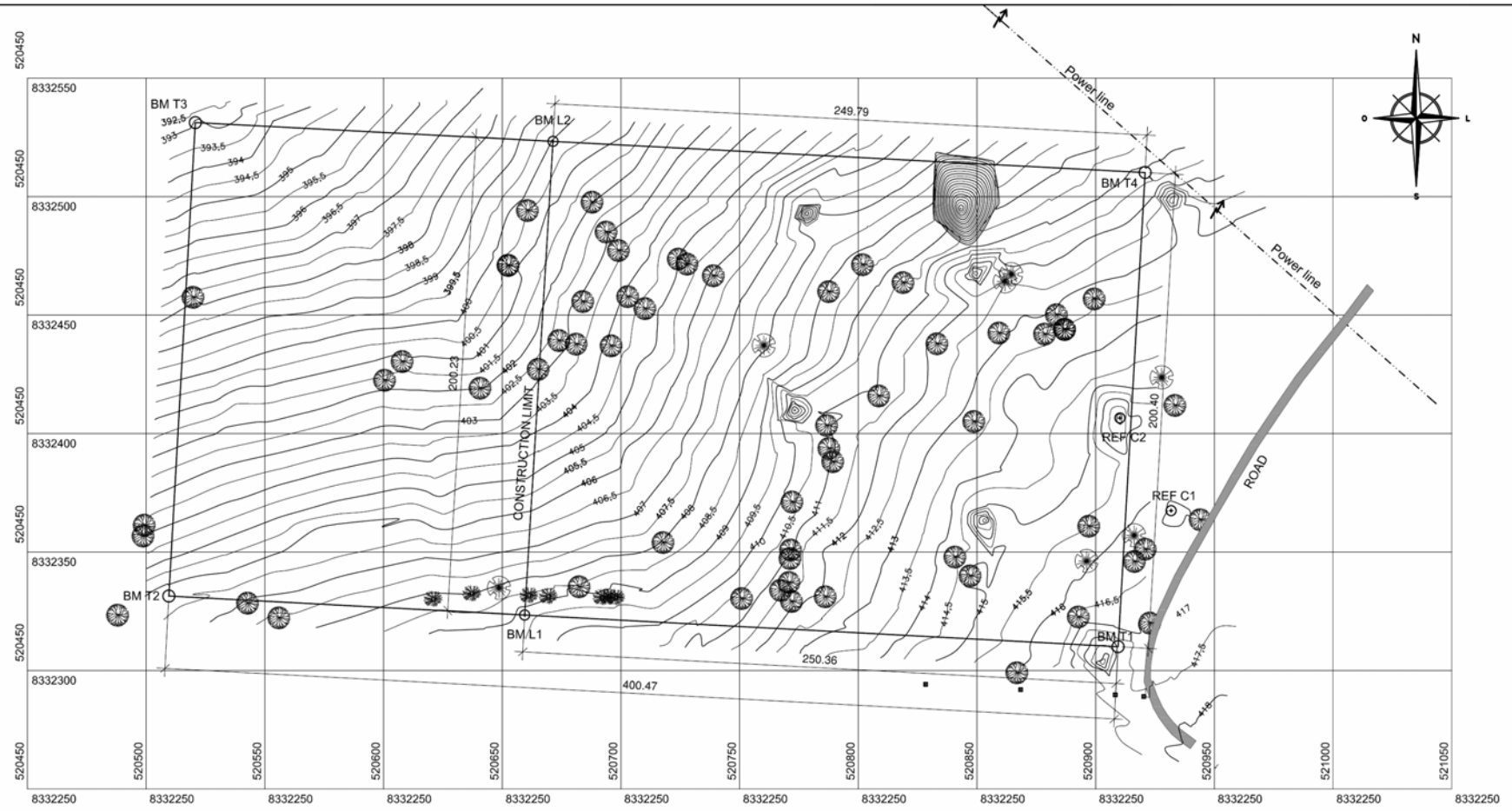
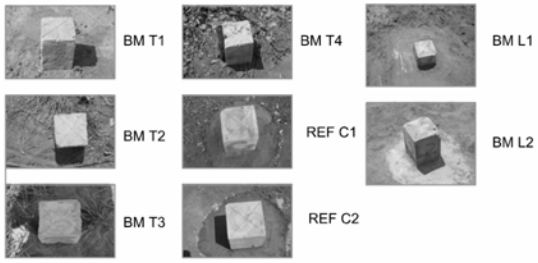
6. Outros Documentos e Informações

- **Cost Estimation to be borne by the Recipient Country**
- **Desenho Topográfico dos Terrenos** (Trabalho Consignado em Moçambique)
- **Relatório do Estudo de Solos-extracto** (Trabalho Consignado em Moçambique)
- **Relatório do Estudo Geo-físico-extracto** (Trabalho Consignado em Moçambique)

■ Cost Estimation to be borne by the Recipient Country

			Site Name			Cid. de Nampula		Namapa-Sede		Memba-Sede		Nacala-A-Velha		Sub-total	Total
			Unit Price		Unit	Q'ty	Amount (Thousand Mt)	Q'ty	Amount (Thousand Mt)	Q'ty	Amount (Thousand Mt)	Q'ty	Amount (Thousand Mt)		Amount (Thousand Mt)
			Unit Price US$	Unit Price Mt											
A:the Work to be done by commencement of construction							3,265.70		2,986.90		3,089.30		3,606.60		12,948.50
A1	EIA License			0.01%	Ls	0.299	10.40	0.234	8.20	0.234	8.20	0.234	8.20		35.00
A2	Site Clearing (tree felling and root removal, land grading)	tree felling and root removal	23.50		No	15.00	11.50	0.00	0.00	17.00	13.00	13.00	9.90	34.40	4,734.40
		land grading	2.00		㎡	20,575.00	1,339.80	16,800.00	1,094.00	17,400.00	1,133.10	17,400.00	1,133.10	4,700.00	
A3	Existing building demolition	temporary shed evacuation	20.00		㎡		0.00		0.00		0.00	150.00	97.70		97.70
A4	Access road set up	Gravel pavement (t=200)	70.18		m3	64.00	146.20	68.00	155.40	90.00	205.70	275.00	628.40		1,135.70
A5	Trial borehole drilling	Drilling on 2 points, water abstraction test, water quality analysis, and reporting	50,000.00		Ls	1.00	1,628.00	1.00	1,628.00	1.00	1,628.00	1.00	1,628.00		6,512.00
A6	Commission on bank transaction			0.10%	Ls	0.299	129.80	0.234	101.30	0.234	101.30	0.234	101.30		433.70
B:the Work to be done during construction							1,019.46		916.52		684.00		1,072.99		3,692.97
B1	Electric supply facility set up				Ls	1.00	576.36	0.00	473.42	1.00	240.90	1.00	629.89		1,920.57
B2	Water supply facility set up	Water supply pipe and pump connection,	13,609.19		Ls	1.00	443.10	1.00	443.10	1.00	443.10	1.00	443.10	1,772.40	1,772.40
C:the Work to be done after inauguration							4,542.10		3,617.30		3,682.50		4,011.60		15,853.50
C1	Exterior work	Boundary wall	100.00		m	900.00	2,930.40	690.00	2,246.60	700.00	2,279.20	800.00	2,604.80	10,061.00	10,451.80
		Gates (Entrance)	3,000.00		Ls	1.00	97.70	1.00	97.70	1.00	97.70	1.00	97.70	390.80	
C2	Landscaping work	lawn in patio	5.70		㎡	1,848.00	343.00	1,120.00	207.90	1,185.00	219.90	1,384.00	256.90	1,027.70	1,493.70
		Lawn on bank	5.70		㎡	431.20	80.00	679.70	126.10	790.30	146.70	609.70	113.20	466.00	
C3	Equipment procurement for IT		1.00		Ls		660.00		660.00		660.00		660.00		2,640.00
C4	Equipment procurement for Laboratory		1.00		Ls		219.00		116.00		116.00		116.00		567.00
C5	Preparation for opening a school		1.00		Ls	1.00	212.00	1.00	163.00	1.00	163.00	1.00	163.00		701.00
Total (A+B+C)							8,827.26		7,520.72		7,455.80		8,691.19		32,494.97





LEGEND

- Cashew Tree
- Mango
- Tree
- Bananas
- Settlement Boundary
- Benchmark
- Control points
- AREA=8.0221ha

BM-T1
REF

Point Table				
Point #	Description	Latitude	Longitude	Elevation
609	BM L1	S15° 05' 04.05"	E39° 11' 32.08"	409.32
610	BM L2	S15° 04' 57.55"	E39° 11' 32.47"	400.05
1	BM T1	S15° 05' 04.48"	E39° 11' 40.45"	417.91
10	BM T2	S15° 05' 03.80"	E39° 11' 27.05"	406.51
12	BM T3	S15° 04' 57.29"	E39° 11' 27.42"	393.12
16	BM T4	S15° 04' 57.97"	E39° 11' 40.83"	411.36
20	REF C1	S15° 05' 02.61"	E39° 11' 41.20"	417.34
21	REF C2	S15° 05' 01.34"	E39° 11' 40.47"	417.19

Point Table				
Point #	Description	Northing	Easting	Elevation
609	BM L1	8332323.44	520659.47	409.32
610	BM L2	8332523.30	520671.40	400.05
1	BM T1	8332310.08	520909.47	417.91
10	BM T2	8332331.43	520509.57	406.51
12	BM T3	8332531.23	520520.72	393.12
16	BM T4	8332510.15	520920.85	411.36
20	REF C1	8332367.48	520931.79	417.34
21	REF C2	8332406.55	520910.23	417.19

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REV	DATA	DESIGNAÇÃO

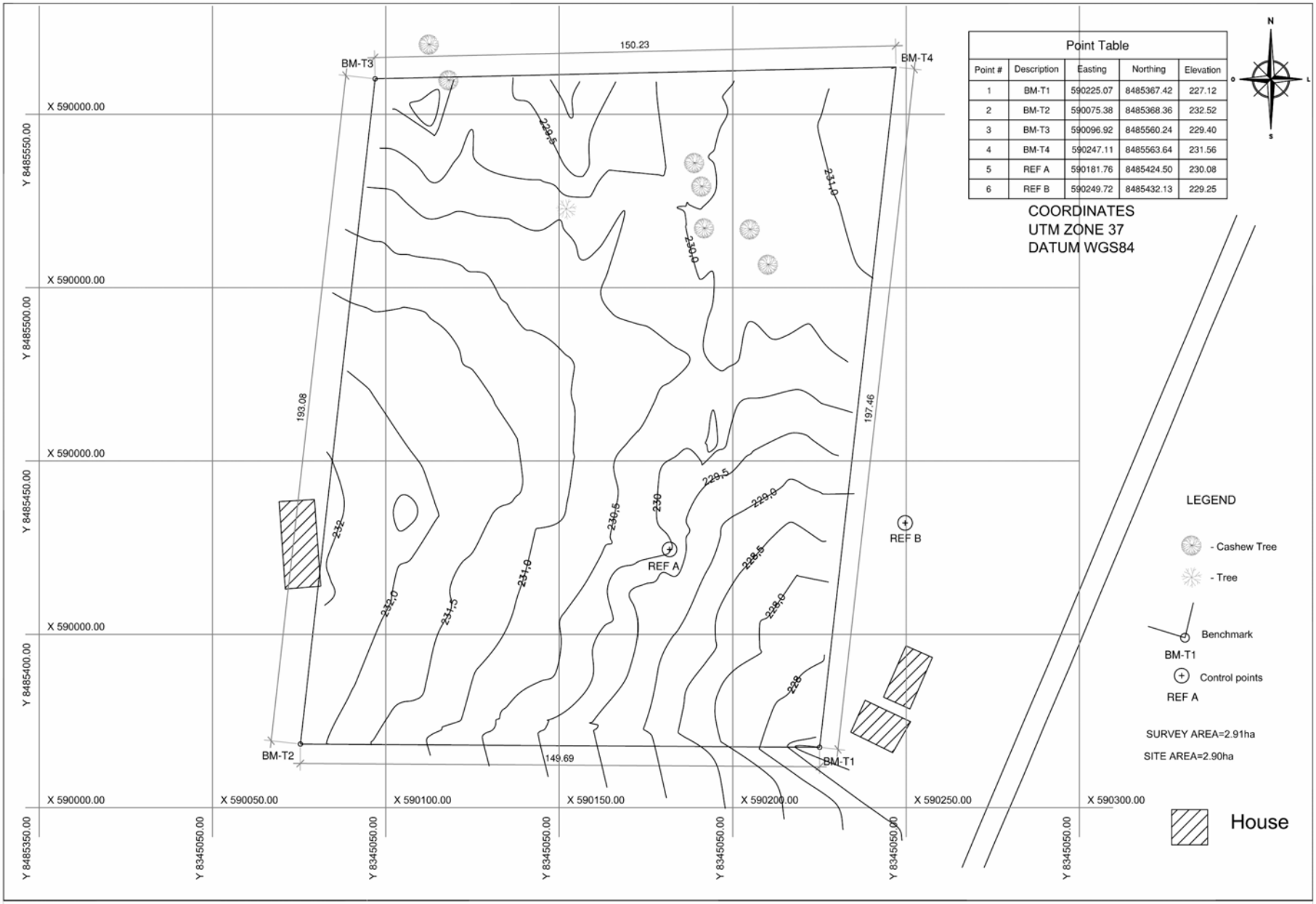
DATA MAIO 2011
PROJECTADO .....
DESENHADO J.Pereira
CALCULADO .....
APROVADO .....

