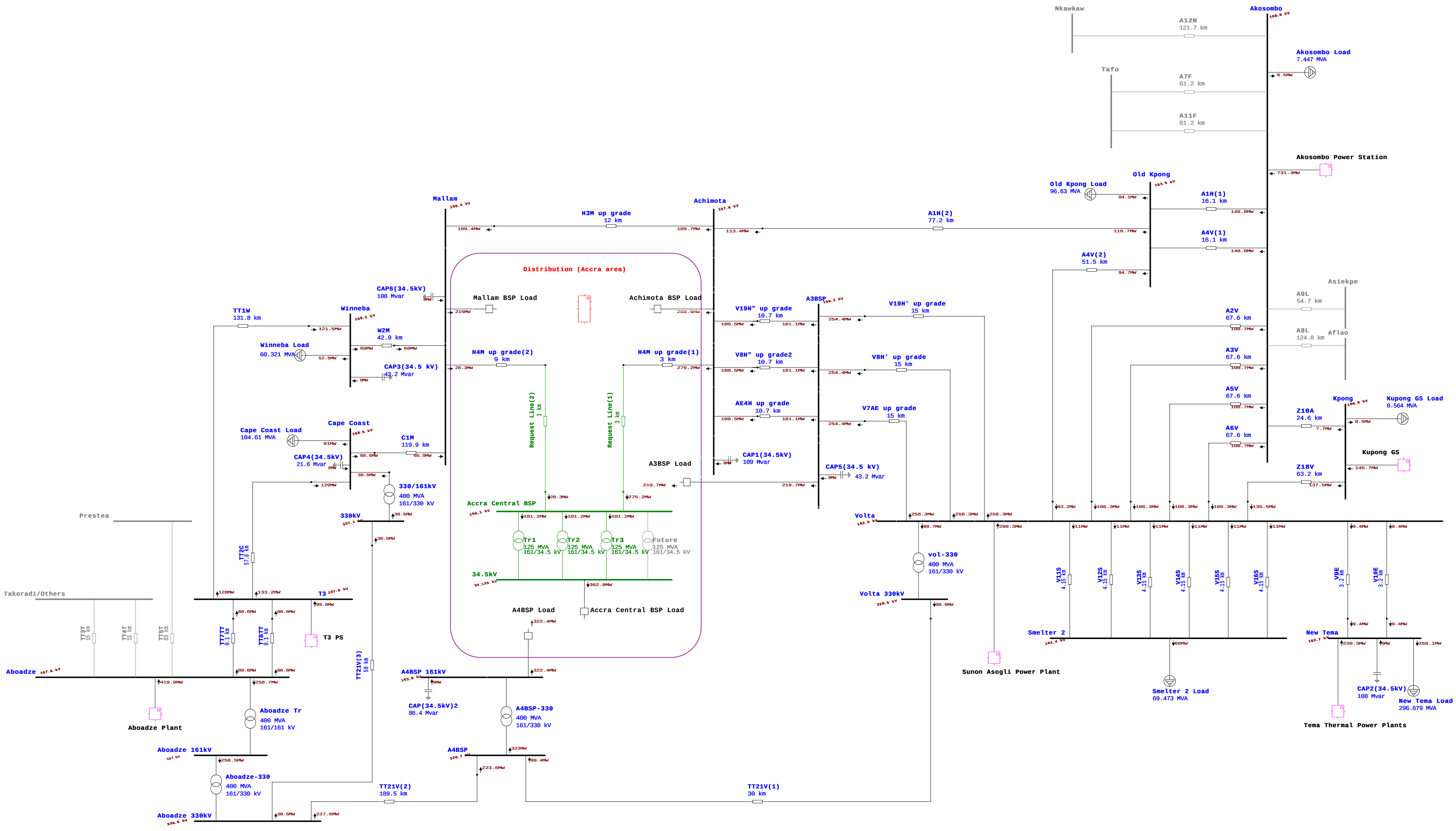


図１４　ケース 14（2026 年、本計画あり、A4 境界変電所あり、送電線増強あり）

9.1 Estimation of Compensation for Construction Costs of Affected Buildings

Table-1: Wooden kiosk with wooden floor & iron sheet roof for commercial/residential use

(Unit: GH¢)

Name of Owner	Number	Cost of wooden materials	Cost of roofing sheets	Transportation	Cost of Labor	Cost of Contractor	Unit cost per structure	Total
Abiba Mohammed	1	1,000	500	300	200	1,000	3,000	3,000
Eva Boadu	1	1,000	500	300	200	1,000	3,000	3,000
Kwasi Abenie	1	1,000	500	300	200	1,000	3,000	3,000
Joe	1	1,000	500	300	200	1,000	3,000	3,000
Kwabina Akorsah	1	1,000	500	300	200	1,000	3,000	3,000
Adjoa Sika	4	850	450	300	150	750	2,500	10,000
Total	9	5,850	2,950	1,800	1,150	5,750	17,500	25,000

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-2: Metal kiosk with concrete bases floor and iron sheet roofing for commercial/residential use

(Unit: GH¢)

Name of Owner	Number	Cost of metal materials	Cost of roofing sheets	Cost of concrete materials	Transportation	Cost of Labor	Cost of Contractor	Unit cost per structure	Total
Emmanuel Eguonu	1	3,000	1,000	1,000	500	1,500	3,000	10,000	10,000
MaameYaa Serwaa	1	5,500	2,000	2,500	1,500	2,500	6,000	20,000	20,000
Nana yaa	1	5,500	2,000	2,500	1,500	2,500	6,000	20,000	20,000
Sister Ama Rose	1	5,500	2,000	2,500	1,500	2,500	6,000	20,000	20,000
Maxwell Akubila	1	3,000	1,000	1,000	500	1,500	3,000	10,000	10,000
Patrick Agyei	1	3,000	1,000	1,000	500	1,500	3,000	10,000	10,000
Prince Appiah Boateng	2	3,000	1,000	1,000	500	1,500	3,000	10,000	20,000
Yaw Ofori	2	1,500	500	500	250	750	1,500	5,000	10,000
Total	10	30,000	10,500	12,000	6,750	14,250	31,500	105,000	120,000

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-3: Metal container with concrete bases floor and iron sheet roofing for commercial only

(Unit: GH¢)

Name of Owner	Number	Cost of metal materials	Cost of roofing sheets	Cost of concrete materials	Transportation	Cost of Labor	Cost of Contractor	Unit cost per structure	Total	Commercial property fee
Eric Boateng	2	6,000	2,500	2,500	1,500	2,500	4,500	19,500	39,000	500x2=1,000
Aminu Yissif	1	6,000	2,500	2,500	1,500	2,500	4,500	19,500	19,500	500x1=500
Benjamin Obiri	1	6,000	2,500	2,500	1,500	2,500	4,500	19,500	19,500	500x1=500
Kwasi Opoku	2	5,500	2,000	2,500	1,500	2,500	5,500	19,500	39,000	500x2=1,000
Seth Kotei Gyan	1	5,500	2,000	2,500	1,500	2,500	5,500	19,500	19,500	500x1=500
Total	7	29,000	11,500	12,500	7,500	12,500	24,500	97,500	136,500	3,500

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-4: Structure with metal or wooden pillars, no concrete floor with iron sheet for livestock trading only

(Unit: GH¢)

Name of Owner	Number	Cost of metal poles	Cost of roofing sheets	Cost of concrete materials	Transportation	Cost of Contractor	Unit cost per structure	Total	Commercial property fee
Rashid Amadu	1	1,000	200	100	50	200	1,550	1,550	50x1=50
Rashid Amadu	1	1,000	200	100	50	200	1,550	1,550	50x1=50
Rashid Amadu	1	1,000	300	100	50	300	1,750	1,750	50x1=50
Total	3	3,000	700	300	150	700	4,850	4,850	150

Note: Labor cost is included in Cost of Contractor as the structures are very simple.

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-5: Wooden Structure with wooden base for residential only

(Unit: GH¢)

Name of Owner	Number	Cost of wooden materials	Cost of roofing sheets	Transportation	Cost of Labor	Contractor	Unit cost per structure	Total
Dela Geraldo	5	850	400	200	50	500	2,000	10,000
Abdulai Abass	1	1,000	500	300	200	1,000	3,000	3,000
Total	6	1,850	900	500	250	1,500	5,000	13,000

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-6: All wooden structure with concrete base floor and iron sheet roofing for residential only

(Unit: GH¢)

Name of Owner	Number	Cost of wooden materials	Cost of roofing sheets	Cost of concrete materials	Transportation	Cost of Labor	Contractor	Unit cost per structure	Total
AmaIssifu	1	1,000	900	1,500	350	250	1,000	5,000	5,000
SulleyKasim	1	1,000	600	2,000	300	300	1,800	6,000	6,000
Prince Appiah	1	1,000	500	1,000	300	200	1,000	4,000	4,000
Victoria Owusu	1	750	250	500	300	200	1,000	3,000	3,000
Ruth Adongo	1	750	250	500	300	200	1,000	3,000	3,000
Hamza Mohammed	1	3,000	1,000	1,000	500	1,500	3,000	10,000	10,000
Kwame Poku	31	268	100	100	150	100	250	968	30,008
Victoria Abrefi	1	500	500	500	300	200	1,000	3,000	3,000
Alhassan Ali	1	3,000	1,000	1,000	500	1,500	3,000	10,000	10,000
Venus Keddy	3	2,000	1,000	1,000	500	1,000	2,500	8,000	24,000
Total	42	13,268	6,100	9,100	3,500	5,450	15,550	52,968	98,008

Source: Study of Environmental and Social Conditions, Resettlement March 2014

9.2 Estimation of Compensation for Income Loss

Table-7: Affected persons who reside and can lose the businesses in the affected sites

(Unit: GH¢)

Monthly income level	Number of affected persons	Total income	Total income for 5 months
960	1	960	4,800
1,200	1	1,200	6,000
1,440	2	2,880	14,400
1,920	2	3,840	19,200
2,520	1	2,520	12,600
2,880	1	2,880	14,400
3,360	2	6,720	33,600
Total	10	21,000	105,000

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-8: Affected persons who reside outside and can lose the businesses in the affected sites

(Unit: GH¢)

Monthly income level	Number of affected persons	Total income	Total income for 5 months
3,840	1	3,840	19,200
4,200	1	4,200	21,000
4,800	1	4,800	24,000
6,720	1	6,720	33,600
9,600	2	19,200	96,000
12,000	1	12,000	60,000
14,400	2	28,800	144,000
Total	9	79,560	397,800

Source: Study of Environmental and Social Conditions, Resettlement March 2014

Table-9: Affected persons who reside in the affected sites

(Unit: GH¢)

Monthly income level	Number of affected persons	Total income	Total income for 1 month
72	1	72	72
192	1	192	192
200	1	200	200
240	1	240	240
720	1	720	720
840	1	840	840
240	1	240	240
360	2	720	720
480	3	1,440	1,440
960	1	960	960
Total	13	5,624	5,624

Source: Study of Environmental and Social Conditions, Resettlement March 2014

9.3 Estimation of Compensation for Vulnerable Peoples

Estimation of Compensation for Vulnerable Peoples

(Unit: GH¢)

Ser. No.	Monthly household income	Average Income/day	Household size	Average Income/day /household member	Compensation period (Approx. 120 days)
1	9,600	320	2	160	19,200
2	12,000	400	2	200	24,000
3	1,200	40	3	13	1,600
4	960	32	8	4	480
5	1,200	40	4	10	1,200
6	1,440	48	7	7	823
7	1,920	64	5	13	1,536
8	2,520	84	7	12	1,440
9	2,880	96	4	24	2,880
10	3,360	112	4	28	3,360
11	480	16	6	3	320
12	840	28	4	7	840
13	720	24	4	6	720
14	240	8	4	2	240
	Total				58,639

Source: Study of Environmental and Social Conditions, Resettlement March 2014

10. JICA ガイドライン・世界銀行セーフガードと「ガ」国用地取得手続規定との乖離

No.	JICA Guidelines/World Bank	Laws of Ghana	Gaps between JICA Guidelines/World Bank and Laws of Ghana
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: Guiding Principles states that a. Except where unavoidable, all necessary steps should be taken to avoid built up areas or sites of environmental and social cultural significance. Alternative sites where the impact will be minimized or avoided should be preferred.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Constitution (Article 20)	Article 20 stipulates that (2) Compulsory acquisition of property by the State shall only be made under a law which makes provision for. (a) the prompt payment of fair and adequate compensation;
		Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana (GRIDCo)	No gaps as: C2.2.1 Policy Statement stipulates that 5. Acquisition of ROW are carried out in such a way as to minimize as much as possible the impact on people; B2.4 Resettlement (Compensation) Scheme stipulates that GRIDCo is committed to ensuring the restoration of the livelihood of all people adversely affected by its operations. Thus, Resettlement Packages are designed to ensure that the affected people are not made worse-off by implementation of its project;
		Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	Guiding Principles states that b. Where right of way restrictions become an issue, a Comprehensive Resettlement Action Plans should be prepared indicating the impacts on the PAP and detailed mitigation measures.
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Same as above	No gaps as same as above and: Guiding Principles states that d. Compensation Payment should be fair and adequate and the affected persons should not be made worse off as a result of the implementation of any of GRIDCo Projects; g. GRIDCo must ensure that the livelihood and living standards of the affected people prior to the displacement should not be made worse off but rather improved;
		Constitution (Article 20)	Article 20 stipulates that (3) Where a compulsory acquisition or possession of land effected by the State in accordance with clause (1) of this article involves displacement of any inhabitants, the State shall resettle the displaced inhabitants on suitable alternative land with due regard for their economic well-being and social and cultural values;
		State Lands Act 125 (Section 4)	Section 4 stipulates that (4) Subject to the Constitution, where a compulsory acquisition or possession of land effected under this Act involves displacement of any inhabitants, the Lands Commission or such other government agency as the President shall direct shall settle the displaced inhabitants on suitable alternative land with due regard for the economic well-being and social and cultural values of the inhabitants concerned.
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	State Lands Act 125 (Section 4)	No gaps as: Section 4 stipulates that (3) In assessing the compensation for land under subsection (2) regard shall be had to (a) the

No.	JICA Guidelines/World Bank	Laws of Ghana	Gaps between JICA Guidelines/World Bank and Laws of Ghana
			market or replacement value of the land;
		Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana (GRIDCo)	C2.3.2.2 Procedure for Cash Compensation stipurates that 2. Resettlement or compensation payments are made on the basis of open market value or Replacement Cost of the property;
		Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	Guiding Principles states that f. Compensation for loss of land, structures, crops other assets should be based in full replacement cost or Market Values (whichever is higher).
5	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: Guiding Principles states that e. Prior to the commencement of constructional activities, the PAPs should have been paid their compensation to enable them relocate. On no account should PAPs be displaced or rendered homeless without first paying them.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana (GRIDCo)	No gaps as: C2.3.1 Policy Statement stipulates that 3. RAP will be prepared by GRIDCo for all projects in accordance with legal regulations and GRIDCo Land Acquisition and Resettlement policy framework;
		Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	Guiding Principles states that b. Where right of way restrictions become an issue, a Comprehensive Resettlement Action Plans should be prepared indicating the impacts on the PAP and detailed mitigation measures.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana (GRIDCo)	No gaps as: RAP includes contents of Participation/consultation of stakeholders including PAP's;
		Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	Guiding Principles states that g. The affected people should be engaged and fully involved in the planning, implementation and monitoring of the resettlement process.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	None	No legislation was identified to stipulate how to explain the affected people understandable in consultations.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: COMMUNITY CONSULTATION states that Community participation in planning and implementing resettlement should be encouraged.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	State Lands Act 125 (Section 5)	No gaps as: Section 5 stipulates that (1) Any person who is aggrieved by a decision of the High Court on any matter dealt with by the High Court under this Act may appeal against the decision to the Court of Appeal;
		Framework for Environmental and Social Management of Bulk	C2.3.2.3 Procedure for Complaints and Grievances Resolution states that 2. During the community consultation process, grievance committees (GC) are formed in various

No.	JICA Guidelines/World Bank	Laws of Ghana	Gaps between JICA Guidelines/World Bank and Laws of Ghana
		Transmission Line Projects in Ghana (GRIDCo)	communities; 3. Any PAP aggrieved by any aspect of the resettlement lodges an oral or written complaint with the GC in his or her area;
		Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	GRIEVANCE REDRESS MECHANISMS states that there are three ways in which grievances shall be resolved. These are: 1. Grievance Redress Committee 2. Arbitration 3. Courts of Law
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: RESETTLEMENT ENTITLEMENT POLICY, BASELINE INFORMATION states A. Census and Inventory, and LEGAL BASIS FOR RESETTLEMENT ENTITLEMENT states that as part of the compensation processes a cut-off date would have to be established for specific resettlement action plans preparation. Compensation would not be made after the cut-off date in compliance with this policy.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: Guiding Principles states that h. Lack of formal title to land should not be a bar to compensation or resettlement / rehabilitation. All affected person are eligible regardless of legal or ownership titles. The compensation package however is dependent on the nature and quantum of loss suffered.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	None	No legislations were identified on preference to land-based resettlement strategies for displaced persons.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: ENTITLEMENT POLICY stipulates that The mechanism for compensating loss of business will be: (1) cash compensation for lost business structure reflecting full replacement cost of the structures, without depreciation; and (2) cash compensation for the loss of income during the transition period.; (3) a percentage of the total sum will be paid to the affected person to cater for disturbance and goodwill established with customers over the years.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	Deaft Land Acquisition and Resettlement Policy Framework (GRIDCo)	No gaps as: Guiding Principles stipulates that i. Land based projects generally affect a number of vulnerable groups such as households headed by women or children, the aged, and the physically disabled etc. Measures are to be provided to improve their socio-economic conditions rather than simply restoring then to their pre-project levels of vulnerability.
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	None	No legislation was identified on the criteria of abbreviated resettlement plan.

