

資料 6. 現地調査結果

資料 6-1 地質調査結果

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REPORT

OC/1501/SI/gg/09

Client : NJS Consultants Co. Ltd



Improvement of Embu Water Supply Geotechnical Investigations

1. Introduction

We were appointed by NJS Consultants Co. Ltd to undertake a geotechnical investigation at the sites of the existing Mukangu Treatment Works and Kangaru Water Storage Facility which forms part of the Embu Water & Sewage Co Ltd. As it is understood our Client was recently commissioned by the Japanese International Co-operation Agency (JICA) to undertake a detailed study of the existing facilities, supported by a detailed design for upgrading and future expansion.

As part of this study, we were engaged to drill a series of boreholes to a specified depth of 10 metres; four of which were located at Mukangu Treatment Works and a further two boreholes at the site of Kangaru Water Storage Facility, both within the Embu District.

In addition to the above exercise we were required to excavate a total of 10 No. Trial Pits, to a specified depth of 2.0 metres, at intervals along the route of the existing water pipeline with the aim of establishing the nature of the soils strata.

In accordance with the instructions issued by the Client we were not required to recover samples from either the boreholes or the trial pits and the testing required was to comprise solely of the determination of the insitu SPT values within each of the boreholes drilled and at a frequency of every one metre.

In this regard, we had proposed that it would be advantageous to recover both undisturbed and disturbed samples during the drilling operations purposely to allow for possible subsequent laboratory testing, however this was considered unnecessary by our Clients representative onsite and the classification of the material types should be based on specialist experience presumably within our laboratories.

Our brief in respect of the trial pit investigations was purely to excavate each hole to a depth of 2 metres and provide a description of the materials encountered, together with photographic records.

As a supplementary part of this investigation we were requested to analyse the quality of both treated and untreated water taken from various processing points within the existing Water Treatment Works. In this regard, samples were recovered from various locations as defined by NJS Consultants and in the presence of their representative and personnel from EWASCO, the local water authority. The results of this latter investigation are presented as a supplementary report.

2. Characteristics of the Area

2.1 : Climatic Conditions & Hydrology

The town of Embu is situated approximately 120Kms north-east of Nairobi and within relatively close proximity to Mount Kenya National Park. It is characterised as typical tropical highlands, midlands, and other features including hills and valleys, with wide variations in altitude. Altitudes from the highlands range from 1,500 to 4,500 at the foothills of Mount Kenya with the midlands ranging from 1,200 to 1,500 metres above sea level.



Plate No.1 : Map of Kenya (Embu)

The mean maximum temperatures range from 24 to 36^oC , whilst the mean minimum temperatures ranges from 10 to 14^oC. Rainfall distribution is controlled by the north-south movement of tropical convergence zone. This gives rise to, basically, two seasons with the dry season normally commencing in January and February followed by the rainy season which commences from March to the end of May; the latter is described as the "long rains". Conversely, the dry season invariably starts from about June to mid October and, thereafter, the wet season from mid-October to the end of December. It will be appreciated that the weather patterns all over the World are changing dramatically, thus the forecast that could have earlier been made can, occasionally be in doubt, mainly as a result of global warming and the like.

The average rainfall is about 1495mm in the region where the terrain is above, which it thought to result from the high capacity of indigenous forest to store water, thereby making most of the water courses and streams perennial. The forest belt between, say, 2,300 to 3,350 metres has the highest water yield per unit area and, equally yields the greatest proportion of surface discharge.



Plate No. 2: Water Runoff from Mount Kenya

The main drainage channels are rivers Kabingazi, Ripinazi, Thuci, and Ena which drain into the south and east respectively; several branches of these rivers form denritic patterns distributed over the region.

2.2 : Geology of Embu Region

The geology of the soils within the Embu region basically falls within a number of categories with the more common type comprising well drained red clayey loam to red/brown highly compacted clayey soils. Most of these soil type tend to be friable when moist and both sticky and plastic when wet, and exhibiting

a very high workability. It is not unusual to find such deposits interlaid with gravel and the occasional rock fragments which in variably are cemented by a surrounding clay matrix.

Land use is a very significant factor in the formation of the upper geological strata and the maintenance of the soil structure. For example, the soil structure under napier grass, tea, and fallow areas are relatively well formed with relatively stable aggregates, whilst land under under maize and coffee tend to be weak and massive, breaking into dust. When wet such soils become puddled with reduced water permeability which is invariably a result of intensive cultivation.

Because of different impacts of different land use types, the soil particles are variously arranged into particles of different sizes and grades giving rise to variation in the absorption and porosity characteristics, and total water retention characteristics. However, these trends can occasionally change periodically due to the dynamic nature of the pore geometry, caused by changes in the management regimes.

Below this upper geological strata, mainly comprising red loamy soils which sometimes comprises substantial depths lays various strata of igneous type rocks originating from the volcanic lava flows that occurred in the region thousands of years earlier. An example of the earlier volcanic reactions and the subsequent uplifts and laying down of magma may be characterised by Mount Kenya and the surrounding environs; all of which are reported to have been derived from the tectonics of the Mozambique Belt east of the Rift Valley. Studies carried out in recent years have tended to progressively reveal the complexity of the geology, structure, and tectonics of the Mozambique Belt in this region.

Previously the geology of the Central Region was thought to comprises predominantly of pelitic and semi-pelitic schists and gneisses, magmatites and amphiboles. Further north in the Chanlers Falls and Archers Post areas this segment is dominated by paragneisses and schists, marbles, and calc-silicate rocks, granulites and metamorphosed mafic and ultramafic rocks.

Complex foldings exhibiting at least three fold generations and which occasionally have formed elliptical domes and basin structures are widespread. The entire segment, however, has several Neoproterozoic faults thrusts and shear zones some of which are of regional dimensions.

The general geology within the close vicinity of Embu can be categorized as falling within the basement system of granite and igneous rocks and invariably comprises moderately dissected undulating peneplain. Within certain portions and especially in the western part the formation is described as being slightly dissected and very gently undulated peneplain.

The overlying soil structure are developed on undifferentiated basement system rocks and are categorised, in most instances, as well drained dark red and occasionally yellow red stony loamy to clay consistency .

These soil types can be highly erodible, especially in areas which have been overgrazed or denuded, and are known to occasionally exhibit high expansive characteristics.

3. Geotechnical Investigations

Following receipt of instructions to commence works two drilling rigs, complete with the required drilling components, were mobilised to site on the 19th October 2009 and during a period of six days extending to the 24th October 2009 a total of 10No. boreholes were drilled at the two locations defined by the Client. It may be noted, it had been intended to commence drilling at the Mukangu Treatment Works, basically as this was thought to be the most difficult location in the event of the onset of rains and our belief that the exposed strata, particularly the red coffee soils may pose problems in gaining access to the four locations defined by the Client.

It had been envisaged from our initial reconnaissance of the Works that one may encounter some minor problems in gaining access to the various parts of the site, however, on arrival we were somewhat taken aback to find the main access had been blocked by excavations by another contractor working on site and as a means of draining some open excavations. In actual fact, the access had been disrupted to an extent there was no passage for vehicular traffic despite the fact that during our initial inspection of the Works the access was reasonable good.



Plate No.3 : Drilling in Progress at Mukangu Water Treatment Plant

The resultant affect was that one had little alternative but to demobilise the equipment and transfer to the second site which was located some distance away, within the Kanguru Water Storage Facility.

During the course of the drilling operations SPT values were recorded at 1 metre intervals down to the base of each borehole; the values of which are presented in Appendix B of this report.

From review of the soils being recovered during the drilling operation the material can be described as soft to very stiff clays of differing bearing values.

Set out in Appendix A of this report are the Borehole Logs describing the materials encountered in each of the holes, together with the respective SPT ("N") values recorded at the time of drilling.

As discussed in the introduction to this report we were required to excavate a series of trial pits along the existing pipeline and in areas where there may be some modification to the existing line.

The investigation comprised excavating each of the trial pits to a specified depth of 2.0 metres in areas pre-defined by the Client. Reference to Appendix D and Appendix E of this report gives details of the materials encountered in each of the trial pits excavated, together with photographic records of the trial pits inspected.

4. Discussion

Reference to the data presented shows the material encountered in each of the boreholes is reasonably similar in composition and tends to vary between firm/stiff to very stiff reddish brown loamy type clays. Notwithstanding, it will be noted the soils encountered at the bottom of the boreholes drilled at Kanguru showed to mainly comprise a greyish/brown clay .at depths of 9.5 and 10.45 metres, respectively.

The results of insitu SPT tests carried out during the drilling of these two boreholes yielded "N" values ranging between 8-32 and 4-62.

Similar tests undertaken on each of the four boreholes drilled at Mukangu Water Treatment Works tended to be a little more consistent with values ranging between say 12-36 if one discards the occasional low and high values.

The density index calculated from the data obtained indicates minimum values as low as 15% with higher value of >85% and an average in the ranged of 40-65%.

In order to understand the data obtained the estimated bearing values have been calculated from each of the individual "N" values recorded from which it can be seen the bearing capacity of the soil encountered at Kangaru ranges from 107KN/M² to 427KN/M², and 53KN/M² to 826KN/M², respectively.