CLIENT MATSUDA CONSULTANTS INTERNATIONAL CO., LTD

PROJECT IMPROVEMENT OF SECONDARY SCHOOLS IN NAMPULA PROVINCE

DESENHO Nº PTO-CP-TOP-005
PROJECTO Nº 469
ASSUNTO GENERAL LAYOUT - ES NATIQUIRE
ESCALA 1 : 1750

04



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REV	DATA	DESIGNAÇÃO

DATA MAIO 2011
PROJECTADO
DESENHADO J.Pereira
CALCULADO
APROVADO

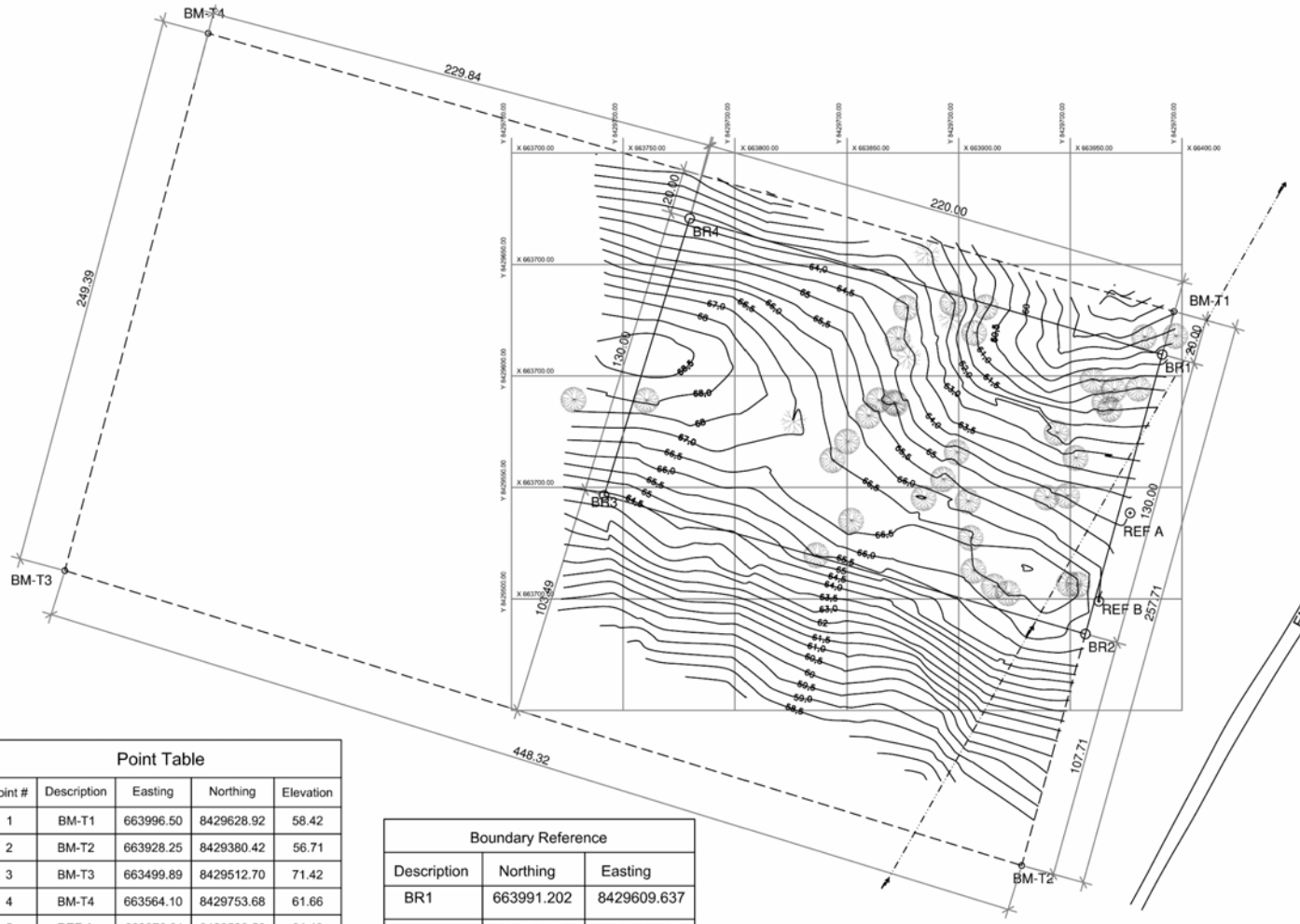
CLIENTE MATSUDA CONSULTANTS INTERNATIONAL CO. LDT

PROJECTO IMPROVEMENT OF SECUNDARY SCHOOLS INSTITUTE IN NAMPULA PROVINCE

DESENHO Nº PTO-CP-TOP-009
PROJECTO Nº 469
ASSUNTO GENERAL LAYOUT- NAMAPA SEDE

ESCALA 1 : 1000

03



Point Table				
Point #	Description	Easting	Northing	Elevation
1	BM-T1	663996.50	8429628.92	58.42
2	BM-T2	663928.25	8429380.42	56.71
3	BM-T3	663499.89	8429512.70	71.42
4	BM-T4	663564.10	8429753.68	61.66
5	REF A	663976.81	8429538.56	64.48
6	REF B	663962.80	8429498.95	65.66

COORDINATES
UTM ZONE 37
DATUM WGS84

Boundary Reference		
Description	Northing	Easting
BR1	663991.202	8429609.637
BR2	663956.774	8429484.279
BR3	663741.485	8429546.405
BR4	663779.824	8429670.623

LEGEND

- Cashew Tree
- Mango
- SITE AREA=113.841ha
- SURVEY AREA=2.86ha
- Middle Voltage Power Line
- Boundary Reference and lines
- Benchmark
- Control points

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REV	DATA	DESIGNAÇÃO

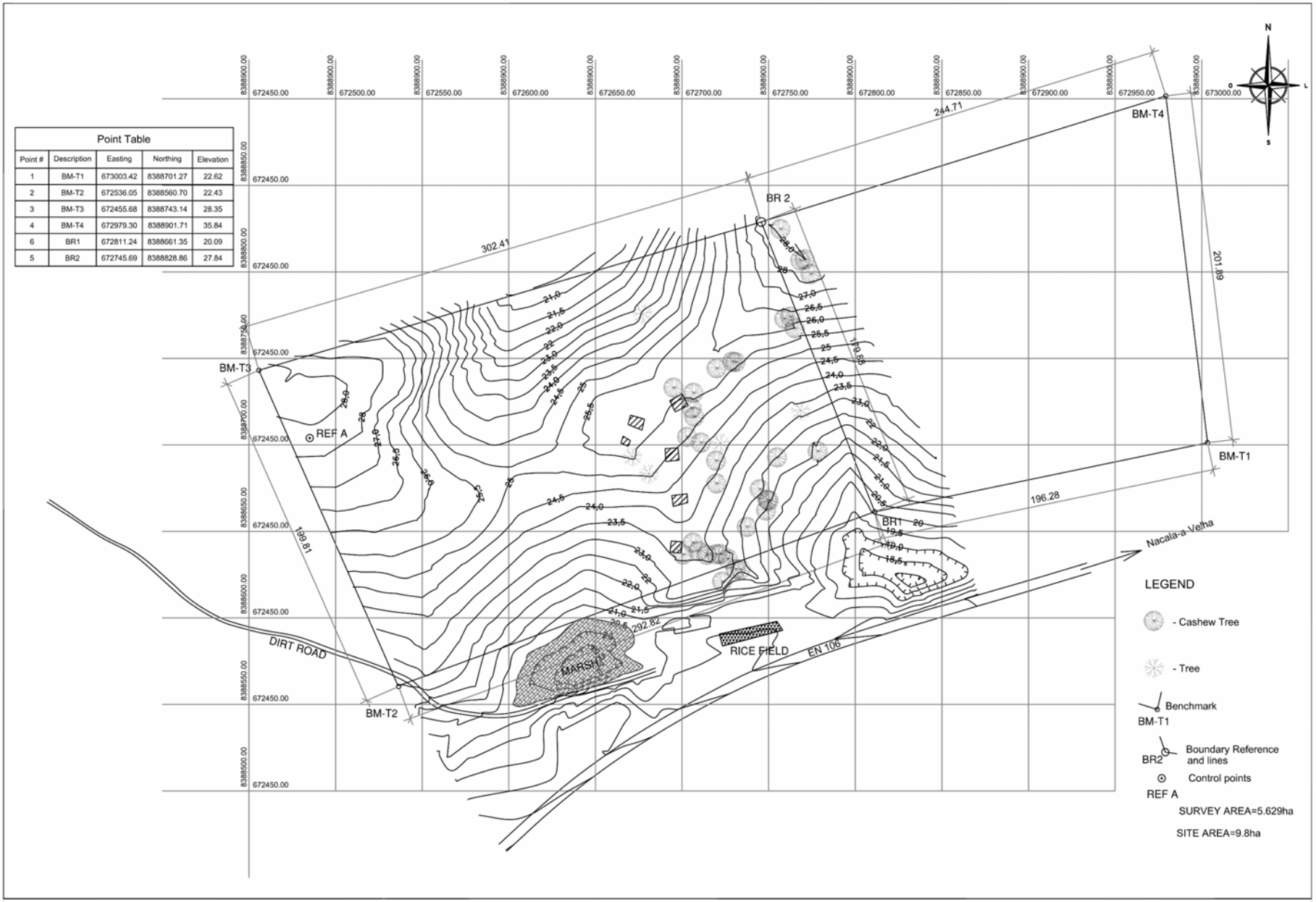
DATA MAIO 2011
PROJECTADO
DESENHADO J.Pereira
CALCULADO
APROVADO

CLIENTE MATSUDA CONSULTANTS INTERNATIONAL CO. LDT

PROJECTO IMPROVEMENT OF SECUNDARY SCHOOLS IN NAMPULA PROVINCE

DESENHO Nº PTO-CP-TOP-007
PROJECTO Nº 469
ASSUNTO GENERAL LAYOUT- MEMBA
ESCALA 1 : 2000

07



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REV | DATA | DESIGNAÇÃO

DATA MAIO 2011
PROJECTADO
DESENHADO
CALCULADO
APROVADO

CLIENT MATSUDA CONSULTANTS INTERNATIONAL CO., LTD

PROJECT IMPROVMENT OF SECONDARY SCHOOLS IN NAMPULA PROVINCE

DESENHO Nº PTO-CP-TOP-006
PROJECTO Nº 469
ASSUNTO GENERAL LAYOUT- NACALA A VELHA
ESCALA 1 : 2000

06

REPÚBLICA DE MOÇAMBIQUE
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DEPARTAMENTO DE GEOTECNIA

Registry N. 28.136

ASSUNTO: **SOIL INVESTIGATION ON THE PROJECT FOR THE IMPROVEMENT OF A PRIMARY TEACHER TRAINING INSTITUTE IN NAMPULA PROVINCE AND THE PROJECT FOR THE IMPROVEMENT OF SECONDARY SCHOOLS IN THE NORTHERN REGION IN THE REPUBLIC OF MOZAMBIQUE**

1. INTRODUCTION

By request of MATSUDA CONSULTANT INTERNATIONAL CO, LTD, through an agreement dated of May 09, 2011, the Engineering Laboratory of Mozambique (LEM), executed field and laboratory tests for the study of the characteristics of the soils, on lands located in some districts , in the province of Nampula.