［出所］準備調査団

11. コンポーネントカットに係る覚書（MOU）

Minutes of Understanding on the Revision of Project Scope for the Project for the Reinforcement of Power Supply to Accra Central in the Republic of Ghana

Based on the request of the Government of the Republic of Ghana (hereinafter referred to as "Ghana") to the Japan International Cooperation Agency (hereinafter referred to as "JICA"), in consultation with the Government of Japan, for a grant aid for the Project for Reinforcement of Power Supply to Accra Central (hereinafter referred to as "the Project"), JICA dispatched a Preparatory Survey Team (the Team) to Ghana from 12th January to 17th February, 2014.

Following the signed Minutes of Discussions (M/D) dated 23rd January, 2014 in Accra between JICA side and the related authorities from the Ghanaian side, and upon the completion of the preparatory survey, the Team found it necessary to revise the scope of the Project. After internal consultations among JICA Headquarters about the issue, JICA Ghana was requested to consult and discuss with the Ghanaian related authorities.

JICA discussed the matter with Ghana Grid Company Limited (GRIDCo), the main implementing agency for the Project and Electricity of Company of Ghana (ECG), the relevant organization.

Responding to the tasks assigned, series of discussions were held with GRIDCo and ECG officials led by Ing. Samuel F. Kwofie, Director of Engineering and Ing. Julius K. Kpekpena, Director of Engineering respectively on 25th August, 2014. Both sides have agreed and confirmed the main items described in the attached sheets hereto.

Tema, Ghana
Monday August 25, 2014

Mr. Makino KOJI
Chief Representative
[JICA Ghana Office]

Mr. William Amuna
Chief Executive
[Ghana Grid Company Limited]

Prof. Thomas Mba Akabzaa
Chief Director
[Ministry of Energy and Petroleum]

Mr. Kwadwo Awua-Peasah
Director, External Resources Mobilization-Bilateral
[Ministry of Finance]

Mr. William Hutton-Mensah
Managing Director
[Electricity Company of Ghana]

ATTACHMENT

Objective of the Meeting

The meeting seeks to achieve a mutual agreement/understanding on the revision of the scope of the Project to eventually amend the agreed M/D.

Background of Matter of Concern

1. Ghana requested to the Japanese government for a grant aid to Reinforce Power Supply to Accra Central.
2. Based on the discussion in January 2014 between the Team and the Ghanaian side, the scope of the Project was agreed among the parties as shown in Table 1 below;

Table1: Items Targeted in the Project

	Components		Capacity
	Procurement and Installation Work		
	1. Accra Central BSP		
Option A	(1) 161 / 34.5 kV Transformers		125MVA×3units
	(2) 161 kV Gas Insulated Switchgears (GIS)		
	1) Incoming Feeders	(Outdoor Type)	2 sets
	2) Transformers Feeders	(Outdoor Type)	3 sets
	3) Bus Coupling	(Outdoor Type)	1 set
	4) Bus System (Double Bus Type)	(Outdoor Type)	1 set
	5) Voltage Transformers	(Outdoor Type)	2 set
	(3) 33 kV GISs (Double Bus Type)	(Indoor Type)	1 lot
	(4) SCADA System		1 set
	2. 161kV Transmission Line from the Avenor Branch Point to Accra Central BSP (1 Circuit for Achimota Line and 1 circuit for Mallam Line)		
	(1) 161 kV Overhead Line (ACSR, TERN, twin bundle or equivalent)		2.75 km
	(2) 161 kV Underground Cable (XLPE Cable, Copper, 1,600 mm^2)		0.4 km
	Procurement Work		
Option B	3. Underground cable for 33 kV Sub transmission Line between Station D and Station E for the decommissioning part (XLPE, Al, 630 mm^2, 3 cores or equivalent)		Approx. 4-6 km ×2 Circuits
	4. Maintenance Tools for the Equipment of the Project		1 lot
	5. Spare Parts for the Equipment of the Project		1 lot

Construction Work 6. Foundation for the Equipment of the Project (Gas Insulated Switchgears, Transformers, Towers for 161 kV Transmission Line) 7. Building for a control room of Accra Central BSP	1 set 1 building

3. After the Preparatory Survey Team conducted its preparatory survey in Ghana and upon the completion of its report, the total cost of the Project was more than the initial estimation.

Necessity to Cut the Scope of the Project

The discrepancy in the project cost necessitates the revision of the Project scope. This requires cutting down the scope of the Project by either shifting some of the cost to the recipient country or eliminating some of the targeted items from the list. This has to be done without compromising the Project purpose.

Key Points Discussed

JICA conveyed to GRIDCo and ECG that to reduce the cost, it intends to remove some of the items from the project scope as suggested below. Two (2) options were presented (as highlighted in Table 1 above) to GRIDCo and ECG on how to cut down the scope of the Project.

Option A: JICA will procure and install two (2) 125MVA transformers while GRIDCo will procure and install one (1) 125MVA transformer and the related gas insulated switchgears (GIS) at their own expense.

Option B: JICA will procure and install all three (3) 125MVA transformers but remove the procurement of underground 33kv sub-transmission line between station D and E from the scope. This implies the Ghanaian side (GRIDCo/ECG) will procure and install the underground 33kv sub-transmission line between station D and E at their own expense either within the project timeframe or at the earliest possible time.

JICA further explained the technical and economic pros and cons of both options summarized in Table 2 below:

Table 2: Pros and Cons for the various Options for the Scope Cut

Options for scope cut	Advantages	Disadvantages
Option A – Remove 1 transformer	* The amount to be reduced from the total cost is larger.	* Several GIS, which are connected to the transformer, will also be reduced * Installation of the transformer and GIS is very complex and not easy for local contractor * Expensive and not easily available in the local market
Option B – Remove 33kv sub-transmission line between station D and E	* Easy to procure by Ghanaian side * Arrangement between GRIDCo and ECG is not complicated. * Installation was already part of the Ghanaian side responsibility under the signed M/D	* Close communication and arrangement between GRIDCo and ECG are needed

GRIDCo accepted **Option B** which was subsequently confirmed by ECG to procure and install 33kv underground cable and sub-transmission line between station D and station E. The GoG side understood that this is an additional responsibility to the already agreed responsibilities under the signed M/D in January 2014.

JICA on the other hand requested GRIDCo to make all the necessary arrangements with ECG to source funds for the procurement and installation of the 33kv cable and sub-transmission line. The GoG side agreed to the request.

GRIDCo, ECG and JICA mutually agreed and understood that the acceptance of this Minutes of Understanding by the designated authorities constitute the amendment of clause 9, paragraph (2) [5] of M/D which states "*the Ghanaian side shall install 33kv underground cables to be procured by the Japanese side for the section between Primary Station D and E, immediately after the cables are delivered to the Project site*".

Reference Document: Minutes of Discussions signed on the 23rd January 2014

JICA / Yachiyo Engineering Co., Limited

[Tokyo, Japan]

Reinforcement Of Power Supply To Accra Central

geotechnical investigation report

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February - 2014

1.0 INTRODUCTION

1.1 Background

As part of the design studies towards the Reinforcement of Power Supply to Accra Central, **JICA** in collaboration with **YACHIYO Engineering Co. Limited** of JAPAN contracted **KALYN SURVEYS & SERVICES** to undertake the preliminary investigation.

Preliminary field geotechnical investigations were carried out at the proposed substation site between the 30th of January and the 5th of February, 2014.

This report describes the field and laboratory investigations carried out at the project site and makes recommendation for the efficient design of the substation.

1.2 Objectives of the Geotechnical Report

The study involves the performance of sub-surface investigations of such nature and intensity as to facilitate adequate geotechnical characterisation of the site for the proposed development. In particular, the findings of the investigation are to facilitate the economic design and construction of the proposed substation.

2.0 THE SITE

2.1 Location

The project site is shown in Appendix A.

The site is geographically located about the co-ordinates 322000'E and 1188000'N, within the city of Accra of the Greater Accra Region of Ghana. The site which is located on the Graphic road is directly opposite the Graphic Communication Group Limited of Ghana.

2.2 GEOLOGY OF THE PROJECT AREA

The Accra area is underlain by three main rock types, namely the **Accraian Series** of sedimentary rocks of Devonian age deposited in a basin formed by the older rocks of the **Dahomeyan Series** (late Pre-Cambrian) consisting of gneisses and schists, which are, in turn, intruded in places by rocks of the **Togo Series,** (early Pre-Cambrian) made up of quartzite's, schists and phyllites. The rocks of the Dahomeyan and the Togo Systems underlie most of the area to the west, north and east of the city of Accra, while rocks of the Accraian Series underlie most of the Central Business District of the city, where intensive physical development has resulted in the geology of the Accraian series being studied in comparatively greater detail than those of the other two rock types.

The geological map of Central Accra based on the original map by **HARRIS, 1970,** given in **Fig A-2.** shows the project area as being underlain by the **Togo Series** which is sufficiently large and covers Ringway Estates (the project area), Accra International Airport and the areas extending westwards of the project site. However, the project site is located quite close to the contact between rocks of the Togo Series and the Dahomeyan Series.

Detailed studies of the Togo Series formation by **BHATIA (1968)** indicate that the soil profile consists of 0.5m-1.0m thickness of hard sandy or silty clay surface soil considered a drift material. This layer is underlain by upto 3m-layer thickness of laterized quartz gravel. The quartz content is a weathered product of the bed rock, mixed with transported sandy and silty clay, laterized and cemented into a concretionary mass (*hardpan*) by the action of repeated hydration and desiccation of iron oxide also of bed rock origin. This hard pan is difficult to dig by pickaxe especially in a dry state, often requiring power equipment to break up. The fines content in the lateritic gravel layers vary in texture from silty sands to silty clays. Due to leaching of the upper layers of gravel the material is generally less plastic near the surface. The plasticity however increases with depth.

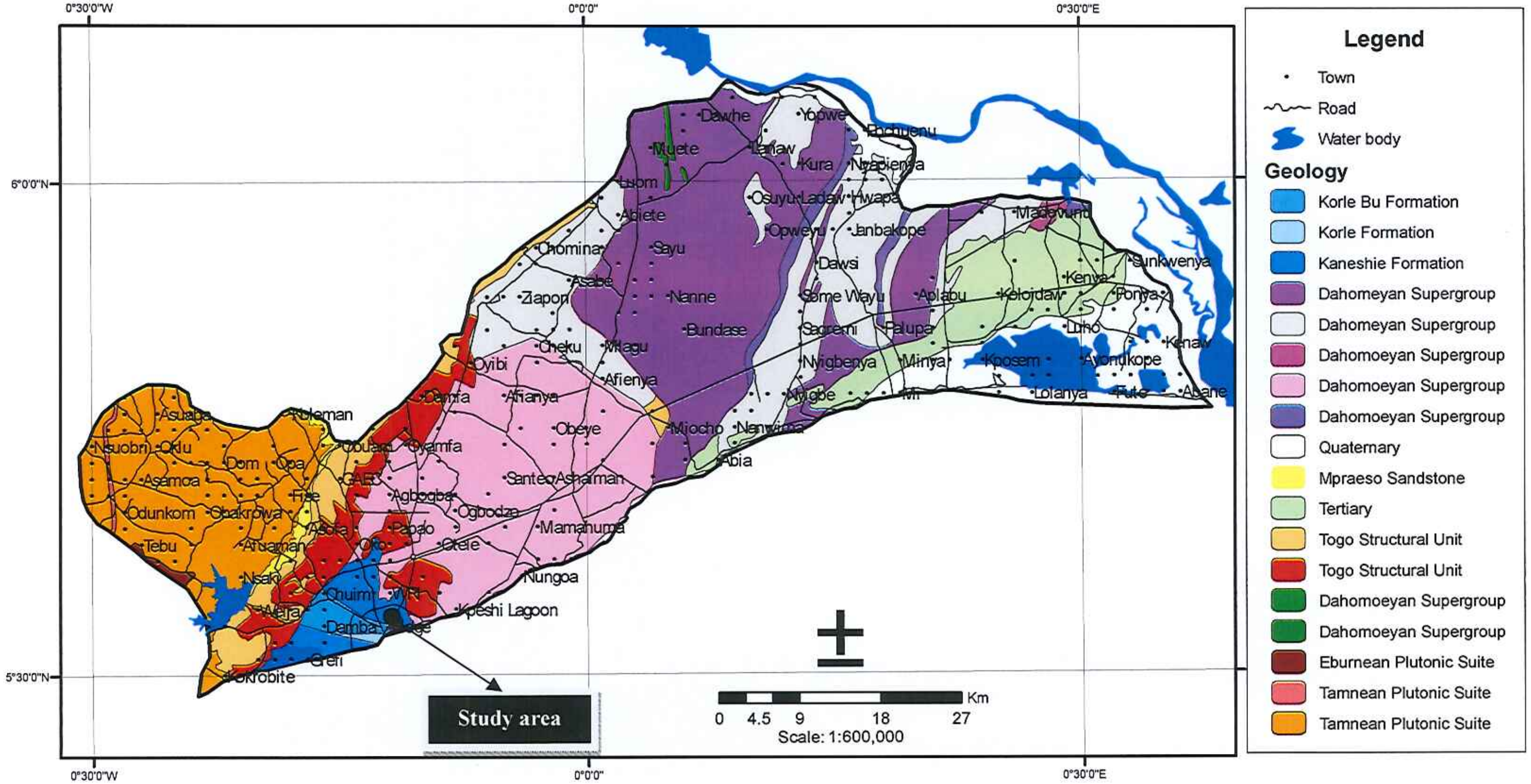

Figure 1: Geological map Greater Accra Region showing study area.

A highly micaceous quartz vein is usually present in-between the hard lateritic gravel and the weathered bed rock. The quartz structure clearly indicates stress, folding and pressure within the profile. The weathered micaceous stuff makes the soil layers within the profile very soft, expansive and compressible when saturated.

The bedrock is made up of mainly quartzites, schists or phyllites. These rock types have significant mica content, which influences the clay content of their weathering products. The phyllites are mainly found intercalated with the quartzites in the valley areas.

The water table in the area is generally between 7-8m from the ground surface.

2.3 Seismicity of the Accra Area

Even though Ghana is situated well clear of the world's main seismic zones*, southern Ghana, in general, and the city of Accra and its environs, in particular, have had a history of seismic activity dating back to **1636,** when a major earthquake was said to have destroyed the town of Axim, in the south-western part of Ghana. As shown in **Table A-1**, numerous other seismic events have been experienced in Ghana since then.

Major seismic events have, for example, been experienced in the Accra area in **1862** and **1939,** in addition to numerous other minor shocks of engineering significance, most of which had their epicentres either along the **Akwapim Range**, about 20km to the west of Accra, or off-shore of Accra, along the **Coastal Boundary Fault**. Indeed, **BLUNDELL,** and **BANSON (1975),** among others, believe that the occurrence of seismic activitiy in the Accra area can be attributed to the fact that the intersection of the seismically active **Akwapim Fault Zone,** which runs along the Akwapim range and the **Coastal Boundary Fault,** approximately 3km off-shore along the edge of the continental shelf, occurs near the village of *Nyanyanu*, about 30km west of Accra.

Continued seismic activity on both causative fault systems is confirmed by the fact that numerous local seismic events of M3 or greater continue to be recorded and assigned to either fault system. An isoseismal map of Accra (after Harris, 1970) is presented as **Fig. A-3**

In the absence of any area specific instrumental data on the characteristics of major local seismic events, seismic considerations in engineering design can only be based on qualitative information on the historical seismicity in the Accra area.