Similar analyses carried out on the data obtained from the boreholes drilled at Mukangu shows the estimated bearing value to range between 240KN/M² to 440KN/M², 53KN/M² to 480KN/M², 173KN/M² to 400KN/M², and 107KN/M² to 560KN/M². Nevertheless, we would prefer to believe a more conservative estimate for design purposes should probably be in the order of 200KN/M², although we are still of the opinion this would be far better confirmed by supportive laboratory testing of soil samples recovered from the intended founding level and one metre below.

It should be borne in mind Kenya has recently undergone an extensive period of dry weather thus the soil structure is relatively dry and considering such soils are known to degrade by the presence of excess moisture this should be taken into account especially in any long-term considerations. This is supported to some extent purely by the fact it was not possible to define the level of the water table, basically as the strata observed throughout the full depth of the boreholes was comparatively dry.

The characteristics of the soils encountered fall within a "Classification" of MH and/or A-7-5. Reference to the Unified Soils Classification System describes such soils as inorganic clays and silts of medium compressibility, whereas reference to ASTM D-2487 defines the soils as "fair to poor" for use as a load bearing material.

Typical dry densities of the soils encountered are invariably low, generally in the order of 1200- 1400Kgs/M³ with relative optimum moisture contents in the range of 32 to 38%. These are values based on a laboratory compaction carried out in accordance with BS.1377 (standard) compaction or the equivalent AASTHO T.99 method. In general, the swell characteristics of the red soils can be quite variable and, on occasions can be quite high; a typical value is in the order of 2.5%. It is with this in mind, that we believe it is rather unwise to rely solely on typical values and ideally any serious consideration to the quality and nature of soils is better confirmed by laboratory tests.

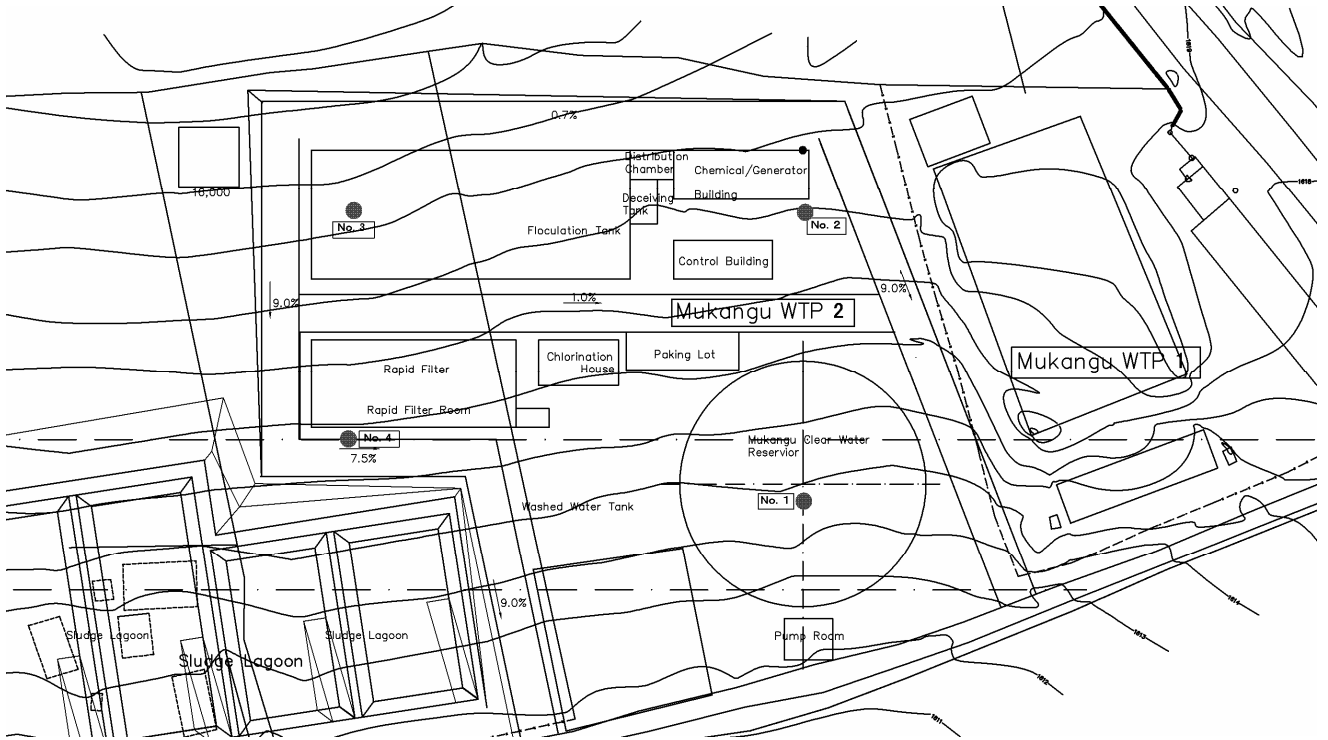
From a review of the trial pit logs produced during the pipeline investigation it is apparent most of the strata encountered, at depths as little as 0.5 metres, appears to comprise clayey gravels or soils containing rock fragments; most of which should prove to be reasonable load bearing material. We would reiterate, however, this assessment has been made purely on a visual basis, therefore, it would be rather difficult to be conclusive.

This completes the investigations outlined in the instructions given by the Client, however, despite the fact there was no requirement for any additional testing, other than those undertaken on site, we have attempted to provide additional information based on our experience of similar soils encountered in this region. Notwithstanding, we can only reiterate our views that it would be advisable to confirm the nature of the soils at the proposed foundation levels in order to establish the safe bearing values and the level of potential settlement before concluding the foundation type and size.

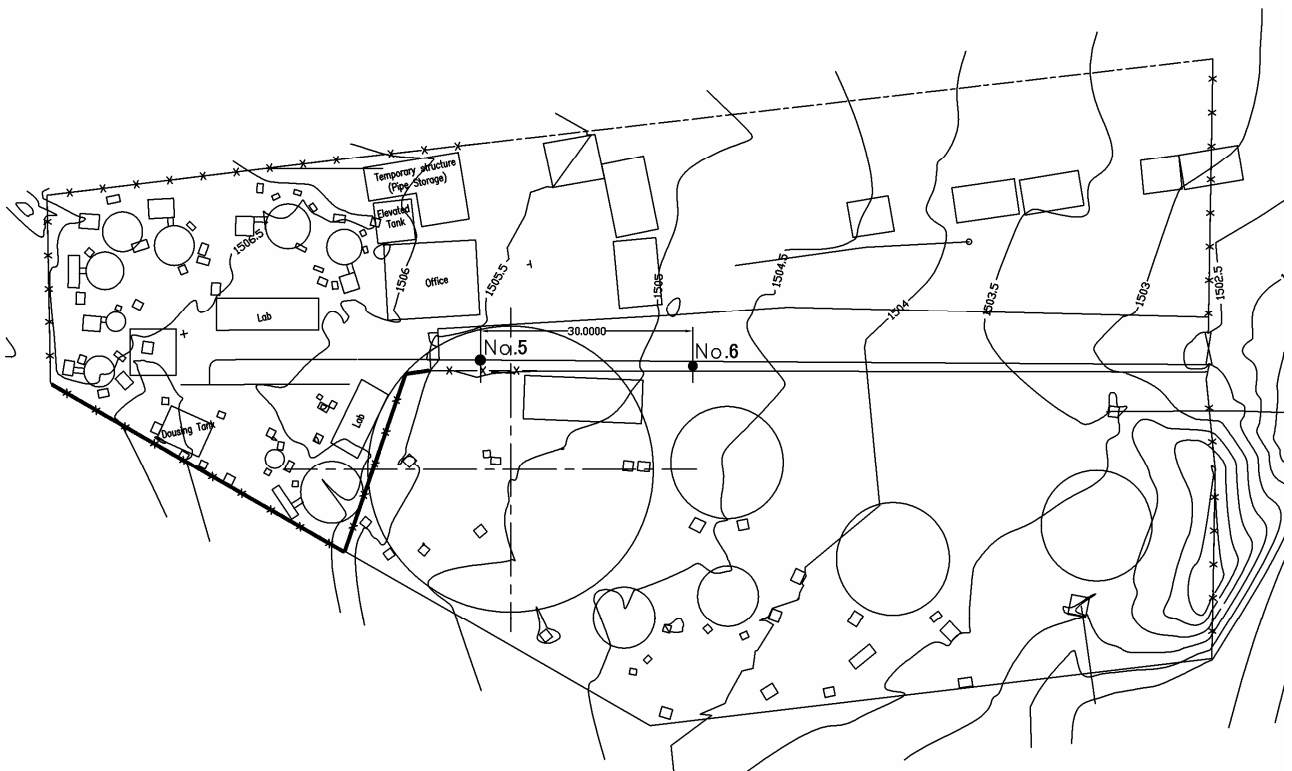
In conclusion, should you require further information or, indeed, clarification of the data presented in this report, please do not hesitate in contacting us.