In the present report the accomplished work is described and the results obtained in the tests are also presented.

2. ACCOMPLISHED WORKS

The initial study plan consisted of the execution of 24 (twenty four) Dynamic Penetration Light (DPL) tests and 24 (twenty four) Hand Auger boreholes up to 5m (five meters) depth, distributed by 8 (eight) sites and 3 (three) points for each site. Because of the soils characteristics it was not possible to reach the initial plan in all.
So, the sites, number of studies and depth reached for each point are presented in the following:

ES Muecate-sede:
Point 1: DPL (3.10m); Hand Auger boring (3.30m)
Point 2: DPL (3.00m); Hand Auger boring (3.35m)
Point 3: DPL (3.00m); Hand Auger boring (3.35m)

ES Memba-sede:
Point 1: DPL (not done); Hand Auger boring (0.70m)
Point 2: DPL (1.80m); Hand Auger boring (1.30m)
Point 3: DPL (2.30m); Hand Auger boring (1.10m)

ES Nacala-a-Velha:
Point 1: DPL (not done); Hand Auger boring (not done)
Point 2: DPL (1.80m); Hand Auger boring (1.80m)
Point 3: DPL (1.80m); Hand Auger boring (0.80m)

ES Namapa-sede:
Point 1: DPL (2.00m); Hand Auger boring (1.90m)
Point 2: DPL (0.60m); Hand Auger boring (0.65m)
Point 3: DPL (2.70m); Hand Auger boring (4.00m)

ES Mossuril:
Point 1: DPL (5.00m); Hand Auger boring (5.00m)
Point 2: DPL (5.00m); Hand Auger boring (5.00m)
Point 3: DPL (5.00m); Hand Auger boring (5.00m)

ES Rapale:
Point 1: DPL (2.60m); Hand Auger boring (2.75m)
Point 2: DPL (1.90m); Hand Auger boring (2.30m)
Point 3: DPL (2.50m); Hand Auger boring (3.00m)

ES Nampula-sede:
Point 1: DPL (3.80m); Hand Auger boring (4.00m)
Point 2: DPL (3.90m); Hand Auger boring (4.00m)
Point 3: DPL (4.50m); Hand Auger boring (0.90m)

IFP Monapo-sede:
Point 1: DPL (2.90m); Hand Auger boring (2.50m)
Point 2: DPL (2.70m); Hand Auger boring (2.10m)
Point 3: DPL (4.10m); Hand Auger boring (1.70m)

The studies locations were identified by MATSUDA CONSULTANT INTERNATIONAL representative and the respective drawing given are shown in attachment (Attachment 1).

2.1. Observation of the boreholes

The lands crossed by the hand auger boreholes, their lithological characteristics, depth and layer thickness are indicated in the enclosed borehole profiles (Attachment 3).
The macroscopic classification was effectuated in agreement with the Portuguese specification E-219 of LNEC. The presence of water at the location was detected during the borehole (HA2) in Monapo, at 2.0m depth.

2.2. Penetration test

2.1.1. Dynamic Penetration Light tests

The dynamic penetration light tests with the normalized probe were executed in the shown sites, in a way to determine the point resistance. The point resistances were executed in all 10 cm (ten centimeters) depth of the boreholes.

The depths at which the DPL tests were carried on, are indicated in the enclosed diagrams (Attachment 2).
In accordance with the diagrams of DPL tests is verified the following:

2.1.1.2. ES Memba-sede

DPL 2

From the mouth of this borehole up to 1.80m (one meter and eighty centimeters) of depth, where the test finished because of the end of apparatus capacity, the point resistances is variable (grow and decrease along the depth).

DPL 3

From the mouth of this borehole the point resistances grow along the depth, up to 2.30m (two meters and thirty centimeters) of depth, where the test finished because of the end of apparatus capacity.

2.1.1.3. ES Nacala-a-Velha

DPL 2 and DPL 3

From the mouth of these boreholes up to 1.80m (one meter and eighty centimeters) of depth, where the test finished because of the end of apparatus capacity, the point resistances is variable (decrease and grow along the depth).

2.1.1.4. ES Namapa-sede

DPL 1

From the mouth of this borehole the point resistances decrease up to 1.50m (one meter and fifty centimeters) of depth. From 1.50m (one meter and fifty centimeters) to 2.0m (two meters) of depth, where the test finished because of the end of apparatus capacity, the point resistances grow.

DPL 2

From the mouth of this borehole the point resistances are constant along the depth, up to 0.60m (sixty centimeters) of depth, where the test finished because of the end of apparatus capacity.

DPL 3

From the mouth of this borehole the point resistances grow along the depth, up to 2.70m (two meters and seventy centimeters) of depth, where the test finished because of the end of apparatus capacity.

2.1.1.7. ES Nampula-sede

DPL 1

From the mouth of this borehole the point resistances grow along the depth, up to 3.80m (three meters and eighty centimeters) of depth, where the test finished because of the end of apparatus capacity.

DPL 2

From the mouth of these boreholes up to 3.90m (three meters and ninety centimeters) of depth, where the test finished because of the end of apparatus capacity, the point resistances is variable (grow and decrease along the depth).

DPL 3

From the mouth of this borehole the point resistances are constant up to 0.80m (eighty centimeters) of depth. From 0.80m (eighty centimeters) to 4.50m (four meters and fifty centimeters) of depth, where the test finished because of the end of apparatus capacity, the point resistances is variable (grow, keep constant and decrease along the depth).

3. LABORATORIAL TESTS

On the samples picked in the hand auger boreholes, there were executed the following tests:

3.1. Sieve analysis;
3.1. Determination of the consistency limits;
3.2. Determination of the moisture content;
3.3. Determination of the soil density;
3.4. Determination of the specific gravity;
3.5. Determination of the porosity

The results of the laboratory tests are part of an enclosed attachment (Attachment 3).

4. RESULTS INTERPRETATION

4.2. ES Memba-sede

Hand Auger boring 1

From the mouth of hand auger 1 (HA1) to 0.70m (seventy centimeters) of depth, the presence of coarse to fine whitish clayey sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SC type.

Hand Auger boring 2

From the mouth of hand auger 2 (HA2) to 1.30m (seventy centimeters) of depth, the presence of coarse to fine whitish clayey sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SC type.

Hand Auger boring 3

From the mouth of hand auger 3 (HA3) to 1.10m (one meter and ten centimeters) of depth, the presence of coarse to fine brownish clayey sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SC type.

4.3. ES Nacala-a-Velha

Hand Auger boring 2

From the mouth of hand auger 2 (HA2) to 0.65m (sixty five centimeters) of depth, the presence of brownish sandy clay, is verified that in accordance with United System of Soil Classification (USCS), are soils of OH type. From 0.65m (sixty five centimeters) to 1.80m (one meter and eighty centimeters) of depth, the presence of brownish sandy clay with gravel is verified.

Hand Auger boring 3

From the mouth of hand auger 3 (HA3) to 0.80m (eighty centimeters) of depth, the presence of coarse to fine brownish silty sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SW-SM type.

4.4. ES Namapa-sede

Hand Auger boring 1

From the mouth of hand auger 1 (HA1) to 1.90m (one meter and ninety centimeters) of depth, the presence of brownish sandy clay, is verified that in accordance with United System of Soil Classification (USCS), are soils of OH type.

Hand Auger boring 2

From the mouth of hand auger 2 (HA2) to 0.65m (sixty five centimeters) of depth, the presence of coarse to fine brownish clayey sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SC type.

Hand Auger boring 3

From the mouth of hand auger 3 (HA3) to 1.60m (one meter and sixty centimeters) of depth, the presence of brownish sandy clay, is verified that in accordance with United System of Soil Classification (USCS), are soils of OH type. From 1.60m (one meter and sixty centimeters) to 3.30m (three meters and thirty centimeters) of depth, the presence of yellowish sandy clay with gravel is verified. From 3.30m (three meters and thirty centimeters) to 4.0m (four meters) of depth, the presence of chalky is verified.

4.7. ES Nampula-sede

Hand Auger boring 1 and Hand Auger boring 2

From the mouth of hand auger 1 (HA1) and auger 2 (HA2) to 3.0m (three meters) of depth, the presence of coarse to fine reddish clayey sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SC type. From 3.0m (three meters) to 4.0m (four meters) of depth, the presence of coarse to fine reddish clayey sands with gravel is verified.

Hand Auger boring 3

From the mouth of hand auger 3 (HA3) to 0.60m (sixty centimeters) of depth, the presence of coarse to fine reddish clayey sands, is verified that in accordance with United System of Soil Classification (USCS), are soils of SC type. From 0.60m (sixty centimeters) to 0.90m (ninety centimeters) of depth, the presence of gravel is verified.

5. DETERMINATION OF BEARING CAPACITY

To determine bearing capacity of foundations, it may be used the following Dutch formulas:

$$r_p = \frac{M^2 H}{(Ss + M)Ae}$$

r_p = **Point resistance (Kg/cm²)**

M = **Hammer weight (Kg)**

H = **height of hammer fall (cm)**

S = **Staff weight + point + conch (kg)**

s = **Staff length**

A = **area of cone section (cm²)**

e = **penetration/blow (cm)**

Admissible strain to calculate superficial foundations

$$\sigma = {}^{r_p}\!/_{20}$$

σ = **Admissible strain (kg/cm²)**

ES – RAPALE

Considering the depth of the foundation (**D**) equal to **100 centimeters**

$\sigma = 1{,}5$ Kg/cm²

ES – NAMPULA

Considering the depth of the foundation (**D**) equal to **80 centimeters**

$\sigma = 2{,}0$ Kg/cm²

ES – MUECATE

Considering the depth of the foundation (**D**) equal to **100 centimeters**

$\sigma = 2{,}0$ Kg/cm²

IFP – MONAPO

Considering the depth of the foundation (**D**) equal to **100 centimeters**

$\sigma = 1{,}3$ Kg/cm²

ES – NAMAPA

Considering the depth of the foundation (**D**) equal to **100 centimeters**

$\sigma = 2{,}0$ Kg/cm²

ES – MOSSURIL

Considering the depth of the foundation (**D**) equal to **100 centimeters**

$\sigma = 1{,}0$ Kg/cm²

ES – NACALA-A-VELHA

Considering the depth of the foundation (**D**) equal to **80 centimeters**

$\sigma = 2{,}5$ Kg/cm²

ES – MEMBA

Considering the depth of the foundation (**D**) equal to **80 centimeters**

$\sigma = 2{,}3$ Kg/cm²

Recommendation

It's recommended after digging up to foundation bottom, compact the soils, in order to settle the foundation on compacted layer. Like this, it will get better substantially the soil resistance on the bottom of the foundation.

