THE CONSORTIUM AGENCIES IN SIERRA LEONE

(OXFAM, ACF & GOAL)

REPORT ON HYDROGEOPHYSICAL INVESTIGATION OF TEN (10) SITES CARRIED OUT AT FREETOWN,

SIERRA LEONE

BY

FATIGEN DRILLING (SL) LTD

CONTACT: NO 80, MAKIEU STREET,

GBONDO TOWN, BO SIERRA LEONE,

Phone Nos: (+232) 781311115 & (+234) 8080321931

Email: fatigendrillingsl@gmail.com

Website: www.waterforthepeople.info

Skype : Fatigen

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1. Introduction

Fatigen Drilling (SL) Ltd was commissioned by the Oxfam Consortium, Sierra Leone, to drill water supply boreholes at ten sites in Freetown, Sierra Leone. The geology of the Freetown area is complex, comprising crystalline intrusive rocks overlain in parts by sedimentary rocks. Groundwater occurs in small discrete pockets in the crystalline rocks which can only be located by hydrogeophysical techniques and in particular layers in the sedimentary rocks. For this reason Fatigen carried out hydrogeophysical surveys at the nominated sites in order to ascertain the groundwater potentials of the areas and where feasible, locate the optimum sites for groundwater development by borehole drilling. The survey was carried out in June 2014. This report presents the work carried out and the recommendations for drilling.

2. Methodology

The methodology followed the standard technique for siting of boreholes comprising the following sequence:

- Remote sensing
- Hydrogeological field surveys
- Geophysical survey

It comprised both desk study and field work.

2.1 Desk study

Existing literature on the geology, land forms and water resources of the project area was collated as well as reports on previous drilling and borehole records proximal to the project sites. The following reports and sources were consulted:

- S.W. Morel (1976) The Geology and Mineral Resources of Sierra Leone
- Mustapha Thomas (2013).Hydrogeological Overview of Sierra Leone
- The 1;2,000,000 Geological Map of Sierra Leone
- Google Earth Image of Freetown
- Miscellaneous borehole records by Fatigen

The information derived was used to describe the physiography of the project area.

2.2 Field work

The field work involved a geological reconnaissance of the project sites to identify the rock types underlying the project sites, their structural disposition, weathering patterns and products and their water bearing potential.

Existing water supplies and mode of abstraction in the project sites were noted. The depth of wells and boreholes and static water levels were measured.

The geological reconnaissance was followed by geophysical survey. The targets of the geophysical survey were the most favourable areas in terms of geology i.e.

- joints and faults in the crystalline rocks
- areas of deep weathering
- deep sedimentary layers where suspected

The vertical electrical sounding (VES) technique was used. The goal of the resistivity survey was to image the surface resistivity distribution which should closely correlate with the sub surface geology. The data collected were analysed in the field and those areas suitable for drilling identified.

3. Location and accessibility

All the nominated sites are in the northern part of the Freetown peninsula. Although the elevations are low, ranging from 22m above sea level at Murray town to 79 m at Alpha lane the sites are actually on steeply sloping ground. The sites are also in built up areas which limited the access and spread of the geophysical arrays. The areas are however accessible to light and heavy duty equipment. Figure 1 shows the locations on a Google earth image.

4. Geology and groundwater occurrence

Groundwater occurrence relates to the geology. The sites are underlain by the layered funnel shaped intrusion of gabbroic rocks, comprising mostly olivine gabbro and anorthosite. Dolerite dykes are also common. It is also suspected that some of the sites might be underlain partially by sedimentary rocks as they are close to the contact zone between the Bullom Group of sediments and the Freetown intrusions.

Figure 1 Location of the nominated sites on Google Earth Image

4.1 Crystalline aquifers

The crystalline rocks generally have no primary porosity and therefore no permeability. Groundwater is only to be found where secondary porosity has developed in the unconsolidated overburden created by weathering and/or joints in the rock. The amount of fracturing in the rocks is low overall. The intrusive gabbros underlying of Freetown peninsula are weathered and jointed and do yield some water in the lower grounds. The dolerite dykes where fractured tend to provide water but otherwise the weathered product tends to be clayey and are rather poor aquifers.

Several of the hand dug wells and handpump fitted boreholes in the country derive their water from the weathered overburden. Yields are of the order of 1 – 5 m^3/hour, although a borehole recently drilled in Freetown was reported to give a yield of 10 m^3/hour. Borehole depths are on average 35 m and maximum 60 m deep.

4.2 Sedimentary aquifers

The sedimentary rocks of the Bullom Group have sandy horizons which constitute both confined and unconfined aquifers. Yields of up to 20 m^3/hour have been recorded from boreholes drilled into the Bullom sands. Drilling depth is of the order of 46 m to 80 m. A major problem with the aquifers is the possibility of saline water in the coastal areas. Care has to be taken to ensure that the pumping is regulated to prevent the reversal of flow and saline intrusion into the borehole. However there is no definitive evidence that there are major sedimentary deposits on the sites.

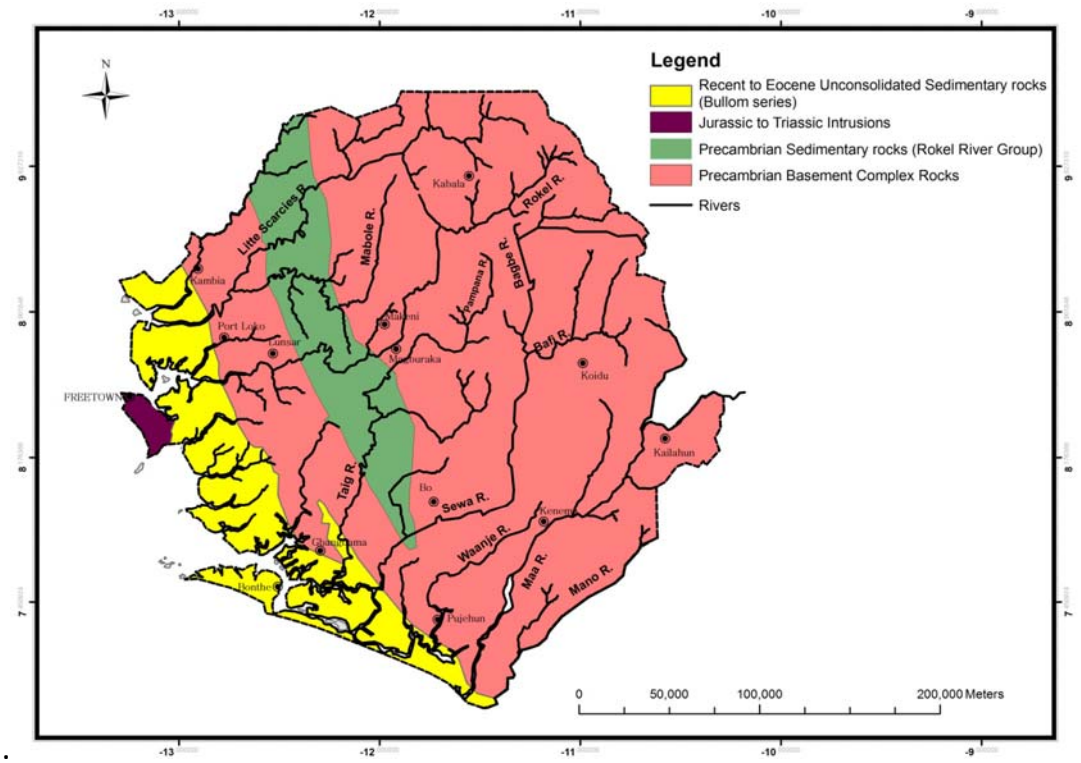


Figure 2 A generalized geological map of Sierra Leone

5. Geophysical Survey

5.1 General description

The vertical electrical soundings (VESs) were conducted using the Schlumberger electrode array with the Omega resistivity meter. AB/2 was 150 m but several times there was not enough access to get the array up to 150 m.

In the resistivity sounding an electric current is passed into the ground through two electrodes, and the resulting potential difference is measured across two more electrodes: the ratio of the potential difference to the current is displayed by the meter as resistivity. The electrodes are arranged in a straight line, symmetrically around a centre point. The electrode spacing is progressively increased, keeping the centre point of the electrode array fixed. At small electrode spacing, the apparent resistivity is nearly the resistivity of the surface material but as the current electrode spacing increases, the current penetrates deeper within the ground and so the apparent resistivity reflects the resistivity of the deeper layers as well.

The data were analyzed in the field and where there was too much scatter in the plotted data the VES was repeated. The GPS reading of each VES were recorded on the VES summary sheets.

5.2 Geophysical Interpretation

The data collected were interpreted using 1D resistivity inversion software that interprets one dimensional electrical resistivity sounding data and produced a layered resistivity model that reveals the subsurface geology.

The interpreted VES curves are presented in the appendix and a summary of the interpretation provided in table 1. Interpreting the VES data was a bit of a challenge as there are not enough available drilling data around Freetown with which to correlate the geophysical data except from Fatigen's previous drilling experience. This will improve as more data accrue into the government's central borehole database. The VESs give in general a 4 layer configuration although interpreted as 5 layers. The first two layers to a depth of 4 or 5 m are rather thin representing top soil/lateritic clay. The top layer usually gives high resistivity values. The underlying layer gives relatively lower values, as the moisture level increases. The penultimate layer gives a much lower resistivity (<400 ohm.m). The last layer gives a high value representing depth of non water bearing, fresh crystalline gabbro. There are cases where much lower resistivity is below the high resistivity which might have been caused by spheroidal weathering. Figure 3 gives a range of resistivity values for different rock materials. The interpretations of the VES points are shown in the table below:

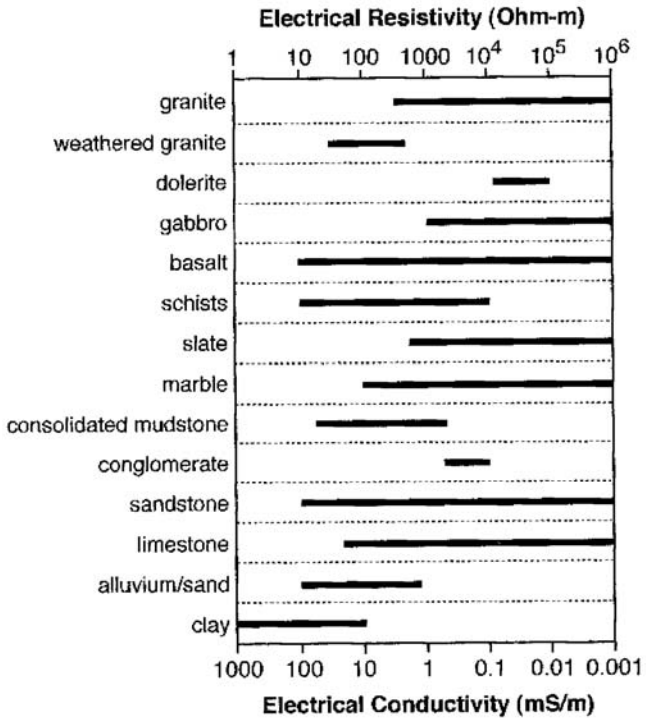


Figure 3 Rock resistivity values (Source: Macdonald, et al 2005)

Table 1: Vertical electric sounding interpretation

Thunder Hill P1 (N08.464470°, W013.188330°)					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	142.91	1.658	1.`658	Topsoil	
2	104.98	3.721	5.380	Slightly Weathered gabbro	
3	163.76	10.601	15.981	Hard gabro	
4	721.99	Infinity	Infinity	Fresh gabbro	
Thunder Hill P2					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	200.5	1.093	1.093	Topsoil	
2	95.90	2.056	3.150	Sandy Clay	
3	1289.49	6.330	9.480	Hard gabbro	
4	1098.91	17.147	26.628	Hard gabbro	

5	369.28	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous

Thunder Hill P3

Layers	Resistivity(Ohm-m)	Thickness(m)	Bottom Depth(m)	Inferred Litho strata	Remarks
1	222.63	1.166	1.166	Lateritic Soil	
2	67.91	2.774	3.940	Sandy Clay	
3	4052.46	11.953	15.893	Hard basement	
4	655.62	Infinity	Infinity	Weathered basement	Possibly aquiferrous

Murray Town Army Municipal School P1 (N08.490081^{o}, W13.269320^{o})

Layers	Resistivity(Ohm-m)	Thickness(m)	Bottom Depth(m)	Inferred Litho strata	Remarks
1	139.95	1.782	1.782	Top soil	
2	159.02	0.112	1.894	Top soil	
3	786.90	32.343	34.237	Gabbro	
4	3072.41	14.645	48.882	Fresh gabbro	
5	3072.41	Infinity	Infinity	Fresh gabbro	

Murray Town Army Municipal School P2 (N8.49028^{o}, W13.269380^{o})

Layers	Resistivity(Ohm-m)	Thickness(m)	Bottom Depth(m)	Inferred Litho strata	Remarks
1	439.79	1.850	1.850	Top lateritic soil	
2	294.46	5.599	7.449	Gabbro	
3	112.77	19.289	26.738	Weathered gabbro	Possibly aquiferrous
4	254.14	Infinity	Infinity	Fresh gabbro	Hard basement

Market SQ P1

Layers	Resistivity(Ohm-m)	Thickness(m)	Bottom Depth(m)	Inferred Litho strata	Remarks
1	253.26	1.66	1.66	Top lateritic soil	
2	220.60	2.770	4.430	Lateritic soil	
3	47.80	9.389	13.818	Weathered gabbro	Possibly aquiferrous
4	144.55	Infinity	Infinity	Fresh Gabbro	Gabbro

Palmer Street P1 (N08.449189^{o}, W13.162996^{o})

Layers	Resistivity(Ohm-m)	Thickness(m)	Bottom Depth(m)	Inferred Litho strata	Remarks
1	116.99	1.207	1.207	Top lateritic soil	
2	972.68	2.704	3.911	Gabbro	
3	389.78	12.546	16.457	Slightly weathered gabbro	
4	137.87	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous
Quarry East P1 (N08.481668°, W13.216241°)					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	165.54	0.965	0.965	Top lateritic soil	
2	85.77	1.730	2.694	Sandy clay	
3	77.00	6.799	9.494	Sandy Clay	
4	604.18	39.491	48.985	Fresh gabbro	
5	126.29	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous
Quarry East P2 (N08.28892°, W13.12912°) ELEV 101m					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	15.94	0.573	0.573	Top soil	
2	53552.22	0.070	0.643	Lateritic Soil	
3	26909.47	6.036	6.679	Lateritic Soil	
4	88.19	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous
Quarry East P3 (N08.28855°, W13.12876°) ELEV 103					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	147.32	1.667	1.667	Top soil	
2	393.73	2.414	4.081	Lateritic soil	
3	257.81	4.123	8.204	Gabbro	
4	135.82	11.634	19.837	Weathered gabbro	Possibly aquiferrous
5	54193.06	Infinity	Infinity	Fresh basement	
33 Mommah Lane P1 (N08.446386°, W13.159051°)					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**

1	78.52	1.246	1.246	Top soil	
2	776.74	3.146	4.392	Granitic Soil	
3	274.4	5.958	10.349	Slightly weathered gabbro	Possibly aquiferrous
4	121.12	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous
Peter Lane P1 (N08.453470°, W13.168718°)					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	328.12	1.094	1.094	Top soil	
2	2561.03	1.845	2.939	Indurated laterite	
3	910.41	2.283	5.222	Slightly weathered gabbro	
4	58.90	8.706	13.928	Weathered gabbro?	Possibly aquiferrous
5	213.82	Infinity	Infinity	Slightly weathered gabbro	
Alpha Lane P1 (N08.954184°, W13.172600°)					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	165.58	1.839	1.839	Top soil	
2	54.85	1.559	1.559	Sandy Clay	
3	20.29	8.241	8.241	Clay	
4	64.78	Infinity	Infinity	Sandy Clay	
No. 30 Old Warf P1 (N08.444678°, W13.158315°)					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	45.14	3.706	3.706	Top soil	
2	303.39	27.837	31.543	Lateritic soil	
3	53.39	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous
Grass field Market P1					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	268.82	1.057	1.057	Top soil	
2	1922.25	2.749	3.806	Granitic soil	
3	521.87	15.391	19.196	Weathered gabbro	Possibly

					aquiferrous
4	12.02	Infinity	Infinity	Clay	
Grassfield Market P2					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(m)**	**Inferred Litho strata**	**Remarks**
1	123.70	0.936	0.936	Top soil	
2	1814.38	1.696	2.633	Indurated laterite	
3	706.28	1.849	4.482	Indurated laterite	
4	427.65	25.436	29.918	Slightly weathered gabbro	
5	239.01	Infinity	Infinity	Weathered gabbro	Possibly aquiferrous
Murray Town Army PHU P1 (N08.488892^{o}, W013.266298^{o})					
Layers	**Resistivity(Ohm-m)**	**Thickness(m)**	**Bottom Depth(M)**	**Inferred Litho strata**	**Remarks**
1	174.98	3.176	3.176	Top soil	
2	36.26	3.819	6.995	Sandy Clay	
3	595.05	8.988	15.984	Granitic rock	
4	85.53	Infinity	Infinity	Fractured basement?	Possibly aquiferrous