for Geoff Griffiths & Associates

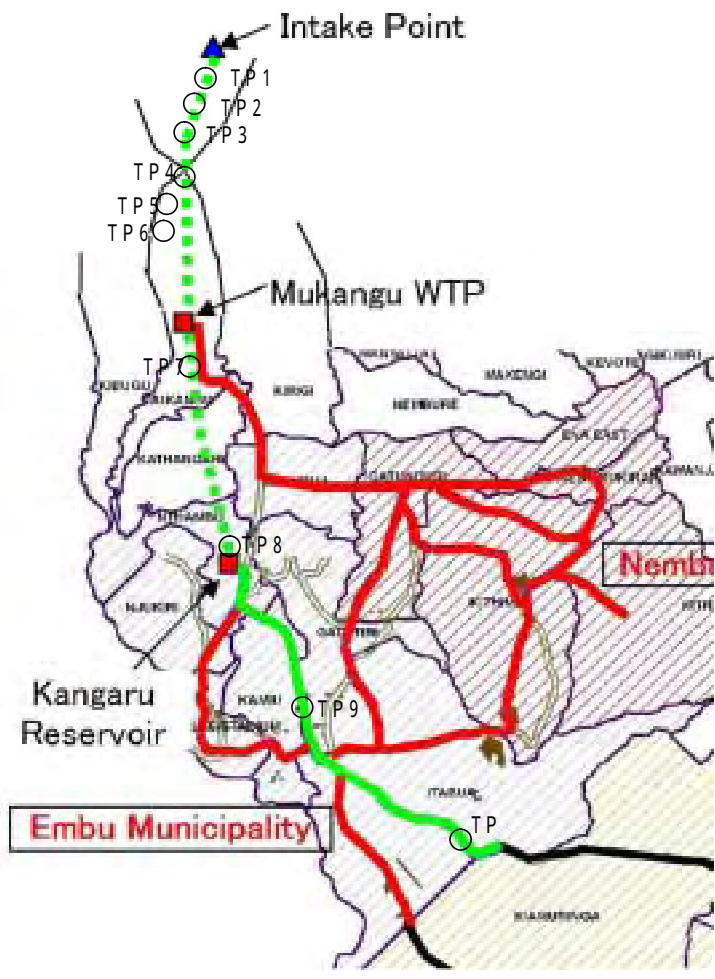
7th November 2009



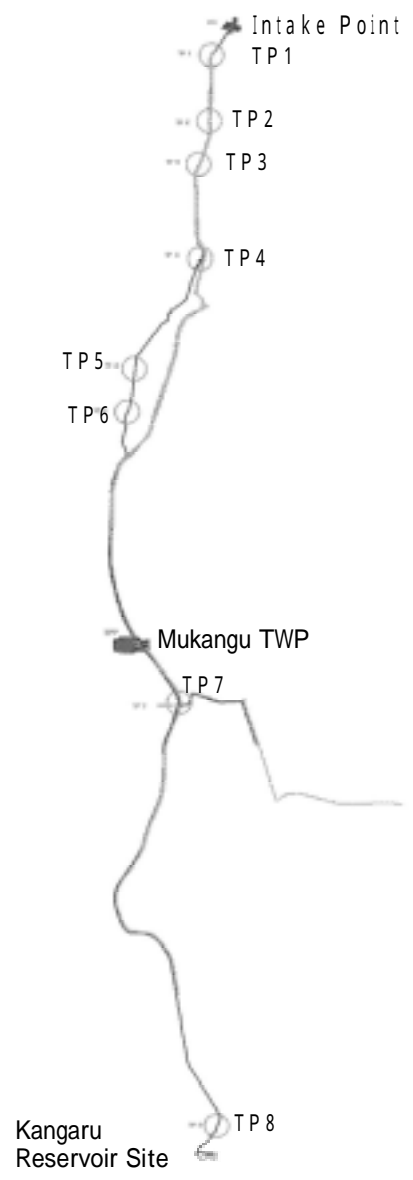
Boring Location in Mukangu WTP



Boring location in Kangaru Reservoir Site



Location of Test Pit



Detail Location TP 1 - 8

N J S CONSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

BOREHOLE LOG					
Location - EMBU		Site Ref. - TSP/14/418/1775			Date - 22-12-2018
BHM No. - 1		Pit No. - 00001 kg			EMBU No. - SPT 1800
SCALE	LEGEND	DEPTH (m)	SPT (blows)	SAMPLE No.	MATERIAL DESCRIPTION
0.00					DARK BROWN CLAY
1.00		1.0-1.40	N=15	D 1	
2.00		2.0-2.40	N=20	D 2	
3.00		3.0-3.40	N=20	D 3	
4.00		4.0-4.40	N=21	D 4	
5.00		5.0-6.40	N=22	D 5	REDDISH BROWN CLAY
6.00		6.0-6.40	N=19	D 6	
7.00		7.0-7.40	N=18	D 7	
8.00		8.0-8.40	N=16	D 8	
9.00		9.0-9.40	N=21	D 9	
10.00	V	10.0-10.40	N=24	D 10	
11.00					
12.00					
13.00					
14.00					
15.00					

N J S CONSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

BOREHOLE LOG					
Location - EMBU		Site Ref. - TSP/14/418/1775			Date - 22-12-2018
BHM No. - 2		Pit No. - 00002 kg			EMBU No. - SPT 1800
SCALE	LEGEND	DEPTH (m)	SPT (blows)	SAMPLE No.	MATERIAL DESCRIPTION
0.00					DARK BROWN CLAY
1.00		1.0-1.40	N=14	D 1	
2.00		2.0-2.40	N=12	D 2	
3.00		3.0-3.40	N=12	D 3	
4.00		4.0-4.40	N=12	D 4	
5.00		5.0-6.40	N=16	D 5	REDDISH BROWN CLAY
6.00		6.0-6.40	N=15	D 6	
7.00		7.0-7.40	N=14	D 7	
8.00		8.0-8.40	N=18	D 8	
9.00		9.0-9.40	N=20	D 9	
10.00	V	10.0-10.40	N=20	D 10	
11.00					
12.00					
13.00					
14.00					
15.00					

No.1, No.2 ボーリング孔柱状図

N J S CONSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

BOREHOLE LOG					
Location: EMBU		Job No: TH/SL/2016/0277		Date: 20-10-18	
BH No: 3		Plant: WASH P/L		Drill: SPT TH	
SCALE	LEND	DEPTH (m)	SPT No.	SAMPLE No.	MATERIAL DESCRIPTION
0.00					REDDISH BROWN CLAY
1.00		1.0-1.40	N-13	D-1	
2.00		2.0-2.40	N-15	D-2	
3.00		3.0-3.40	N-18	D-3	BROWN CLAY
4.00		4.0-4.40	N-21	D-4	
5.00		5.0-5.40	N-23	D-5	
6.00		6.0-6.40	N-25	D-6	
7.00		7.0-7.40	N-28	D-7	
8.00		8.0-8.40	N-29	D-8	
9.00		9.0-9.40	N-30	D-9	
10.00		10.0-10.40	N-34	D-10	
11.00					
12.00					
13.00					
14.00					
15.00					

N J S CONSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

BOREHOLE LOG					
Location: EMBU		Job No: TH/SL/2016/0277		Date: 20-10-18	
BH No: 4		Plant: WASH P/L		Drill: SPT TH	
SCALE	LEND	DEPTH (m)	SPT No.	SAMPLE No.	MATERIAL DESCRIPTION
0.00					REDDISH BROWN CLAY
1.00		1.0-1.40	N-6	D-1	
2.00		2.0-2.40	N-24	D-2	
3.00		3.0-3.40	N-29	D-3	BROWN CLAY
4.00		4.0-4.40	N-28	D-4	
5.00		5.0-5.40	N-27	D-5	
6.00		6.0-6.40	N-31	D-6	
7.00		7.0-7.40	N-35	D-7	
8.00		8.0-8.40	N-38	D-8	
9.00		9.0-9.40	N-42	D-9	
10.00		10.0-10.40	N-49	D-10	
11.00					
12.00					
13.00					
14.00					
15.00					

No.3, No.4 ボーリング孔柱状図

N J S CONSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

BORRHOLE LOG					
Location : EMBU		JOB No. : 15710-20/06/07		Date : 22-10-08	
BH No. : 4		Piers : 1002 No		Drills Tests : SPT Test	
SCALE	LEADING	DEPTH (m)	SPT (bl)	SAMPLE No.	MATERIAL DESCRIPTION
0.00					BROWN GRAVELS (FILL MATERIAL)
1.00		1.0-1.45	N=6	D-1	REDDISH BROWN CLAY
2.00		2.0-2.45	N=13	D-2	
3.00		2.0-3.45	N=8	D-3	
4.00		4.0-4.45	N=17	D-4	
5.00		5.0-5.45	N=18	D-5	
6.00		6.0-6.45	N=25	D-6	
7.00		7.0-7.45	N=32	D-7	
8.00		8.0-8.45	N=22	D-8	
9.00		9.0-9.45	N=20	D-9	GREYISH BROWN CLAY
10.00		10.0-10.45	N=20	D-10	
11.00					
12.00					
13.00					
14.00					
15.00					

N J S CONSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

BORRHOLE LOG					
Location : EMBU		JOB No. : 15710-20/06/07		Date : 22-10-08	
BH No. : 5		Piers : 1003 No		Drills Tests : SPT Test	
SCALE	LEADING	DEPTH (m)	SPT (bl)	SAMPLE No.	MATERIAL DESCRIPTION
0.00					DARK BROWN CLAY
1.00		1.0-1.45	N=4	D-1	REDDISH BROWN CLAY
2.00		2.0-2.45	N=6	D-2	
3.00		3.0-3.45	N=11	D-3	
4.00		4.0-4.45	N=24	D-4	
5.00		5.0-5.45	N=40	D-5	
6.00		6.0-6.45	N=51	D-6	
7.00		7.0-7.45	N=53	D-7	
8.00		8.0-8.45	N=27	D-8	
9.00		9.0-9.45	N=15	D-9	GREYISH BROWN CLAY
10.00		10.0-10.45	N=42	D-10	
11.00					
12.00					
13.00					
14.00					
15.00					