2.4 The 1939 Accra Earthquake

Undoubtedly, the best-documented local major earthquake was the 1939 event **(JUNNER et al, 1941).** This earthquake, which had a focal depth of 13km and an epicentre located approximately 40km out to sea, to the south-east of Accra, shook most of West Africa on **22nd June, 1939** at approximately **19:21 hours** GMT and produced shocks of intensity between **VII** and **IX** on the 10-point modified Mercalli Scale* within the city of Accra. The event had an estimated magnitude of **6.5** on the Richter scale within the city of Accra, with the main shock having an estimated duration of **10 seconds.**

A detailed study relating the extent of structural damage caused by this earthquake in the city of Accra to the geology of Accra revealed the following facts pertinent to this investigation:

- there was no evidence of significant movement along any of the numerous faults in Accra, nor was there any evidence of appreciable changes in the levels of bench marks following the earthquake;
- **structures founded on massive sandstone bedrock generally suffered much less damage than those founded on shale;**
- **the greatest structural damage was done in areas underlain by shales or interbedded shale and sandstone formations, particularly where they are covered by substantial thicknesses of saturated sand, silt or clay;**
- the effects of the earthquake were appreciable at contacts of rocks of dissimilar composition, particularly at the contact of soft water-logged

alluvium and solid rock;

From Fig. A-3 it can be seen that project site is close to isoseismal VII derived from this earthquake, compared with the maximum shock intensity of Magnitude IX experienced in the *Weija* area.

TABLE-1 HISTORICAL SEISMICITY OF SOUTHERN GHANA

DATE	APPROXIMATE LOCATION OF EPICENTRE	AREA AFFECTED BY THE SHOCK	PROBABLE CAUSATIVE FAULT	REMARKS
1862	Off-shore Near Accra	City of Accra and areas to the east as far as Anecho in Togo	Coastal Boundary Fault	City of Accra reported to be "almost completely destroyed "
1906	Along Akwapim range near Ho	Maximum intensity felt at Ho, Accra and other towns to the east of Akwapim range	Akwapim Fault Zone	Extensive cracks in Govt. buildings. All forts in Accra cracked but not rendered uninhabitable
1st Sept. 1923	?	?	?	The seismograph then in operation in Accra, recorded a shock with maximum amplitude of 9mm. It was not clear whether this was a local event or a teleseism
22nd June 1939	40km out sea, SSE of Accra	Most of West Africa, covering and area of 77,000km^2	Coast Boundary Fault	Seismograph out of operation at time of shock, estimated at M=6.5. Maximum damage in city of Accra – event recorded by seismological stations all over the World. Main shock followed by numerous after shocks lasting over months
26th Dec. 1966	Weija area	Accra and nearby villages up to 40 km to the north	Akwapim Fault Zone	Shocks attained Intensity IV on the Modified Mercalli Scale in Accra
9th Feb. 1977	Approx. 8km out of sea, south of Tema	City of Accra and its environs.	Coastal Boundary	M 4.9 event recorded by 22 other seismological stations in Europe and Canada. Several cracks developed in large buildings in Accra.
1st March 1977	25km north of Accra along Akwapim Fault Zone	City of Accra and its environs	Akwapim Fault Zone	M.3.4
5th Sept. 1978	5km north of Weija	City of Accra and its environs	Akwapim Fault Zone	Main M=4.7 shock followed by two after-shocks
9th Jan. 1979	Weija area	City of Accra	Akwapim Fault Zone	M 3.6
7th June 1980	Weija area	City of Accra	Akwapim Fault Zone	M.3.6
25th June 1985	Epicentral distance = 15.66km	City of Accra	Akwapim Fault Zone	M 3.1
10th May 1985	Epicentral distance = 47km	City of Accra and its environs	Akwapim Fault Zone	M 4.0
27th Feb. 1988	15km SW of Weija	City of Accra and its environs	Akwapim Fault Zone	M 3.4
14th April 1990	Weija area	City of Accra and its environs	Akwapim Fault Zone	M 3.5
23rd Aug. 1991	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 3.9
28th Jan. 1995 (2 shocks within 1 minute)	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 3.3 and M 3.4
1st Feb. 1995	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 3.8
9th March 1995	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 3.4
2nd Feb. 1996	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M.3.6
8th Jan. 1997	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 3.8
14th Feb. 1997	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 4.1
6th March 1997	Offshore	City of Accra and its environs	Akwapim Fault Zone ?	M 4.8
18th May 2003	Weija area	City of Accra and its environs	Akwapim Fault Zone ?	M 3.8

3.0 FIELDWORK

3.1 Geotechnical Investigation

The ground investigation was undertaken in accordance with the BS 5930 Standard Code of Practice for Site Investigations. The investigation was commenced on the 30th of January and was completed on the 5th of February, 2014.

3.2 Borehole Drilling and Sampling

Three boreholes were drilled at the proposed locations indicated by the Engineer. The location of the boreholes has been shown in Appendix A. The boreholes were drilled using the shell and auger method. The Pilcon wayfarer 1 ton cable percussion rig was employed to advance 150-mm diameter holes using steel casings and standard cable percussion tools. The boreholes were terminated when the standard penetration test (SPT) recorded refusal (i.e. N > 50 blows/300mm) and chiselling could not advance the hole appreciably. The borehole logs are presented in Appendix B.

The boreholes were distributed so as to give a fair representation of the existing subsurface conditions across the site.

Plate_1: Borehole Drilling In Progress

Bulk disturbed soil samples were taken from the boreholes at regular intervals. Undisturbed U100 samples were also recorded when cohesive soils were encountered. In-situ Standard Penetration Test (SPT) was carried out frequently in the overburden as drilling progressed.

Samples of the ground water recovered during the investigation were submitted to the laboratory for testing to determine the presence of ions known to be deleterious to Ordinary Portland Cement and steel.

3.3 Geophysical Investigation

Geophysical exploration involving the use Seismic refraction surveys was undertaken at the proposed project site on the 1st of February, 2014.

The Smartseis Seismic Refraction seismograph equipment (made by Geometric Inc. of USA) was employed for the investigation using six (6) main lines running across the site. The time-distance graph and soil profiles were drawn using the SIPIK programme developed by RIMROCK Geophysics of USA.

The geophysical technique employed was the Vertical Electrical Sounding (VES). The VES was used to estimate the depth to bedrock, the number of subsurface geological layers, and their corresponding resistivities as well as their conductivity values.

Plate_2: Electrical Sounding Was Also Employed In The Investigations

3.4 Vertical Electrical Sounding (VES)

The project site was evaluated and suitable sites were selected for geophysical investigations (Geo-technical). The VES measurements were confined to selected points using an ABEM Terrameter SAS 1000C and the Schlumberger electrode array. To ensure reliable and consistent readings, measured results were plotted in the field during the measurements and inconsistent values were repeated to ensure uniformity in the readings.

3.5 DATA ANALYSIS

3.6 Vertical Electrical Sounding (VES)

Vertical Electrical Sounding (VES) studies were carried out at three (3) selected points, where boreholes are intended to be drilled to provide sub-surface geo-technical information. The points investigated are presented in . The field data were analyzed using the 'IPI2WIN' software program. Model outputs include the number of geological layers in the sub-surface, and their corresponding resistivity and thickness. The VES results at all the selected points predicted that the area is underlain by a three-flour layered sub-surface structure. VES field measurements data and output of VES modeling are respectfully presented in **Error! Reference source not found.** and **Error! Reference source not found.** of this report.

Table 2: Summary VES results showing depth-to-bedrock and bedrock resistivity of the area.

VES Point	Geographic location	Layer	ρ (Ω-m)	Thickness (m)	Depth (m)	Depth-to-bedrock (m)	Remarks
BH1	5.58277 -0.18208	1	95.8	2.33	2.33	29.0	Moderately weathered quartzitic bedrock
		2	42	26.5	28.9		
		3	170				
BH2	5.58277 -0.182194	1	66	1.03	1.03	16.0	Highly weathered quartzitic bedrock.
		2	93.2	1.88	2.91		
		3	28.8	13.2	16.1		
		4	51				
BH3	5.58294 -0.18190	1	90.4	0.75	0.75	41.0	Relatively hard or un-weathered bedrock
		2	251	1.08	1.83		
		3	57.6	39.5	41.3		
		4	1440				

3.7 Discussions on Soil Resistivity and Conductivity

A summary of the results obtained for the soil resistivity, conductivity, bedrock resistivity and their respective conductivities values as well as depth-to-bedrock are presented in **Error! Reference source not found.**.

Table 3: Summary VES results showing depth-to-bedrock and bedrock resistivity of the area.

VES Point	Geographic location	Layer	ρ (Ω-m)	Thickness (m)	Depth (m)	Depth-to-bedrock (m)	Remarks
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		2	42	26.5	28.9		
		3	170				
BH2	5.58277 -0.182194	1	66	1.03	1.03	16.0	Highly weathered quartzitic bedrock.
		2	93.2	1.88	2.91		
		3	28.8	13.2	16.1		
		4	51				
BH3	5.58294 -0.18190	1	90.4	0.75	0.75	41.0	Relatively hard or un-weathered bedrock
		2	251	1.08	1.83		
		3	57.6	39.5	41.3		
		4	1440				

The topsoil had apparent resistivity values ranging between 66.0- 95.8 Ω-m. The soil resistivity values seek to suggest that the soil is most or clayey contains some amount of clay component. A contoured section of resistivity distribution is presented in Figure 2. Qualitatively, the soil resistivity section suggests that the soil cover at BH3 is dry or the bedrock outcrops there. The soil resistivity tends to reduce towards BH2 with BH1 having relatively moderate soil resistivity value.

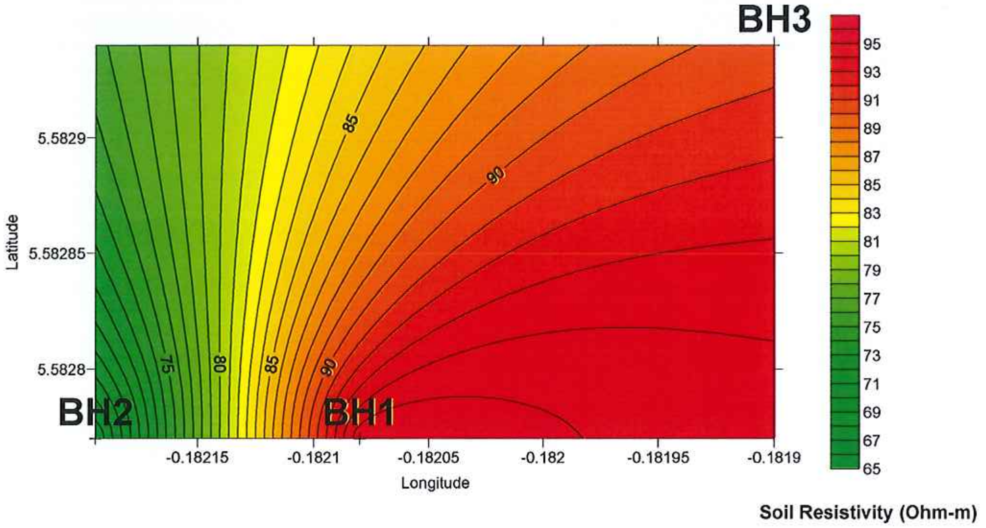


Figure 2: Contoured soil resistivity of the area showing the borehole points

On the other hand, a contoured section of the soil conductivity values indicates that borehole BH3 has the least value with BH2 having the highest value. Thus, the soil conductivity tends to increase from east to west. The soil conductivity values ranged between $1.04*10^{-2}$ mS/m and $1.52*10^{-2}$ mS/m with an average value of $1.22*10^{-2}$ mS/m.

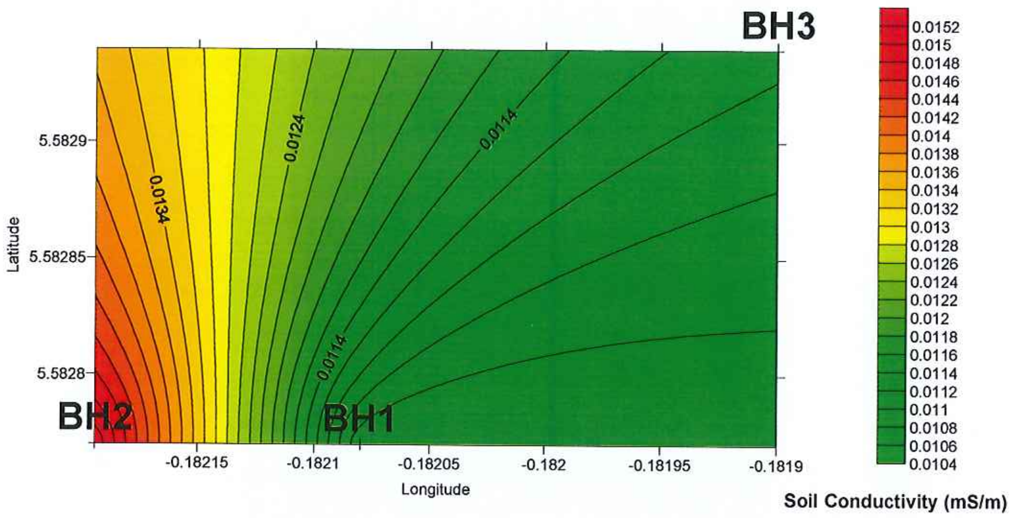


Figure 3: Contoured soil conductivity of the area showing the borehole points

3.8 Discussions on Bedrock Resistivity

The bedrock resistivity, which is a measure of the hardness of the rock, varied widely from 451 - 1440 Ω-m with an average value of 553.67 Ω-m. Contoured sections of the bedrock resistivity are presented in Figure 4 and Figure 5. From these sections it can be deduced that the north-western corner around BH3 is more resistive similarly to the soil resistivity section. Thus it can be inferred the bedrock is less resistive at the south-western portion as compared to the northern section.

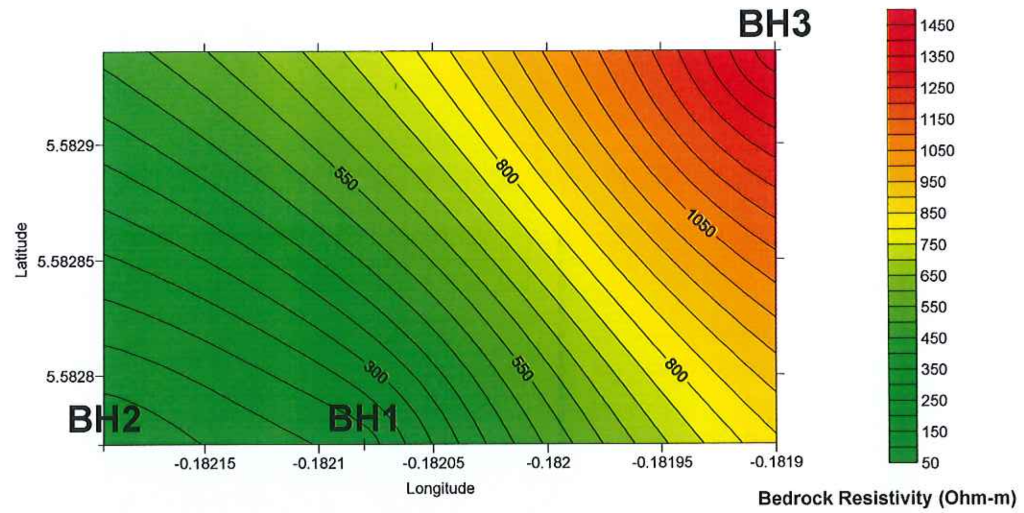


Figure 4: Contoured bedrock resistivity showing the borehole points

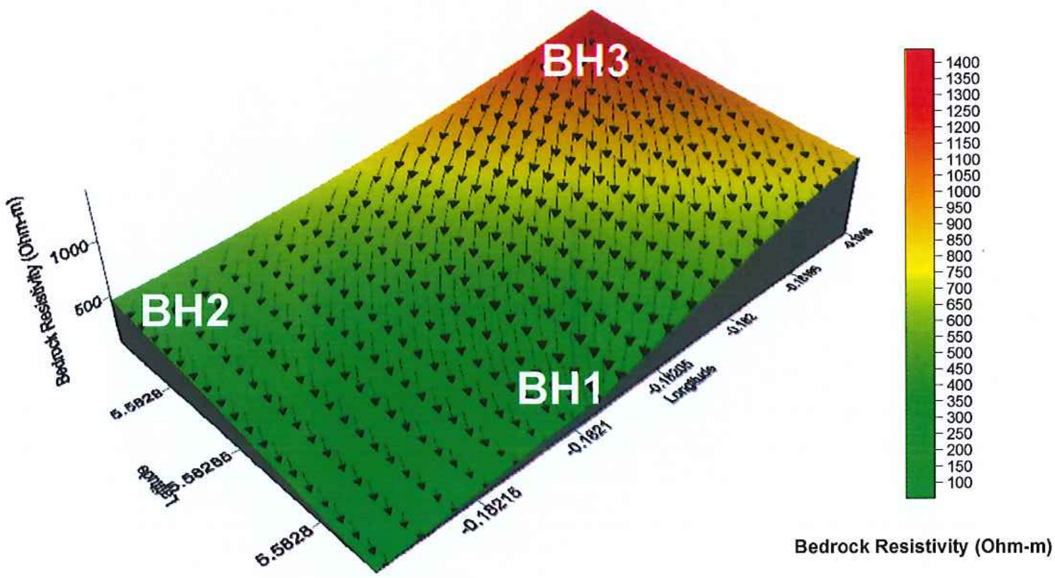


Figure 5: Topography of Bedrock Resistivity showing the VES points

3.9 Discussions on Depth-to-Bedrock

The spatial variation of depth-to-bedrock is presented in Figure 6 and Figure 7. Qualitatively, the depth-to-bedrock increases south-western corner around BH2 towards the north eastern section of the area around BH3 . The depth-to-bedrock ranges between 16 – 41 m as clearly indicated in Figure 6.