6. Table Summary of Sites Surveyed

S/N	LOCATION	CLIENT	NO. OF VES POINT(S) SURVEYED	COMMENT
1	Thunder Hill	Oxfam	3	P2 Recommended for Drilling
2	Army Municipal School	Oxfam	3	P2 Recommended for drilling
3	Murray Town Army PHU	Oxfam	1	Not feasible for drilling and replaced with Grassfield
4	Grassfield Market	Oxfam	2	P2 Recommended for drilling
5	Quarry East	GOAL	3	P3 Recommended for drilling

6	Market square	ACF	1	P1 recommended for drilling
7	Palmer Street	ACF	1	P1 recommended for drilling
8	Mommah Lane	ACF	1	P1 recommended for drilling
9	Peter Lane	ACF	1	P1 recommended for drilling
10	Alpha Lane	ACF	1	P1 recommended for drilling
11	Bando Lane	ACF	1	Not feasible and replaced with No. 30 Old Wharf Road
12	No. 30 Old Warf Road	ACF	1	P1 recommended for drilling

7. Conclusion and Recommendation

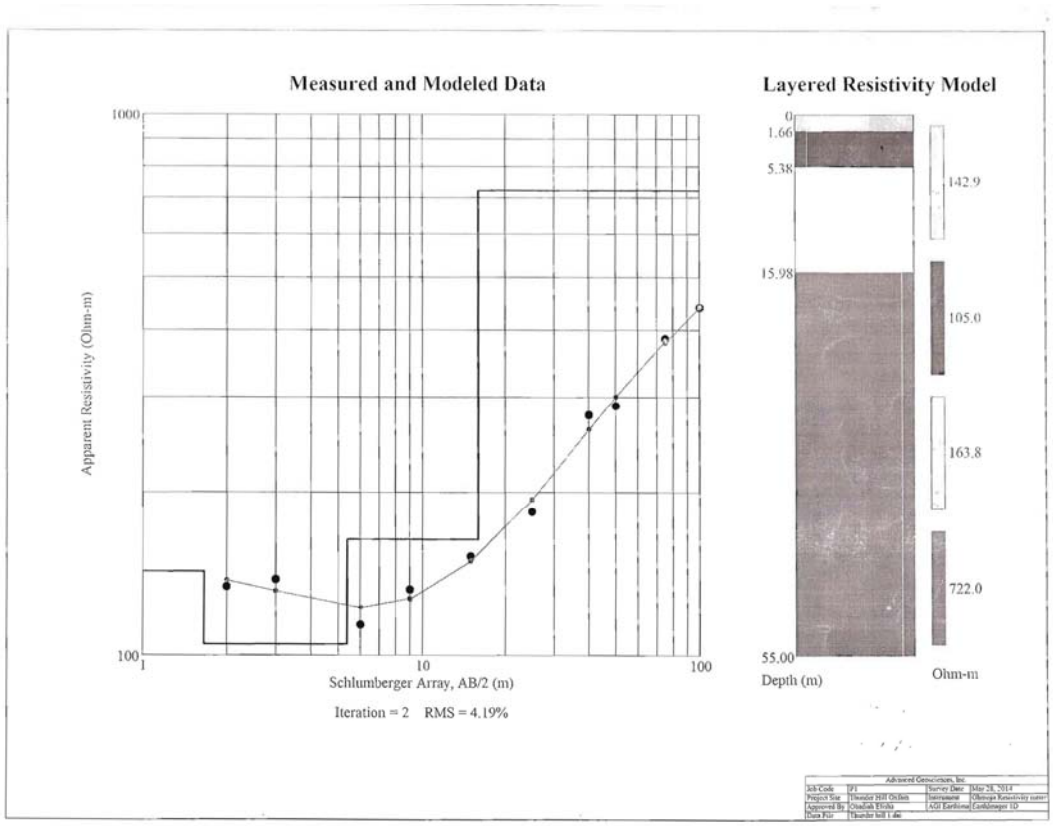
Vertical electric soundings were carried out in all the locations and their interpretations displayed various geo electric layers as Lateritic soil, weathered/fractured and fresh gabbros. Recommended VES points for drilling, probable drilling depth and groundwater potential are presented in table 2.

Interpreting the VES data was a bit of a challenge as there are not enough available drilling data around Freetown with which to correlate the geophysical data except from Fatigen's previous drilling experience. This will improve as more data accrue into the government's central borehole database.

S/N	Communities	Client	Recommend-ed VES point	Probable drilling depth(m)	Groundwater potential
1	Thunder Hill	Oxfam	P2	35	Fair
2	Army Municipal School	Oxfam	P2	30	Good
3	Market square	ACF	P1	25	Moderate
4	Palmer Street	ACF	P1	30-35	Fair
5	Quarry East	GOAL	P3	30	Fair
6	Mommah Lane	ACF	P1	30	Fair
7	Peter Lane	ACF	P1	25-30	Fair
8	Alpha Lane	ACF	P1	30	Fair
9	No. 30 Old Warf Road	ACF	P1	40-45	Fair
10	Grassfield Market	Oxfam	P2	30-35	High

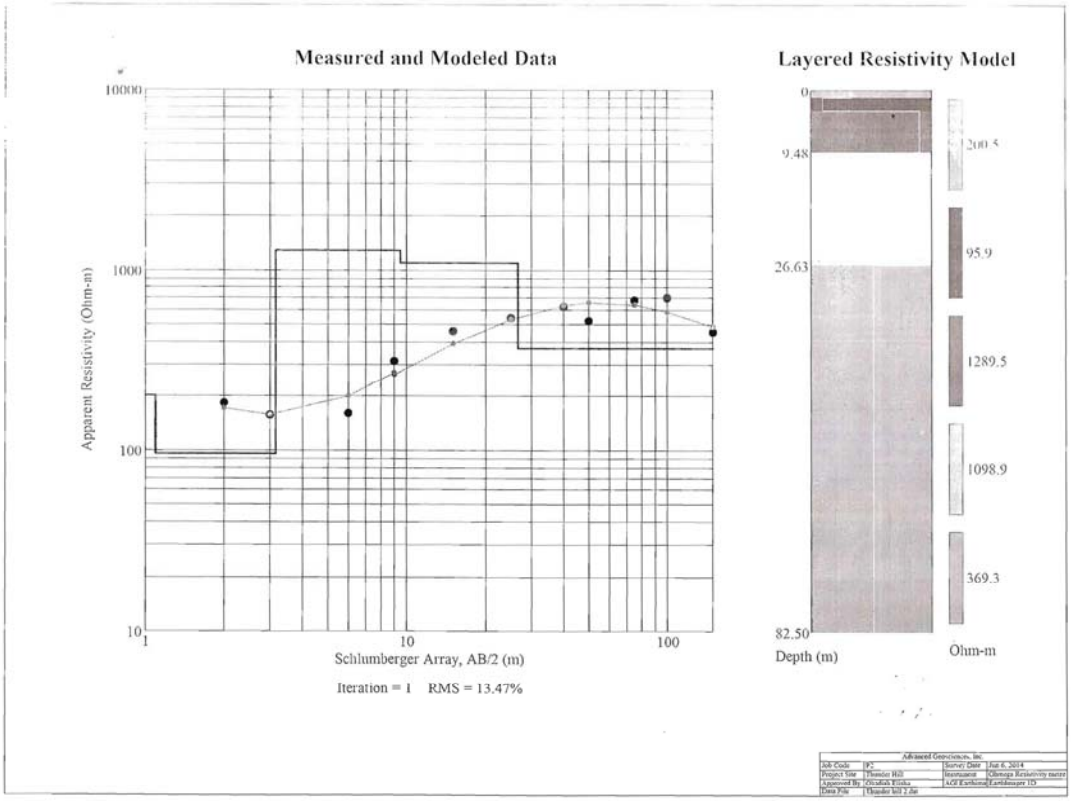
Appendix 1 VES Curves

a. Thunder Hill



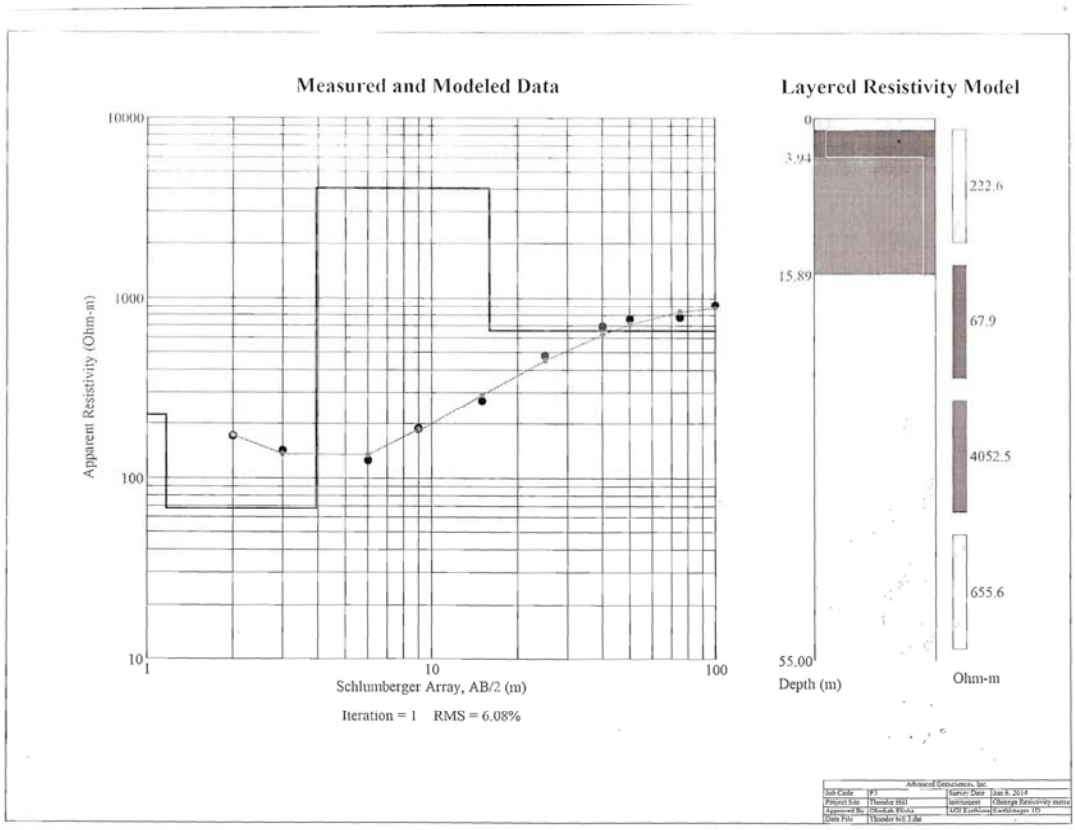
Inverted Resistivity Model For Thunder hill P 1

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	142.91	1.658	1.658
2	104.98	3.721	5.380
3	163.76	10.601	15.981
4	721.99		


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
10000
1000
100
10
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 13.47%
Layered Resistivity Model
0
9.48
26.63
82.50
Depth (m)
95.9
1289.5
1098.9
369.3
Ohm-m

Inverted Resistivity Model For Thunder Hill P2

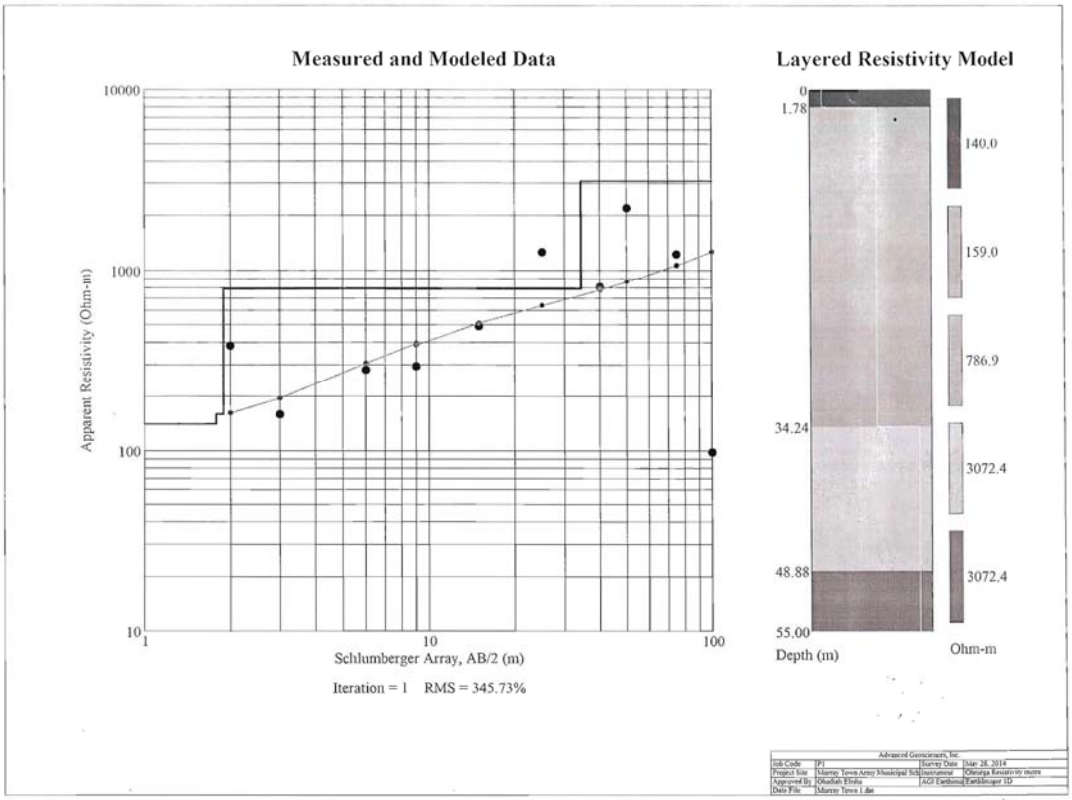
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	200.50	1.093	1.093
2	95.90	2.056	3.150
3	1289.49	6.330	9.480
4	1098.91	17.147	26.628
5	369.28		


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
10000
1000
100
10
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 6.08%
Layered Resistivity Model
0
3.94
15.89
55.00
Depth (m)
222.6
67.9
4052.5
655.6
Ohm-m