No.4, No.5 ボーリング孔柱状図

N J S CONSULTANTS

IMPROVEMENT OF EMBU WATER SUPPLY

SPT VALUES

Site : MUKANGU

Date of Test : 20-10-09

TEST LOCATION	DEPTH (m)	SPT N-Value	Relative Density		APPROXIMATE UNDRAINED SHEAR STRENGTH (KN/M ²)
			Description	Density Index (Id)	
Borehole No. 1	1.45	18	VERY STIFF CLAY	47%	240
	2.45	25	VERY STIFF CLAY	58%	333
	3.45	33	HARD CLAY	66%	440
	4.45	33	HARD CLAY	66%	440
	5.45	22	VERY STIFF CLAY	53%	293
	6.45	19	VERY STIFF CLAY	49%	253
	7.45	18	VERY STIFF CLAY	47%	240
	8.45	16	VERY STIFF CLAY	44%	213
	9.45	23	VERY STIFF CLAY	55%	307
	10.45	24	VERY STIFF CLAY	56%	320
Borehole No. 2	1.45	4	SOFT CLAY	15%	53
	2.45	12	STIFF CLAY	38%	160
	3.45	12	STIFF CLAY	38%	160
	4.45	14	STIFF CLAY	41%	187
	5.45	15	STIFF CLAY	43%	200
	6.45	15	STIFF CLAY	43%	200
	7.45	14	STIFF CLAY	41%	187
	8.45	15	STIFF CLAY	43%	200
	9.45	26	VERY STIFF CLAY	59%	347
	10.45	36	HARD CLAY	71%	480

Kenya

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IMPROVEMENT OF EMBU WATER SUPPLY

SPT VALUES

Site : MUKANGU

Date of Test : 23-10-09

TEST LOCATION	DEPTH (m)	SPT N-Value	Relative Density		APPROXIMATE UNDRAINED SHEAR STRENGTH (KN/M ²)
			Description	Density Index (Id)	
Borehole No. 3	1.45	13	STIFF CLAY	40%	173
	2.45	15	STIFF CLAY	43%	200
	3.45	16	VERY STIFF CLAY	44%	213
	4.45	21	VERY STIFF CLAY	52%	280
	5.45	29	VERY STIFF CLAY	64%	387
	6.45	29	VERY STIFF CLAY	64%	387
	7.45	25	VERY STIFF CLAY	58%	333
	8.45	29	VERY STIFF CLAY	64%	387
	9.45	30	VERY STIFF CLAY	65%	400
	10.45	24	VERY STIFF CLAY	56%	320
Borehole No. 4	1.45	8	FIRM CLAY	28%	107
	2.45	24	VERY STIFF CLAY	56%	320
	3.45	29	VERY STIFF CLAY	64%	387
	4.45	26	VERY STIFF CLAY	62%	373
	5.45	27	VERY STIFF CLAY	61%	360
	6.45	31	VERY STIFF CLAY	66%	413
	7.45	36	VERY STIFF CLAY	71%	480
	8.45	36	VERY STIFF CLAY	71%	480
	9.45	42	VERY STIFF CLAY	77%	560
	10.45	35	VERY STIFF CLAY	70%	467

No. 1 ~ No. 4 ボーリング孔 N 値・支持力換算表

N J S COSULTANTS
IMPROVEMENT OF EMBU WATER SUPPLY

SPT VALUES

Site : KANGARU

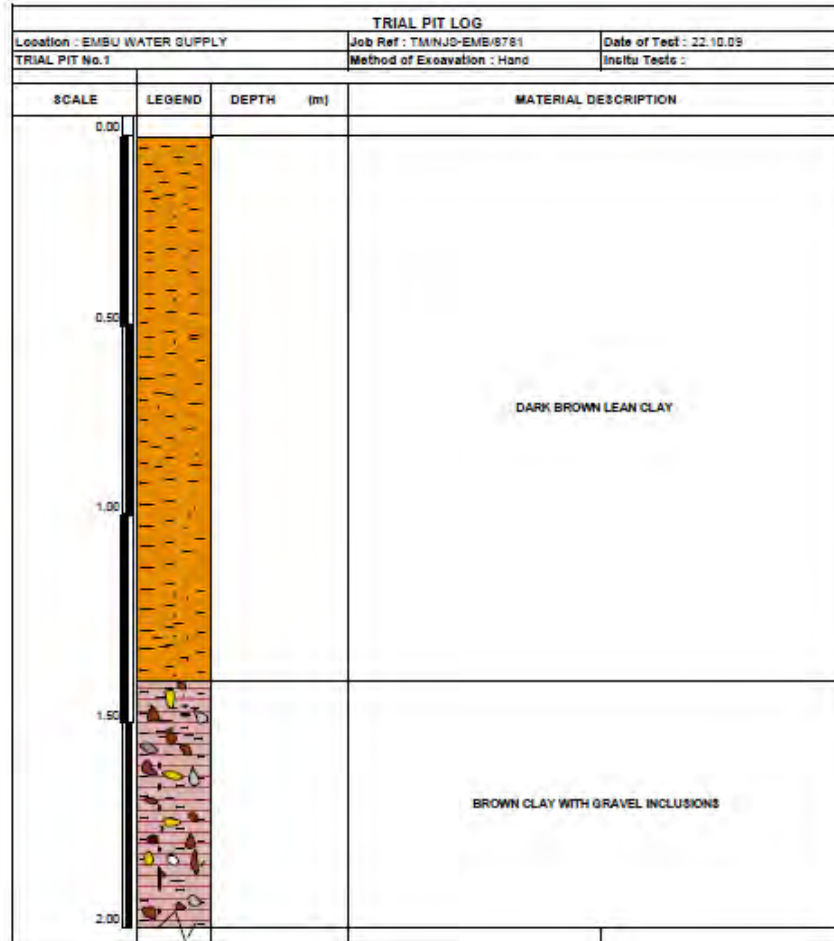
Date of Test : 24-10-09

TEST LOCATION	DEPTH (m)	SPT N-Value	Relative Density		APPROXIMATE UNDRAINED SHEAR STRENGTH (KN/M ²)
			Description	Density Index (I _d)	
Borehole No. 5	1.45	8	FIRM CLAY	26%	107
	2.45	13	STIFF CLAY	40%	173
	3.45	8	FIRM CLAY	26%	107
	4.45	17	VERY STIFF CLAY	46%	227
	5.45	16	VERY STIFF CLAY	44%	213
	6.45	25	VERY STIFF CLAY	58%	333
	7.45	32	HARD CLAY	67%	427
	8.45	22	VERY STIFF CLAY	53%	293
	9.45	20	VERY STIFF CLAY	50%	267
	10.45	20	VERY STIFF CLAY	50%	267
Borehole No. 6	1.45	4	SOFT CLAY	15%	53
	2.45	6	FIRM CLAY	22%	80
	3.45	11	STIFF CLAY	37%	147
	4.45	24	VERY STIFF CLAY	56%	320
	5.45	46	VERY HARD CLAY	81%	613
	6.45	51	VERY HARD CLAY	>85%	680
	7.45	33	HARD CLAY	68%	440
	8.45	27	VERY STIFF CLAY	61%	360
	9.45	15	VERY STIFF CLAY	43%	200
	10.45	62	VERY HARD CLAY	>85%	826

No.5 ~ No.6 N 値・支持力換算表

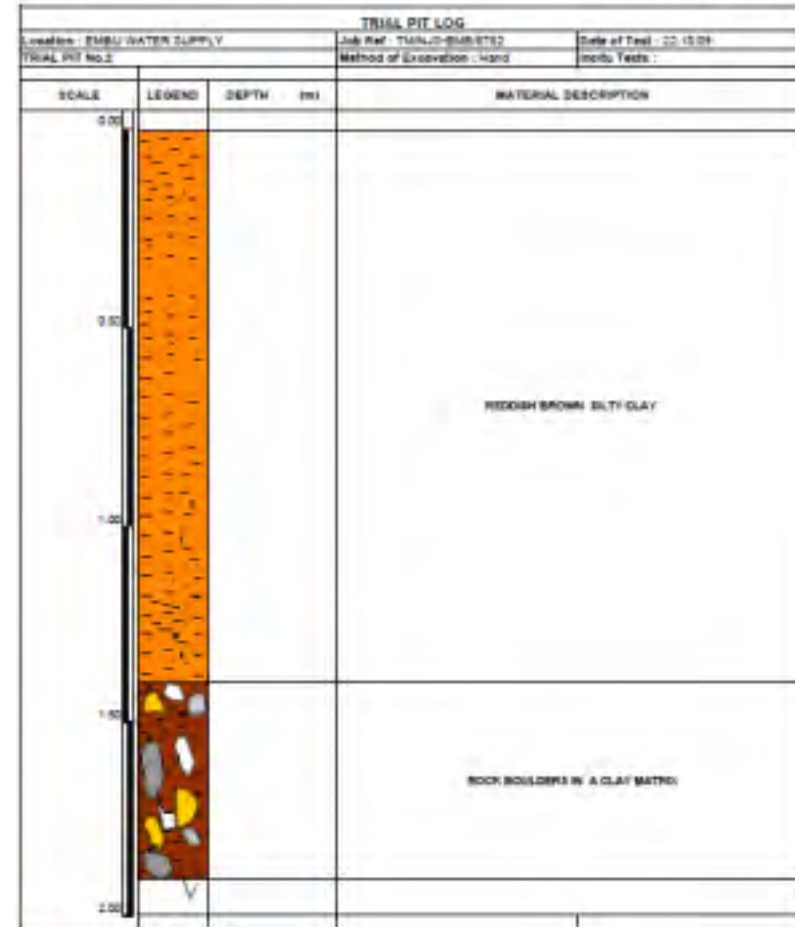
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IMPROVEMENT OF EMBU WATER SUPPLY