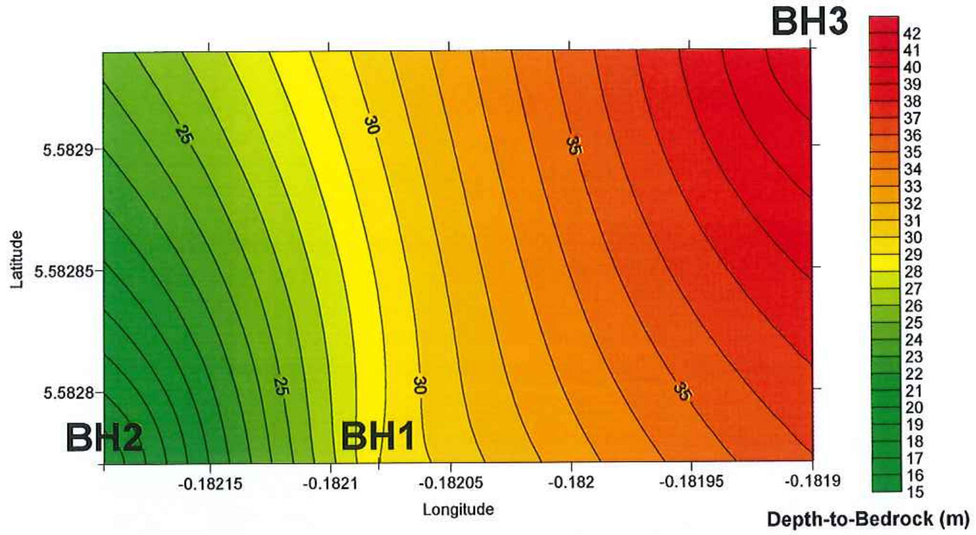


Figure 6: Contoured depth-to-bedrock at the showing the borehole points

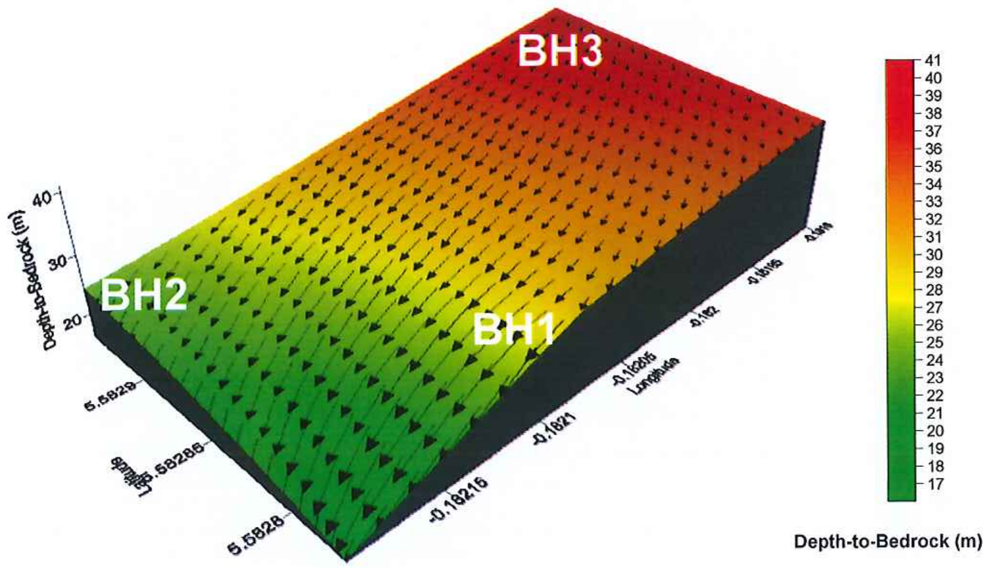


Figure 7: Topography of Depth-to-Bedrock showing the borehole points

Summarised results and plots of geophysical testing have been provided in Appendix D.

4.0 LABORATORY TESTING

The disturbed and SPT samples recovered from the boreholes have been tested for the following;

Natural Moisture Content
Liquid, Plastic and Plasticity index
Particle Size Distribution
Specific gravity of soil
Bulk density determination

In addition to these test, the undisturbed samples have been subjected to the one dimensional consolidation and the Triaxial compression tests. Other tests have included the determination of the bulk density and specific gravity.

The chemical tests which were done included pH, sulphate and chloride content.

All the laboratory test results have been summarised in Appendix C.

5.0 SUBSURFACE CONDITIONS

5.1 Stratigraphy

BH1 to BH3 revealed that the soil profile consists of 0.7m – 1.0m thick medium dense clayey GRAVEL with sand deposited fill material. This was underlain by up to 10m layer thick soft grey/yellowish brown clayey SAND with gravel. The later was further underlain by a nearly 5.2m of Soft Sandy CLAY/clayey SILT of decomposed Shale rock formation, this happens to be weathering product of the bedrock, mixed with transported quartzite gravel/pebbles at places. These soils were virtually cemented into concretionary mass by the action of repeated hydration and desiccation of iron oxide also of bedrock origin.

The bulk density of the surficial soil material is about 1.72 Mg/m^3, with an average permeability coefficient of 4.64×10^{-8} m/s, this confirms soils to be silty with poor drainage characteristics of low permeability.

A highly micaceous quartz vein usually presents in-between the shaly formation and the weathered bedrock. The quartz structure clearly indicates stress, folding and pressure within the profile. The weathered micaceous stuff makes the soil layers within the profile very soft, expansive and compressible when saturated.

5.2 Highly Weathered SHALE

The bedrock is made up of mainly Shale's, Schist or Sandstones. These rock types have significant mica content, which influences the clay content of their weathering product. The Shale's which are the main bedrock type at the site were found at 18m - 20m across the site. The borehole logs have been presented in Appendix B.

5.3 Surficial Groundwater

Groundwater was encountered in both boreholes drilled between 1.2 – 1.8m below ground level. This is suspected to be in consonance with the sea (Gulf of Guinea).

The chemical analysis of samples of groundwater indicates that the concentrations of unsaturated sulphate ion, and the pH are beyond the tolerable limits and special precautions need to be applied. The chemicals test results have been presented in Appendix C.

6.0 Shallow Foundation Recommendations

Foundation construction need to satisfy two basic and independent design criteria, firstly the bearing pressure transmitted to the foundation soils should not exceed the net allowable soil bearing capacity with an appropriate safety factor. Secondly, settlements during the operating life of the structure should not be of magnitude that will cause structural damage to the structures or their utility connections. Settlements are a function of, among other things, the underlying soil condition, the foundation size and shape, and the applied foundation pressure of the foundation elements.

The existing subsurface soils of the Substation are not suitable to support shallow foundations besides they are considered as potentially liquefiable. Therefore soils need to be improved before shallow foundation construction. Ground improvements options available include preloading (surcharging), soil grouting, dynamic compaction and vibro replacement.

Preloading	Surcharging, this method may reduce settlement of layers less than a meter but may not improve bearing capacity and or liquefaction of underlying soil layers, also it is time consuming.
Soil grouting	Soils to nearly 10m are sands with little cohesive stuff, this may be an expensive venture
Dynamic compaction	May not be feasible with submerged sandy formation, on site water tables do rise for nearly half a year
Vibro replacement	**This Method replaces portions of weaker soils with preferably crushed stone to a determined depth to improve bearing ability, reduce settlement and liquefaction, this is most preferred.**

Stone columns have been extensively used across the Globe depending on factors such as the design loading, experience of the operator, arrangement and spacing of vibrator positions and depth of densifying soils amongst others. Moreover, the stone columns acting as vertical drains also allow a rapid dissipation of the excess pore water pressures arising from the construction process generated by loading. Vibro replacement technique using boulders may be possible at this site to support the process structures if stringent quality assurance and quality control measures are established. The boulders can be properly constructed to depth in the region of peak cone resistance and sleeve friction of between 2.0 - 4.0m depth. Plate Load tests may be required to establish the required bearing pressure attained.

Raising site grade by nearly 1.0m will not incur any long term significant settlement within the underlying foundation soils since soils are granular sands. Any grade raise induced settlement will occur nearly immediately during the construction. Soils replacement may be employed amongst other option

6.0 GEOTECHNICAL INTERPRETATIONS

6.1 Bearing Capacity Estimation

The following recommendations for the design and construction of the foundations of the proposed substation are based on the results of this investigation, supplemented, where necessary with pertinent geotechnical experience in comparable geo-environmental situations. Column loading for this substation may be in the neighbourhood of 200 - 300 kN/m^2.
It is technically possible to found on spread footings in either the surficial soils or the decomposed Shale bedrock.
The bedrock is however at about 16m - 20m depth and has sandy SILT/silty CLAY overlying it, which will make it difficult to found on.

6.2 Foundation Depth & Type

Structures for the site can be founded on raft type foundation in the surficial formation at between 2.0 – 2.5m depth range below existing ground level and below ground water level at all locations. Surficial soils are of moderate strength and appreciable compressibility with least SPT N value of about 8.
The logs of boreholes at the site indicate that within the surficial soils of sandy silt/silty clay overlying highly weathered Shale, the average shear strength parameters of the clayey sand soils were C_u = 10kPa, ϕ_u = 4^0 and γ =17kN/m^3.
The general ultimate bearing capacity equation is given as;

$$q_{ult} = C_u N_c S_c + \gamma_z D_f N_q S_q + \frac{\gamma B N_\gamma S_\gamma}{2}$$

For ϕ = 4^o, N_c = 1.0, N_q = 1.5 and N_γ = 0.6 and for a square footing S_c = 1.3, S_q = 1.2 and S_γ= 0.8. Hence for a foundation depth (D_f) of 2.0m and a footing width (*B*) of 2.0m, we have

$$q_{ult} = [10x1x1.3] + [17x2.0x2x1.2] + \left[\frac{17x2.0x0.8x0.8}{2}\right]$$

= 105.5 kPa

∴ Considering a factor of safety of 2.5 against shear failure, the allowable bearing pressure may be estimated using the equation;

Q_{all} = Q_{ult} /2.5 kPa = 105.5/2.5 = 42.2 kPa say 40 kPa is assumed, this may be inadequate for the load envisage for a Substation.

6.3 Probable Settlement

Oedometer Consolidation test results gave typical M_v value of 0.32 within the 200 kN/m^2 range (see Appendix C, consolidation plot), considering σ of 150 kN/m^2 and compressible layer thickness of (H_o) 5.0m and applying the equation for final settlement S_f ;

$S_f = M_v \sigma H_o$

= 0.32 m^2/MN x 150 kN/m^2 x 2.0m

= 96.5mm is estimated (say 97m)

On the other hand an average of Mv-value of 0.32 m^2/MN means a predicted uncorrected consolidation settlement of some

0.32 x 2.0 x 0.2 x 1000 = 128mm

would occur. This predicted value could possibly be halved if the effect of preconsolidation is taken into account i.e. 60mm with possibly some 40% of this value being built-out during construction if this construction period were longer than three months. Thus the consolidation settlement which would be experienced by a structure at about 2.0m depth would in all likelihood be

0.6 x 60mm = 36mm. This will be greater with depth

Due to variations in the soil profile, the differential settlement could be about half this value i.e. say 18mm. In a structure of this type a grid column spacing of 5m is typical. Thus a differential settlement of 9mm would induce an angular distortion of 9/5000 i.e. 1: 550. Damage is usually initiated at values of 1: 500 thus the 1: 550 is not acceptable.

6.4 Alternate Deep Foundation Design Recommendations

Pile foundations founded in the underlying weak Shale rock may provide alternative to raft footings even though the machinery may have to be imported. The pile design procedure will depend on the type of pile and the method of installation. A number of pile types can be used in connection with this project. The following pile types are considered;

- Driven piles (precast concrete and steel circular)
- Bored cast in-situ pile
- Caisson/rock socket

Driven Piles (Precast Concrete)

At depths of between 10 – 30m, driven piles do appear to be more attractive than other forms of piling from the point of view of economics, the rate and ease of construction. They have the added advantage of eliminating excavations to great depth, dewatering of holes and possible support to the walls of the excavation, which would be required in the construction of other foundation types especially in the water bearing sands. However, it may or may not be possible to secure pile driving equipment locally and would have to be arranged from abroad. SPT blow count of 70blows/300mm penetration have been used in estimating the bearing capacity of the founding level should this type of foundation be adopted. Allowing for about 1m of cap, pile lengths of the order of 25m would be required. Piles usually penetrate several different soil types, each providing different shaft resistances and the total shaft resistance is the summation of the individual values. The weight of the pile is usually ignored in the above equations, since it is approximately equal to the weight of soil removed or displaced.

Capacity Predition of Piles

The study of driven piles provides to a large extent some empirical values for the base resistance and the skin friction for the different pile systems as a function of the soil strength. Based on comparative statistical analysis of pile load tests on different pile systems, it becomes possible to derive a consistent analysis of bearing behaviour of pile systems, which provides a safe and an economical pile bearing capacity depending on the extend of preliminary soil investigations.

There are two forms of resistance provide by the pile to the applied vertical loads:

- shaft resistance
- base resistance

At failure the ultimate values of both these resistances are mobilized to give:

$$Qu = Qs + Qb$$

Where;

Qu = ultimate pile capacity, Qs = ultimate shaft resistance, Qb = ultimate base resistance,

Ultimate Base Resistance

$$Qb = q_p \times A_p = \text{base bearing capacity} \times \text{area of pile tip}$$

$$= A_p \, q^1 \, N^*q \leq A_p \, q_l$$

Where;

q^1 = effective vertical stress of tip, N^*q = bearing capacity factor,

q_l = (kN/m^2) = limiting point resistance = $50 \, N^*q \tan\varphi$

for homogeneous Sands;

$$q_p \,(kN/m^2) = 40 \, N_{corr} \; L/D < 400 \, N_{corr}$$

for saturated cohesive soil material;

$$(\varphi = 0), \quad q_p = 9 \, C_u \, A_p$$

Ultimate Shaft Resistance

$$Qs = \Sigma \rho \Delta L f$$

Where;

ρ = perimeter of pile section, ΔL = increment in length at constant ρ and f, f = unit frictional resistance at depth d.

Frictional resistance in Sands;

$$f = k \, \sigma_0 \tan \delta$$

where;

earth pressure coefficient which varies with depth of pile, $K \sim 1.0$ to $1.8 \, (1 - \sin\varphi)$,

σ_0 = increase in depth to about L = 15D, σ_0 = 0.5 – 0.8φ and (kN/m²) = 1 to 2 N_{corr}

Frictional Resistance in cohesive soils;

$$f = a\, C_u$$

where; a = empirical adhesion factor, this brings the final equation of pile friction resistance to

$$Qs = \Sigma \rho \Delta L f = \Sigma\, a\, C_u\, \rho \Delta L$$

Comparison of the base resistance against pile system and the bearing capacity was analysed using various pile installation methods, these produced a graph shown below as Figure 5. Driven displacement piles generate a higher base resistance because of the displacement and compaction of the soil below the pile tip while driving the pile. The empirical values for the base resistance in non cohesive soils for driven precast pile sand cast in place simplex piles are similar because the installation method is the same. On the other hand, the shaft resistance of the driven piles is lower than the other pile systems as it can be seen in the figure below. The ratio between the upper and lower empirical values falls approximately between 1.3 and 1.4.