Inverted Resistivity Model For Thunder Hill P3

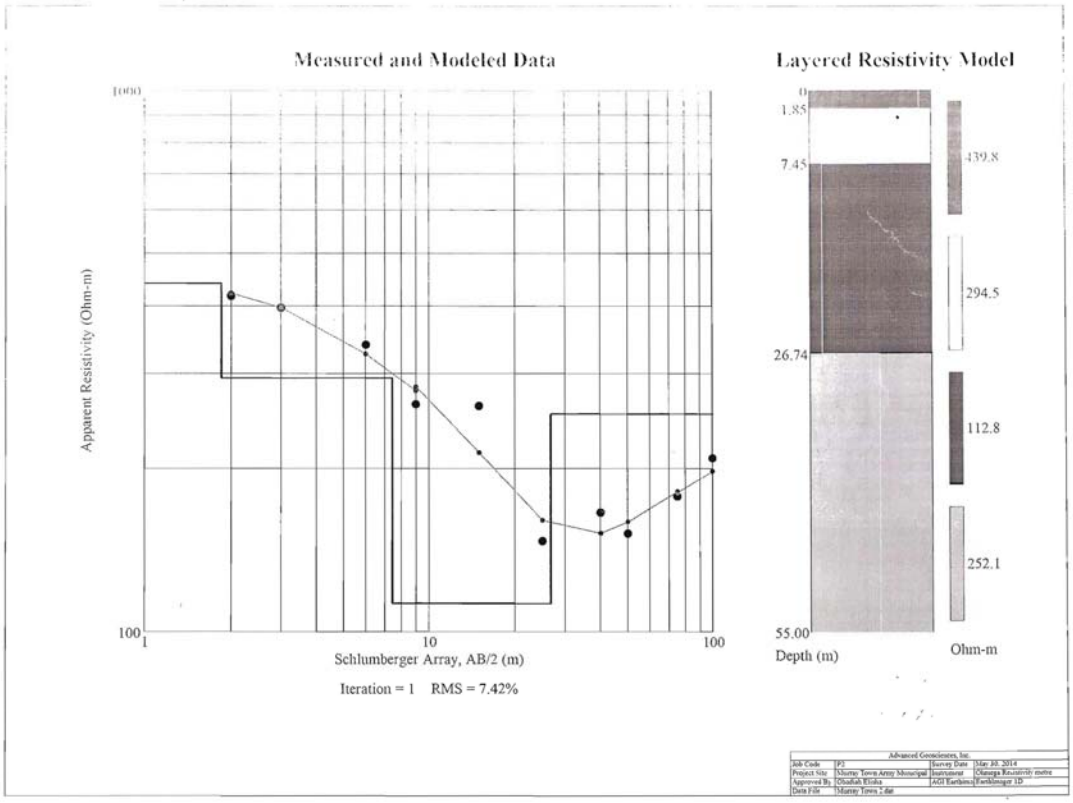
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	222.63	1.166	1.166
2	67.91	2.774	3.940
3	4052.46	11.953	15.893
4	655.62		

b. Army Municipal School



Inverted Resistivity Model For Army Municipal Sch

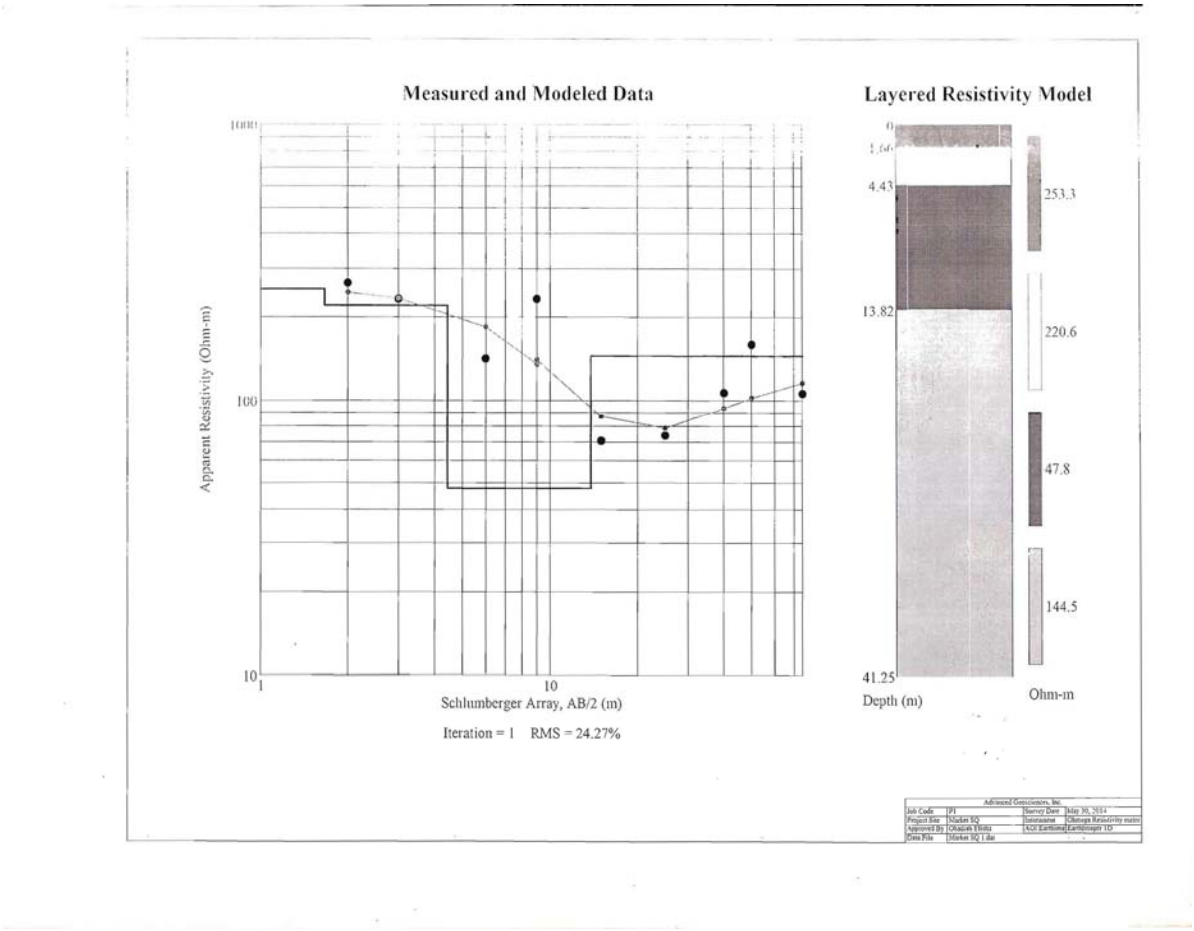
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	139.95	1.782	1.782
2	159.02	0.112	1.894
3	786.90	32.343	34.237
4	3072.41	14.645	48.882
5	3072.41		


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
1000
100
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 7.42%
Layered Resistivity Model
0
1.85
7.45
26.74
55.00
Depth (m)
439.8
294.5
112.8
252.1
Ohm-m

Inverted Resistivity Model For Army Town Municipal P2

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	439.79	1.850	1.850
2	294.46	5.599	7.449
3	112.77	19.289	26.738
4	252.14		

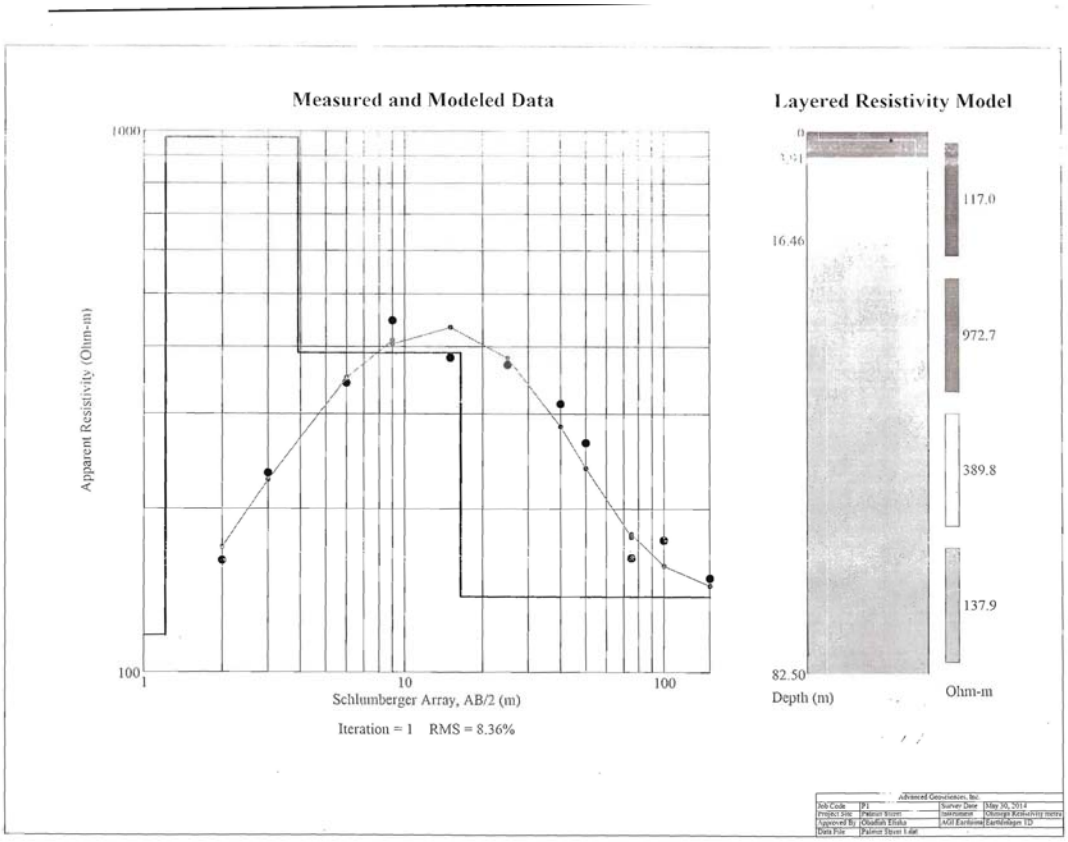
c. Market Square



Inverted Resistivity Model For Market SQ 1

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	253.26	1.660	1.660
2	220.60	2.770	4.430
3	47.80	9.389	13.818
4	144.55		

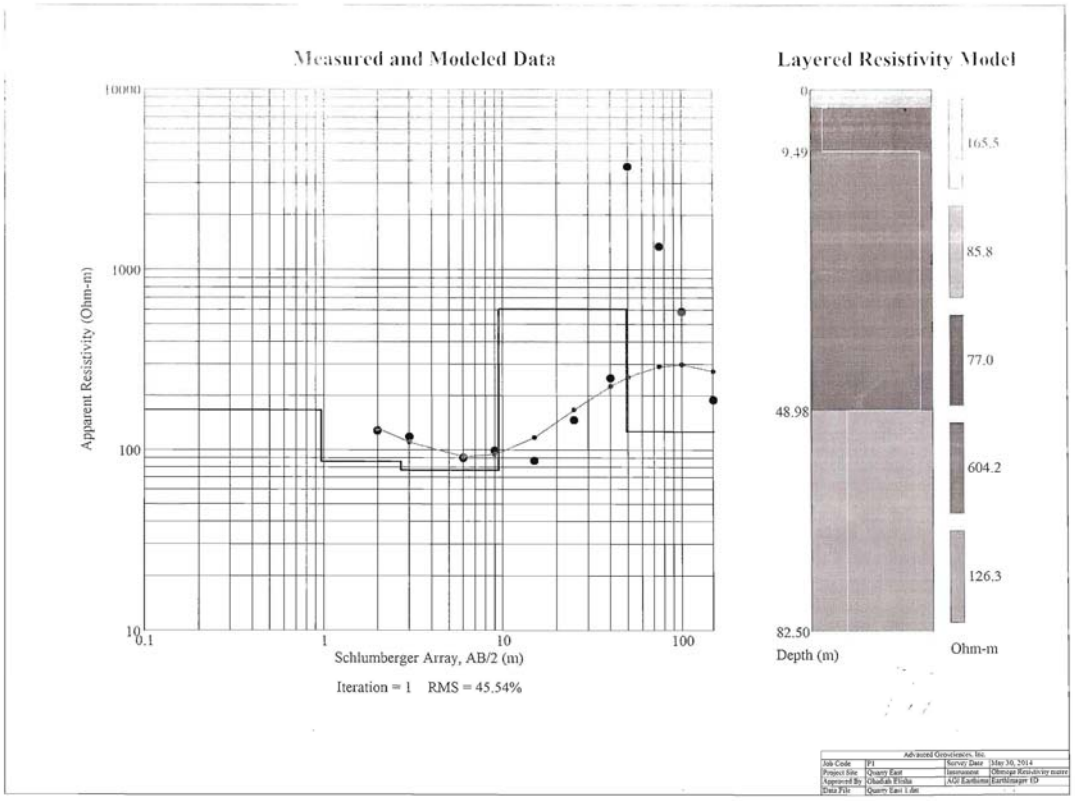
d. Palmer Street



Inverted Resistivity Model For Palmer St P 1

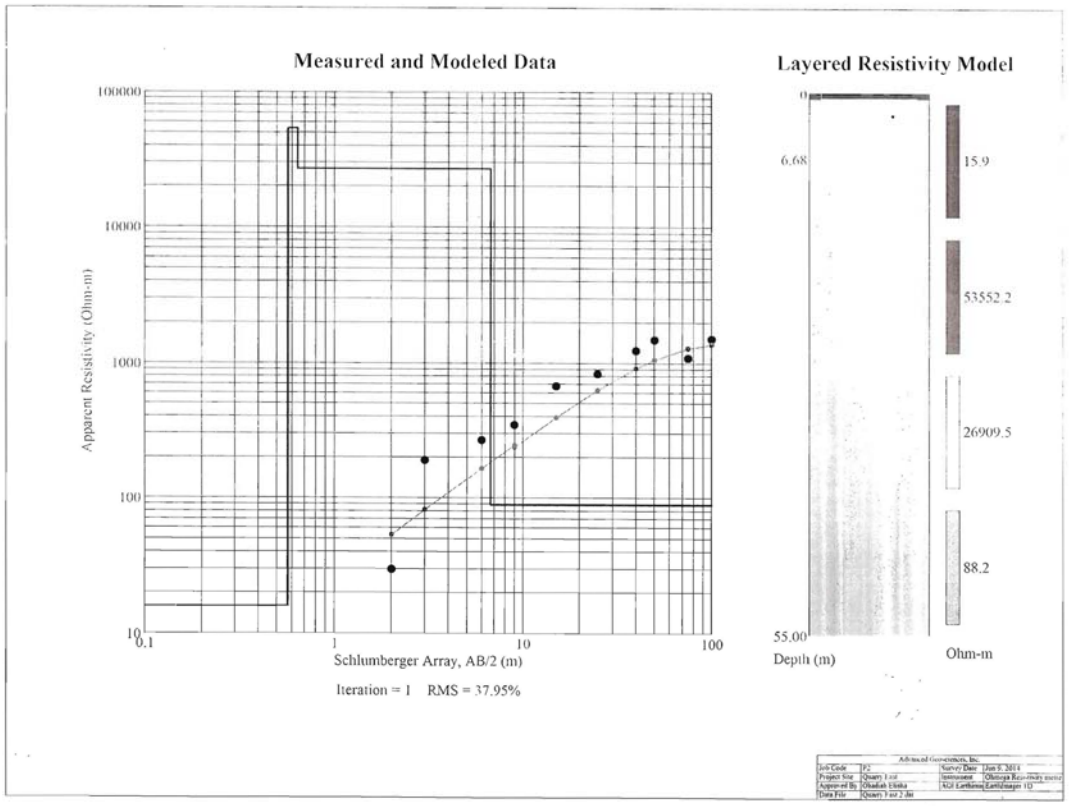
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	116.99	1.207	1.207
2	972.68	2.704	3.911
3	389.78	12.546	16.457
4	137.87		

d. Quarry East



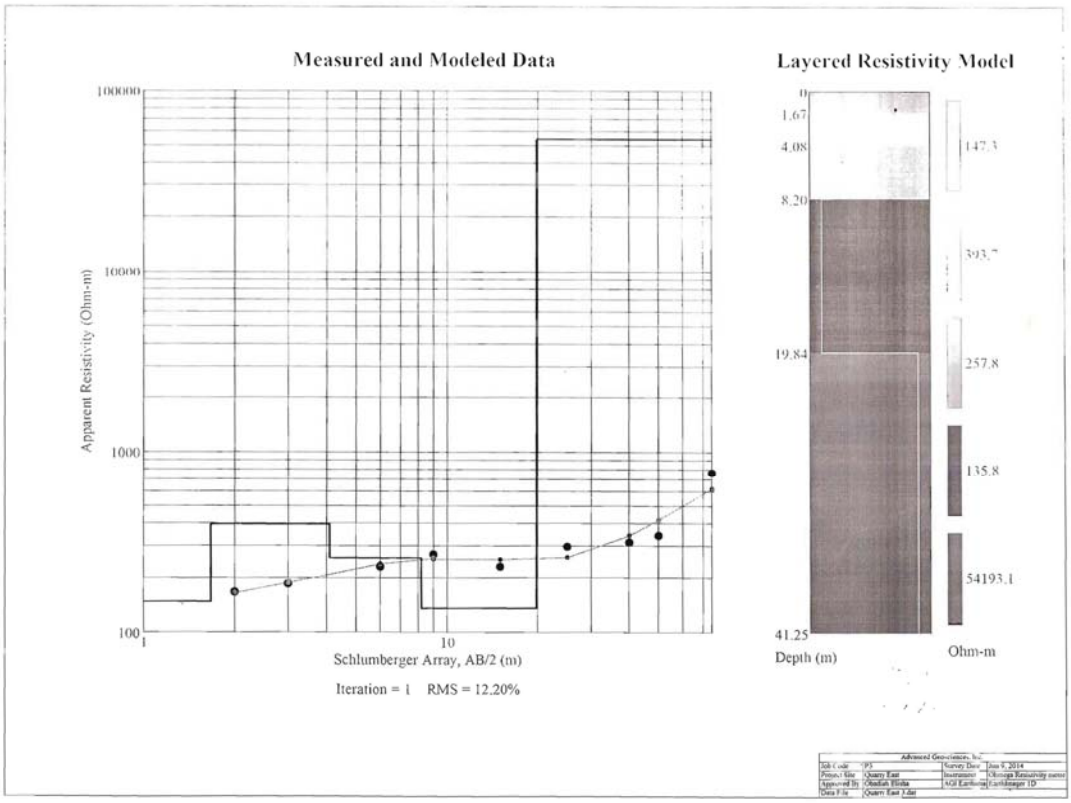
Inverted Resistivity Model For Quary East P I