N J S CONSULTANTS

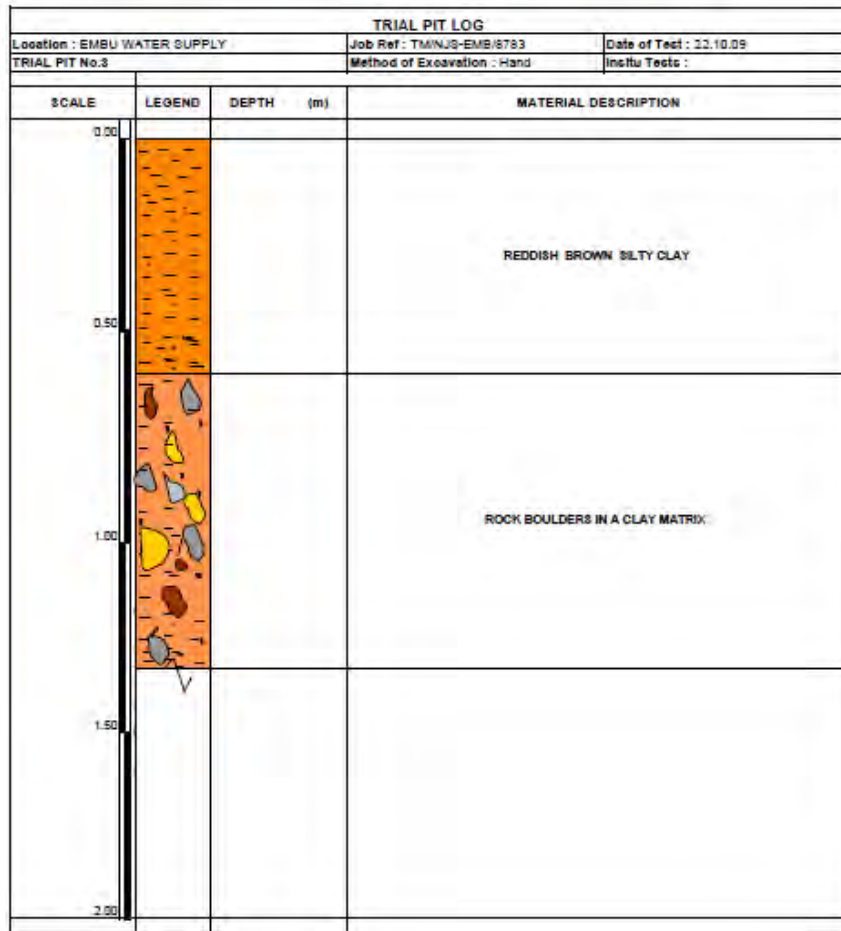
IMPROVEMENT OF EMBU WATER SUPPLY



TP1・TP2 テストピット柱状図

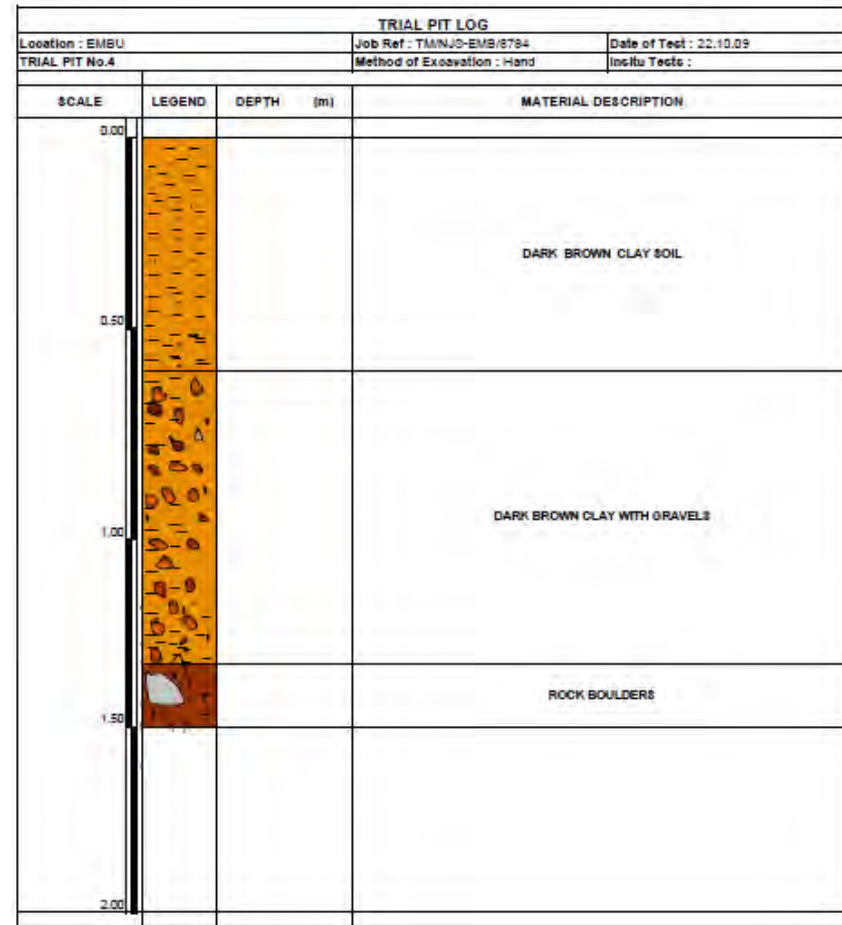
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IMPROVEMENT OF EMBU WATER SUPPLY



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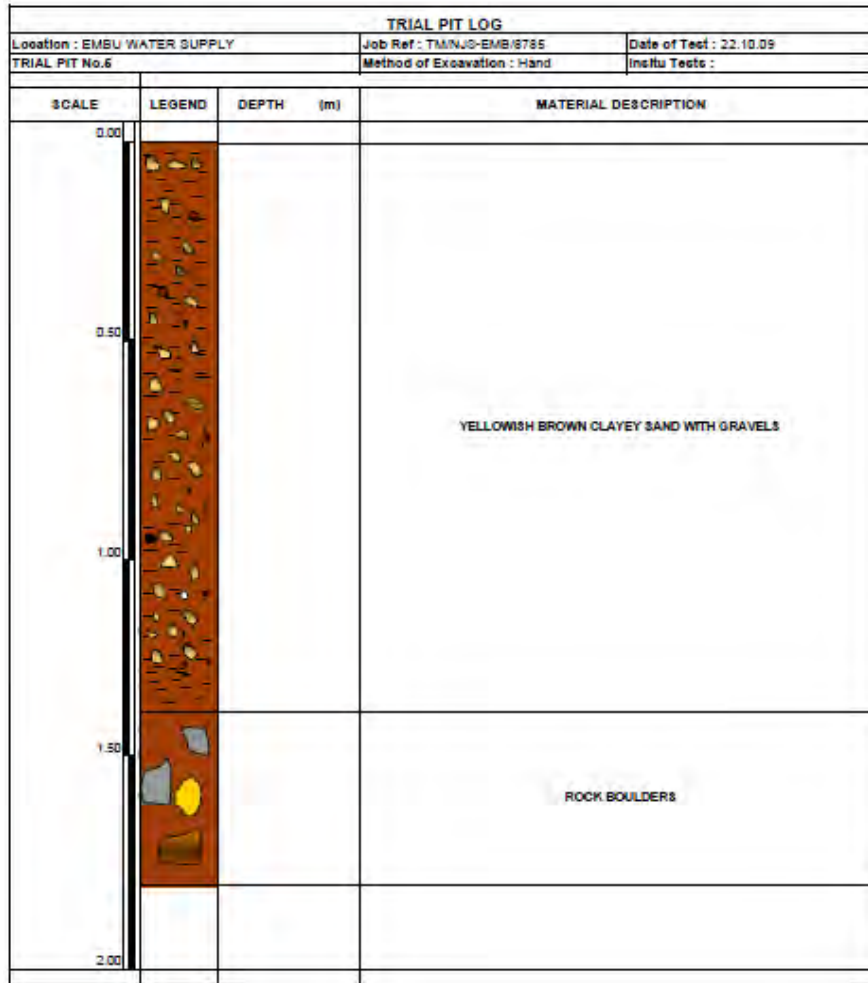
IMPROVEMENT OF EMBU WATER SUPPLY