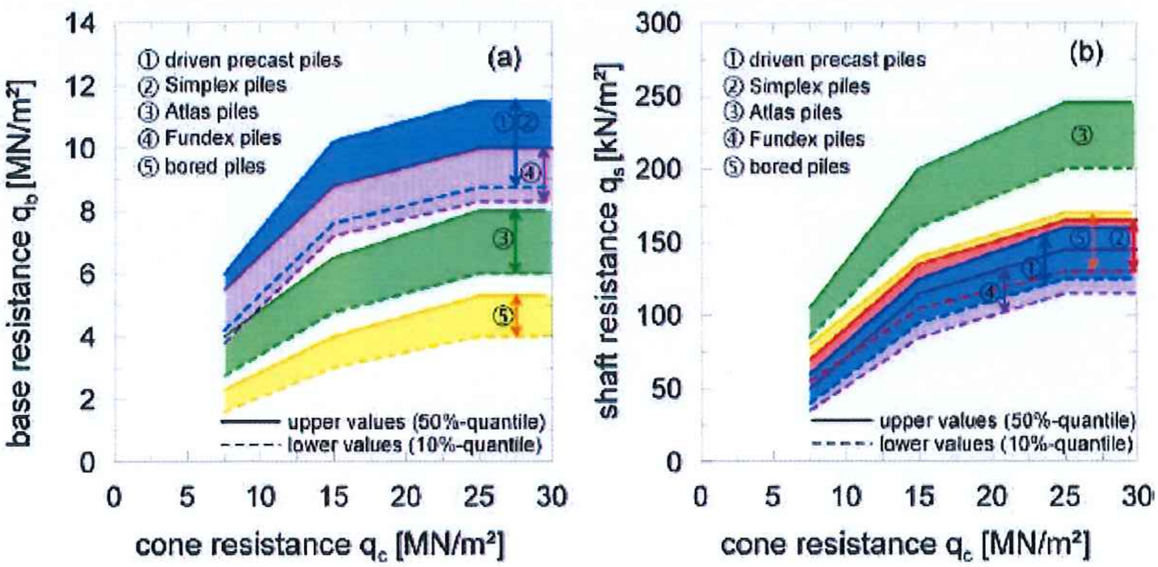


Fig_8

Pile Tests

The weathered and decomposed Shale type rock was cored to a limited depth only during the site investigation. The bearing capacity and load deflection behaviour of piles should therefore be confirmed by static load tests. It is also recommended that at least one working pile be load tested to 1.5 times its working load. It is also recommended that both the raft foundation and piled foundation solutions be fully costed and compared for the most cost effective solution to be adopted.

6.5 Weathered Shale Bedrock

Weak, highly weathered Shale underlie the site and the depth to reasonable sound rock head would not be less than 180m in borehole number_1.
The country rock material encountered could best be described as Very weak, chocolate brown, moderately to highly weathered SHALE with relic structures. Equivalent SPT - N/300mm value of between 25 and 40 were recorded indicating it to be weak - moderately strong. However, a lower presumed bearing stress of 800 kN/m^2 is recommended for design should deep foundations to be placed in Shale rock formation be employed.

6.6 Groundwater Chemistry

The chemical analysis of samples of groundwater indicates that the concentrations of unsaturated sulphate ion, and the pH are beyond the tolerable limits and special precautions need to be applied. The chemicals test results have been presented in Appendix C, it can be inferred from the results that levels of sulphate in groundwater may not be accommodating, the use of Class 1 concrete as recommended in BRE Digest 363 may be required. Concrete cover to reinforcement may be required with a dense concrete mix consistent enough to counteract possible concrete deterioration due to chemical decomposition of Shale rock formation or corrosion from harsh sea breeze at the site. A likely reaction against concrete and steel may be expected, however concrete to be used for construction is expected to have a minimum cement content of 330 kg/m^3 as the maximum free water to cement ratio is put at 0.5 to avoid concrete corrosion.

6.7 Construction Expedients

For a substation of that magnitude with its other infrastructure of light buildings, a foundation depth of about 2.5m (from existing ground surface) is recommended. This depth will be mainly in the less competent clayey SILT/sandy CLAY region (not necessary on the same elevations)

Though soil moisture condition at this depth is expected to vary with climatic conditions, it will not be detrimental to the performance of the more vulnerable light structure that might be erected.

Due to the poor bearing ability of the soil with depth and also to bring the foundation depth to an economic reach , the foundation would be carried to a least depth of 3.2m and it is then expected to be backfill with compacted boulders of about 1.0m thick and a compacted 0.2m thick gravel material at its OMC and 98% MDD (AASHTO – 180) or quarry waste. A raft foundation will now be placed on the 1.2m thick mattress of boulders (400 - 600mm size) and gravel or quarry waste as foundation.

With the above mentioned technique a safe bearing of 300kN/m^2 could be used for design.

7.0 SUMMARY AND RECOMMENDATIONS

7.1 Summary

The preliminary field geotechnical investigations for the proposed Substation on the Graphic road was undertaken between the 30th January and 5th of February, 2014.

The following results were arrived at;

BH1 to BH3 revealed that the soil profile consists of 0.7m – 1.0m thick medium dense clayey GRAVEL with sand deposited fill material. This was underlain by up to 10m layer thick soft grey/yellowish brown clayey SAND with gravel. The later was further underlain by a nearly 5.2m of Soft Sandy CLAY/clayey SILT of decomposed Shale rock formation, this happens to be weathering product of the bedrock, mixed with transported quartzite gravel/pebbles at places. These soils were virtually cemented into concretionary mass by the action of repeated hydration and desiccation of iron oxide also of bedrock origin.

Bedrock was at about 20m deep.

The physical and engineering properties of the soils at the time of the investigation show that they were not capable of accommodating Super structure loads.

The foundations are however expected to be designed to negligible settlement; as such it is therefore proposed that;

- ground improvement techniques may be employed to fortify subsoil before shallow foundations are placed on to reduce overall settlement, improve bearing capacity, and reduce liquefaction potential.

- Vibro Replacement with boulders appears to be a suitable ground improvement option for in-situ soils at the site

- Soils should be improved to achieve a minimum normalized SPT N-value of between 20 – 25

- a conservative raft on boulders support type of foundation is hereby proposed for the substation

- the foundations are expected be carried to a least depths of 3.2m from natural ground level placed over a 1.2m thick compacted mattress of boulders (400 - 600mm size) and gravel or quarry waste

- a gross allowable bearing stress of 300kN/m² could then be used for design if the above technique is adopted

- trench walls must be supported during excavation due to the soft nature of the foundation soils

- the designer has all the options to choose another type of foundation and depth for the project. However, if that happens then below are the in-situ safe bearing pressures he could worked with.

Con

SPT – N values [BH_1]			Average Safe Bearing Capacity (KN/m²)
Depth (m)	N-Values	Safe B.C. (kN/m²)	
0.00	0	0	**0**
1.00	14	155.6579	**156**
2.00	10	111.1842	**111**
3.00	8	88.94737	**89**
4.00	16	177.8947	**178**
5.00	11	122.3026	**122**
6.00	9	100.0658	**100**
7.00	10	111.1842	**111**
8.00	14	155.6579	**156**
9.00	16	177.8947	**178**
10.00	8	88.94737	**89**
11.00	8	88.94737	**89**
12.00	12	133.4211	**133**
13.00	15	166.7763	**167**
14.00	10	111.1842	**111**

GHANA INSTITUTION OF ENGINEERS

Ing. KWEKU M. SOLOMON
(MGhIE)
GEOTECHNICAL ENGINEER
Reg. No. 06006
Date:-

15.00	13	144.5395	**145**
16.00	16	177.8947	**178**
17.00	22	244.6053	**245**
18.00	24	266.8421	**267**
19.00	31	344.6711	**345**
20.00	40	444.7368	**445**

TR

SPT – N Values [BH_2]			**Average Safe Bearing Capacity (KN/m^2)**
Depth (m)	**N-Values**	**Safe B.C. (kN/m^2)**	
0.00	0	0	**0**
1.00	5	55.59211	**56**
2.00	13	144.5395	**145**
3.00	7	77.82895	**78**
4.00	15	166.7763	**167**
5.00	10	111.1842	**111**
6.00	8	88.94737	**89**
7.00	8	88.94737	**89**
8.00	12	133.4211	**133**
9.00	16	177.8947	**178**
10.00	19	211.25	**211**

GIS

SPT – N Values[BH_3]			**Average Safe Bearing Capacity (KN/m^2)**
Depth (m)	**N-Values**	**Safe B.C. (kN/m^2)**	
0.00	0	0	**0**
1.00	7	77.82895	**78**
2.00	11	122.3026	**122**
3.00	7	77.82895	**78**
4.00	14	155.6579	**156**
5.00	9	100.0658	**100**
6.00	10	111.1842	**111**
7.00	7	77.82895	**78**

REFERENCES

Bowles J E,	Foundation Analysis and Design McGraw - Hill Book Company, New York
Bhatia H S,	A Study of Geotechnical Characteristics of Accra Formation, BRRI - Kumasi, Ghana
Dr. A-Neizer et al	Ghana Building Code : Part 3: Structural Loads and Procedures Part 4: Foundations Building & Road Research Institute (BRRI) Kumasi, Ghana

8.00	11	122.3026	**122**
9.00	15	166.7763	**167**
10.00	9	100.0658	**100**

- Base on the soil chemistry, a likely reaction against concrete and steel may be expected, however concrete to be used for construction is expected to have a minimum cement content of 400 kg/m^3 and the maximum free water to cement ratio is put at 0.45 to avoid concrete corrosion. An associated slump test value of 25 – 50mm as limit. The Class 42.5N type cement from GHACEM (Local suppliers using the silicate/gypsum type cement) is suitable to be used, this is likely to generate an expected strength in the domain of C30 (35 – 40N/mm^2). This is however to be confirmed with sufficient concrete mix design using the available material components on site.

7.2 Earthquake Considerations

The coastal area of Ghana including Accra is seismically active and it would be advisable that consideration be given to designing against earthquakes.

The site falls within zone 3 seismicity of Accra. Even though this can be considered stable enough to withstand load, In the absence of any site specific instrumental data, a minimum horizontal ground acceleration of 0.12g may be considered.

Appendix – A

Site Details

Appendix – B

Borehole Logs

Project : Reinforcement of Power Supply to Accra Central | **Borehole No._1**

Date: 30th January 14

Client : JICA | **Location Graphic Road**

Co-ordinate: X.97958.247, Y. 360973.764

Boring Equipment And Method :

Light Cable Tool Percussion Rig . 150mm Dia. Hole
Rotary Coring: Water Fush

Legend	Stratigraphic Description	Depth (m)	Reduced Level (m)	Layer Thickness (m)	Water Level (m)	Core Recov. (%)	R.Q.D. (%)	N'Value	Sample In-Situ Test And Coring Runs – Sample: Depth (m)	Type	No.	Field Records
		0										
		0.1										
		0.2										
	Medium Dense Clayey GRAVEL	0.3										
	With Sand Deposite **[FILL MATERIAL]**	0.4		0.7								
		0.5						10	0.4	D	1	
		0.6										
		0.7										
		0.8										
		0.9										
		1						14	1.0	D	2	
		1.1										
		1.2			▼							
		1.3										
		1.4										
		1.5							1.5	D	3	
		1.6										
		1.7								D	4	
		1.8										
		1.9										
		2							2.0	U	5	
		2.1						10	2.1	D		
		2.2										
		2.3										
		2.4										
		2.5										
		2.6							2.6	D	6	
		2.7										
		2.8										
		2.9										
		3							3.0	U	7	
		3.1						8	3.1	D		
		3.2										
		3.3										
		3.4										
		3.5										
		3.6										
		3.7								D	8	
		3.8										
		3.9										
		4						16	4.0	D	9	
		4.1										
		4.2										
		4.3										
		4.4										

	4.5										
	4.6										
	4.7										
	4.8										
Soft Grey / Yellowish Brown Clayey **SAND** With Some Gravel	4.9										
	5		10.0				11	5.0	D	10	
	5.1										
	5.2										
	5.3										
	5.4										
	5.5										
	5.6										
	5.7										
	5.8										
	5.9										
	6						9	6.0	D	11	
	6.1										
	6.2										
	6.3										
	6.4										
	6.5										
	6.6										
	6.7										
	6.8										
	6.9										
	7						10		D	12	
	7.1										
	7.2										
	7.3										
	7.4										
	7.5										
	7.6										
	7.7										
	7.8										
	7.9										
	8						14		D	13	
	8.1										
	8.2										
	8.3										
	8.4										
	8.5										
	8.6										
	8.7										
	8.8										
	8.9										
	9						16		D	14	
	9.1										
	9.2										
	9.3										
	9.4										
	9.5										
	9.6										
	9.7										
	9.8										
	9.9										
	10						8		D	15	
	10.1										
	10.2										
	10.3										
	10.4										
	10.5										

	10.6										
	10.7										
	10.8										
	10.9										
	11						8		D	16	
	11.1										
	11.2										
	11.3										
	11.4										
	11.5										
	11.6										
	11.7										
	11.8										
	11.9										
	12						12		D	17	
	12.1										
	12.2										
	12.3										
	12.4										
	12.5										
	12.6										
	12.7										
	12.8										
	12.9										
	13						15		D	18	
	13.1										
Soft Sandy **CLAY**/clayey **SILT**	13.2										
of Decomposed Shale Rock formation	13.3		5.2								
	13.4										
	13.5										
	13.6										
	13.7										
	13.8										
	13.9										
	14						10		D	19	
	14.1										
	14.2										
	14.3										
	14.4										
	14.5										
	14.6										
	14.7										
	14.8										
	14.9										
	15						13		D	20	
	15.1										
	15.2										
	15.3										
	15.4										
	15.5										
	15.6										
	15.7										
	15.8										
	15.9										
	16						16		D	21	
	16.1										
	16.2										
	16.3										
	16.4										
	16.5										
	16.6										

Moderatly Strong Highly micaceous quartz Vein **SHALE** Formation	16.7										
	16.8										
	16.9		2.1								
	17						22		D	22	
	17.1										
	17.2										
	17.3										
	17.4										
	17.5										
	17.6										
	17.7										
	17.8										
	17.9										
	18						24		D	23	
Very Weak, Completely To Highly Weathered **SHALE** Formation	18.1										
	18.2										
	18.3										
	18.4										
	18.5										
	18.6										
	18.7										
	18.8										
	18.9										
	19		2.0				31		D	24	
	19.1										
	19.2										
	19.3										
	19.4										
	19.5										
	19.6										
	18.7										
	19.8										
	19.9										
	20						40				

Legend

D - Disturbed Sample Recovery
U - Undisturbed " "
N - Standard Pen. Resistance (SPT)
▼- Water Level

Hole was terminated at 20.0m

T: Total Recovery
S: Solid Core Recovery
RQD Rock Quality Designation

Records Of Borehole - 1

Project : Reinforcement of Power Supply to Accra Central | **Borehole No._2**

Date: 2th February 14

Client : **JICA**

Location **Graphic Road**

Co-ordinate: X.97949.639, Y.360945.141

Boring Equipment And Method :

Light Cable Tool Percussion Rig . 150mm Dia. Hole
Rotary Coring: Water Fush

Legend	Stratigraphic Description	Depth (m)	Reduced Level (m)	Layer Thickness (m)	Water Level (m)	Core Recov. (%)	R.Q.D. (%)	N'Value	Sample In-Situ Test And Coring Runs – Sample: Depth (m)	Type	No.	Field Records
		0										
		0.1										
		0.2										
	Medium Dense Clayey GRAVEL With Sand Deposite **[FILL MATERIAL]**	0.3		0.5								
		0.4								D	1	
		0.5						14	0.5	D	2	
		0.6										
		0.7										
		0.8										
		0.9										
		1						5	1.0	D	3	
		1.1										
		1.2										
		1.3										
		1.4										
		1.5							1.5	D	4	
		1.6										
		1.7										
		1.8			▼							
		1.9										
		2						13	2.0	D	5	
		2.1										
		2.2										
		2.3										
		2.4										
		2.5										
		2.6										
		2.7										
		2.8										
		2.9										
		3							3.0	U	6	
		3.1						7	3.1	D		
		3.2										
		3.3										
		3.4										
		3.5										
		3.6										
		3.7								D	7	
		3.8										
		3.9										
		4						15	4.0	D	8	
		4.1										
		4.2										
		4.3										
		4.4										

	4.5										
	4.6										
	4.7										
	4.8										
Soft Grey / Yellowish Brown Clayey **SAND**	4.9										
With Some Gravel	**5**		8.2				10	5.0	D	9	
	5.1										
	5.2										
	5.3										
	5.4										
	5.5										
	5.6										
	5.7										
	5.8										
	5.9										
	6						8	6.0	D	10	
	6.1										
	6.2										
	6.3										
	6.4										
	6.5										
	6.6										
	6.7										
	6.8										
	6.9										
	7						8		D	11	
	7.1										
	7.2										
	7.3										
	7.4										
	7.5										
	7.6										
	7.7										
	7.8										
	7.9										
	8						12		D	12	
	8.1										
	8.2										
	8.3										
	8.4										
	8.5										
	8.6										
	8.7										
	8.8										
	8.9										
	9						16		D	13	
	9.1										
	9.2										
	9.3										
	9.4										
	9.5										
Soft Sandy **CLAY**/clayey **SILT**	9.6		0.8								
of Decomposed Shale Rock formation	9.7										
	9.8										
	9.9										
	10						19		D	15	