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	165.54	0.965	0.965
2	85.77	1.730	2.694
3	77.00	6.799	9.494
4	604.18	39.491	48.985
5	126.29		


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
100000
10000
1000
100
10
0.1
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 37.95%
Layered Resistivity Model
0
6.68
55.00
Depth (m)
15.9
53552.2
26909.5
88.2
Ohm-m

Inverted Resistivity Model For Quarry East P2

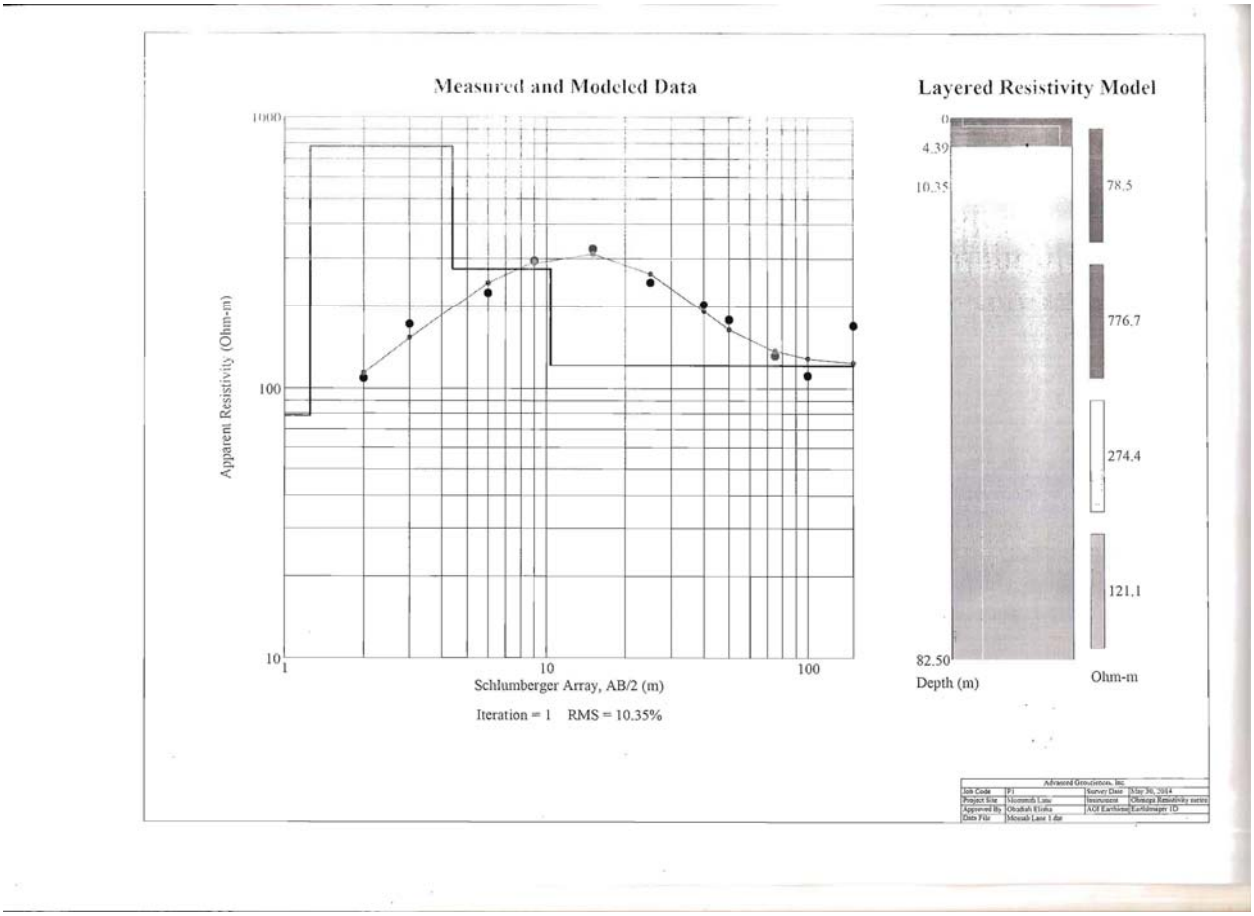
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	15.94	0.573	0.573
2	53552.22	0.070	0.643
3	26909.47	6.036	6.679
4	88.19		


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
100000
10000
1000
100
1
10
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 12.20%
Layered Resistivity Model
0
1.67
4.08
8.20
19.84
41.25
Depth (m)
147.3
393.7
257.8
135.8
54193.1
Ohm-m

Inverted Resistivity Model For Quarry East P 3

Layer#	Ohm-m	Thickness (m)	Bottom Depth (n
1	147.32	1.667	1.667
2	393.73	2.414	4.081
3	257.81	4.123	8.204
4	135.82	11.634	19.837
5	54193.06		

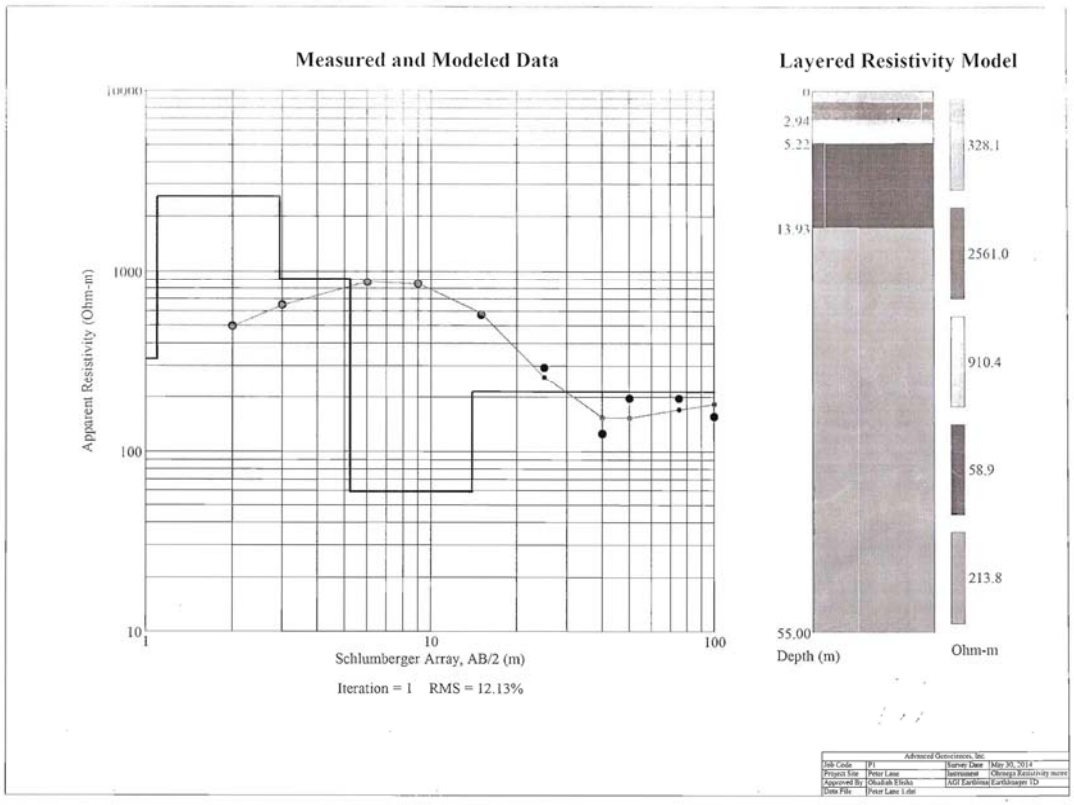
f. Mommah Lane



Inverted Resistivity Model For Mommah Lane P 1

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	78.52	1.246	1.246
2	776.74	3.146	4.392
3	274.40	5.958	10.349
4	121.12		

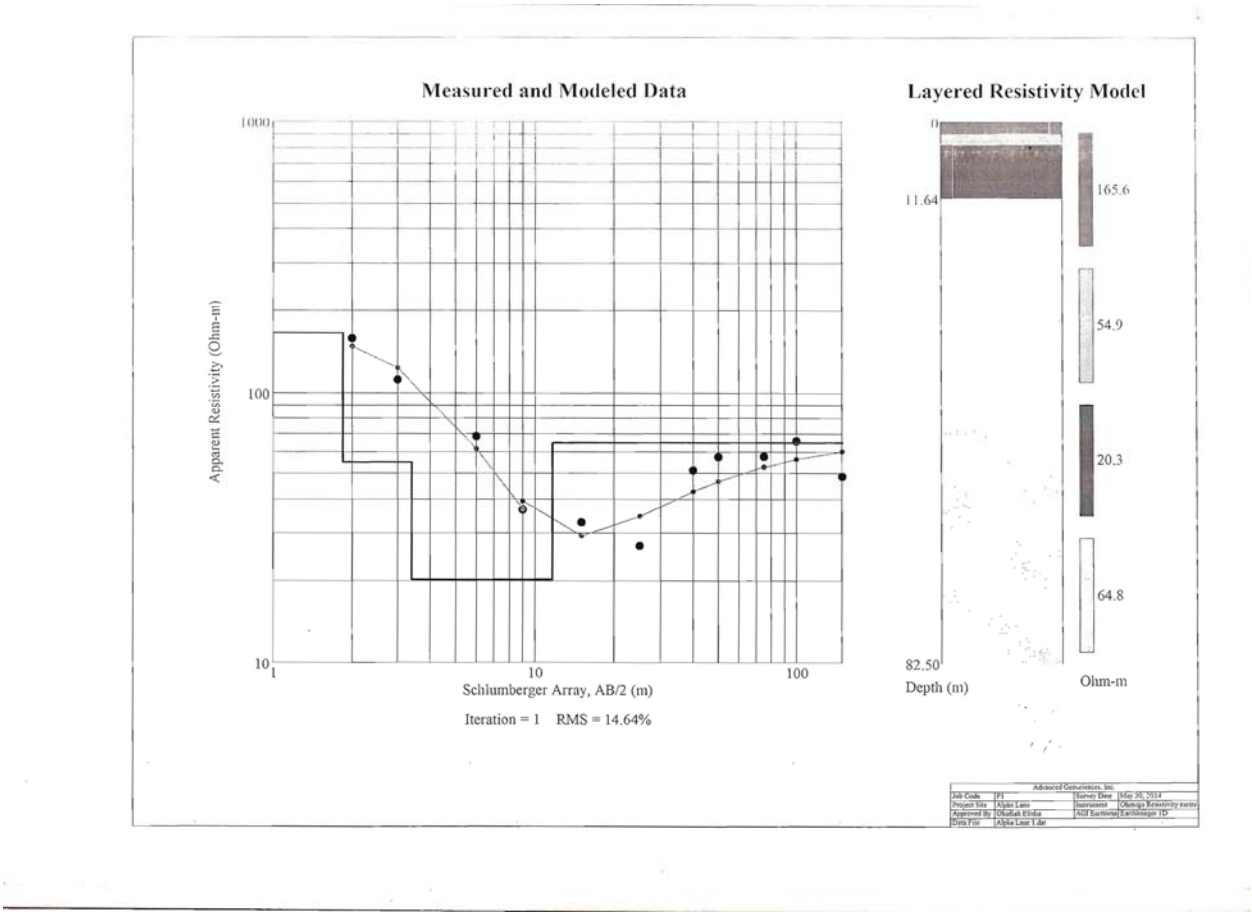
g. Peter Lane


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
10000
1000
100
10
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 12.13%
Layered Resistivity Model
0
2.94
5.22
13.93
55.00
Depth (m)
328.1
2561.0
910.4
58.9
213.8
Ohm-m

Inverted Resistivity Model For Peter Lane

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	328.12	1.094	1.094
2	2561.03	1.845	2.939
3	910.41	2.283	5.222
4	58.90	8.706	13.928
5	213.82		

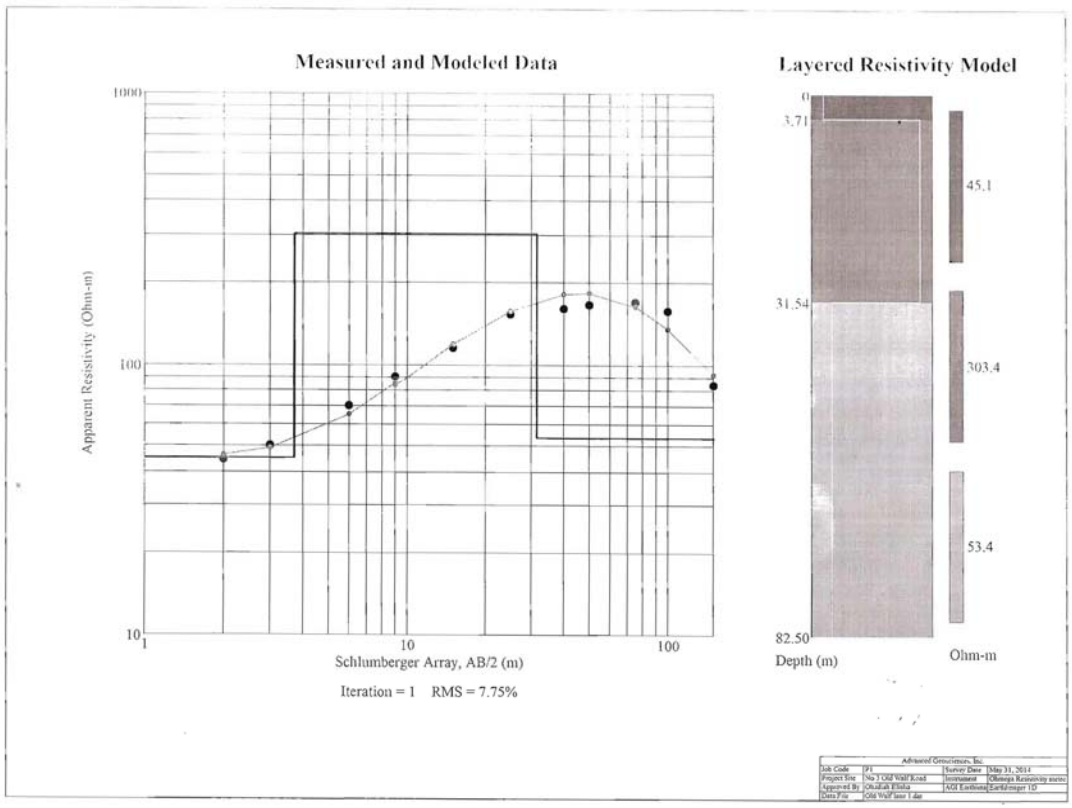
h. Alpha Lane


Measured and Modeled Data
Layered Resistivity Model
Apparent Resistivity (Ohm-m)
1000
100
10
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 14.64%
0
11.64
82.50
Depth (m)
165.6
54.9
20.3
64.8
Ohm-m