6. USED NORMATIVE DOCUMENTS

For the accomplishment of this work, the following normative documents of LNEC, Portugal, were used:

6.1. E-218 1968– Geotechnical boreholes of lands;

6.2. E-196 1966– Sieve Analysis;

6.3. NP-143 1969–Determination of the consistency limits;

6.4. NP – 83 1965 – Determination of soil density;

6.5. NP – 83 1965 – Determination of the specific gravity;

6.6. E – 16 1953 – Determination of the moisture content

Maputo, June 2011

The Technician:

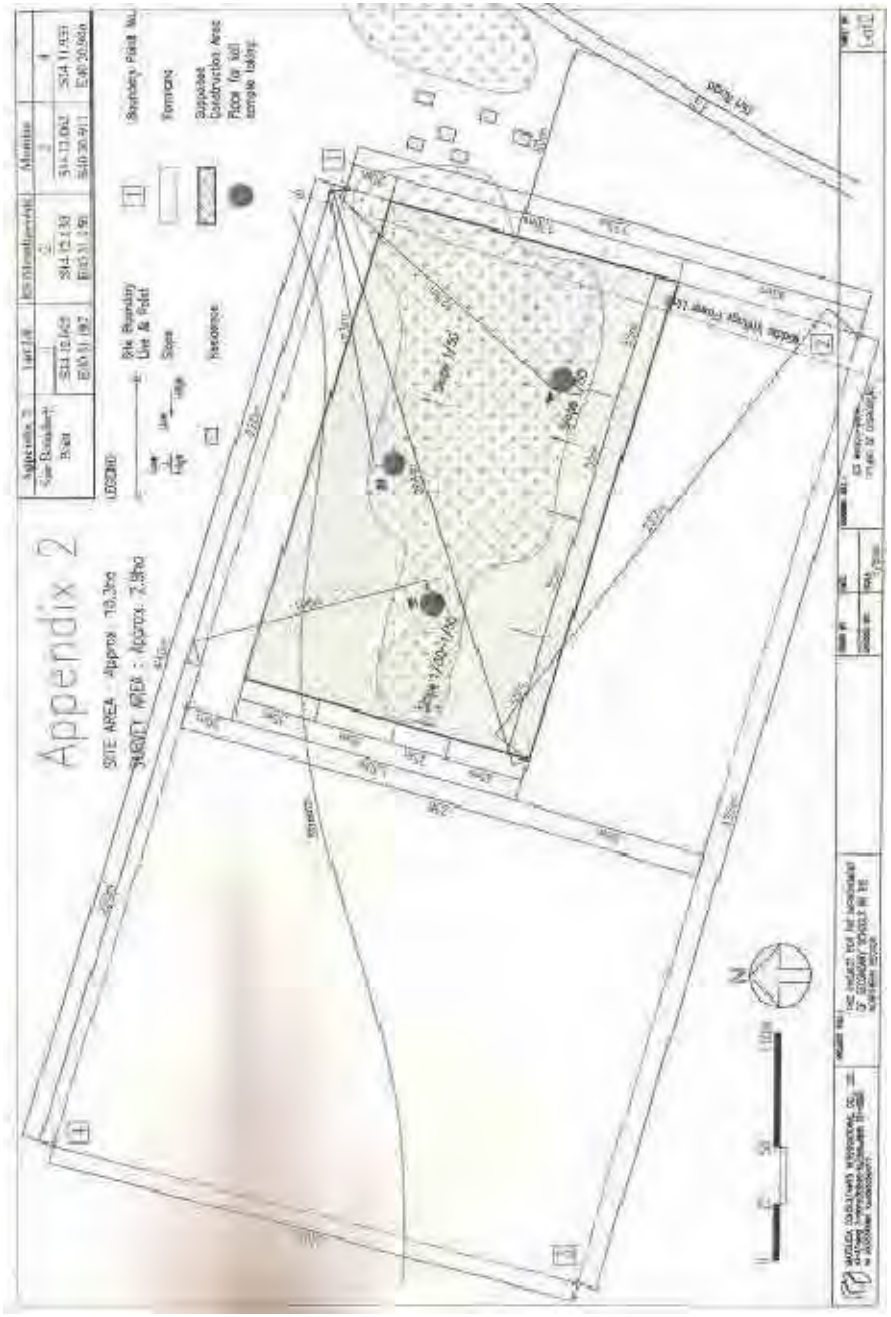
Manuel P. Mascarenhas Arouca
(Civil Eng. Technician)

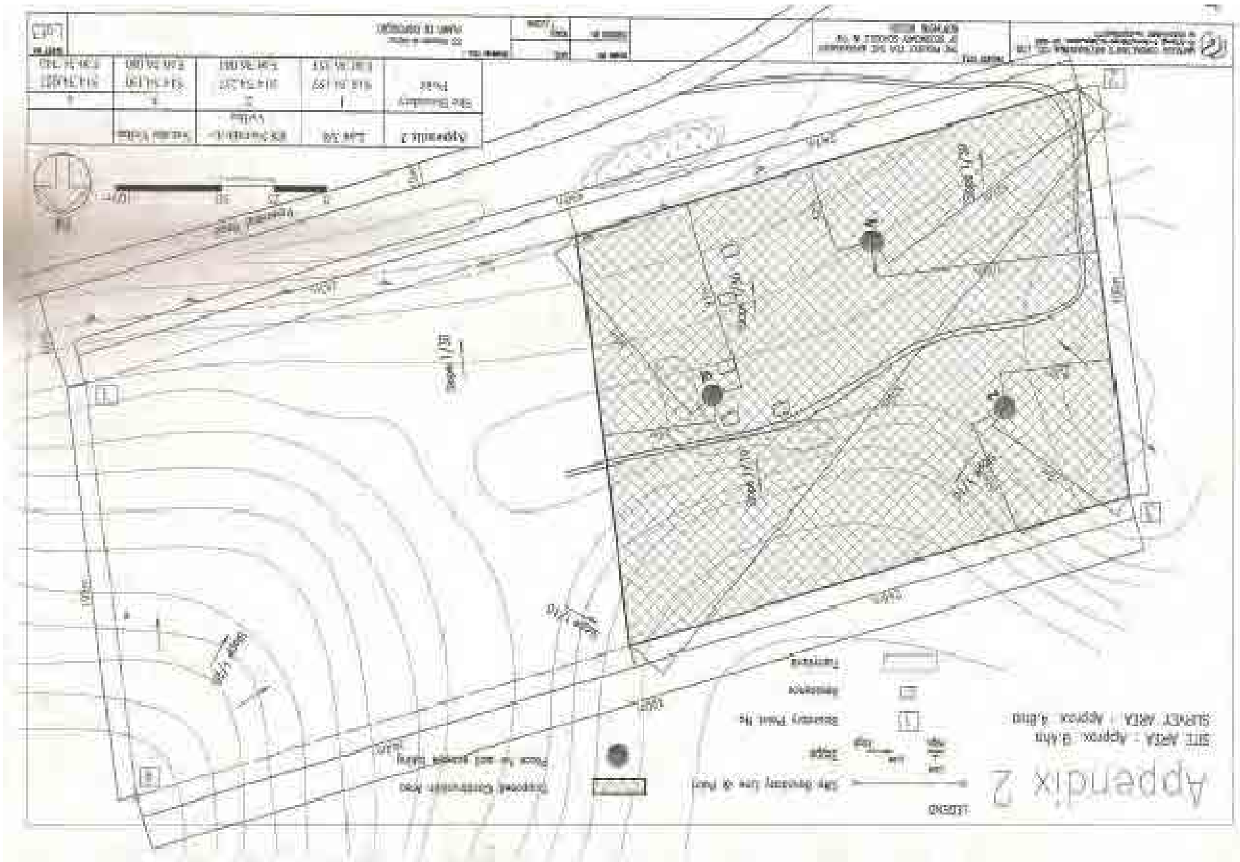
The Coordinator of the Department

Manuel P. Mascarenhas Arouca

The Executive Chief

dr. Henrique Vasco Filimone
(Assistent Investigator)




Appendix 2
LEGEND


Appendix 2
LEGEND

Geotec
Consultoria em Geologia, Geotecnia e Ambiente,Lda

REPORT ON

GEOTECHNICAL SITE INVESTIGATION

FOR PROPOSED CONSTRUCTION OF A SECONDARY SCHOOL

IN NAMPULA

Prepared for:
Matsuda Consultants International Co., Ltd

GTC/016/2011

MAPUTO

JANUARY, 2012

A53

2. SITE DESCRIPTION

2.1 Location of the Site

The investigated area is 5.1 ha and is located in Natikiri, within the sub-urban area of Nampula City. To access the site from the city center of Nampula just follow the western main road to Murrupula for about 4 km, then turn right through the road to Ribáuè for about 2 km and then turn left and follow a track that leads to Quinta do Galo for approximately 1.5 km (Fig.1 and Appendix A).

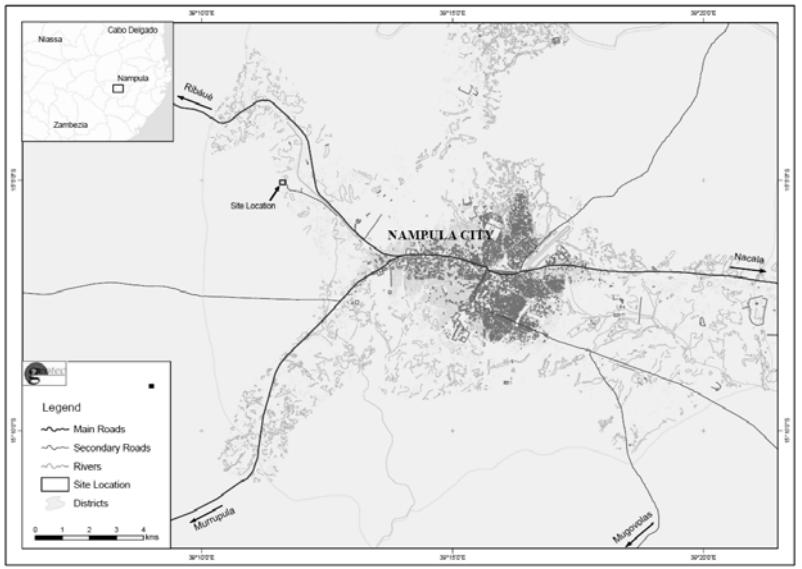


Figure 1 – Location map of the site investigated

2.2 Geology

We reviewed existing geological data and information in our files. Based on this review the geological stratigraphy consists of Pleistocene Age upland terrace deposits over residual materials derived from the Nampula gneissic complex Formations. The terrace deposits are alluvial soils that typically consist of a mixture of clay, silt, sand and gravel. These soils typically exhibit moderate to high strength and low to moderate compressibility. The residual soils result from chemical and physical weathering of the underlying crystalline rocks of the Nampula gneissic complex Formations (Figure 2).

Table 1 – Geographical location of the test pit and sampling sites

Sample	Latitude	Longitude
Npl – 1	15° 05' 01.0" S	39° 11' 38.7" E
Npl – 2	15° 04' 59.0" S	39° 11' 35.1" E
Npl – 3	15° 05' 03.1" S	39° 11' 34.8" E

3.2 Sampling

A total of three undisturbed soil samples were taken from the sites indicated by the client, i.e., from the place where the test pit were excavated (Table 1). The depth of sampling was between 0.8m and 1.5m below ground, as stated in the scope of work.

After sampling, the container of each sample was adequately sealed to prevent them from loosing soil moisture and the samples were taken to the ANE laboratory in Nampula to undertaken the required laboratory tests.

3.3 DCP Test

DCP tests were performed on both sites down to 2.5m below ground surface as requested by the client (Photo-4, Appendix E). A systematic penetration interval of 10 cm was used and the results were plotted to generate a curve relating the number of blows to the depth penetrated (Appendix C). Depending on the soil resistance structure and environmental conditions the plot is divided into "best fit" straight lines in a procedure meant at allowing the identification of soil units of similar penetration resistance. These units will have slope values representing the average penetration rate of the unit expressed as mm/blow.

Next the relationship between DCP slope and CBR was determined using the model derived by Kleyn and Van Heerden (1983). Then, DCP values are related to CBR using the following equation:

$$\text{Log CBR} = 2.628 - 1.273 \log(\text{DCP})$$

where DCP = penetration mm/blow

3.4 Laboratory Testing

The scheduling of geotechnical laboratory tests was undertaken by Geotec Lda and the soil samples were submitted to ANE's (National Authority for Roads) Laboratory in Nampula. The laboratory testing program consisted of determining moisture content,

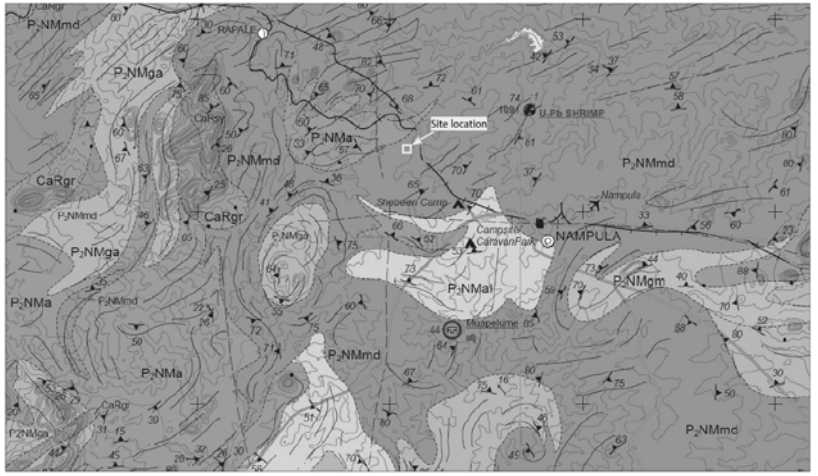


Figure 2 – General geological map of the site investigated (Source: Council for Geoscience, 2006)

3. GROUND INVESTIGATION

A meeting with the client was held on site on 30th November 2011 meant at introducing the contractor to the investigation sites. Afterwards a 2nd phase of preparations was initiated to gather and mobilize the equipmemt to the site including a TLB and a DCP. In the end the actual fieldwork investigation activities were undertaken on 2nd and 3rd December 2011 and comprised the excavation of three test pits, logging of the soil profile, performing DCP tests for estimation of bearing capacity of the soils and sampling of undisturbed soil. A geotechnical engineer supervised the excavation and sampled the soil profile. Visual and tactile techniques were used to assess the soil profile.
Finally the samples were taken to the Laboratory in Nampula for testing.