TP3・TP4 テストピット柱状図

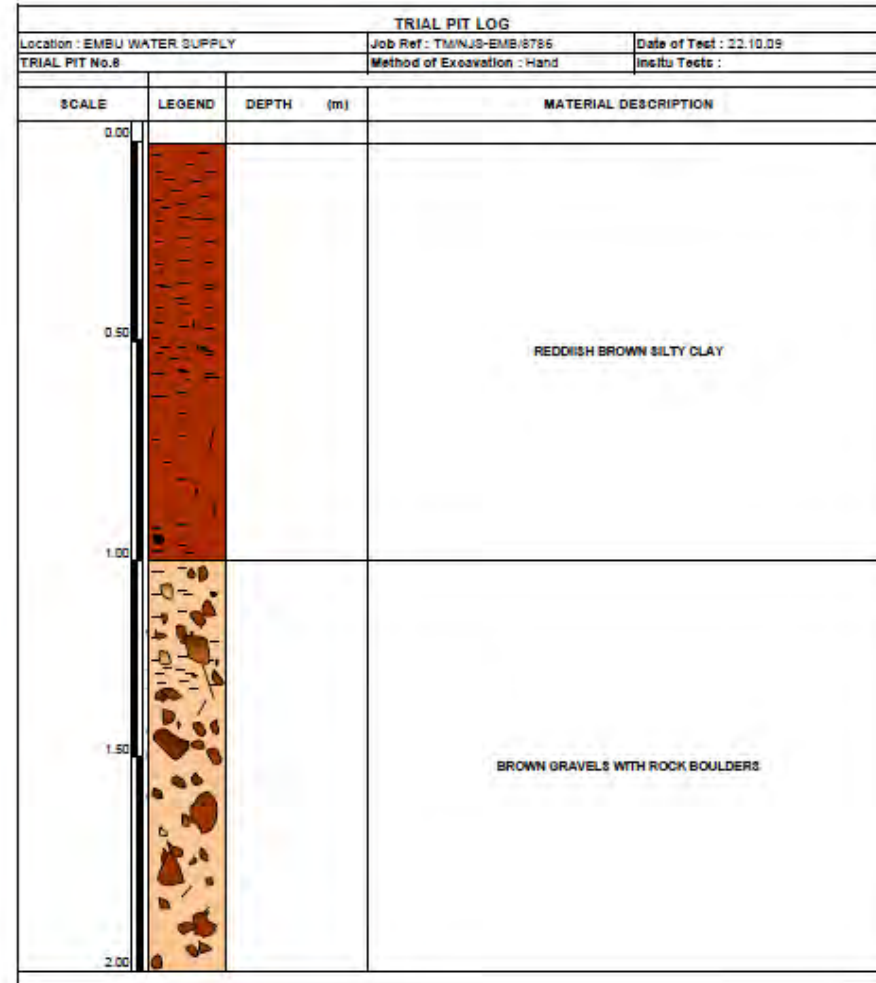
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IMPROVEMENT OF EMBU WATER SUPPLY



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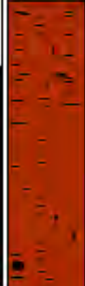
IMPROVEMENT OF EMBU WATER SUPPLY



TP5・TP6 テストピット柱状図


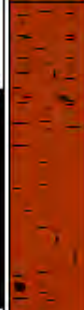
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IMPROVEMENT OF EMBU WATER SUPPLY

TRIAL PIT LOG			
Location : EMBU WATER SUPPLY		Job Ref : TM/NJS-EMB/8787	Date of Test : 22.10.09
TRIAL PIT No.7		Method of Excavation : Hand	In situ Tests :
SCALE	LEGEND	DEPTH (m)	MATERIAL DESCRIPTION
0.00			DARK BROWN LOAMY CLAY (SUB-SOIL)
0.50			
1.00			REDDISH BROWN CLAY
1.50			
2.00			

N J S CONSULTANTS

IMPROVEMENT OF EMBU WATER SUPPLY

TRIAL PIT LOG			
Location : EMBU WATER SUPPLY		Job Ref : TM/NJS-EMB/8788	Date of Test : 22.10.09
TRIAL PIT No.8		Method of Excavation : Hand	In situ Tests :
SCALE	LEGEND	DEPTH (m)	MATERIAL DESCRIPTION
0.00			DARK BROWN CLAY
0.50			
1.00			REDDISH BROWN SILTY CLAY
1.50			
2.00			

TP7・TP8 テストピット柱状図

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IMPROVEMENT OF EMBU WATER SUPPLY

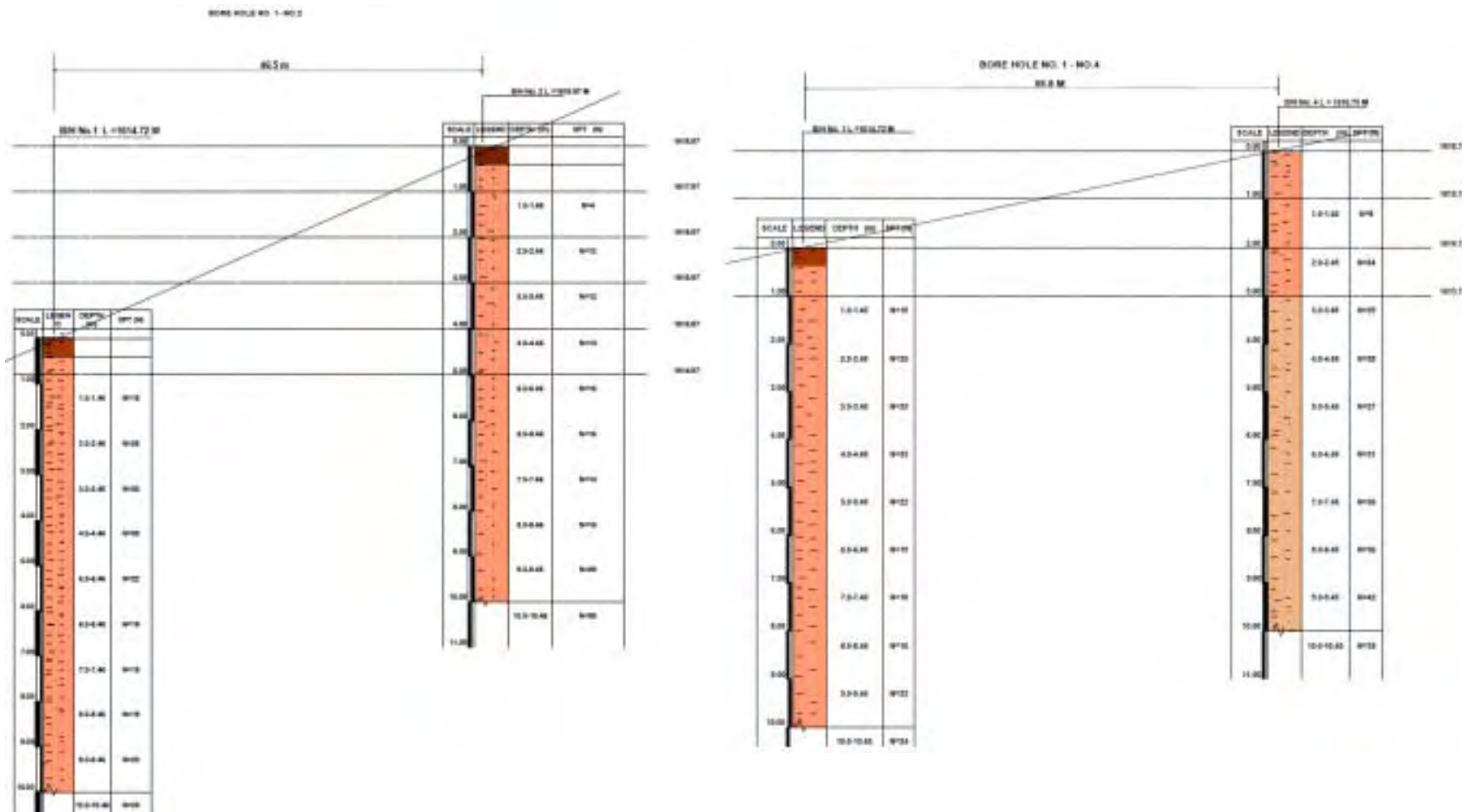
TRIAL PIT LOG			
Location : EMBU WATER SUPPLY		Job Ref : TM/NJO-EMB/8789	Date of Test : 24.10.09
TRIAL PIT No.8		Method of Excavation : Hand	In situ Tests :
SCALE	LEGEND	DEPTH (m)	MATERIAL DESCRIPTION
0.00		0.00	
0.50		0.80	DARK BROWN LOAMY CLAY
1.00		2.00	REDDISH BROWN SILTY CLAY