Inverted Resistivity Model For Alpha Lane 1

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	165.58	1.839	1.839
2	54.85	1.559	3.398
3	20.29	8.241	11.639
4	64.78		

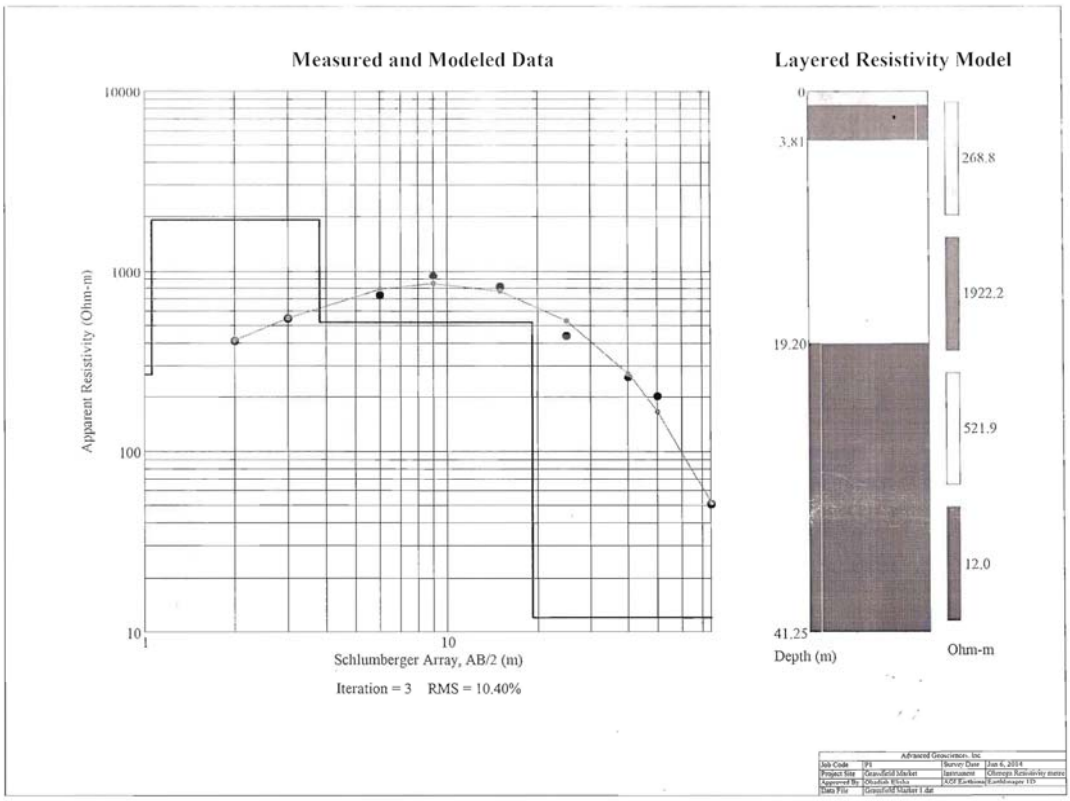
i. Old Wharf Road



Inverted Resistivity Model For Old Walf Road P 1

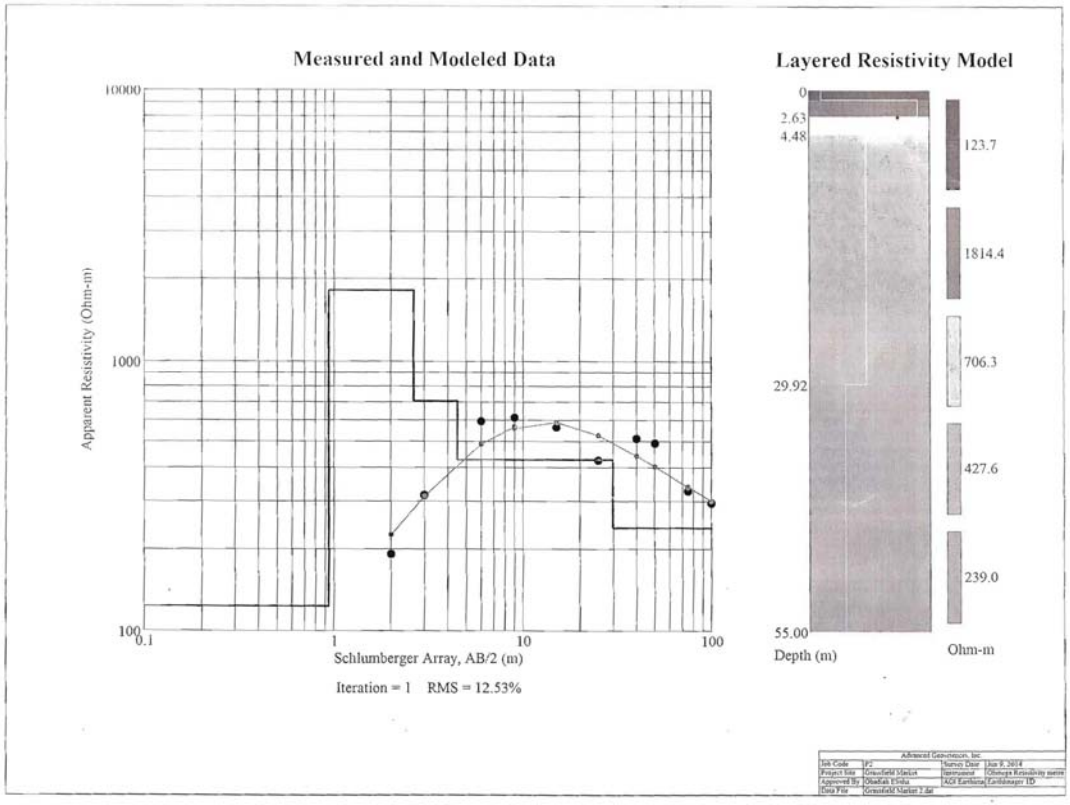
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	45.14	3.706	3.706
2	303.39	27.837	31.543
3	53.39		

j. Grassfield Market



Inverted Resistivity For Grassfield P 1

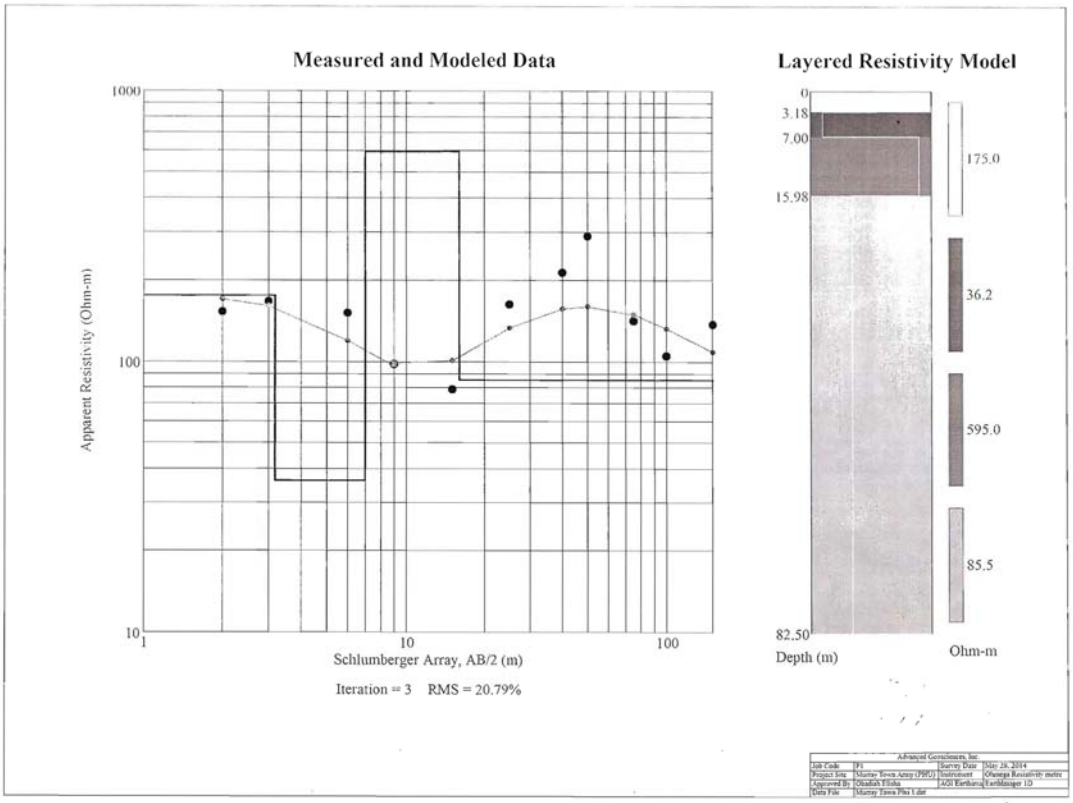
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	268.82	1.057	1.057
2	1922.25	2.749	3.806
3	521.87	15.391	19.196
4	12.02		


Measured and Modeled Data
Apparent Resistivity (Ohm-m)
10000
1000
100
0.1
1
10
100
Schlumberger Array, AB/2 (m)
Iteration = 1 RMS = 12.53%
Layered Resistivity Model
0
2.63
4.48
29.92
55.00
Depth (m)
123.7
1814.4
706.3
427.6
239.0
Ohm-m

Inverted Resistivity Model For Grassfield Market P2

Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	123.70	0.936	0.936
2	1814.38	1.696	2.633
3	706.28	1.849	4.482
4	427.65	25.436	29.918
5	239.01		

k. Murray Town Army PHU

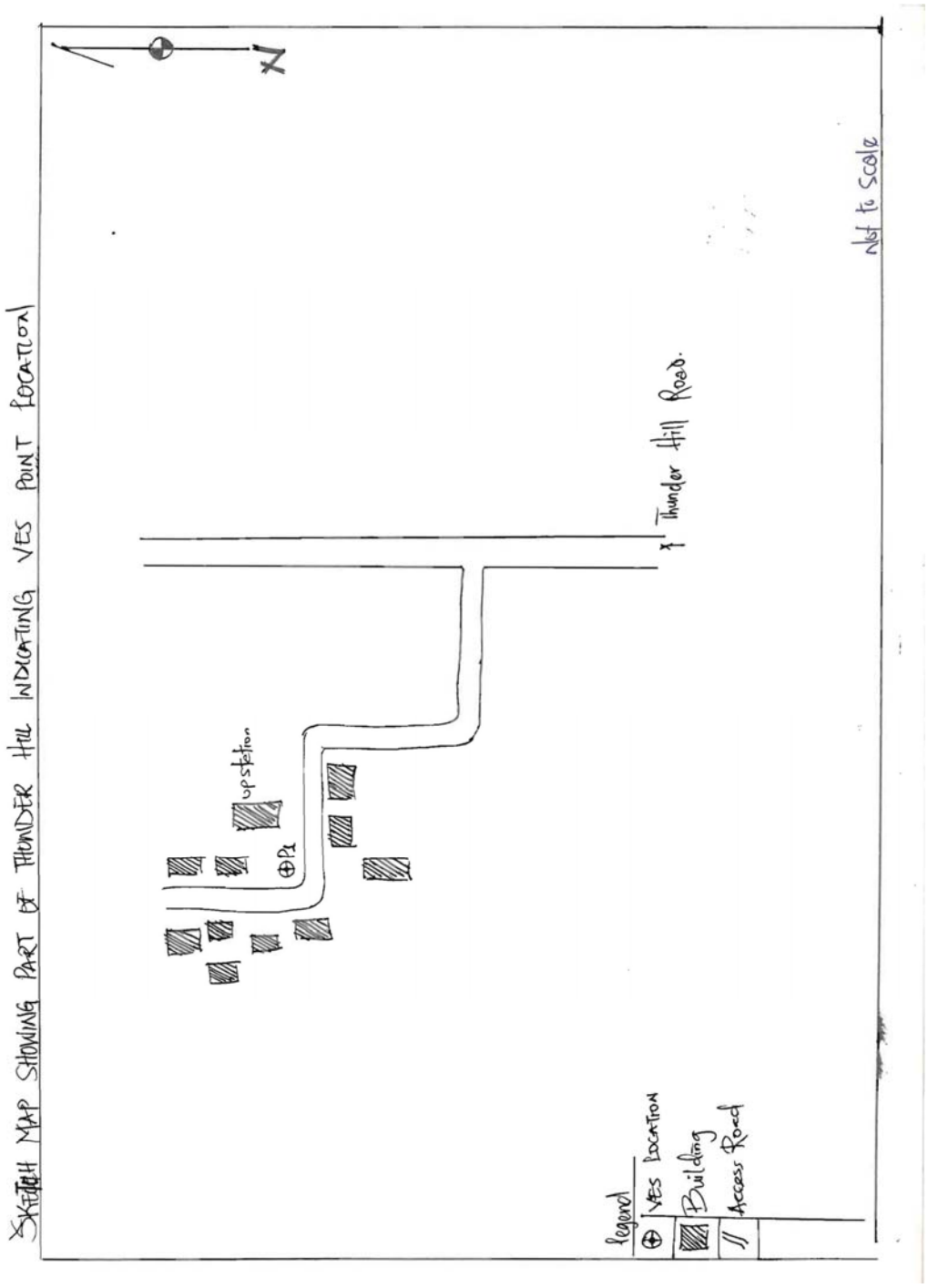


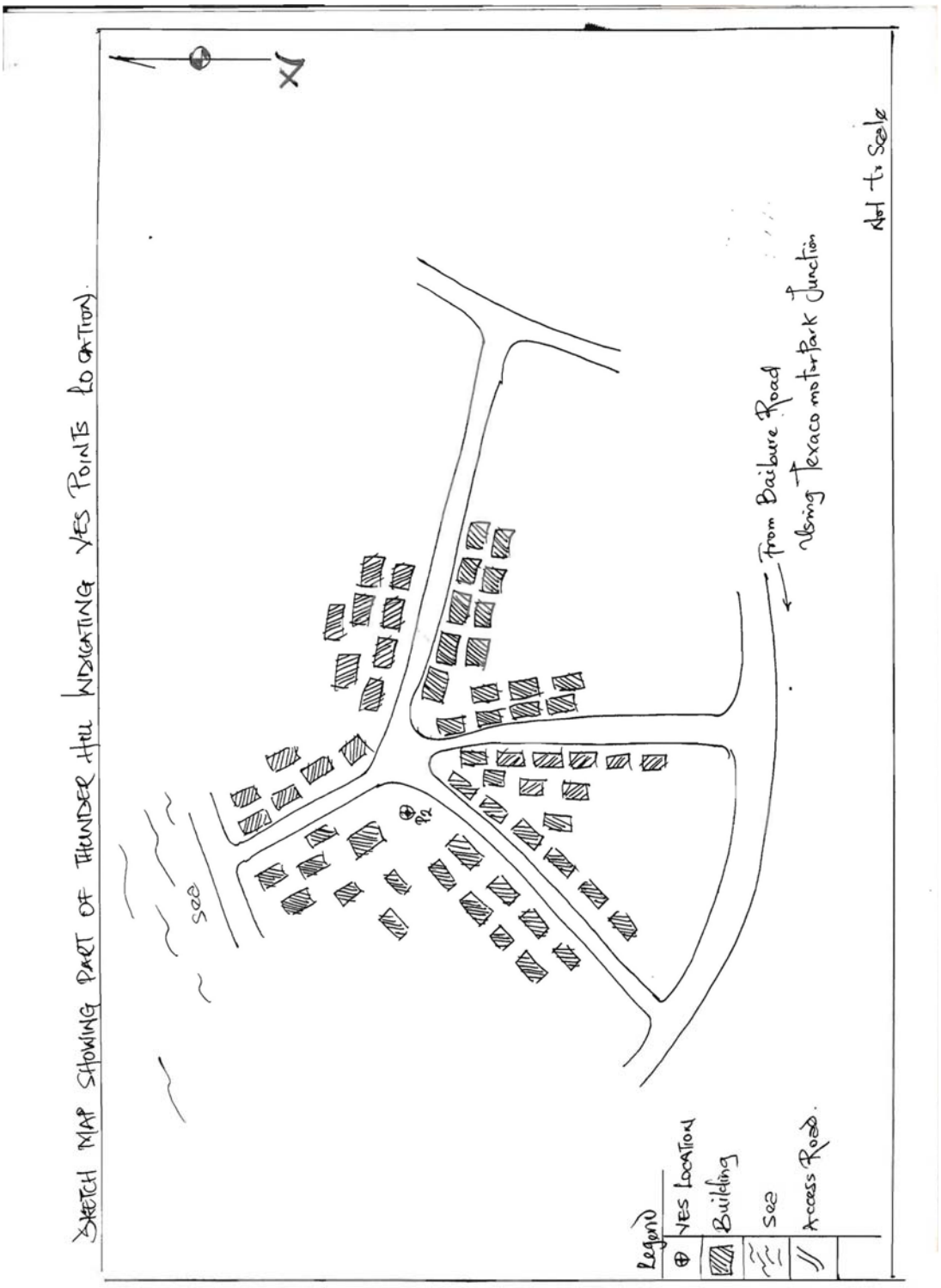
Inverted Resistivity Model For Murray Town Army P 1