3.1 Test Pit Excavation and Logging

Three test pits of about 3 m x 2m were excavated to a maximum depth of 1.5 meter, using a TLB Massey Ferguson 60 HX (Appendix C – Photo 2). A GPS (Garmin GPSmap76CSx) was used to setup the test pit positions and the geographical coordinates of the sites are given in Table 1. These positions correspond to the exact sites indicated by the client.

After excavation of the test pit, the walls of the excavation were examined visually and manually as part of the soil profile geotechnical description procedure. The test pits were then logged by a geotechnical engineer in accordance with the MCCSSO system (Jennings *et al.*, 1973). The descriptions of the strata encountered together with the samples taken are presented on the test pit records (Appendix B).

porosity, specific gravity grain size, distribution and atterberg limits. The test results are presented in detail in Appendix D and discussion around the geotechnical parameters resulting from the laboratory tests is given in Section 4.

Descriptive classifications of the soils are in accordance with the Unified Classification System. Also shown are estimated Unified Soil Classification Symbols.

3.5 Groundwater level

The test pits were monitored while excavating and after completion for the presence of groundwater but no water was registered in the pits at 1.5 m below ground level, and there was no indication on the DCP equipment that reach 2.5 m deep.

It should be recognized that fluctuations of groundwater table may occur due to seasonal variations in the amount of rainfall and resulting runnof.

4. RESULTS AND SITE EVALUATION

4.1 Typical Soil Profile

To better describe the area in terms of the most representative soil profile, a sketch is provide in Appendix A showing the geographical location of the test pits points Npl-1, Npl-2 and Npl-3. The sketch also shows the approximate altitude of those points and the exact geographic coordinates of the sites are shown in Table 1.

The positioning of these points was carefully setup together with Mr Hyodo Kaname from Matsuda Consultants International, as to reveal in broad terms the underlying geotechnical conditions with focus to the place where significant developments were envisaged to take place within the investigated area.

The geotechnical soil profile of area is given in Figure 5 and with more detail in Appendix B. These results suggest that the shallow soils from the area are in general transported with the top 0.8 to 1.0m consisting of a slightly moist, reddish brown, medium dense clayey sand layer of medium to coarse grain size. In general the upper 30 cm of this layer is loose sand with some organic content and many roots of plants.

The next layer is at least 1m thick, slightly moist, reddish brown, medium dense clayey gravel of fine grained size, containing a lot of sand. This layer was only found on the test pit Npl-2 indicating that there are slight lateral variations on the soil horizons as we move northwest of the area under investigation towards a valley located north of the area where a small stream flows in the E-W direction.

Apart from the occurence of clayey gravel layer the textural variations are also observed at Npl-3 where the top sand layer is rich in silt instead of clay as described at Npl-1. These textural differences are tipical of alluvial depositional environments.

4.2 Soil Classification

A summary of results from sieve analysis and atterberg limits tests is presented in Table 2. The criteria used to assign group symbols and group names based on results from sieve analysis and Atterberg limits is in accordance with Unified Soil Classification System (ASTM D-2487) is given Appendix D.

The results indicate that soils from the site fall into different soil classes (Table 2). Sample Npl-1 is Clayey SAND (SC), Sample Npl-2 classifies as Clayey GRAVEL with Sand (GC) and Sample Npl-3 is a Silty SAND (SM). These differences are in correlation with the visual descriptions given in the trial pit logs translating lateral textural variations of the soil layers from sand to fine-grained gravel and in some places with significant increase in the amount of fines. The textural lateral variations are attributed to the alluvial nature of the soils (Figure 5).

The results also indicate the clay content ranges from 16.08% to 35.44%. Plasticity tests were carried out on samples from the site suggest that the material can be classified as CLAY of low to medium plasticity, except at site Npl-3 where it classifies as SILT of high plasticity. The soil contains a significant amount of fines grained particles and this classification agrees with the argument presented in the next section that the soil is potentially expansive. The plots of atterberg limits test results on the Casagrande Plasticity Chart are shown in Figure 3.

Table 2 – Summary of results from grain size distribution and atterberg limits tests

Sample Nr.	LL (%)	PL (%)	PI (%)	Silt/Clay (%)	Sand (%)			Gravel (%)		Group Symbol	Group Name
					Fine	Medium	Coarse	Fine	Medium		
Npl-1	41.42	23.58	17.84	35.44	9.08	15.26	39.42	0.81	0.0	SC	Clayey Sand
Npl-2	33.39	20.79	12.60	16.08	6.68	7.64	22.73	35.98	10.89	GC	Clayey Gravel w/ Sand
Npl-3	52.68	33.59	19.09	29.13	6.86	11.88	45.90	6.23	0.0	SM	Silty Sand

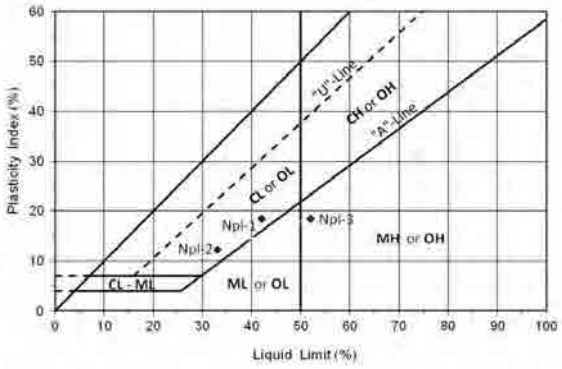


Figure 3 – Plot of results from the atterberg limits test on the Casagrande Plasticity Chart

4.3 Soil Expansive Potential

The expansive potential of a soil depends upon its clay content, the type of clay mineral, its chemical composition and mechanical character. To assess soil expansion caused by increase in water content Kantey and Brink (1952) suggests that a material is potentially expansive if it exhibits the following properties: clay content >12 %, plasticity index > 12%, liquid limit > 30 % and linear shrinkage > 8%. The soils from the site under investigation contain significant amount of fine-grained particles (Table 2) and all other requirements meet the criteria indicating that the soils from the site investigated are potentially expansive.

4.4 Soil Strength

The assessment of soil strength was estimated from DCP tests carried out at the same position where the test pits were escavated. As explained in Section 3.3, the results were then correlated to CBR and then an estimated recommended bearing pressure was casted accordingly.

The results were plotted to generate a curve relating the number of blows to the depth penetrated (Figure 4), from which the general trend of the curve was used to define layers (or units) with approximately the same rate of penetration. It is important to note that the layers do not necessarily correspond to the layering of soil types but the resistance of the soil to penetration of the DCP. For instance, if the upper part of a sand layer is loose and the lower part dense, the resistance to penetration of the DCP will be higher in the dense sand and therefore the bearing capacity in the dense sand will also be relatively higher.

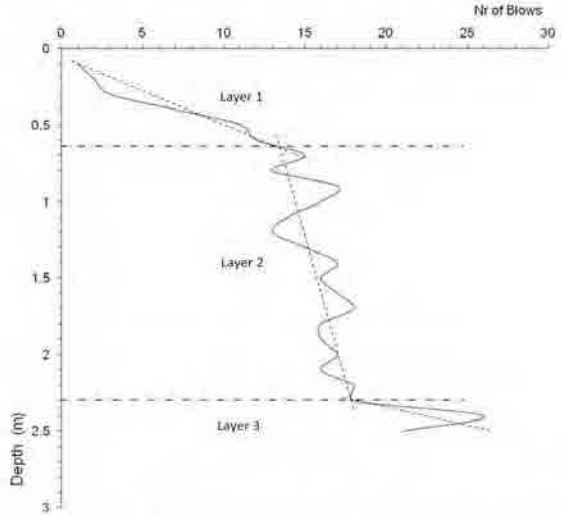


Figure 4 – Plot of DCP number of blows versus depth of penetration used to determine soil layers of approximately the same bearing capacity

The results, when plotted together show the layer CBR values varying from 4.46 to 66.23%. The corresponding estimantes of safe bearing pressure ranges from 100 to 350 kPa (Figure 5). These values are typical of medium dense clayey sand and clayey gravel with sand, and are considered to be moderate to high.

These estimates of soil resistance are in agreement with the soil descriptions and testing conducted *in situ* and it appear to increase with depth as the sand changes from loose to medium dense.

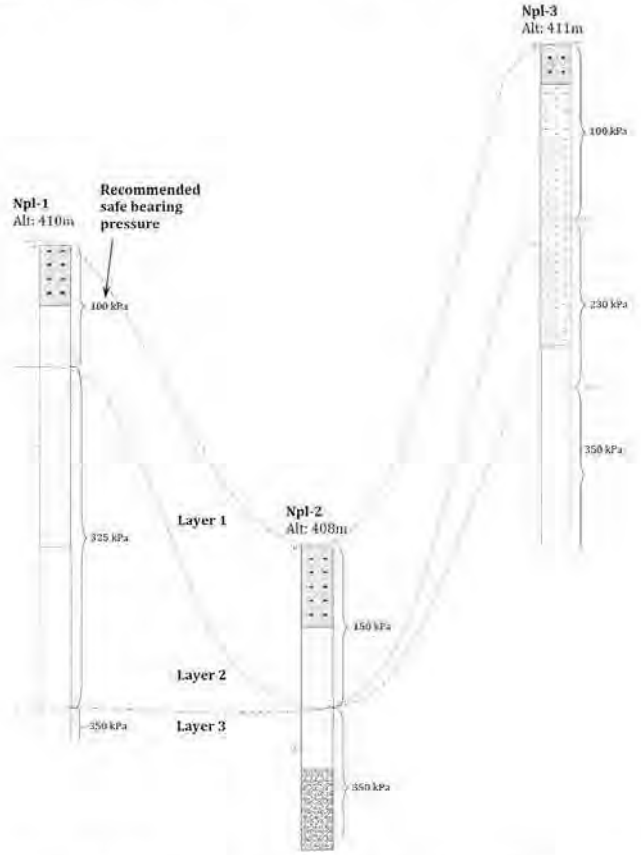


Figure 5 – Soil profile with plotted layers representing approximately homogeneous units in terms of safe bearing pressure

4.5 Moisture Content

The moisture contents recorded from the investigations indicate a range from 15.35% to 18.09% within the depth of 0.8 to 1.5m where the soil samples were taken. The moisture content results generally lie close to the plastic limit for the soil indicating that the material should be firm to stiff. This pattern of results is as expected for clayey sand. The moisture contents results are given in Appendix D.

5. RECOMMENDATIONS FOR GEOTECHNICAL DESIGN

1. A site of approximately 5.1 hectare located at Natikiri, outskirts Nampula City was investigated to determine the geotechnical properties that might influence the proposed construction of the of the Secondary School and provide parameters for geotechnical design.

2. The site is underlain by gneissic bedrock of the Nampula Complex. The bedrock is covered by residual and transported soils consisting of Clayey Sand (SC) of low to medium plasticity, with textural variations into Clayey Gravel (GC) and Silty Sand (SM).

3. The soil has expansive potential due to its relatively high content of fines of medium to high platicity. Therefore the foundations will require modified normal or special foundation techniques such as proper compaction techniques and slightly reinforced strip footings. No problems are expected regarding the excavatability of the soil therefore we trust that a competent TLB might be sufficient for the purpose.

4. We consider that either shallow strip footins or spread footings will be suitable to support the proposed structure after adequate excavation and compaction of the natural soils. Footings may be designed for an allowable bearing pressure of 230 to 325 kPa.