Legend

D - Disturbed Sample Recovery
U - Undisturbed " "
N - Standard Pen. Resistance (SPT)
▼- Water Level

Hole was terminated at 10.0m

T: Total Recovery
S: Solid Core Recovery
RQD Rock Quality Designation

Project : Reinforcement of Power Supply to Accra Central	Borehole No._3
	Date: 5th February 14
Client : JICA	Location Graphic Road
	Co-ordinate: X.97978.938, Y.360951.684

Boring Equipment And Method :

Light Cable Tool Percussion Rig . 150mm Dia. Hole
Rotary Coring: Water Fush

Legend	Stratigraphic Description	Depth (m)	Reduced Level (m)	Layer Thickness (m)	Water Level (m)	Core Recov. (%)	R.Q.D. (%)	N'Value	Sample In-Situ Test And Coring Runs – Sample: Depth (m)	Type	No.	Field Records
	Medium Dense Clayey GRAVEL With Sand Deposite **[FILL MATERIAL]**	0										
		0.1										
		0.2										
		0.3								D	1	
		0.4										
		0.5		1.0				17	0.5	D	2	
		0.6										
		0.7										
		0.8										
		0.9										
		1						7	1.0	D	2	
		1.1										
		1.2										
		1.3										
		1.4										
		1.5							1.5	D	3	
		1.6										
		1.7										
		1.8			▼				1.8	D	4	
		1.9										
		2							2.0	U	5	
		2.1						11	2.1	D		
		2.2										
		2.3										
		2.4										
		2.5										
		2.6							2.6	D	6	
		2.7										
		2.8										
		2.9										
		3						7	3.0	D	7	
		3.1										
		3.2										
		3.3										
		3.4										
		3.5										
		3.6										
		3.7								D	8	
		3.8										
		3.9										
		4						14	4.0	D	9	
		4.1										
		4.2										
		4.3										
		4.4										

	4.5										
	4.6										
	4.7										
	4.8										
Soft Grey / Yellowish Brown Clayey **SAND**	4.9										
With Some Gravel	**5**		**7.8**				9	**5.0**	D	**10**	
	5.1										
	5.2										
	5.3										
	5.4										
	5.5										
	5.6										
	5.7										
	5.8										
	5.9										
	6						10	**6.0**	D	**11**	
	6.1										
	6.2										
	6.3										
	6.4										
	6.5										
	6.6										
	6.7										
	6.8										
	6.9										
	7						7		D	**12**	
	7.1										
	7.2										
	7.3										
	7.4										
	7.5										
	7.6										
	7.7										
	7.8										
	7.9										
	8						11		D	**13**	
	8.1										
	8.2										
	8.3										
	8.4										
	8.5										
	8.6										
	8.7										
	8.8										
	8.9										
	9						15		D	**14**	
	9.1										
	9.2										
Soft Sandy **CLAY**/clayey **SILT**	9.3										
of Decomposed Shale Rock formation	9.4		**1.2**								
	9.5										
	9.6										
	9.7										
	9.8										
	9.9										
	10						9		D	**15**	

Legend

D - Disturbed Sample Recovery

U - Undisturbed " "

N - Standard Pen. Resistance (SPT)

Hole was terminated at 10.0m

T: Total Recovery

S: Solid Core Recovery

	▼- Water Level	RQD Rock Quality Designation
		Records Of Borehole - 3

Appendix – C

Laboratory Test Summary

Mass of Sample after Pretreatment M_p = 23.24 gms.   Particle Density = 2.57 Mg/m^3

BH_1 [Sample ud_5 Depth 2.0m]   Volume of Pipette = 11.48 ml

The % of soil in the original sample shall be calculated from the following equation:

$100 * M_g / M_p$

FINE SIEVING

% of Gravel = **0.47**
(over 2.0mm)

% of Coarse Sand = **1.25**
(2.0 to 0.6mm)

% of Medium Sand = **4.95**
(0.6 to 0.2mm)

% of Fine Sand = **22.46**
(0.2 to 0.06mm)

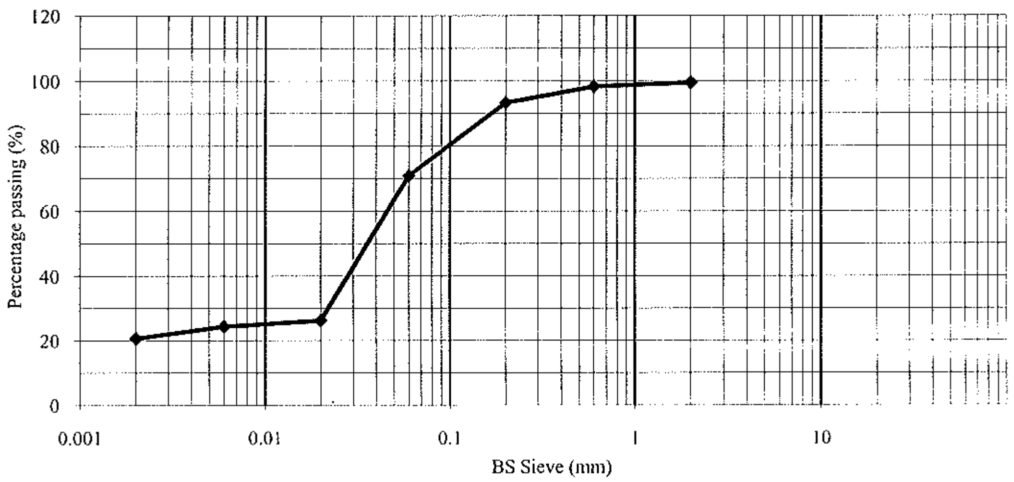
	B.S Sieve mm	Wt. retained
Gravel	2.0	0.11
Coarse Sand	0.6	0.29
Medium Sand	0.212	1.15
Fine Sand	0.063	5.22

% retained	sieve	% passing
0.47	2	99.53
1.25	0.6	98.28
4.95	0.2	93.33
22.46	0.06	70.87
44.63	0.02	26.24
1.87	0.006	24.36
3.75	0.002	20.62
20.62		
100		

SEDIMENTATION

Pipette Sample no. & time	Pipette mass Calculation		Mass in 500ml in suspension $m_1 \times 500/V_p$	Percentage Calculation			Particle Diameter Dmm
1	Bottle + sample	8.98		W_1	14.81		% of Medium Silt
	Bottle	8.64	14.81	W_2	14.37		0.02 to .006mm
	Mass of sample m_1	0.34	W_1	$W_1 - W_2$	0.44	**1.9** %	0.02
2	Bottle + sample	13.35		W_2	14.37		% of Fine Silt
	Bottle	13.02	14.37	W_3	13.50		0.006 to .002mm
	Mass of sample m_2	0.33	W_2	$W_2 - W_3$	0.87	**3.7** %	0.006
3	Bottle + sample	19.47		W_3	13.50		% of Clay
	Bottle	19.16	13.50	W_4	8.71		Less than 0 .002mm
	Mass of sample m_3	0.31	W_3	$W_3 - W_4$	4.79	**20.6** %	0.002
4	Bottle + sample	5.70					
	Bottle	5.50	8.71				
	Mass of sample m_4	0.20	W_4				

% of Coarse Silt = $\frac{M_p - (M_g + M_{cs} + M_{ms} + M_fs + W_1 - W_4) \times 100}{M_p}$ **44.63** %
(.06 to .02mm)



Mass of Sample after Pretreatment M_p = 20.87 gms. Particle Density = 2.57 Mg/m^3

BH_2 [Sample ud_6 Depth 3.0m] Volume of Pipette = 11.48 ml

The % of soil in the original sample shall be calculated from the following equation:

$100 * M_g / M_p$

FINE SIEVING

% of Gravel = (over 2.0mm)	0.62
% of Coarse Sand = (2.0 to 0.6mm)	0.48
% of Medium Sand = (0.6 to 0.2mm)	6.71
% of Fine Sand = (0.2 to 0.06mm)	19.93

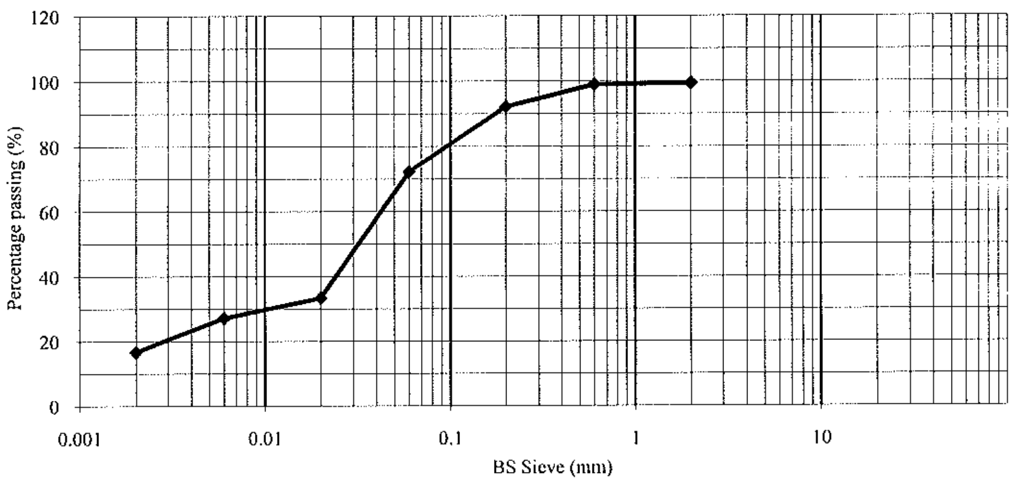
	B.S Sieve mm	Wt. retained
Gravel	2.0	0.13
Coarse Sand	0.6	0.1
Medium Sand	0.212	1.4
Fine Sand	0.063	4.16

% retained	sieve	% passing
0.62	2	99.38
0.48	0.6	98.90
6.71	0.2	92.19
19.93	0.06	72.26
38.87	0.02	33.39
6.26	0.006	27.13
10.43	0.002	16.70
16.70		
100		

SEDIMENTATION

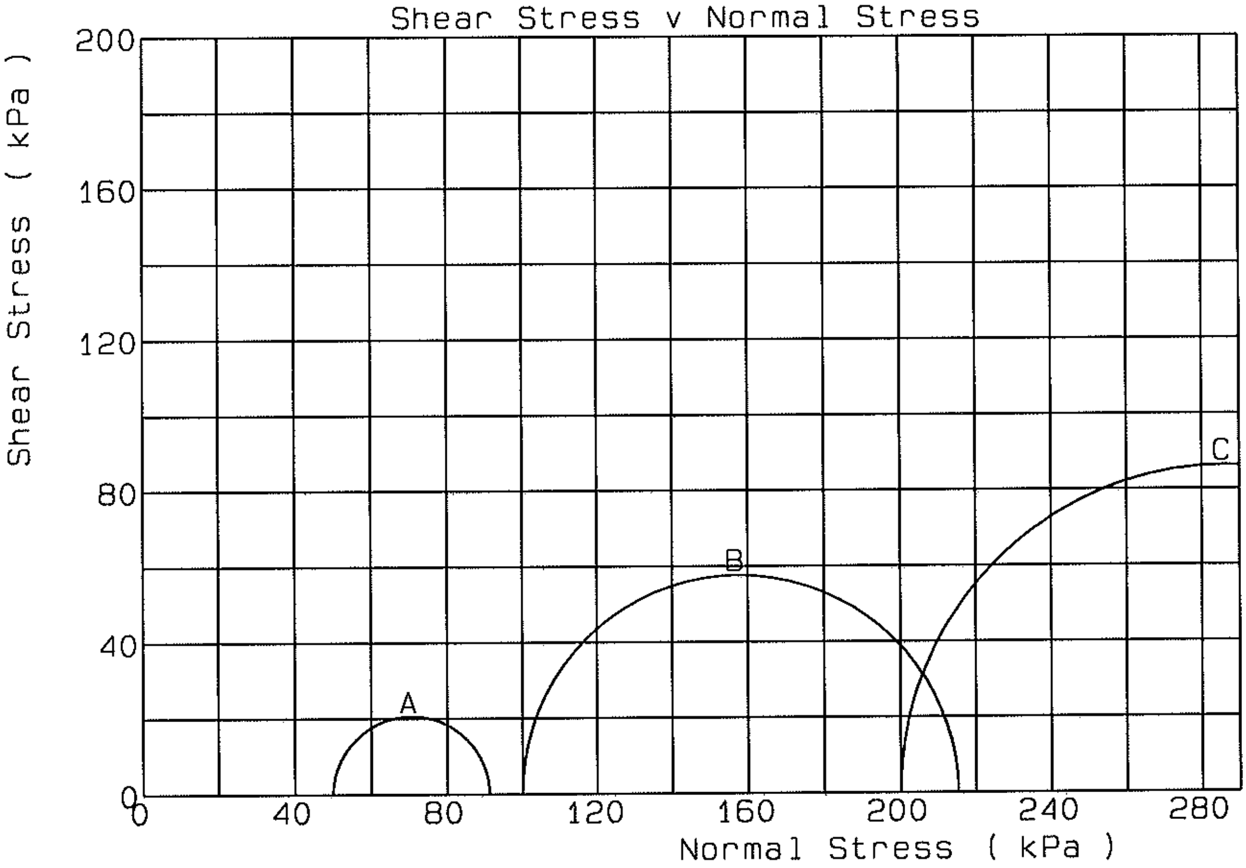
Pipette Sample no. & time	Pipette mass Calculation		Mass in 500ml in suspension $m_1 \times 500/V_p$	Percentage Calculation			Particle Diameter Dmm
1	Bottle + sample	19.19		W_1	15.68		% of Medium Silt
	Bottle	18.83	15.68	W_2	14.37		0.02 to .006mm
	Mass of sample m_1	0.36	W_1	$W_1 - W_2$	1.31	6.3 %	0.02
2	Bottle + sample	36.15		W_2	14.37		% of Fine Silt
	Bottle	35.82	14.37	W_3	12.20		0.006 to .002mm
	Mass of sample m_2	0.33	W_2	$W_2 - W_3$	2.18	10.4 %	0.006
3	Bottle + sample	32.54		W_3	12.20		% of Clay
	Bottle	32.26	12.20	W_4	8.71		Less than 0 .002mm
	Mass of sample m_3	0.28	W_3	$W_3 - W_4$	3.48	16.7 %	0.002
4	Bottle + sample	5.70					
	Bottle	5.50	8.71				
	Mass of sample m_4	0.20	W_4				

% of Coares Silt = (.06 to .02mm) $\frac{M_p - (M_g + M_{cs} + M_{ms} + M_fS + W_1 - W_4) \times 100}{M_p}$ **38.87** %



Job: Accra Power Supply_1 Triaxial Undrained Shear

BoreHole: _#_1 Sample: ud_5 Depth: 2.0m



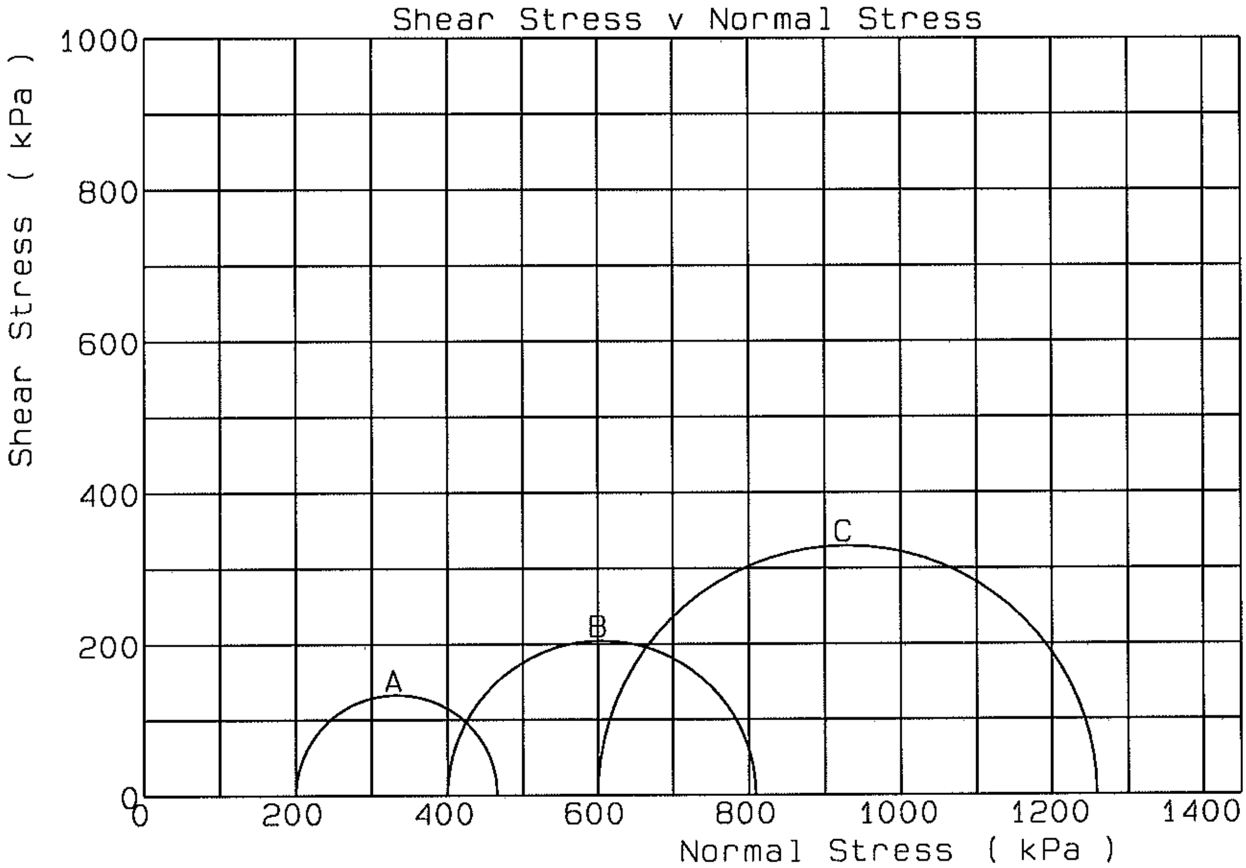
Reference		A	B	C
Height	mm	100.0	100.0	100.0
Diameter	mm	50.0	50.0	50.0
Bulk Density	Mg/cum	1.988	1.988	1.988
Moisture content	%	30.06	32.31	30.11
Dry Density	Mg/cum	1.528	1.502	1.528
Cell pressure	kPa	50	100	200
Loading rate	mm/min	0.900	0.968	0.889
Shear Stress *	kPa	20.6	57.6	86.3
Strain *	%	2.4	5.1	3.5