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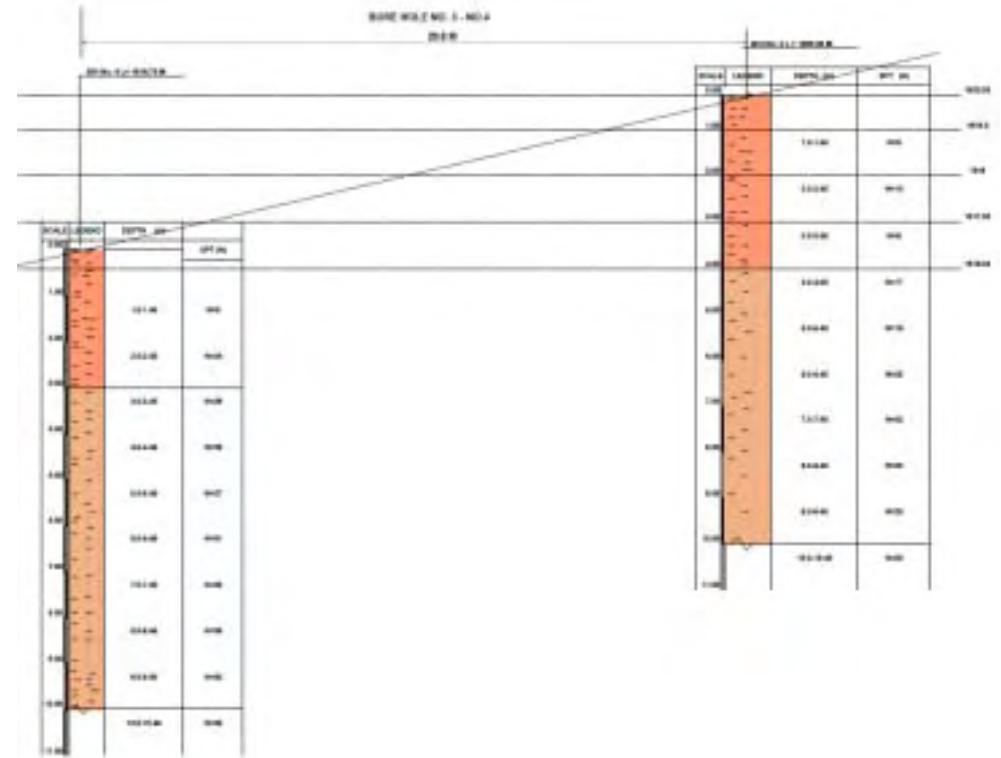
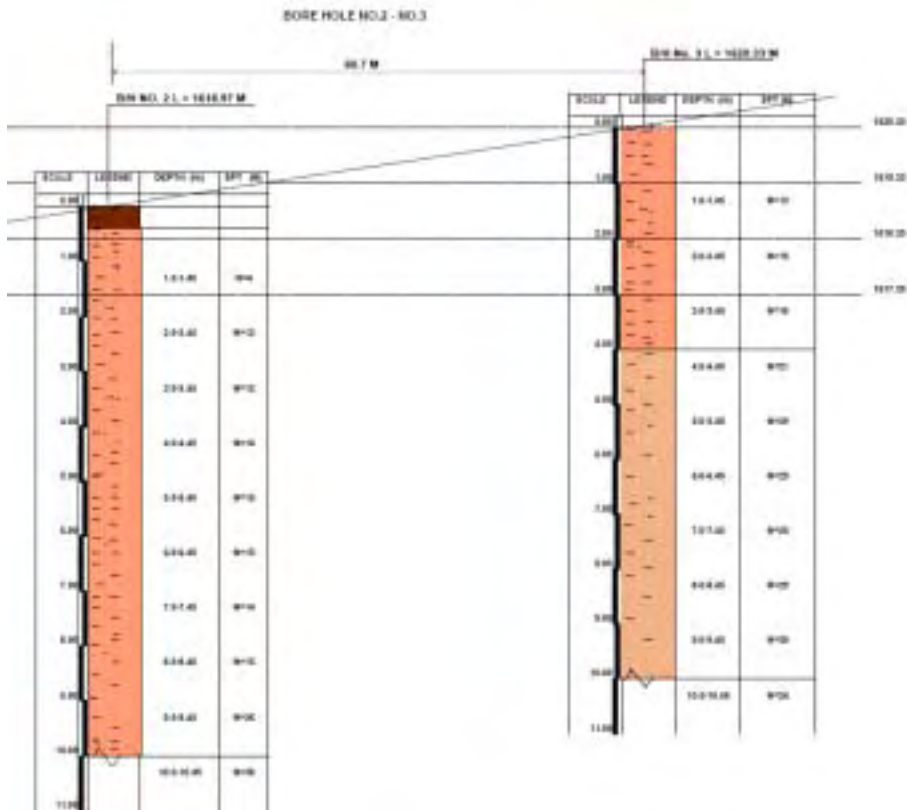
IMPROVEMENT OF EMBU WATER SUPPLY

TRIAL PIT LOG			
Location : EMBU WATER SUPPLY		Job Ref : TM/NJO-EMB/8790	Date of Test : 24.10.09
TRIAL PIT No.10		Method of Excavation : Hand	In situ Tests :
SCALE	LEGEND	DEPTH (m)	MATERIAL DESCRIPTION
0.00		0.00	
0.50		0.50	DARK BROWN CLAY
1.00		2.00	REDDISH BROWN CLAY

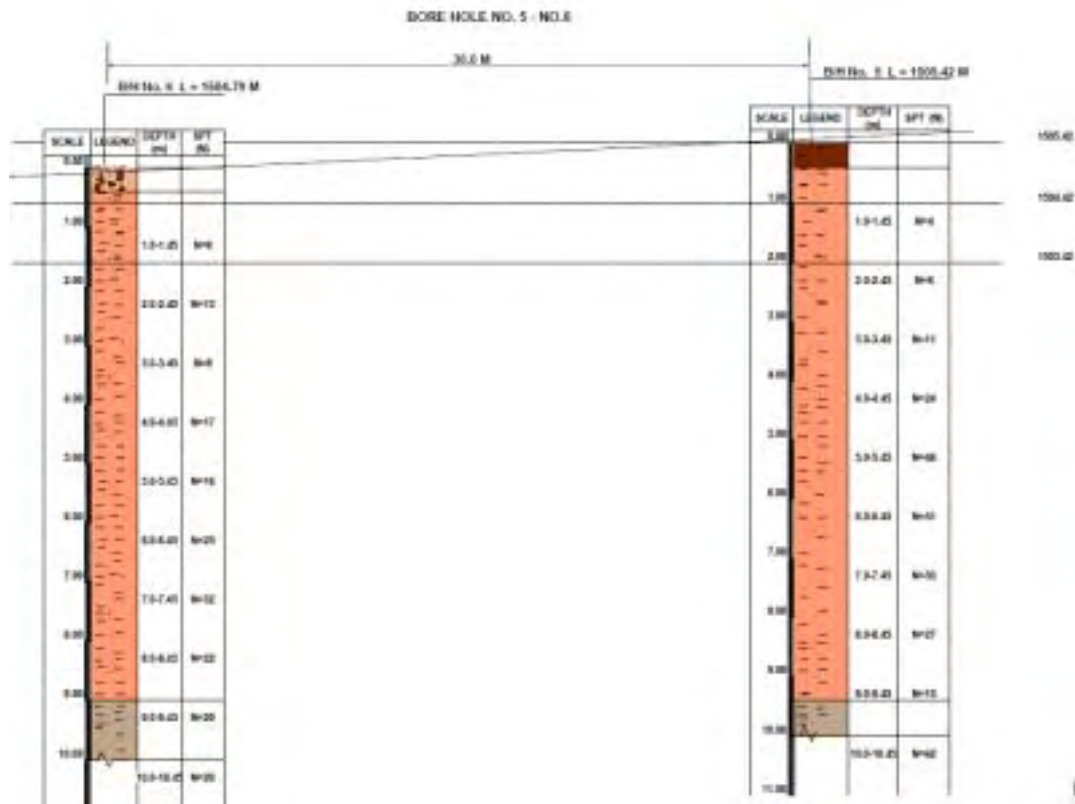
TP9・TP10 テストピット柱状図



No.1-No.2 及び No.1-No.4 土質断面図



No.2-No.3 及び No.3-No.4 土質断面図



No.5-No.6 土質断面図

**SOCIAL CONDITION SURVEY ON THE PROJECT
FOR THE IMPROVEMENT OF
WATER SUPPLY SYSTEM IN EMBU
AND SURROUNDING AREAS**



FOR

NJS CONSULTANTS CO. LTD.

BY



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OCTOBER 2009

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- Planner (Mrs) Joyce Kariuki, for her invaluable assistance in getting a foothold in the survey regions.
- Fr. Vincent Ireñi, Mr and Mrs Johnson Musomba and Mr. Samuel Kariuki Mugo our Regional Coordinators for their hard work that greatly contributed to the success of the study.
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1 INTRODUCTION

The current social economic survey was conducted in the Embu Municipality, Nembure and Gachoka regions of Embu District. Embu town is located about 120 kilometres from Nairobi and has an average height of 1,350 meters above sea level. The town is located on the south-eastern slopes of Mount Kenya.

The primary objective of the study was to establish the necessary conditions for possible improvement of water supply and sanitation in the said areas both through a questionnaire survey and participant observation by the interviewers. Pertinent issues such as water availability, distribution, affordability, hygiene sanitation etc. were addressed.

2 SAMPLING METHODS AND QUESTIONNAIRE ADMINISTRATION

As can be seen on the map below, the three study areas are next to each other. Individual regional maps for the three areas are shown as appendix 2, 3 and 4. Gachoka by far covers the largest area and had serious accessibility challenges.



Source: Embu Water Supply and Sanitation Company (EWASCO)

The study instructions by NJS Consultants Company Limited was to administer 150 questionnaires in Embu, 200 in Gachoka and 50 in Nembure making a total of 400. These were further categorized in terms of residential (household), commercial and institutional land uses at percentage ratios of 60, 30 and 10 respectively to make up the totals for each region as shown on Table 1 below.