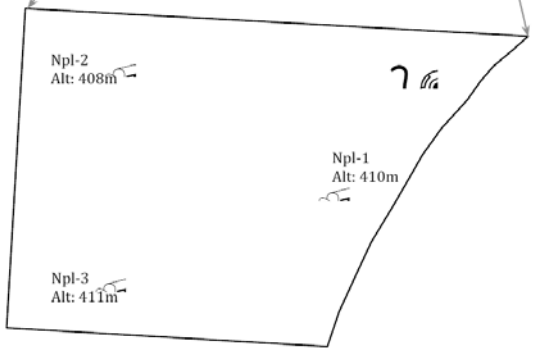
5. For design purposes the unit weight of the soils from the site can be taken as 19.0kN/m^3 and the relative density will be around 40%. It`s expected that the soils of the site will exhibit moderate drainage characteristics and may require the application of a minor correction to estabilize the soils under the footings.

We trust that the information contained in this report meets your immediate requirements. Should you require any additional information, please do not hesitate to contact us.

7. APPENDICES

7.1 Appendix A: Sketch Plan of the site and Location of Test Pits, DCP Soundins and Sampling

Source: Matsuda Consultants International Co., Ltd



Location of test pits, DCP soundings and soil sampling

7.2 Appendix B: Geotechnical Soil Profiles

GEOTECHNICAL SOIL PROFILE

Client: MATSUDA CONSULTANTS INTERNATIONAL Co. Ltd	SITE No. Npl-1	Sheet No. 1 of 1
Project: Nalikiri Secondary School	Site Location (Datum: WGS84)	Lat. 15° 05' 01.0" S; Long. 39° 11' 38.7" E; Altitude: 410 m
Total Depth: 1.50 m; Log Date: 03 / 12 / 2011	Logged By: D.P. De Amurane	

Depth (m)	Graphic Log	% of core recovery	Sample No.	Description	Remarks
0				Topsoil: Slightly moist, brown, very loose, silty sand of medium to coarse grain size and transported origin	This layer contains roots of plants
-1-				Silty Sand: Slightly moist, reddish brown, massive, medium dense, Silty Sand of medium to coarse grain size and transported origin	Termites do occur in the area

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GEOTECHNICAL SOIL PROFILE

Client: MATSUDA CONSULTANTS INTERNATIONAL Co. Ltd	SITE No. Npl-2	Sheet No. 1 of 1
Project: Nalikiri Secondary School	Site Location (Datum: WGS84)	Lat. 15° 04' 59.0" S; Long. 39° 11' 36.1" E; Altitude: 408 m
Total Depth: 1.50 m; Log Date: 03 / 12 / 2011	Logged By: D.P. De Amurane	

Depth (m)	Graphic Log	% of core recovery	Sample No.	Description	Remarks
0				Topsoil: Slightly moist, brown, very loose, silty sand of medium to coarse grain size and transported origin.	This layer contains roots of plants
				Silty Sand: Slightly moist, reddish brown, massive, medium dense, silty Sand of medium to coarse grain size and probably transported origin	Termites do occur in the area
-1-				Sandy Gravel: slightly moist, reddish brown, fining up-ward, dense, Sandy Gravel of fine grain size and transported origin.	No pebble mark observed

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GEOTECHNICAL SOIL PROFILE

	SITE No. Npl-3	Sheet No. 1 of 1
Client: MATSUDA CONSULTANTS INTERNATIONAL Co. Ltd	Site Location	Lat: 15º 05' 03.1" S
Project: Natikiri Secondary School	(Datum: WGS84)	Long: 39º 11' 34.8" E
Total Depth: 1.50 m	Log Date: 03 / 12 / 2011	Altitude: 411 m
	Logged By: D.P. De Amurane	

Depth (m)	Graphic Log	% of core recovery	Sample No.	Description	Remarks
0				Topsoil: Slightly moist, greyish brown, loose, Silty Sand of medium to coarse grain size and transported origin.	This layer contains roots of plants
				Clayey Sand, Slightly moist, reddish brown, massive, medium dense, Clayey Sand with some gravel and probably transported origin	Termites do occur in the area
-1					

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7.4 Appendix D: Laboratory Test Results

The group symbols used in this report represent the Unified Soil Classification System Group Symbols (ASTM D-2487), based on visual observation and limited laboratory testing of the samples presented below.

Unified Soil Classification System (ASTM D-2487)

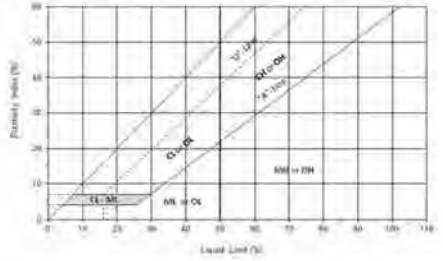
Criteria for Assigning Group Symbols and Group Names using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils (More than 50% retained on N° 200 sieve)	Gravels (More than 50% of coarse fraction retained on N° 4 sieve)	Clean Gravels (Less than 5% fines)[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3^E$	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3^E$	GP	Poorly graded gravel[F]
		Gravels with Fines (More than 12% fines)[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands (50% or more of coarse fraction passes N°-4 sieve)	Clean Sands (Less than 5% fines)[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3^E$	SW	Well graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3^E$	SP	Poorly graded sand[I]
		Sands with Fines (More than 12% fines)[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soil (50% or more passes the N° 200 sieve)	Silts and Clays (Liquid limit less than 50)	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
	Silts and Clays (Liquid limit 50 or more)	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		Organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

[A] Based on the material passing the 3-in. (75mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly-graded gravel with silt, GP-GC poorly-graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly-graded sand with silt, SP-SC poorly-graded sand with clay.
[E] $Cu = \frac{D_{60}}{D_{10}}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus N° 200, add "with sand" or "with gravel" whichever is predominant.
[L] If soil contains ≥ 30% plus N° 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus N° 200 predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

For classification of fine-grained soils and fine-grained fractions of coarse-grained soils

Equation of "A"-Line:
Horizontal at PI = 4 to LL = 25.5
then PI = 0.73 (LL – 20)

Equation of "U"-Line:
Vertical at LL = 16 to PI = 7
then PI = 0.9 (LL – 8)



THE PROJECT FOR THE IMPROVEMENT OF A PRIMARY TEACHER TRAINING INSTITUTE IN NAMPULA PROVINCE AND THE PROJECT FOR THE IMPROVEMENT OF SECONDARY SCHOOLS IN THE NORTHERN REGION IN THE REPUBLIC OF MOZAMBIQUE

Second Round of Geophysical Surveys at Seven Districts, in Nampula Province.

FINAL REPORT

Data: July, 2011

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1. Introduction

WE Consult was contracted by Matsuda Consultants to carry out the Geophysical Surveys for the Project for the Improvement of Secondary Schools in the Northern Region in the Republic of Mozambique. The purpose of the survey is to determine the exact borehole drilling point at each target site.

This report aims to present the final results of the surveys carried out in the districts of Nampula-sede, Erati-Namapa, Memba, Nacala-a-Velha, Mossuril, Muecate and Rapale indicating the potential of the selected sites for the drilling of production boreholes on the site with the purpose to supply the Secondary Schools with drinkable water in enough quantities.

The field work regarding this phase began on the 18th of June in the district of Rapale and was completed by the 5th of July in the same district of Rapale. In total, seven districts were visited and the geophysical surveys were carried out in all seven district sites.

The district of Rapale was initially visited during the preparation of the overall fieldwork and the survey team conducted the preliminary geophysical survey. Due to changes on the plan of activities, instructed by the Client, the Consultant interrupted the works and re-visited this site and conduct additional profiles and VESes to verify, confirm and validate the data collected initially. In total 1305 meters of profiling and 4 VESes were carried out.

2. Work Methodology

The approach to carry out this survey was designed by the Client and the Consultant set up the methodology which suits better to both the project objectives and each site's local situation. Based on the number and lengths of profiles requested by the Client and after a preliminary visit to the sites, the Consultant set up a sketch of the profiles to be carried out at each site, targeting to cover and explore, as much as possible the whole area through its contours.

Once in the field and after the execution of at least two main profiles, the Consultant changed the profiles alignment, following the interest areas and registered anomalies. Additional profiles were carried out at these interesting areas to confirm the anomalies, followed by vertical electrical soundings to estimate the depths of the anomalies seeking for high productivity aquifers.

After one or two interesting locations were identified and mapped, the Consultant extended the survey to other areas of the site, to increase the chances to find other and possibly better options. Additional profiling and VESes were then carried out in other portions of the plot, upon availability of time and other local conditions. All in all, the Consultant tried, as much as possible, to stick to the number and total lengths of profiles and VESes required by the Client.

Summarizing, the decision to change from original to actual distribution of profile lines was based on the need to: (1) cover all area provided and (2) reach the project's main objective, to identify the best locations to drill and abstract water to supply the planned facilities. The Consultant considered of outmost importance to identify the most potential location than to solely focus on the need to cover the whole area. However an attempt to survey the contours of the plot's extension was done and the expected total length of profiles was reached whenever possible.

The Project for Improvement of a Primary Teacher Training Institute in Nampula Province and the project for the Improvement of Secondary Schools in the Northern Region, The Republic of Mozambique

3. Field work

3.1 Introduction

Field work was carried out at all seven sites of the districts of Nampula-sede, Erati-Namapa, Memba, Nacala-a-Velha, Mossuril, Muecate and Rapale and the results are presented in this report. In general 7855 meters (97%) of profiles and 30 VESes (111%) were carried out in these districts. Specifically, the works were distributed as shown in Table 1 below:

Table 1 Summary of works accomplished at each site

Site	Community Name	Profiles		VES
		Units (Un)	Total Length (m)	Units (Un)
Nampula-sede	Mulhaku	5	1215	4
Erati-Namapa	Nacucha	4	780	5
Memba	Puajini	5	920	5
Nacala-a-Velha	Naculue	4	1235	4
Mossuril	Mingurini	4	885	4
Muecate	Naputa	5	1515	5
Rapale	Rapale-sede	4	1305	5
TOTAL		**31**	**7855**	**31**

The final set up of the profiles is different from the original planning due to several reasons. The justification for the change of the profile arrangement is mentioned in Chapter 2, above and further details is provided below on the description of the survey carried out in each site. In general, the motivation to change was guided more on the need to target the most potential location to drill for abstraction of ground water in acceptable quantities, than solely to cover the whole provided area.

Regarding the total length of profiling per site, whenever the best locations for drilling were already identified on the sites, the Consultant opted to save time and resources to be further invested in hydrogeologically more difficult sites. However, more VESes were carried out at the identified anomalies to increase the chance to select the best locations. However, even with extensive profiling and soundings, the hydrogeological potential of some of the sites showed to be low.

Concerning the quantity and quality of the water expected to be abstracted from the surveyed locations, it must be emphasized that the techniques used does not allow the Consultant to inform about exact quantities and quality, indicating any specific figures related to it. It is acknowledged that the Client has set up target levels to be achieved and the Consultant performed to its best to match these expectancies but no specific quantities can be advanced.

3.2 Data collection and analysis

The works carried out at all sites allowed the collection of the data presented below and a brief discussion is provided for each site surveyed. Although some illustrations do not show this, potentially due to GPS unit's accuracy, all VESes were carried out at the profile alignment, so they should be referred to the nearest profile of the sketch.

3.2.1 Memba

Four profiles distributed orthogonally along the area were planned to be carried out, with the aim to cover and investigate the whole area provided. However, once on the site and after the completion of the first profile the survey team identified some areas of interest which required further investigation. In total, 920 meters (73%) of profiles and 5 VESes (125%) were carried out at this site, specifically in the community called Puajini. The profiles carried out indicated the presence of several anomalies. The indentified anomalies were further investigated through Vertical electrical soundings (VESes) and two, out of four, locations are recommended to be attempted to drill. Figure 1 provides an illustration of the profiles and VESes location on the site.

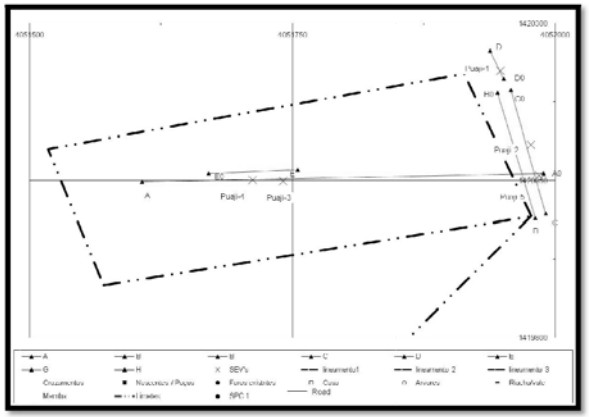


Figure 1 Location Map of Profiles and VESes carried out in Memba

In this particular site, the alternative location to drill is located at some twenty (20) meters out of the boundary. However, the district staff was duly informed about the situation and authorization was provided to continue with the investigation. The annexes provide more detail about the data collected in this site.