* At maximum deviator stress

Cohesion (c) 10 kPa

Angle of Shear Resistance (phi) 4 deg

Job: Accra Power Supply. Triaxial Undrained Shear
BoreHole: _#_3 Sample: ud_5 Depth: 2.0m

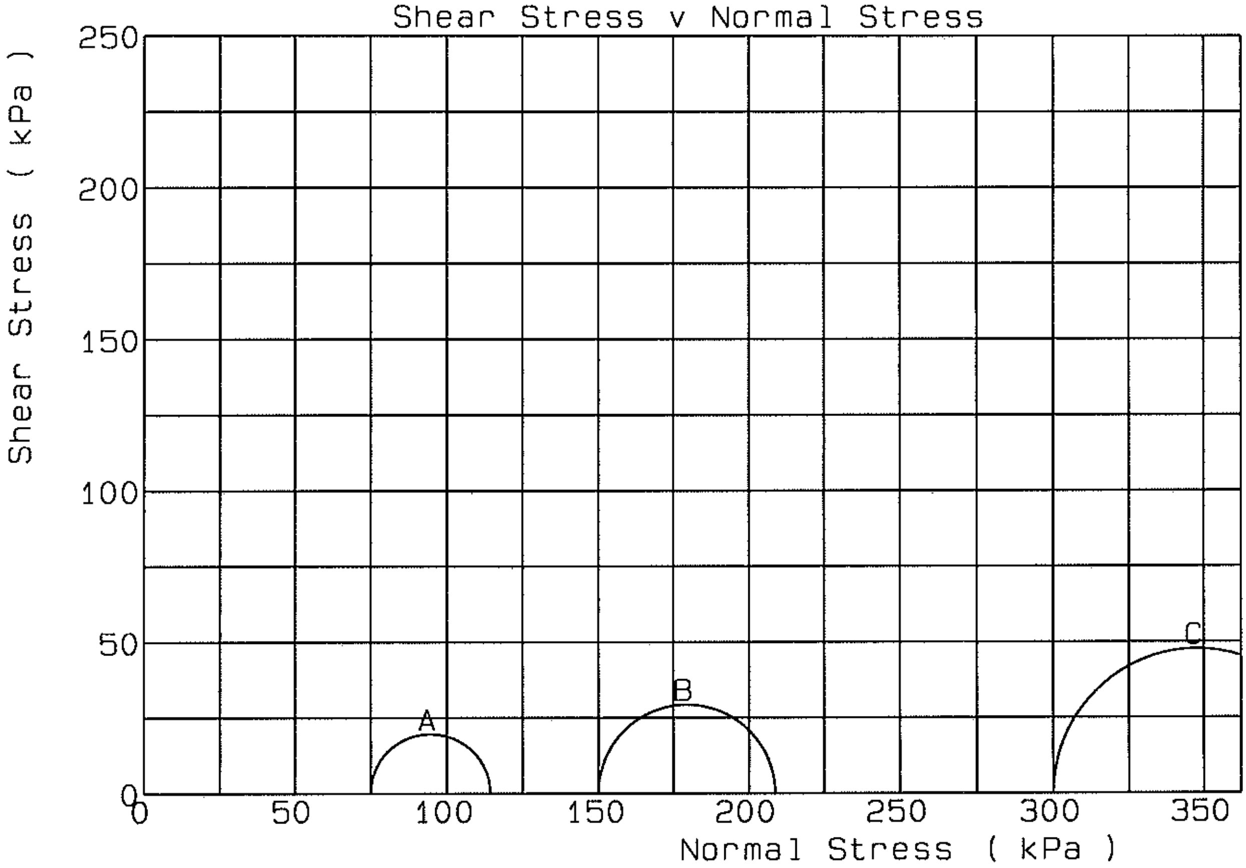


Reference		A	B	C
Height	mm	100.0	100.0	100.0
Diameter	mm	50.0	50.0	50.0
Bulk Density	Mg/cum	1.997	1.997	1.997
Moisture content	%	20.32	20.62	20.62
Dry Density	Mg/cum	1.660	1.656	1.656
Cell pressure	kPa	200	400	600
Loading rate	mm/min	0.910	0.874	0.877
Shear Stress *	kPa	133.2	204.7	329.5
Strain *	%	2.1	5.1	8.2

* At maximum deviator stress

Cohesion (c) 50 kPa
Angle of Shear Resistance (phi) 20 deg

Job: Accra Power Supply- Triaxial Undrained Shear
BoreHole: _#_6 Sample: ud_6 Depth: 3.0m

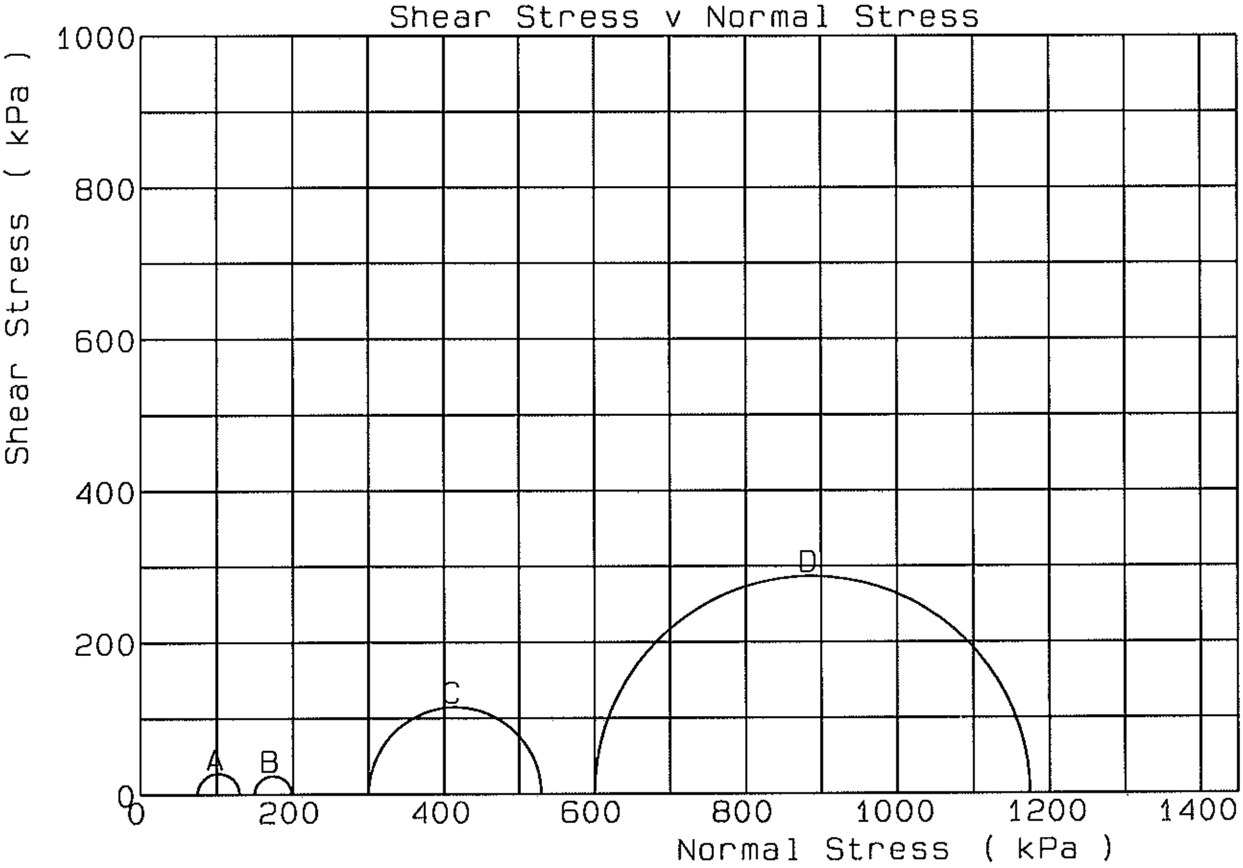


Reference		A	B	C
Height	mm	100.0	100.0	100.0
Diameter	mm	50.0	50.0	50.0
Bulk Density	Mg/cum	2.008	2.008	2.008
Moisture content	%	7.07	7.07	7.07
Dry Density	Mg/cum	1.875	1.875	1.875
Cell pressure	kPa	75	150	300
Loading rate	mm/min	1.017	0.993	0.975
Shear Stress *	kPa	19.7	29.4	47.7
Strain *	%	1.4	2.9	1.5

* At maximum deviator stress

Cohesion (c) 15 kPa
Angle of Shear Resistance (phi) 5 deg

Job: Accra Power Supply_ Triaxial Undrained Shear
BoreHole: _#_1 Sample: ud_7 Depth: 3.0m

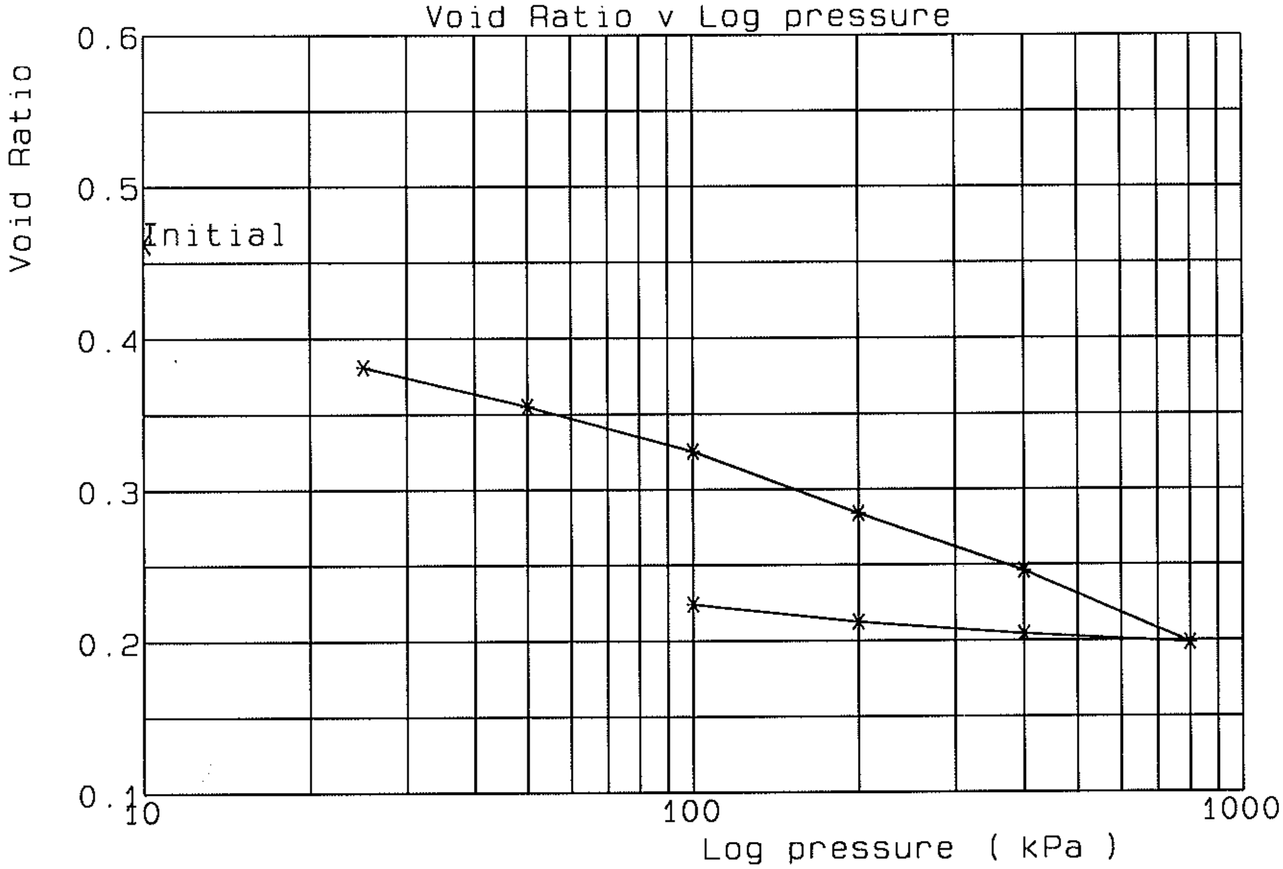


Reference		A	B	C	D
Height	mm	100.0	100.0	100.0	100.0
Diameter	mm	50.0	50.0	50.0	50.0
Bulk Density	Mg/cum	1.789	1.789	1.789	1.789
Moisture content	%	46.39	46.32	45.71	46.33
Dry Density	Mg/cum	1.222	1.223	1.228	1.223
Cell pressure	kPa	75	150	300	600
Loading rate	mm/min	0.968	0.976	0.968	0.966
Shear Stress *	kPa	27.4	24.1	114.5	287.0
Strain *	%	2.4	4.9	10.5	4.9

* At maximum deviator stress

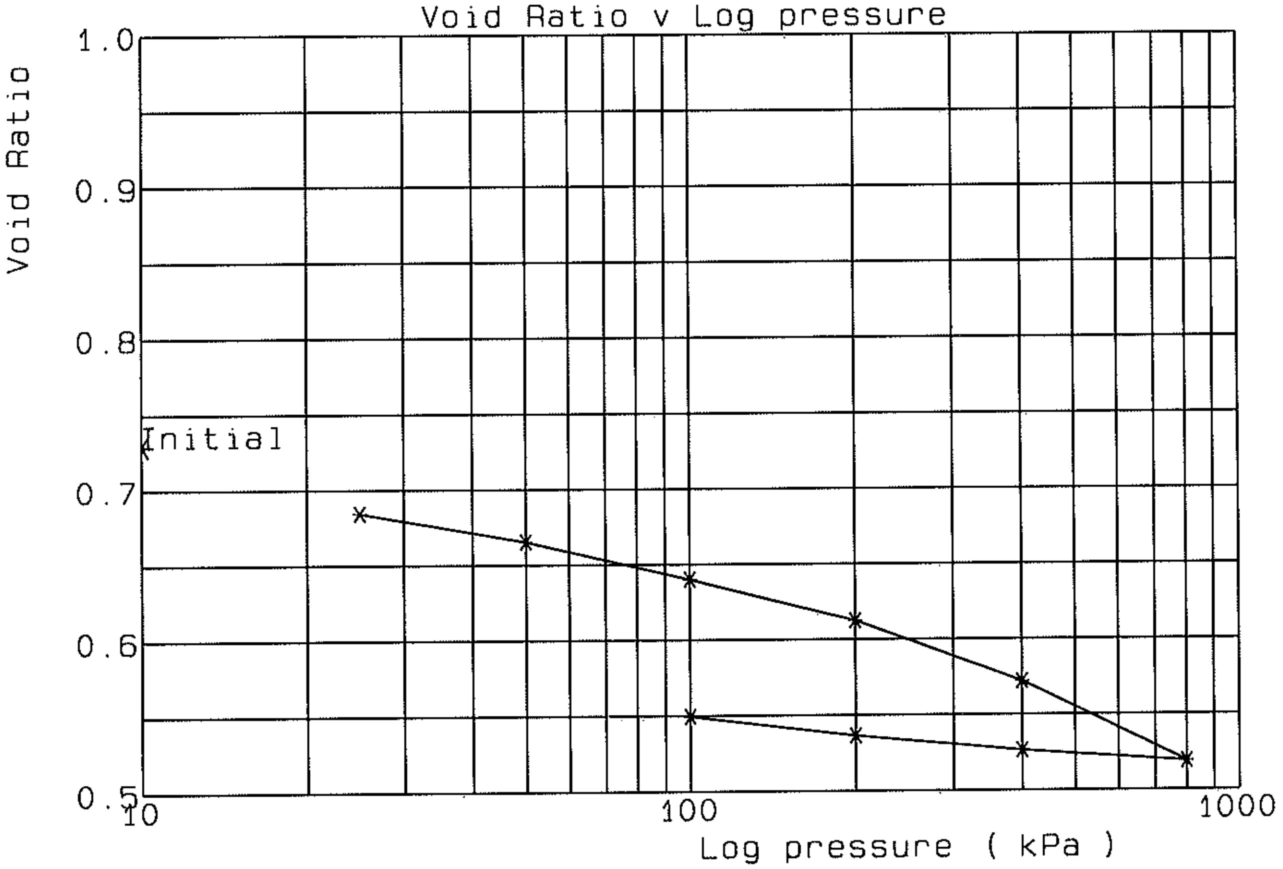
Cohesion (c) 30 kPa
Angle of Shear Resistance (phi) 23 deg