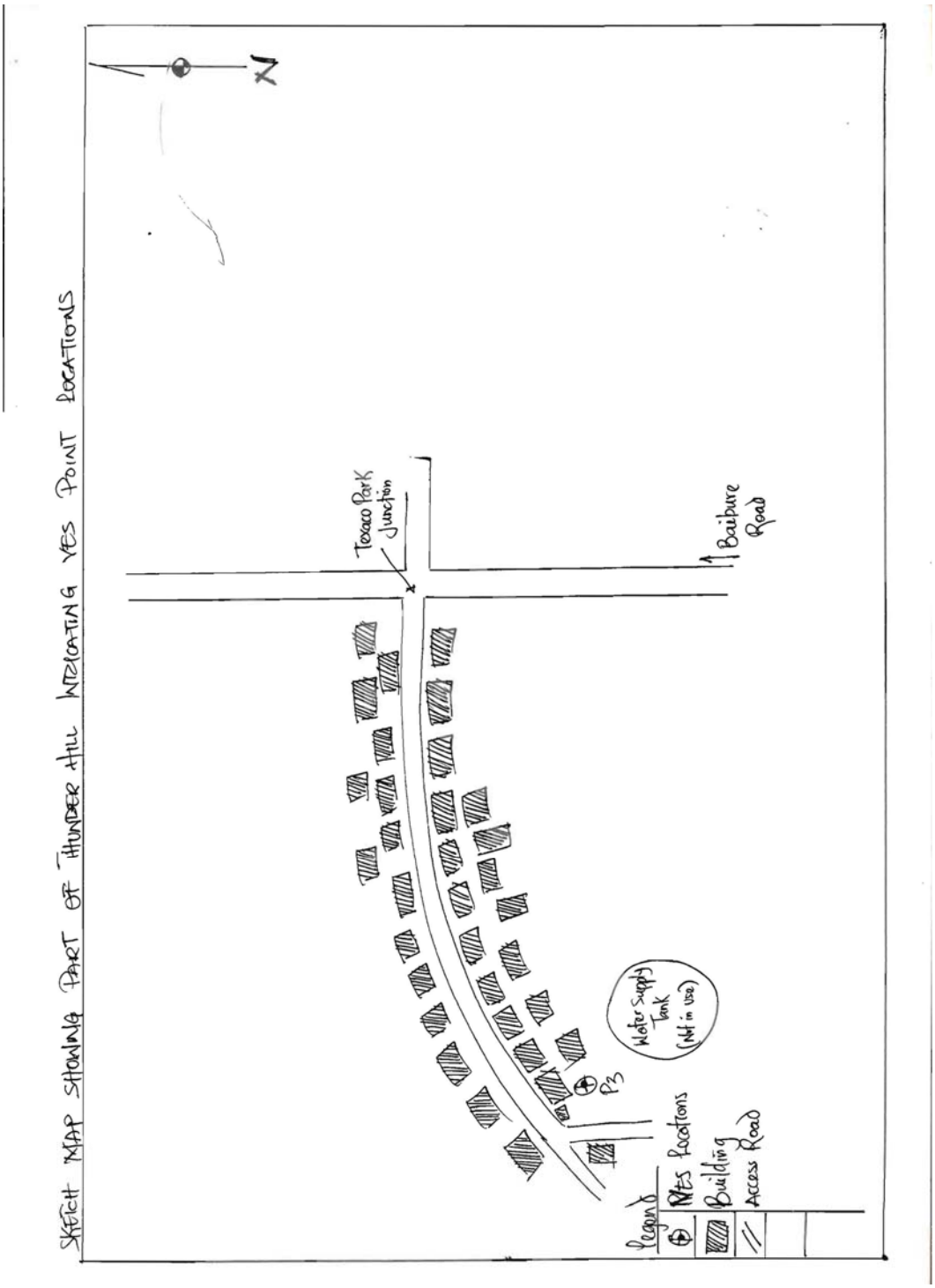
Layer#	Ohm-m	Thickness (m)	Bottom Depth (m
1	174.98	3.176	3.176
2	36.23	3.819	6.995
3	595.05	8.988	15.984
4	85.53		

Appendix 2: Sketch Maps

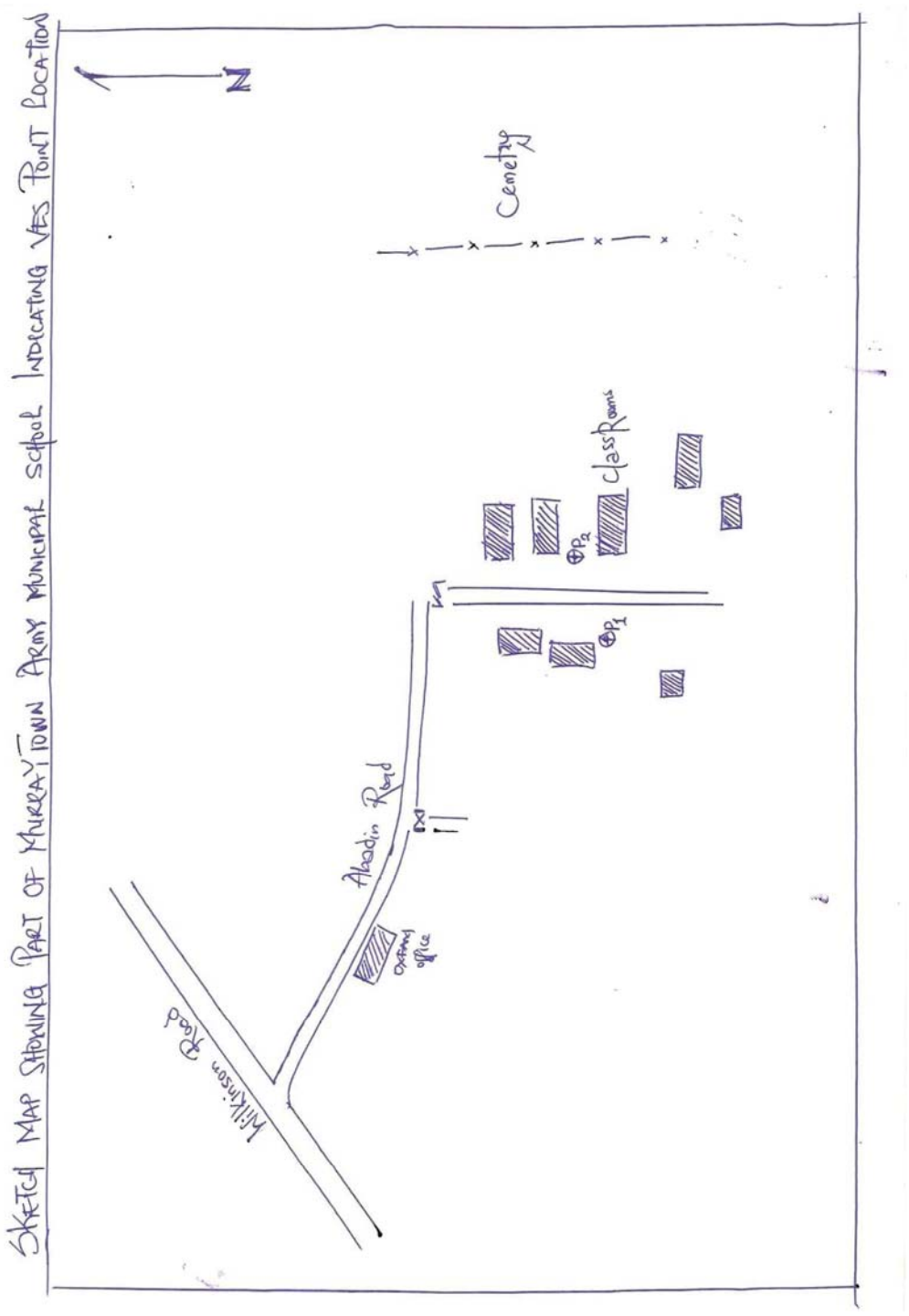
a. Thunder Hill



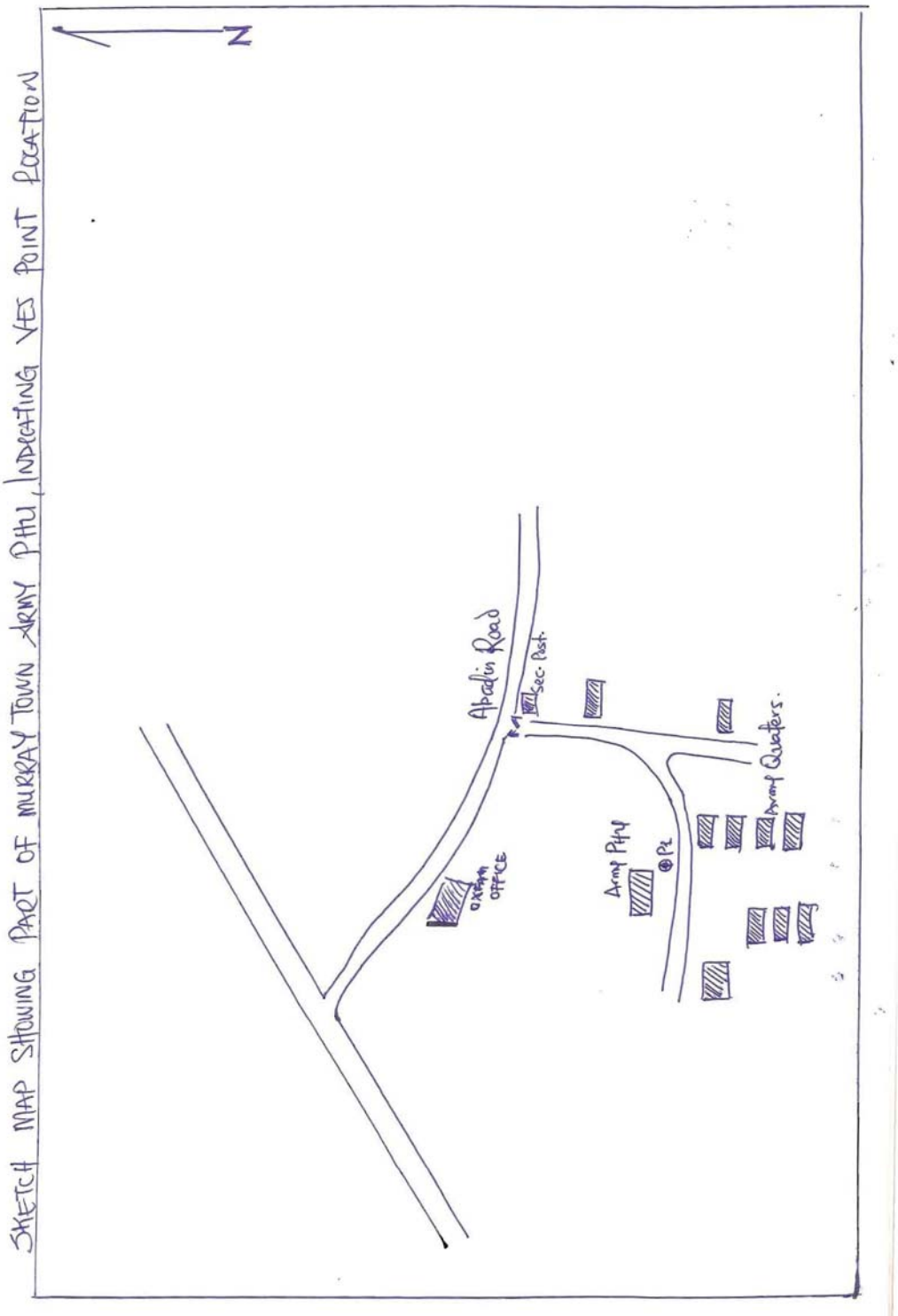

SKETCH MAP SHOWING PART OF THUNDER HILL INDICATING YES POINTS LOCATION.
N
Not to Scale
From Bailure Road
Using Texaco motorPark Junction
Sea
Legend
Yes Location
Building
Sea
Access Road.


SKETCH MAP SHOWING PART OF THUNDER HILL INDICATING YES POINT LOCATIONS
N
Texaco Park Junction
Bairure Road
Water Supply Tank (Not in use)
P3
Legend
YES Locations
Building
Access Road