3.2.2 Nampula-sede

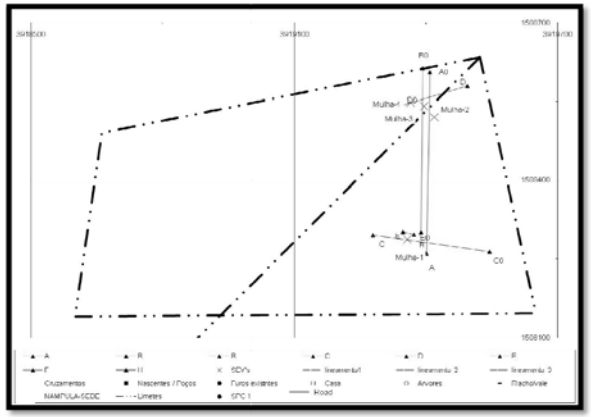


Figure 2 Nampula Site Location Map

In Nampula-sede's site five profiles were carried out. Two parallel profiles – A and B – of 385 and 340 meters respectively; other two parallel profiles – C and D – orthogonal to the first two, of 290 and 170 meters respectively and a fifth profile – E, of 30 meters – parallel to profile C, to confirm an anomaly identified in profile C. The total profile length achieved is 1215 meters, 85% of planned profiling (reference is made to Figure 2).

The final alignment (direction) of the profiles was set up based on the preliminary results of the first profile and the anomalies identified. On the interesting anomalies identified in the profiles, a total of four (4) VESes were carried out. From these, two locations were selected to be attempted to drill. There no much that can be said about the potential of groundwater in this site but a considerable amount of water is expected to be abstracted. Details about data collected can be accessed on the annexes.

3.2.3 Erati-Namapa

In Namapa, hydrogeology interest has driven the Consultant's survey team to move into the alignments and lengths as provided in Figure 3 below. Total length (780m) and number of profiles (5) exceeded the planed profiling. The motivation behind this change was the identification of interesting features which required further investigation on the site.

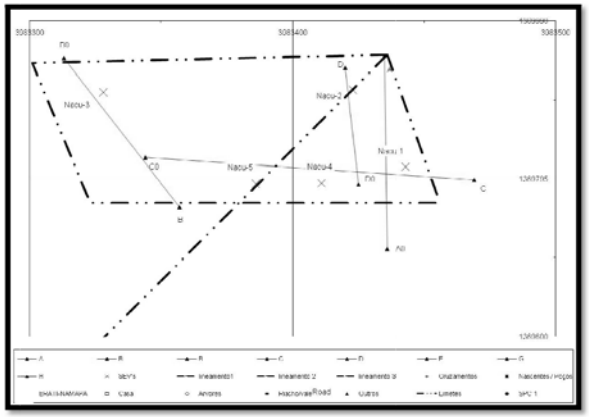


Figure 3 Location Map of Works carried out in Erati-Namapa

Preliminary results of the survey indicated the occurrence of some anomalies which were after investigated through vertical electrical soundings and led to the recommendation of two, out of four, surveyed locations. The potential of this site can be regarded as medium and a considerable amount of water is expected to be abstracted from the indicated location.

3.2.4 Nacala-a-Velha

This site, located in relatively low land deserved dedicated attention of the Consultant. Five profiles, totaling 1235 meters were carried out along the site, complemented by 4 VESes. The actual direction of the profiles was not far different from the planned one, as not very expressive anomalies were identified along the survey. Apart from the original sketch, few smaller profiles were carried out to confirm some anomalies detected in the main profiles.

Figure 4 A VES ongoing in Nacala-a-Velha

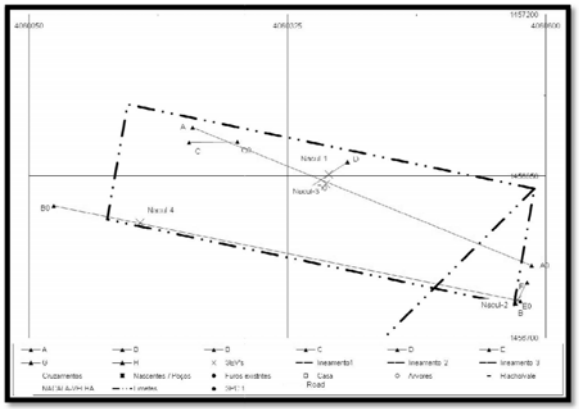


Figure 5 Location Map of Profiles and VESes carried out in Nacala-a-Velha

The preliminary analysis of the collected data gives an indication of presence of clayey soils and possibly brackish water in the area. Very low readings of resistivity were registered and a brief analysis of both the landscape and soil morphology suggest that the area was somehow affected by saline intrusion in far past.

In principle, this site is not recommended to drill but the Client can proceed with a well monitored drilling envisaging the abstraction of fresh water from the top aquifer. In this case, the drilling should now go beyond 27 meters deep and salinity must be continuously monitored. Alternatively, the Client can consider abstracting water from town's well field, located some 1200 meters NE from the site. Other options include abstraction from Nacala river bank, located some 100 meters to the North of the site. However, for both alternatives proposed here, further studies are required.

3.2.5 Mossuril

In Mossuril, the Consultant's survey team conducted 885 meters of profiling and 4 VESes, as illustrated in below. Not very interesting anomalies were identified as this is mostly sedimentary zone. However, some points of interest were sounded at the site.

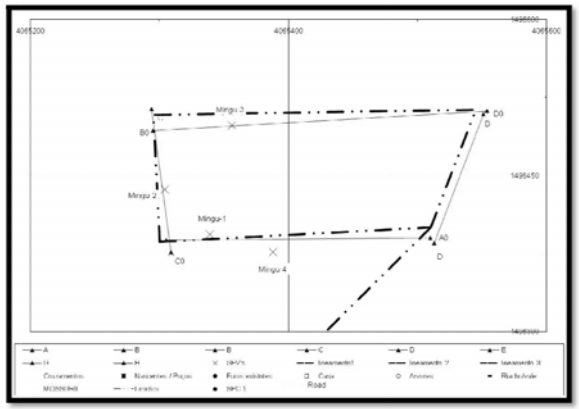


Figure 6 Location Map of Profiles and VESes carried out in Mossuril

Mossuril hydrogeology is not very promising for groundwater abstraction in generous quantity. The preliminary results of the survey indicate that some water can be acquired from the wells to be constructed on the site but it should not be expected to match the required amounts.

The Client must consider abstracting relatively smaller quantities of groundwater from a well field located within the school area premises or at the foot of the dunes where most of the drinkable water consumers get the water from – located some 700 meters SE of the school site. The abstraction of groundwater from this location should be carried after preliminary studies and taking into account the current yields abstracted and future needs.

3.2.6 Muecate

The hydrogeology survey carried out in Muecate comprised 1515 meters of profiling. The set up of the profiles does not differ so much from the planned one and several interesting anomalies were found. 4 VESes were carried at the points of outmost importance and the analysis of the field data led to the recommendation of two of the five locations sounded. Figure 7 below illustrates the locations of the profiles and VESes accomplished in Muecate.

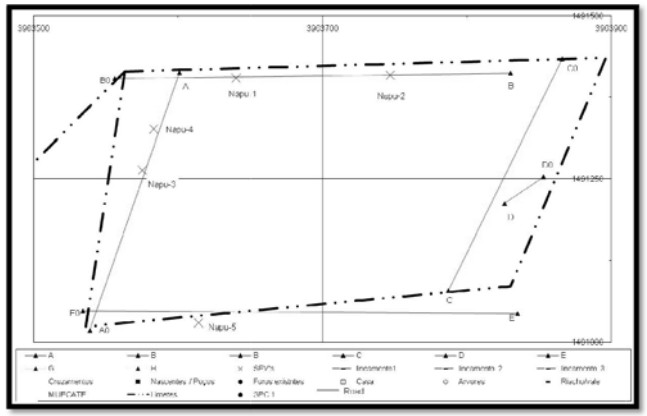


Figure 7 Location Map of Profiles and VESes carried out in Muecate

As mentioned above, the interpretation and analysis of the data collected in Muecate indicates that the selected locations are more promising for groundwater in relatively higher quantities, compared to other sites. In Muecate, it is expected to drill through more than one single aquifer at the points indicated thus, the drilling team must pay special attention on the depths to reach in order to abstract the highest ecological yield.

3.2.7 Rapale

It was mentioned in the beginning of this report that the district of Rapale was visited during the preparation of the overall fieldwork and the survey team conducted the preliminary geophysical survey. Due to changes on the plan of activities, instructed by the Client, the Consultant interrupted the works and re-visited this site and conduct additional profiles and VESes to verify, confirm and validate the data collected initially. In total 1305 meters of profiling and 5 VESes were carried out.

During the initial survey in this site, the Consultant's team found the readings relatively high, compared to other sites. The resurveying confirmed the values read on the profiles and VESes were carried out at the interesting locations.

The analysis of the data collected and interpreted recommends the drilling with high uncertainty about both the quantity and the quality of water to be obtained in this site. However, the Consultant will recommend the Client to drill in this location bearing on mind the remarks made above.

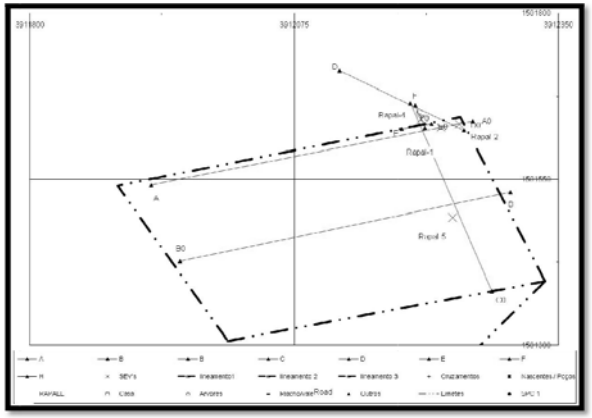


Figure 8 Location Map of Profiles and VESes carried out in Rapale

3.3 Constraints

Although this was not mentioned on the preliminary visit report, when compared with other districts, the district's education staff was not available to join and guide the Consultant's team. Due to this, some contradiction was experienced in the field, where some local residents and leaders approached the Consultant's team requesting for information about what was going on and regarding the premises boundaries.

Another constraint is related to the small size of the plots made available for the survey is some locations. The small size of these plots limited the field team to extend the survey to some potential areas that could be identified on the surroundings of the site. This was not a major constraint as the Client as referred to the possibility of surveying in the neighboring premises but not very far from the boundaries.

4. Results

The preliminary analysis of the surveys lead to the following recommendations:

Table 2 Summary of expected results

Site	Community Name	Recommended Location		Alternative Location		Maximum Depth	Potential
		VES	Coordinates	VES	Coordinates		
Nampula-sede	Mulhaku	MULHA-2	S 15,08520 E 39,19419	MULHA-4	S 15,08548 E 39,19365	60	Medium
Erati-Namapa	Nacucha	NACU-1	S 13,59423 E 40,07810	NACU-2	S 13,69905 E 39,83423	60	Medium
Memba	Puajini	PUAJI-3	S 14,20049 E 40,51741	PUAJI-5	S 14,20058 E 40,51985	70	Medium
Nacala-a-Velha	Naculue	NACUL-2	S 14,56759 E 39,60570	NONE		27	Low
Mossuril	Mingurini	MINGU-3	S 14,96498 E 40, 65359	MINGU-4	S 14,96376 E 40,65388	18	Low
Muecate	Naputa	NAPU-3	S 14,91263 E 39,63575	NAPU-4	S 14,91326 E 39,63583	120	High
Rapale	Rapale-sede	RAPAL-4	S 15,01640 E 39,12207	NONE		80	Low

As it can be seem from Table 2 above, not all the sites are potential for groundwater abstraction. However there is some uncertainty about the quality of groundwater in Memba, a generous quantity might be expected, according to the results of the surveys. In contrast, the risk of drilling for brackish groundwater contained in clayey substrates is higher in Nacala-a-Velha.