Job: Accra Power Supply* Oedometer Consolidation
BoreHole: _#_1 Sample: ud_5/A Depth: 2.0m



			Pressure kPa	Laboratory Coefficients	
				m_v sqm/MN	c_v sqm/yr
Sample dimensions Initial height 20.00 mm Area 4417.9sq.mm			0		
			25	2.228	17.98
			50	0.725	1.11
			100	0.459	1.80
Particle density (assumed) 2.68			200	0.323	2.40
			400	0.320	2.52
	Initial Values	Final Values	800	0.095	1.33
			400	0.012	6.37
Moisture Content %	12.1	17.4	200	0.029	0.79
			100	0.079	0.20
Bulk Density Mg/cum	2.05	2.57			
Dry Density Mg/cum	1.83	2.19			
Void Ratio e	0.462	0.224			
Saturation%	70.2	208.1			

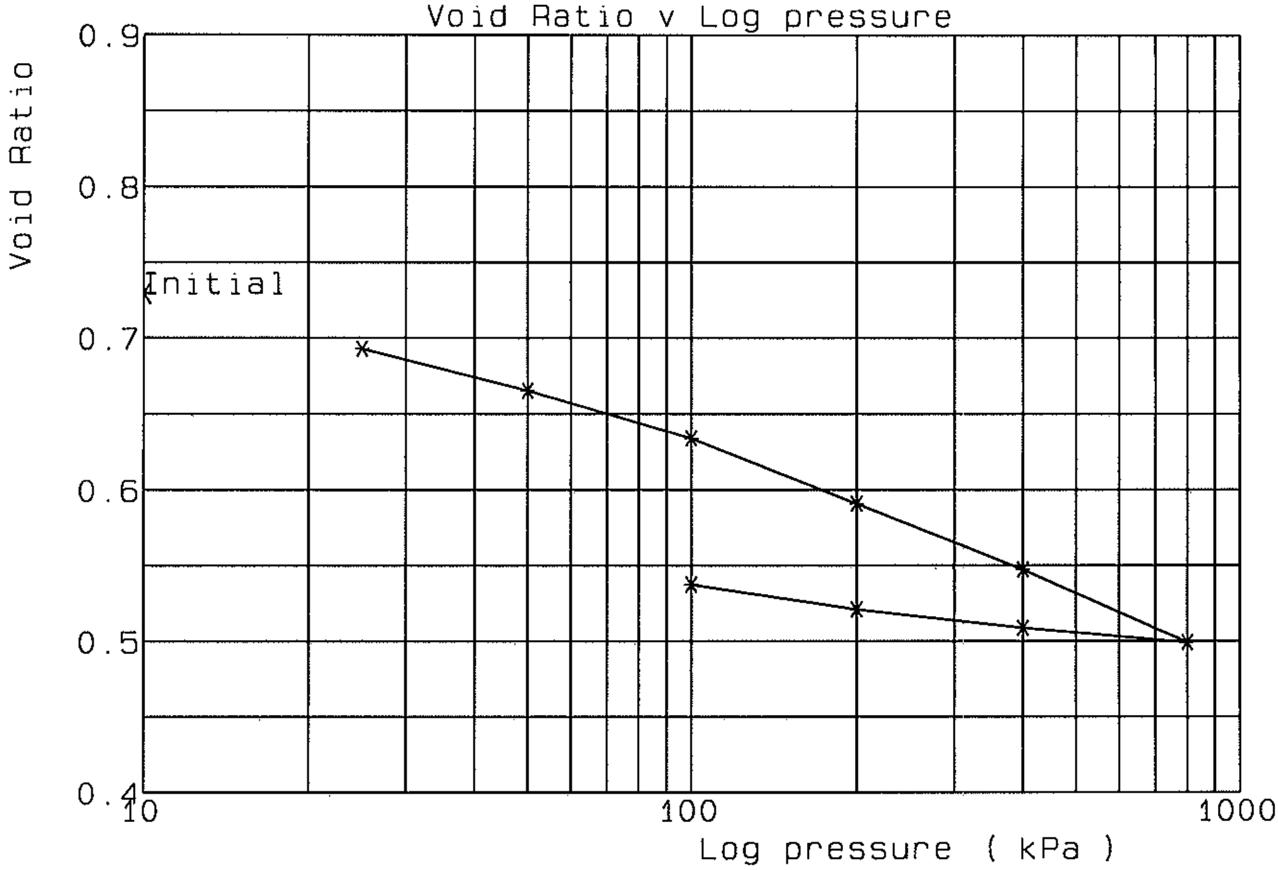
Job: Accra Power Supply.. Oedometer Consolidation
BoreHole: _#_2 Sample: ud_6/A Depth: 3.0m



			Pressure kPa	Laboratory Coefficients	
				m_v sqm/MN	c_v sqm/yr
Sample dimensions Initial height 20.00 mm Area 4417.9sq.mm			0		
			25	0.939	1.45
			50	0.545	7.23
			100	0.311	1.25
Particle density (assumed) 2.78			200	0.172	0.97
			400	0.126	1.11
	Initial Values	Final Values	800	0.086	0.98
			400	0.012	0.86
Moisture Content %	16.4	21.9	200	0.029	4.67
			100	0.073	0.81
Bulk Density Mg/cum	1.87	2.19			
Dry Density Mg/cum	1.61	1.79			
Void Ratio e	0.729	0.550			
Saturation%	62.5	110.8			

Job: Accra Power Supply. Oedometer Consolidation

BoreHole: _#_1 Sample: ud_7/A Depth: 3.0m



Sample dimensions

Initial height 20.00 mm

Area 4417.9sq.mm

Particle density (assumed) 2.68

	Initial Values	Final Values
Moisture Content %	10.9	21.9
Bulk Density Mg/cum	1.72	2.13
Dry Density Mg/cum	1.55	1.74
Void Ratio e	0.729	0.537
Saturation%	40.2	109.4

Pressure kPa	Laboratory Coefficients m_v sqm/MN	c_v sqm/yr
0	0.843	
25	0.739	6.59
50	0.392	6.75
100	0.264	7.34
200	0.139	10.51
400	0.077	24.79
800	0.016	
400	0.034	25.04
200	0.090	2.70
100		

Appendix – D

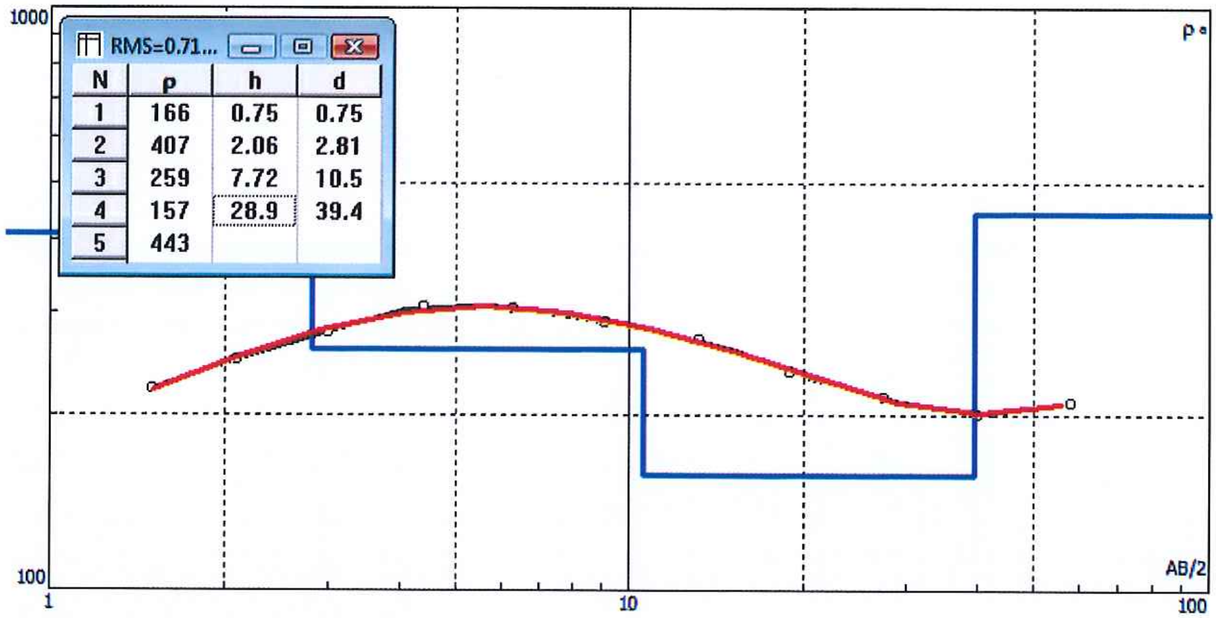
Geophysical Test Data

VES measurement data at points investigated

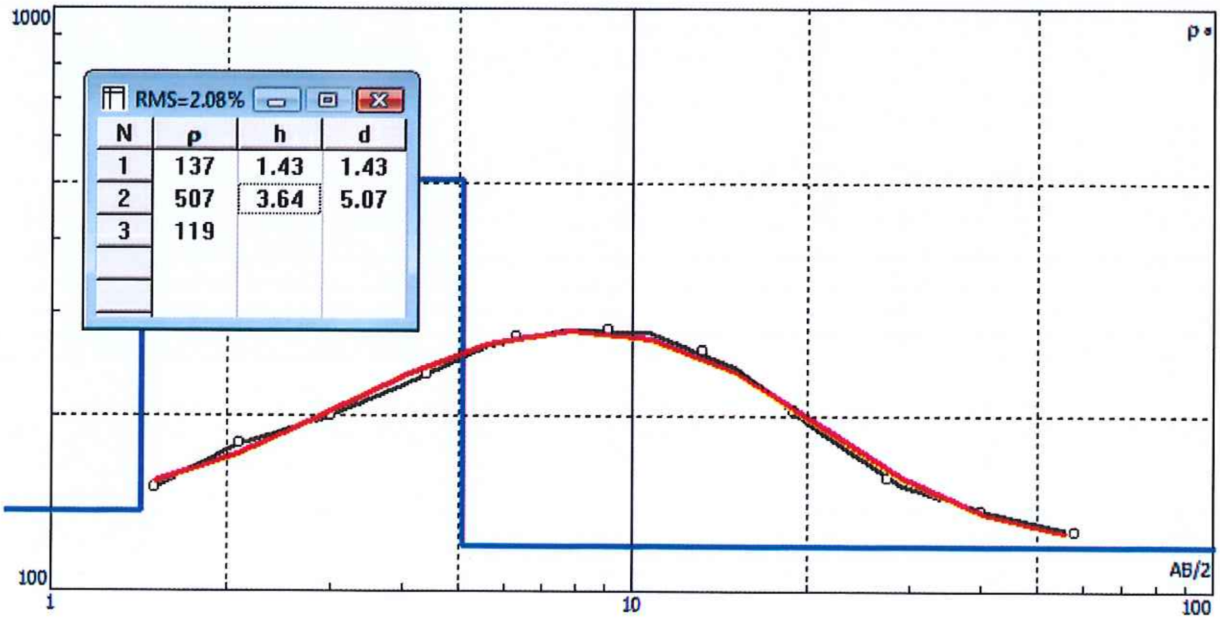
Community: Date:

District: Measured by:

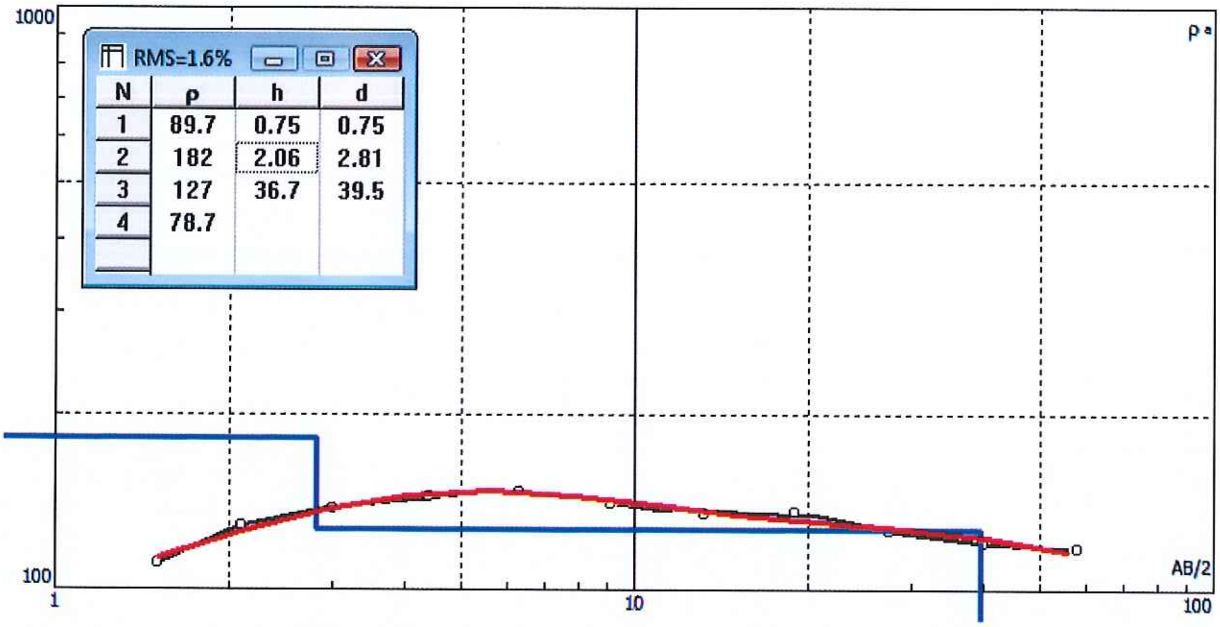
L/2 (m)	a/2 (m)	Resistance (Ω)			Multiplying Factor	Apparent Resistivity (Ω-m)		
		BH1	BH2	BH3		BH1	BH2	BH3
1.5	0.5	35.210	23.930	16.010	6.3	221.8	150.8	100.9
2.1	0.5	19.010	13.680	9.840	13.1	249.0	179.2	128.9
3.0	0.5	9.270	7.280	5.020	27.5	254.9	200.2	138.1
4.4	0.5	5.140	3.010	2.410	60.0	308.4	180.6	144.6
6.3	0.5	2.460	2.200	1.320	124.0	305.0	272.8	163.7
9.1	0.5	1.120	1.100	0.510	259.0	290.1	284.9	132.1
13.2	0.5	0.530	0.500	0.240	547.0	289.9	273.5	131.3
13.2	5.0	6.167	5.818	2.792	47.0	289.9	273.4	131.2
19.0	0.5	0.210	0.180	0.120	1133.0	237.9	203.9	136.0
19.0	5.0	2.243	1.923	1.281	106.0	237.8	203.8	135.8
27.5	0.5	0.090	0.062	0.042	2375.0	213.8	147.3	99.8
27.5	5.0	0.928	0.639	0.432	230.0	213.5	147.0	99.5
40.0	0.5	0.040	0.028	0.020	5026.0	201.0	140.7	100.5
40.0	5.0	0.405	0.283	0.202	495.0	200.4	140.1	99.9
58.0	5.0	0.220	0.160	0.110	1049.0	230.8	167.8	115.4
58.0	25.0	1.341	0.975	0.670	172.0	230.6	167.6	115.2



Analyzed VES curve for point BH1



Analyzed VES curve for point BH2



Analyzed VES curve for point BH3