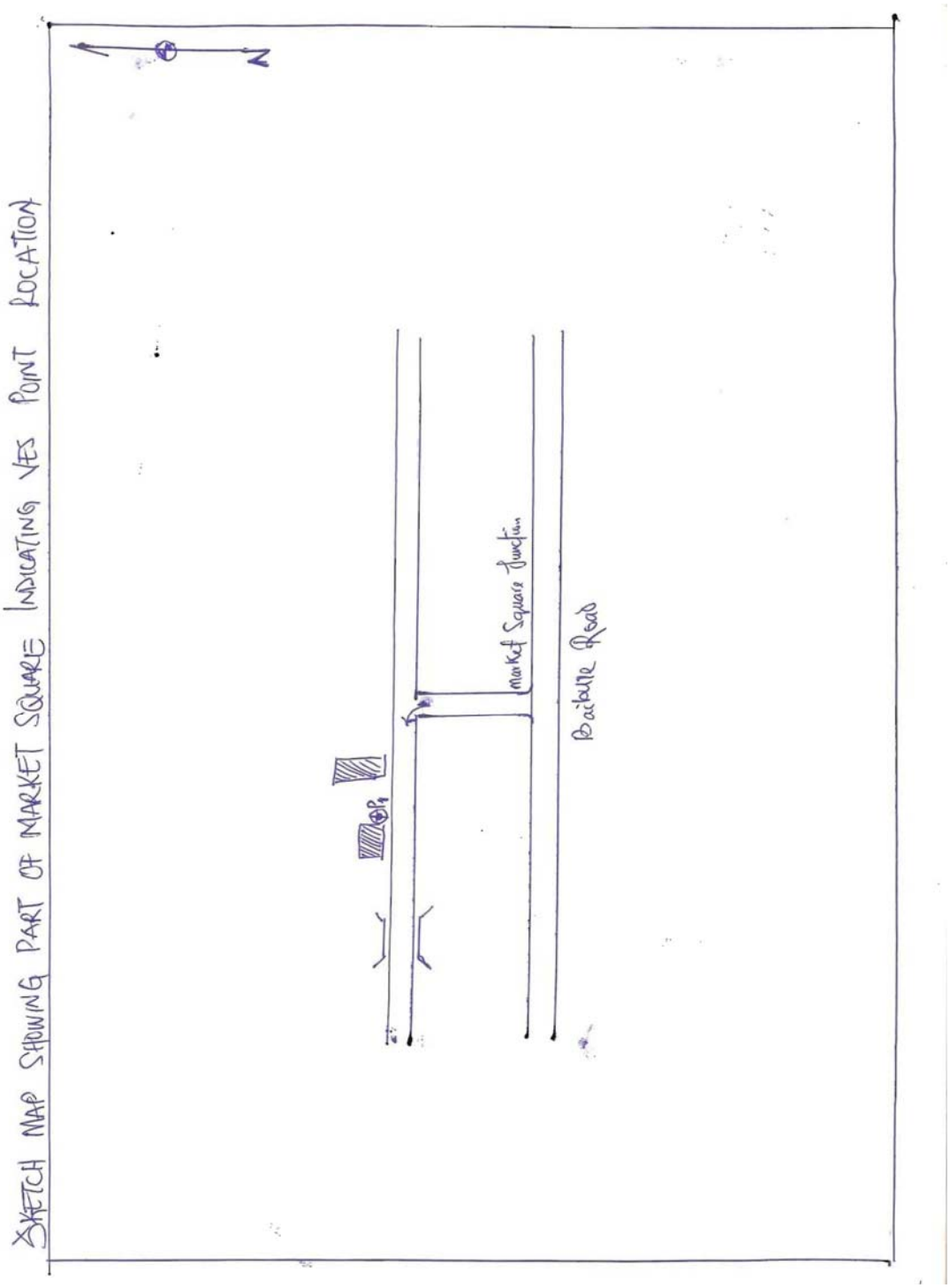
b. Murray Town Army Municipal



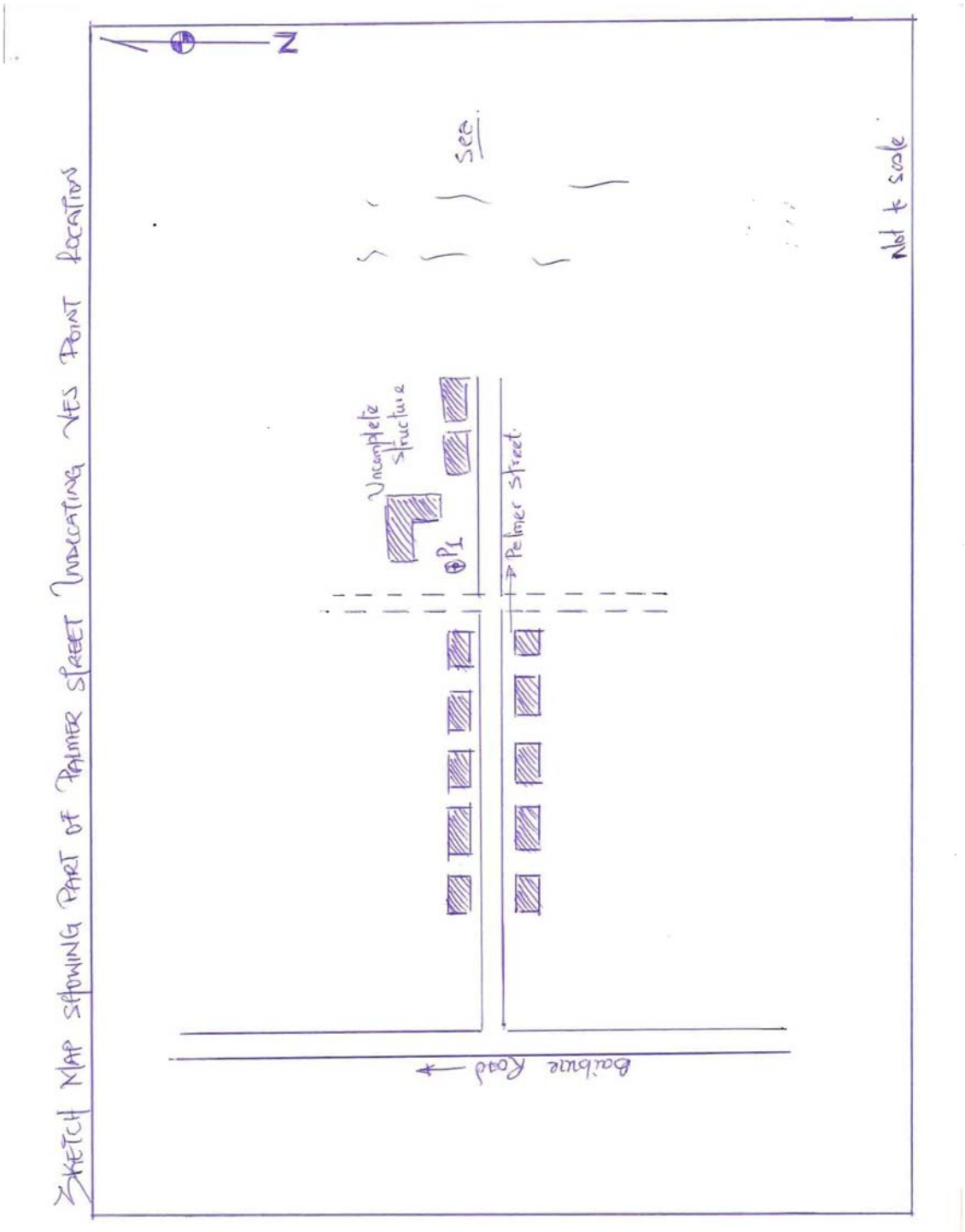
c. Murray Town Army PHU



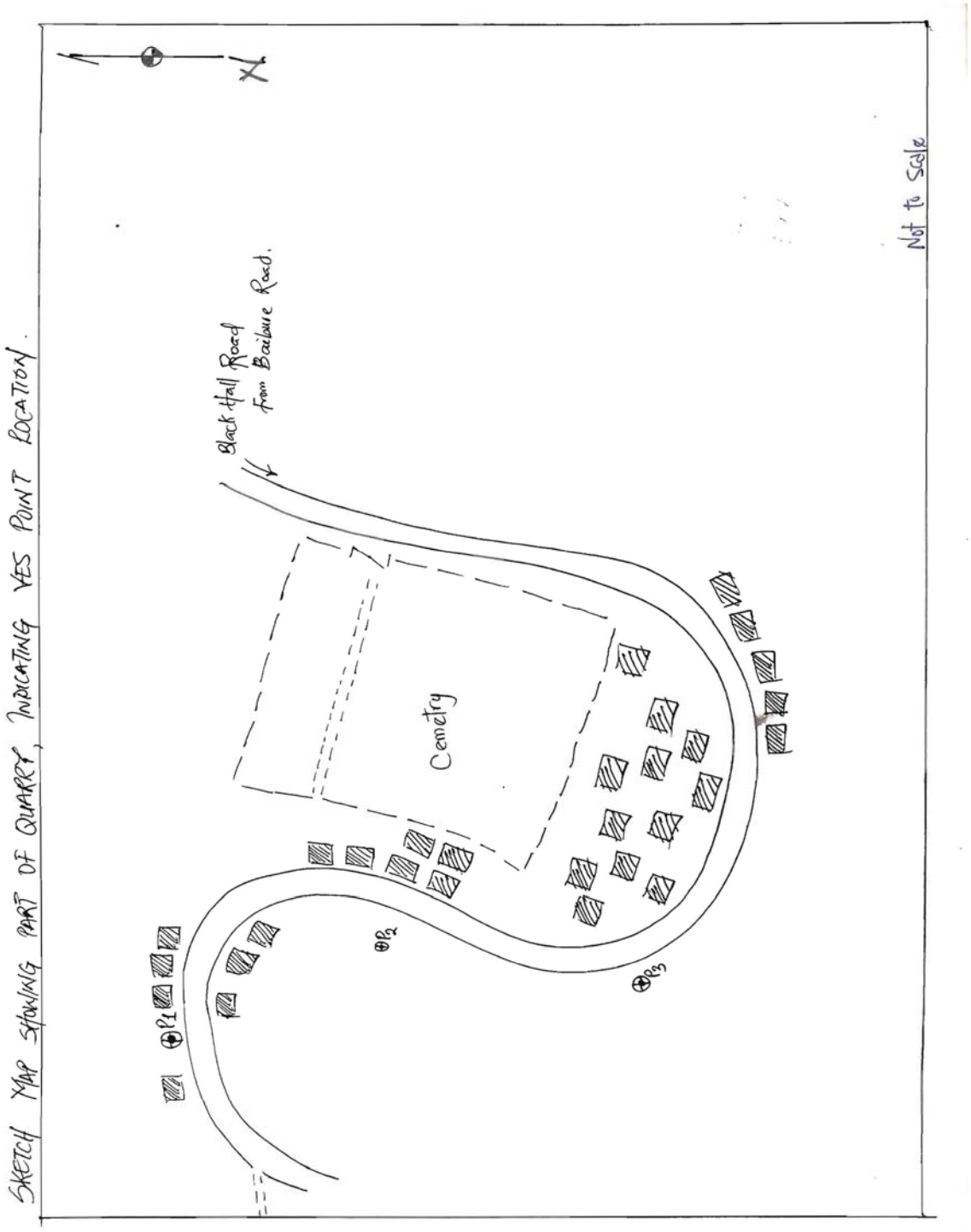
d. Market Square



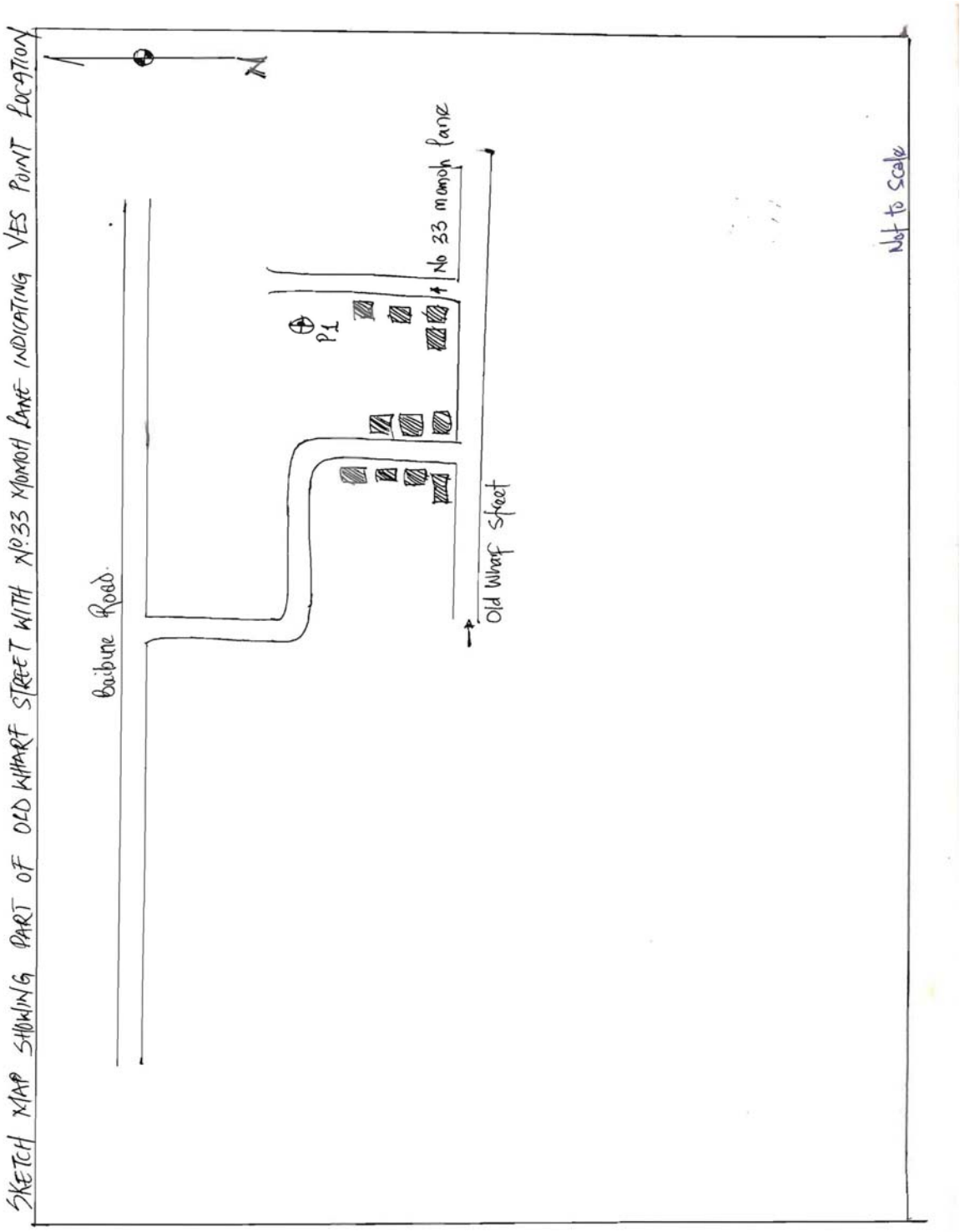
e. Palmer Street



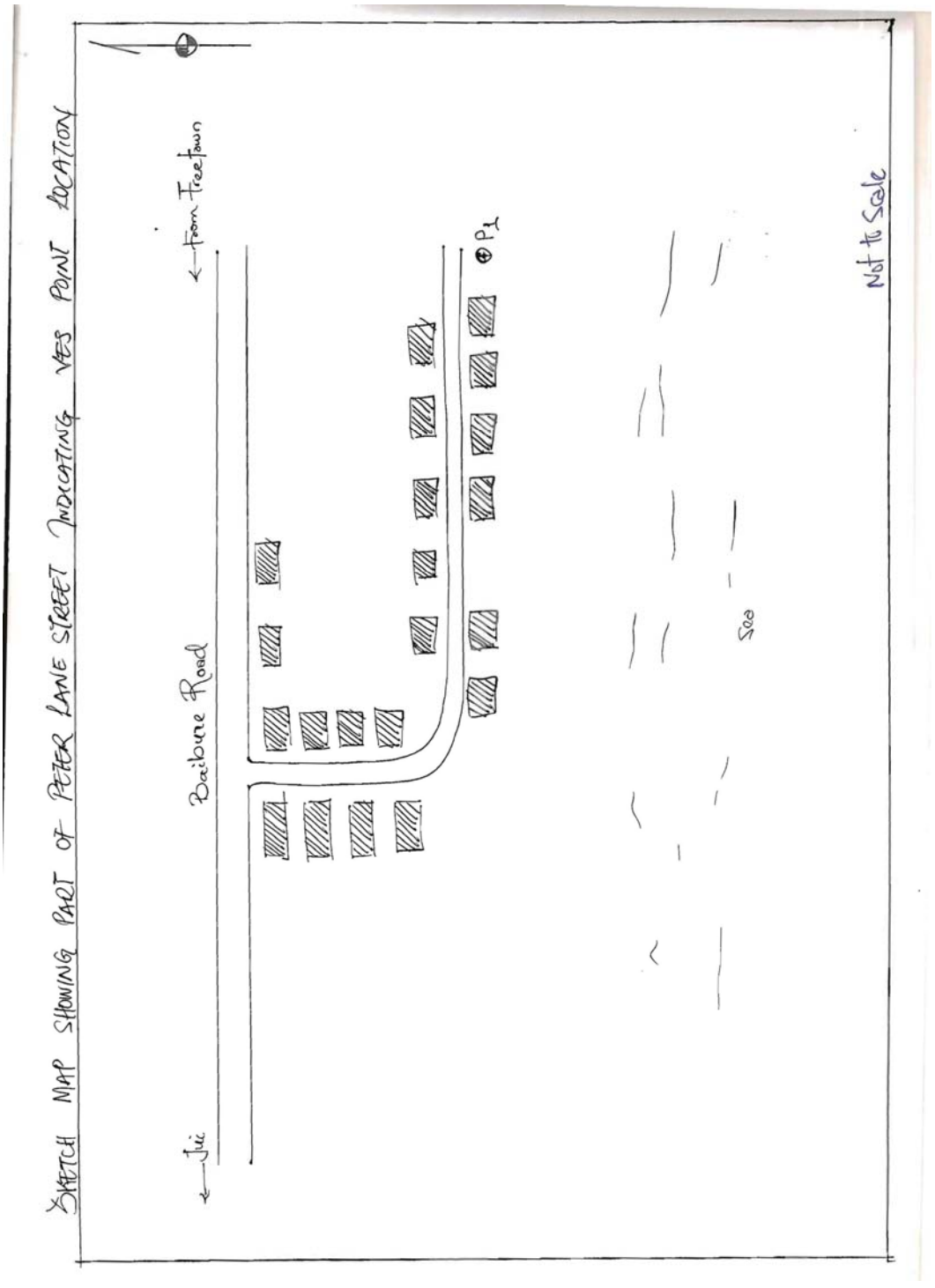
f. Quarry East



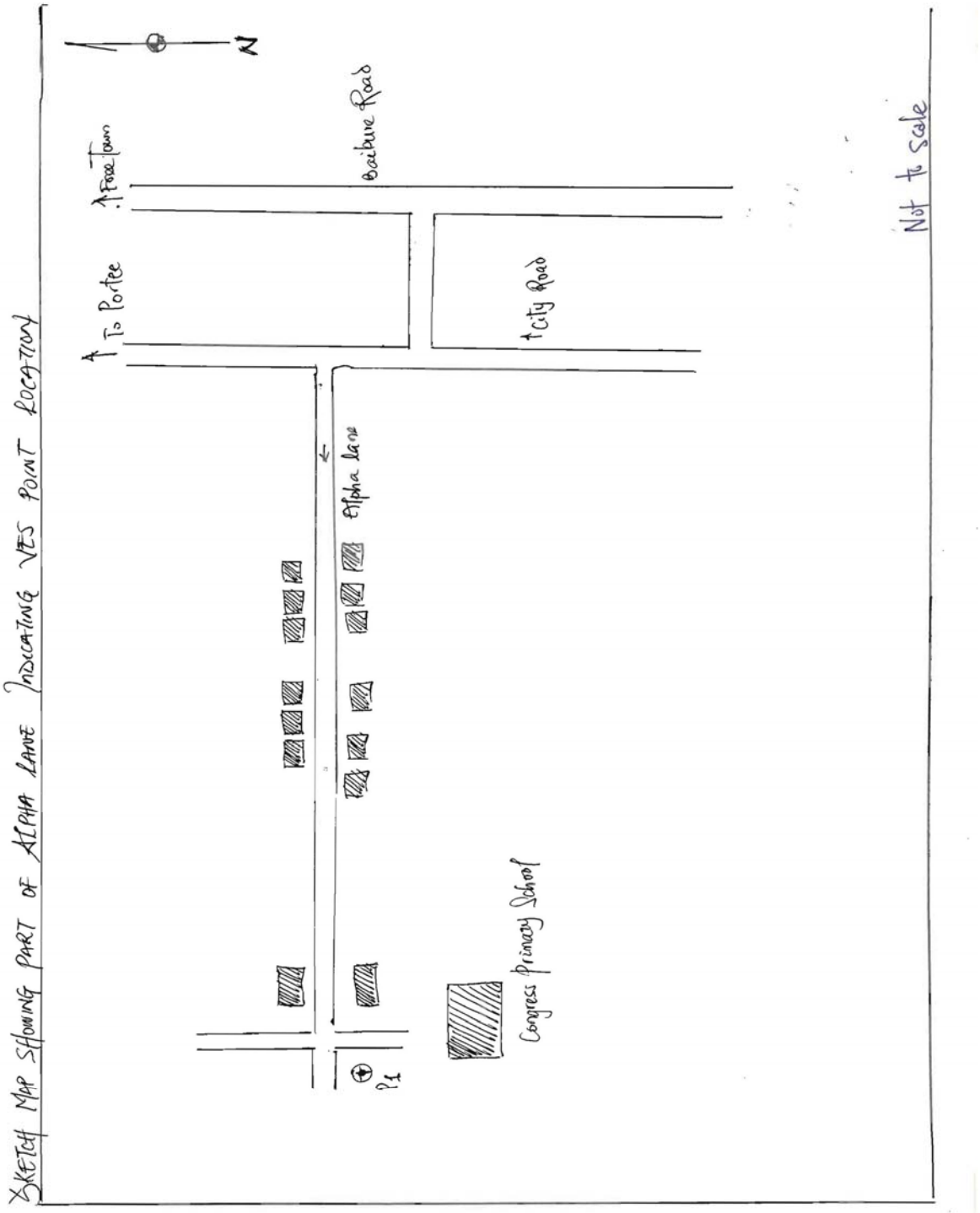
g. Mommah Lane



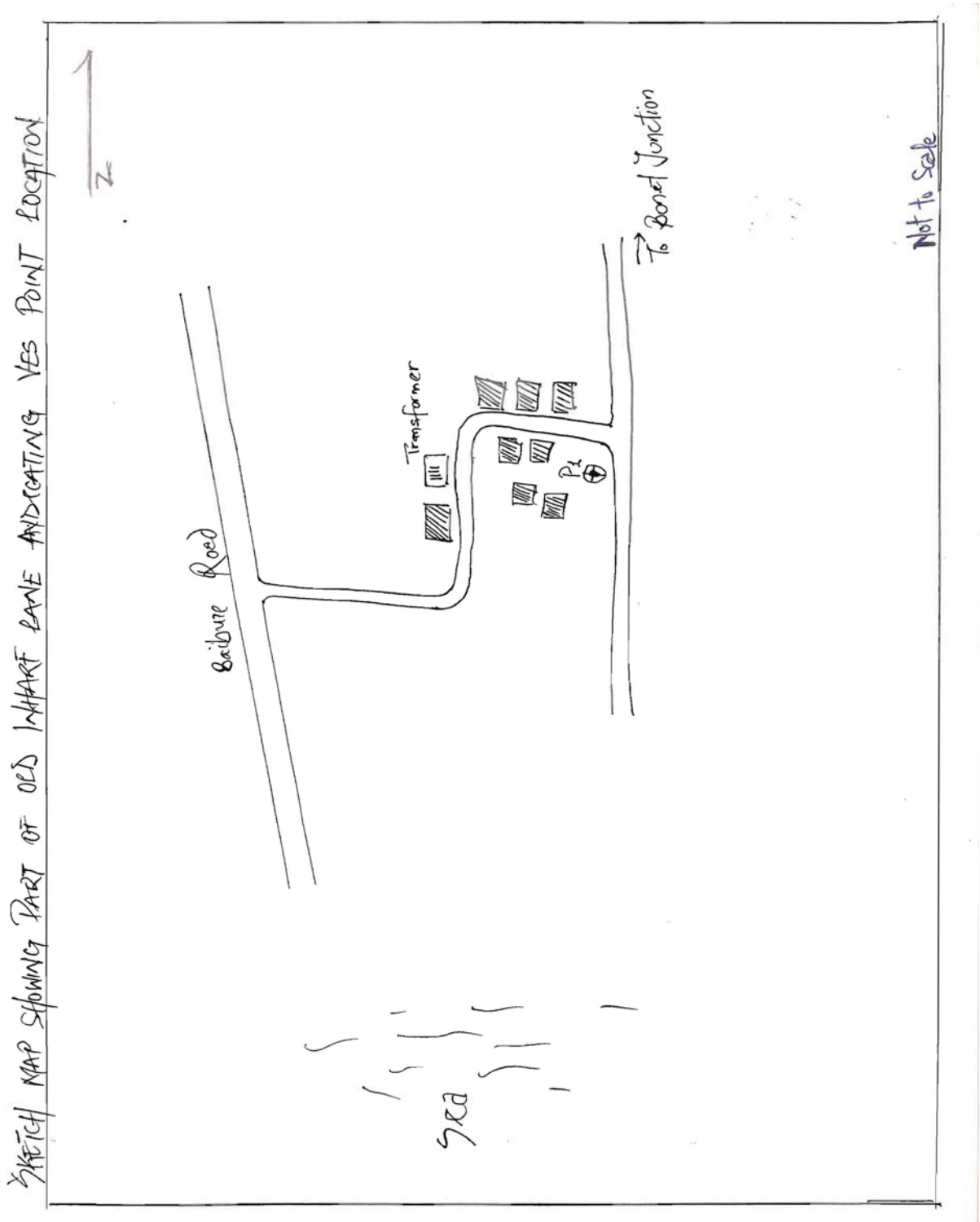
h. Peter Lane


SKETCH MAP SHOWING PART OF PETER LANE STREET INDICATING VES POINT LOCATION