Some good quality water is expected in Nampula-sede and Erati-Namapa. There is also an indication of high potential for abstraction of groundwater in Muecate and a risk to abstract brackish/saline water in Mossuril is expected if higher depths are reached during the drilling. In Rapale, the results do not allow the team to say about the potential with much category, there must be water but nothing can be advanced about its quality.

According to an assessment of information available in Nampula Province Database, the average and maximum yields encountered on the sites are given in Table 3 below.

Table 3 Average and maximum yields of the target district (Source: Nampula Province Database/DAS)

Memba		Nampula		Erati		Nacala-velha		Mossuril		Muecate		Rapale	
Av.	Max	Av.	Max	Av.	Max	Av.	Max	Av.	Max	Av.	Max	Av.	Max
3	9	**1.5**	2,57	**1.6**	2	**2.7**	7	**1.8**	3	**1.4**	2	**1.6**	3

Although this table shows relatively small amounts, it should be remarked that at most of the times the test pumping is performed with low capacity pumps – usually up to 3.0 m^3/hr – as most of the boreholes are constructed to be equipped with hand pumps and the minimum yield required is 1.0 m^3/hr.

For the most of the surveyed sites it is expected to reach a minimum yield of 3.0 m^3/hr which will lead to pumping time of 12 hours per day to reach the 35.0 m^3/hr. If the yield does not reach 6.0 m^3/hr in Nampula site then it should be considered to drill two (2) boreholes that should be pumped simultaneously at the rate of 3.0 m^3/hr during 12 hours/day.

All relevant information regarding the recommendations, location, etc., were left in Portuguese in the annexes of this report to allow an easy guiding to: the drilling units that will visit the communities, the district staff accompanying the works, and the community members that has been participating in all earlier stages of the project.

5. Recommendations

Therefore, the Consultant recommends to drill in four of the seven sites, considering that the geophysical survey cannot assure the expected results, good or bad, will be 100% observed on the site. Furthermore, the Consultant recommends that proper supervision is carried out to ensure that all water strikes are duly identified during the drilling and adequate casing installation is done to guarantee the highest efficient and safe yield is abstracted.

If however the Client decides to drill at low potential sites, attention should be paid to the drilling process and a proper monitoring of materials and aquifers found in order to achieve the best hydrogeological layer and explore good quality water.

At all sites, the provided alternative location should only be drilled after the recommended location has failed to provide water in quantity and quality due to any reason such as bad hydrogeology, problems with accessibility, accidents during drilling, collapse, etc. in general, the accessibility to all locations is good, except in Rapale where a railway line has to be crossed over to reach the site

The sequence of drilling – from site to site – should target preferentially the high potential locations first, followed by the medium and the low potential locations should only be attempted to drill after those.

GPS coordinates of the locations are indicated in the annexes, together with additional details such as location maps, profile readings, vertical electrical soundings readings, and other relevant references. Wooden pegs were left on the ground at ALL locations sounded and community members were duly instructed to not remove these pegs until the construction team (drilling rigs) reaches the site.

The Project for Improvement of a Primary Teacher Training Institute in Nampula Province and the project for the Improvement of Secondary Schools in the Northern Region, The Republic of Mozambique

Summary Table of Location of all VESes carried out

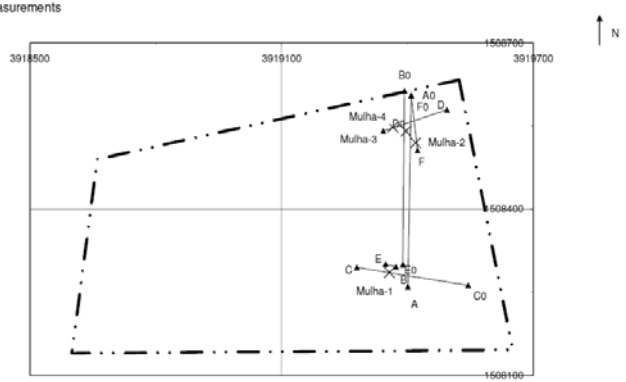
Site	VES1	VES2	VES3	VES4	VES5
Memba	X = 40.52948 Y = 14.20225	X = 40.51977 Y = 14.20107	X = 40.51741 Y = 14.20049	X = 40.51712 Y = 14.20051	X = 40.51985 Y = 14.20058
Mossuril	X = 40.65339 Y = 14.96393	X = 40.65304 Y = 14.96436	X = 40.65356 Y = 14.96498	X = 40.65388 Y = 14.96376	
Muecate	X = 39.63640 Y = 14.91404	X = 39.63747 Y = 14.91409	X = 39.63575 Y = 14.91263	X = 39.63583 Y = 14.91326	X = 39.63614 Y = 14.91029
Nacala Velha	Bad data	X = 40.60570 Y = 14.56759	X = 40.60369 Y = 14.56953	X = 40.60168 Y = 14.56878	
Namapa	X = 39.83443 Y = 13.69810	X = 39.83423 Y = 13.69905	X = 39.83328 Y = 13.699020	X = 39.83411 Y = 13.69790	X = 39.83386 Y = 13.69789
Nampula	X = 39.19357 Y = 15.08286	X = 39.19419 Y = 15.08520	X = 39.19396 Y = 15.08541	X = 39.19365 Y = 15.08548	
Rapale	X = 39.12247 Y = 15.01632	X = 39.12228 Y = 15.01627	X = 39.12058 Y = 15.01575	X = 39.12207 Y = 15.01640	X = 39.12240 Y = 15.01492

Second-round Survey Final Report WE Consult

Localização:	Nampula-Mulhako				
Melhor SEV	Mulha-2	Longitude(E)	3919419	Latitude(S)	1508520
Recomendada para perfuração:	Sim	Altitude (amsl)		420	
Profundidade esperada rocha duras (m)	40	SEV alternativa		Mulha-4	
Profundidada recomendada (m):	60	Acessibilidade da comunidade:		Bom	
Formação esperada:	Gnaisse	Acessibilidade do Sitio:		Facil	
Potencial:	Média	Pessoa contactavel:			
Observações:	O local recomendado esta dentro do terreno				

Nome da fonte	Nampula-Mulhako	Comunidade	Niparula
Localidade	Nahopa	Districto	Nampula
Posto Administrativo	Natikiri	Provincia	Nampula

Geophysical measurements

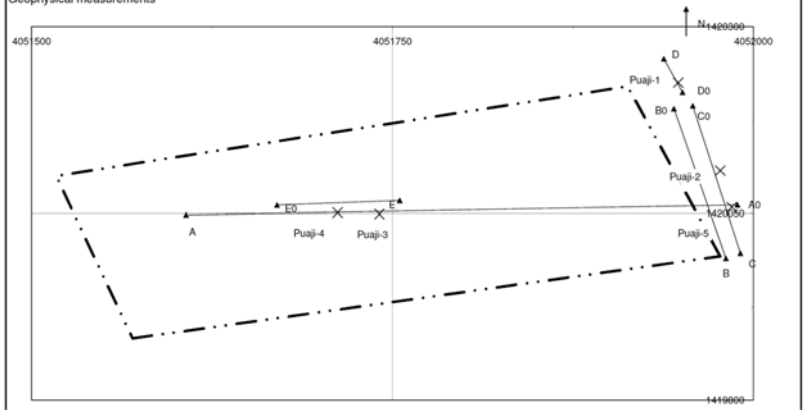


WE Consult

Localização:	Memba-Puajini				
Melhor SEV	Puaji-3	Longitude(E)	4051741	Latitude(S)	1420049
Recomendada para perfuração:	Sim	Altitude (amsl)		75	
Profundidade esperada rocha duras (m)	40	SEV alternativa		Puaji-5	
Profundidada recomendada (m):	70	Acessibilidade da comunidade:		Bom	
Formação esperada:	Gnaisse	Acessibilidade do Sitio:		Facil	
Potencial:	Média	Pessoa contactavel:			
Observações:	O local recomendado esta 20m do limite do terreno.				

Nome da fonte	Memba-Puajini	Comunidade	Puajini
Localidade	Memba-sede	Districto	Memba
Posto Administrativo	Memba-sede	Provincia	Nampula

Geophysical measurements

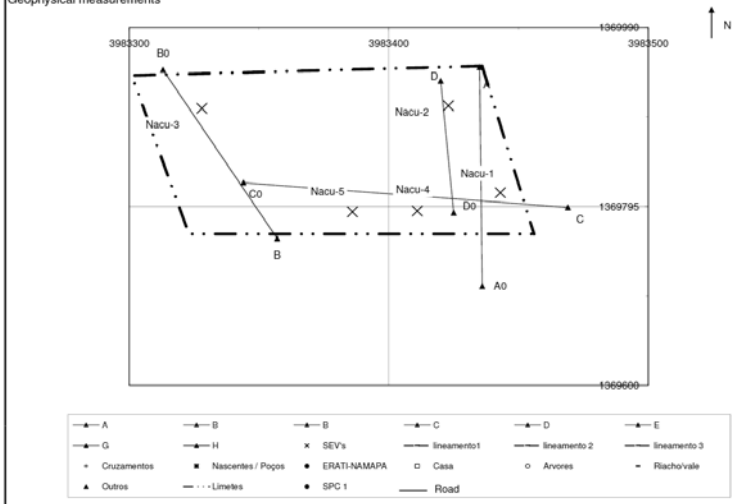


WE Consult

Localização:	Namapa-Nacucha					
Melhor SEV		Nacu-1	Longitude(E)	4007810	Latitude(S)	1359423
Recomendada para perfuração.:		Sim	Altitude (amsl)		256	
Profundidade esperada rocha duras (m)		40	SEV alternativa		Nacu-2	
Profundidada recomendada (m):		60	Acessibilidade da comunidade:		Bom	
Formação esperada:		Gnaisse	Acessibilidade do Sitio:		Dificil	
Potencial:	Média		Pessoa contactavel:			
Observaçõ.s:	O local recomendado esta no patio da escola					

Nome da fonte	Namapa-Nacucha	Comunidade	Nacucha
Localidade	Namapa-sede	Districto	Namapa
Posto Administrativo	Namapa-sede	Provincia	Nampula

Geophysical measurements

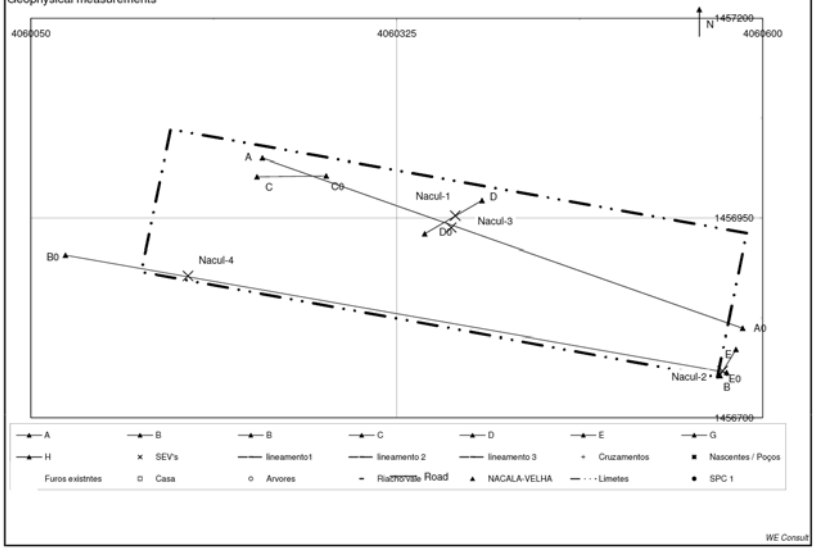


WE Consult

Localização:	Nacala Velha-Naculue					
Melhor SEV		Nacul-2	Longitude(E)	4060570	Latitude(S)	1456759
Recomendada para perfuração.:		Nao	Altitude (amsl)		36	
Profundidade esperada rocha duras (m)			SEV alternativa		Nacul-N tem	
Profundidada recomendada (m):		27	Acessibilidade da comunidade:		Bom	
Formação esperada:		Argila	Acessibilidade do Sitio:		Dificil	
Potencial:	Muito Baixo		Pessoa contactavel:			
Observaçõ.s:	O local recomendado esta perto do marco 4 do terreno.					

Nome da fonte	Nacala Velha-Naculue	Comunidade	Naculue
Localidade	Nacala-a Velha	Districto	Nacala-a Velha
Posto Administrativo	Nacala-a Velha	Provincia	Nampula

Geophysical measurements



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