From Freetown
Bailoue Road
Jui
P1
Sea
Not to Scale

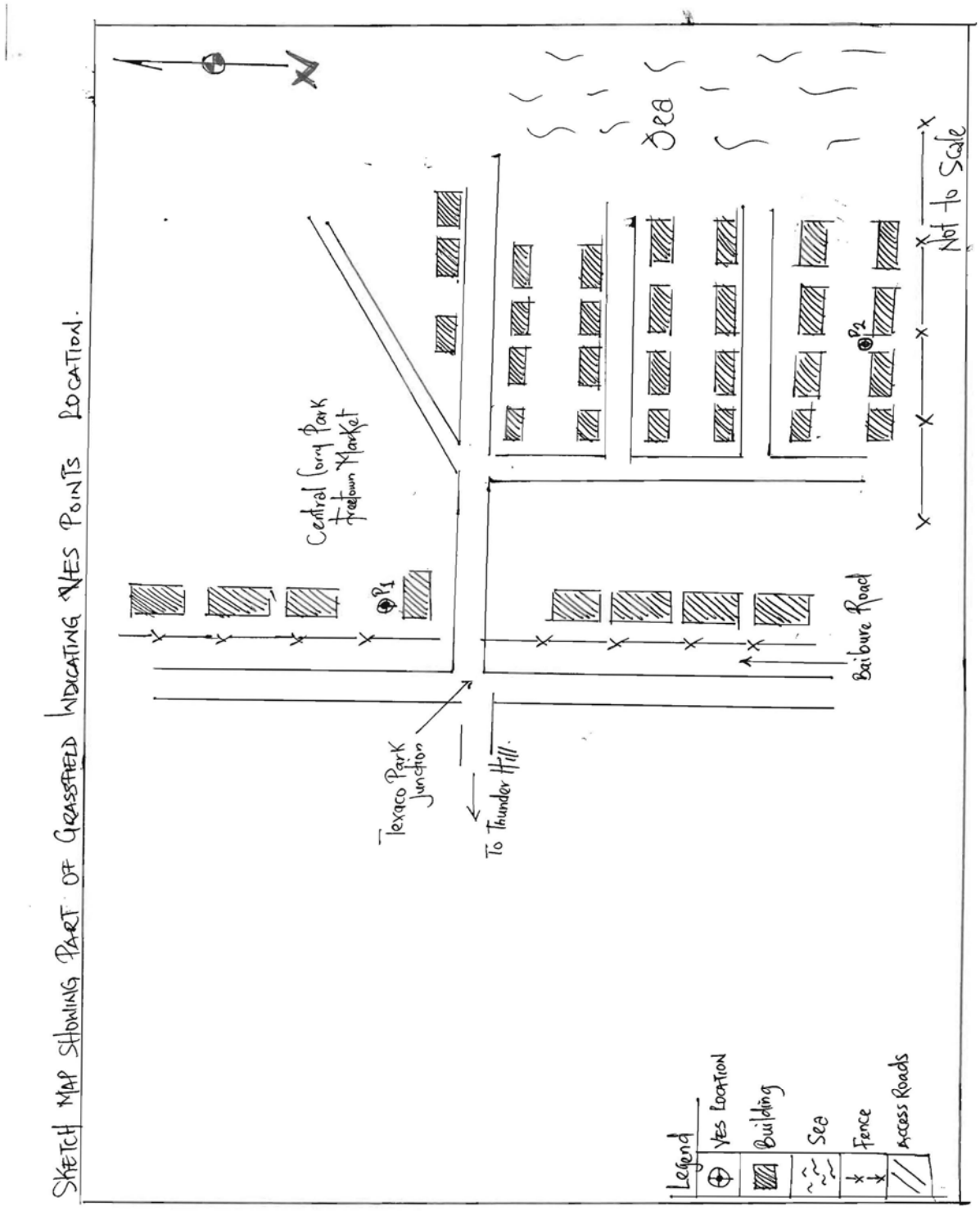
i. Alpha Lane


SKETCH MAP SHOWING PART OF ALPHA LANE INDICATING VES POINT LOCATION
N
To Portee
Freetown
Bai bure Road
City Road
Alpha lane
Congress Primary School
P1
Not to scale

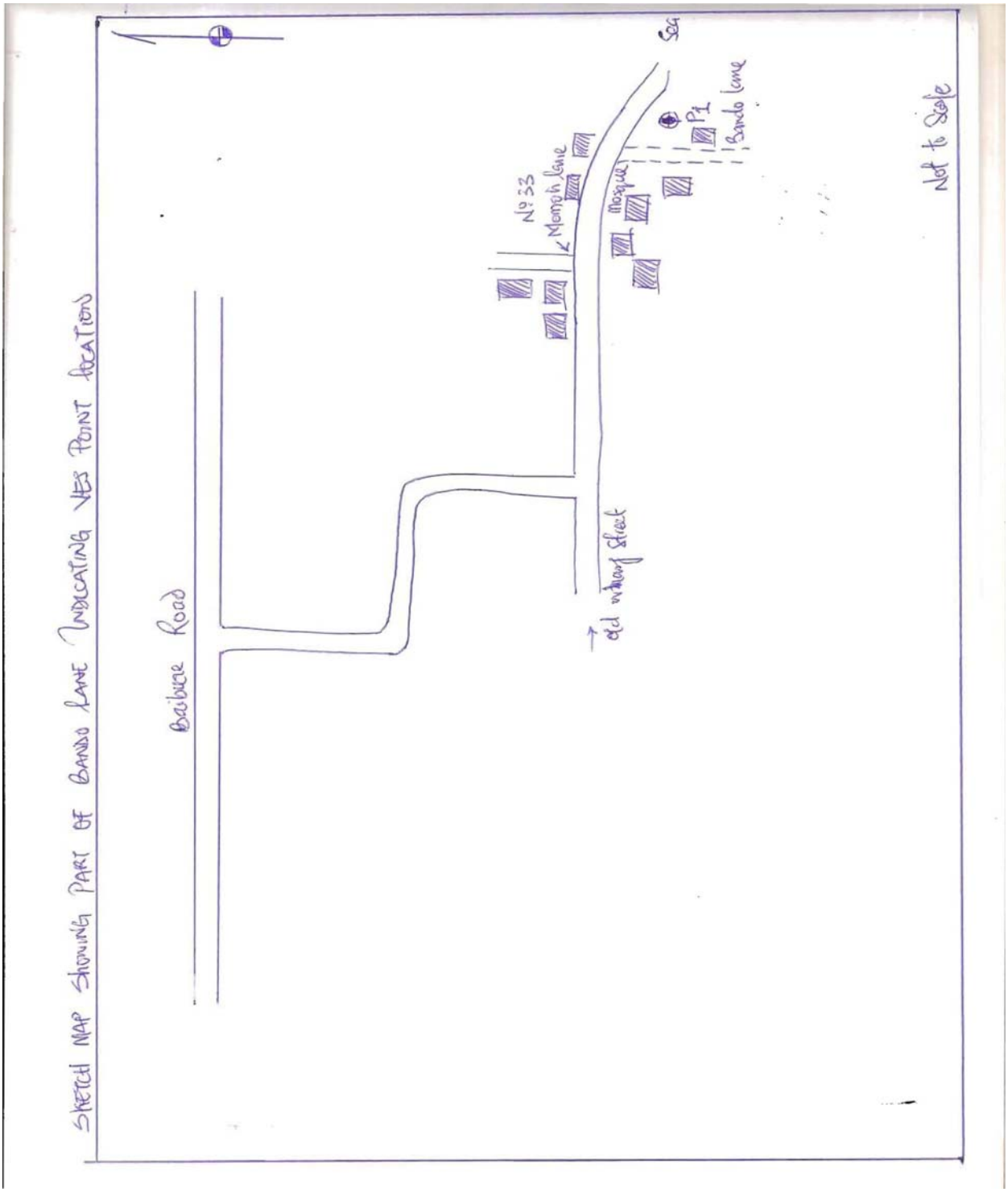
j. Old Wharf Road



k. Grassfield



l. Bando Lane


SKETCH MAP SHOWING PART OF BANDO LANE INDICATING VES POINT LOCATIONS
Bailunde Road
Old railway Street
No 33
Mongoh Lane
Mosque
P1
Bando Lane
Sea
Not to Scale