The three regions were further categorized by existing administrative sub-locations as outlined in the Table below to ensure total coverage of the study area. Using the above distribution ratio, each sub-location was allotted its fair share of questionnaires per given land use category

Two Directors from Townscape Consulting Planners visited Embu on Friday 9th of October to meet with the Survey principles and the Managing Director, EWASCO for further briefing and collection of maps and other relevant data. On the same day they also met with the coordinator for Embu who kindly made the necessary arrangements for recruitment of the interviewers and office space for use by the team. On the 10th of October, 5 staff members from Townscape Consulting Planners and Mrs. Joyce Kariuki, a Registered Physical Planner who had previously worked in Embu, met with the other two Team Leaders for Gachoka and Nembure in St Mary's School and at Izaak Walton Inn. Joyce was of immense help to the entire team as she assisted us in identifying the region coordinators who in turn helped us identify the most suitable interviewers drawn from each region. The names and qualifications of our very hard working survey partners are shown as Appendix 1.

The coordinators were important and well respected area leaders. These were:

- a) **Gachoka:** Mr. Johnson Musomba, Owner/Director and Mary Musomba Owner/Director/Principle of St. Mary's School.
- b) **Embu:** Fr Vincent Ireri, the Embu diocese Development Coordinator and highly respected member of the community.
- c) **Nembure:** Mr. Samuel Kariuki Mugo, the Principle St. Christopher's Mixed Secondary School.

The following day the three teams seen on the photographs below met in the two schools and in the Catholic Diocese's Development Office in Embu town for briefing, induction sessions and distribution of questionnaires.

Induction session for Gachoka in a St. Mary's School classroom by a Townscape Director



The three centres in addition were the study's regional headquarters during the data collection day. From these centres the Townscape teams toured the various study areas or answered calls seeking certain information. In the centres the filled questionnaires were

returned, confirmed rightly done and payments made and the interviewers paid accordingly. Comments on their experiences were also received in these centres.



Enumerators and coordinators outside the briefing station in Nembure

Enumerators and coordinators outside the Gachoka briefing station



Enumerators and coordinators outside the Embu briefing station

The three study areas were allocated reference zones as noted in the questionnaire as shown in Table 1 below for ease of analysis.

Names of the institutions and commercial land uses to be interviewed were identified during the induction sessions. The choice of households was by **Mbari (family of)** or **extended family setups**. Where for instance a father, mother and married sons are living on the same compound, the interviewers were instructed to interview just a single branch of the family.

Table 1

Questionnaire distribution analysis by land use

REGION	SUB - REGION	HOUSEHOLD	COMMERCIAL	INSTITUTION	TOTAL
EMBU	Dallas/stadium	14	10	2	26
	Njukiri	14	8	3	25
	Gatundiri	12	5	2	19
	Kamiiu	14	7	2	23
	Itabua	12	5	2	19
	Gatufiri	12	5	1	18
	Nihabo	12	5	3	20
	SUBTOTAL	90	45	15	150
GACHOKA	Kiamuringa	10	4	2	16
	Gachuriri	10	6	2	18
	Kirima	10	6	1	17
	Gachoka	10	6	3	19
	Mbita	10	4	1	15
	Nyangwa	10	8	5	23
	Kithunthiri	10	4	1	15
	Mavuria	10	4	1	15
	Gichiche	10	4	1	15
	Kiambere	10	8	1	17
	Gacabari	10	4	1	15
	Riachina	10	4	1	15
	SUBTOTAL	120	60	20	200
	NEMBURE	Ena east	5	2	1
Ena west(rukira)		5	2	1	8
Kirigi		5	3	0	8
Nembure		5	3	1	9
Kiangima		5	2	1	8
Gatunduri		5	3	1	9
SUBTOTAL		30	15	5	50
TOTAL		240	120	40	400

The survey was carried out on 12th October 2009, from 6.00hrs to 20.00hrs. While the physical surveys were completed by 18.00 hours in Nembure and Embu, Gachoka took along time to complete due to the distances covered.

On the 13th of October 2009, the Townscape staff together with the best two interviewers authenticated, coded, and keyed in part of the data in to the computers at the Izaak Walton Inn for further analysis which was carried out in Nairobi.

2.1 Data collection and interpretation challenge

The survey team was gratified to note that the data collection exercise went on smoothly and peacefully with maximum assistance from the interviewees and other members of the community. The survey was conducted during the hottest and driest period experienced in living memory. Mention of possible water provision worked on the community like magic. However, the respondents especially in the institutional and commercial categories were reluctant to fully disclose their incomes on account of confidentiality and need for higher authority to release certain information. The enumerators were however able to estimate the income from figures vaguely quoted during the interviews and in relation to the expenditure statistics which were reluctantly given.

The interpretation of the family size within the commercial and institutional categories posed some problems. In the case of dispensaries and sub-hospitals, the daily/weekly/monthly number of patients was given as the family size. Schools, both primary and secondary (boarding or day) gave the number of students as the family size. For commercials, the number of customers per day/week/month was generally given as the family size while coffee factories and commercial farms gave total membership as family size.

Due to the wide coverage of the survey, most interviewers especially in Gachoka covered a minimum radius of ten kilometres within their allotted areas. Accessibility was a real challenge and some of the interviewers had to be transported on motor cycles and bicycles. Those in the furthest areas of Mbeere such as Gachururiri, Mavuria and Gacabari had to be offered 4-wheel drive transportation on account of the depth of the sandy soils that cover the roads of access.

2.2 General observation

The three survey areas differ substantially in terms of altitude above sea level, average annual rainfall and vegetation. Nembure is the most agriculturally endowed being at the immediate slopes of Mt. Kenya. It has coffee, tea and dairy farming as main sources of income. The region's greatest challenge is widespread deforestation especially on hilltops. The area has too many eucalyptus trees which are said to inordinately consume underground water that ought to be preserved and increased for the betterment of the general environment.



Serious hilltop deforestation for tea plantations



A dry river bed at Kapingazi water intake

Nembure was in addition was noted to draw water from the Kapingazi River in an irresponsible manner that pollutes and denies water to downstream users as demonstrated in the photographs below.



Heavily polluted water at Kapingazi water intake dam



Eucalyptus trees planted next the Rupingazi water intake dam

At the time of the survey, most of Gachoka with the exception of the areas served by EWASCO had serious water problems. Empty rivers pose real health and economic challenges. Residents are forced to dig wells on river beds in order to get pools of water from which they draw for their needs and those of their animals. Gachoka also has serious environmental degradation challenges. Most of the region is generally devoid of trees while others are colonized by bushes as shown in the photographs below.



Wells some of which are dug in the empty river beds are the main sources of water in the many areas. Some public wells are fitted with manual pumps. Although this lessens the burden of drawing up the water in some containers, the use of the manual pumps is still very difficult particularly for young children. The water is transported to the end user on human or donkey backs.



People come from long distances to draw water queuing for many hours sometimes long into the night. The teachers interviewed in some of the schools in the area reported high absenteeism rates particularly of the girl children precisely on account of this problem.



Women in Gachoka drawing water from a well

The time loss in the process of drawing and transporting just a few gallons of water to various users is astronomical. This also takes quite a heavy toll particularly on women whose job it is to provide domestic water. Men usually draw water mainly for sale on order.

The best water infrastructure provision appears to be under the management of EWASCO. It has fairly well established water infrastructure part of which is currently under major repair.



Mukangu water siltation tanks under repair

EWASCO water storage tanks in Embu



EWASCO water treatment plant in Embu town

Additional land has been made available for the extension of Mukangu Treatment Plant. The plant treats water from both Kapingazi and Rupingazi Rivers. As noted earlier, the Kapingazi water is highly polluted and is initially separately treated before it is mixed with the higher volume and cleaner water from Rupingazi. This river has plenty of yet untapped water supply potential.

A large section of Nembure and some part of Embu like Gatituri and Itabua were supplied piped water by Ngandori-Nginda Water Company. This is a community funded and managed water supply and distribution company. During the field surveys, the supply was reported as fairly inadequate.

3 DATA PROCESSING

The data collected from the three regions was analyzed by questionnaire and the average statistics placed in one table. This produced unrealistic results that did not reflect the actual situation on the ground. To ensure clarity of survey results, the three categories of users were classified separately in terms of:

- a) Household size,
- b) Number of sick days per year,
- c) Monthly income and expenditure
- d) Medical expenses
- e) Preferred water charges per month

The combined data matrix shown as Table 2 below reflects the above variables for regular households only plus all the other variables given in the questionnaire. Tables 3 and 4 reflect the information noted above separately for institutions and commercial land use only.

Table 2

Questionnaire survey data matrix

	Item	Description.	Average absolute Variable		
			Area		
			Embu	Nembure	Gachoka
Households Only		Family Size	5	5	6
	Income	Monthly income (Kshs)	10,387	15,422	9,046
	Expenditure	General Monthly Expenditure (Kshs)	7,608	8,078	7,678
		Monthly water expenditure (Kshs)	529	549	1,363
		Medical Expenses per years per family (Kshs)	6,970	2,617	4,334

	Willingness to pay for piped water	preferred charges if piped water is provided in Kshs. per month	325	382	1,304
All (Household, Commercial and Institutions)	Sewerage connectivity	Connected	59	15	8
		Not connected	91	30	192
	Water usage	Kitchen	144	42	173
		Laundry	128	32	137
		Bath/Shower	115	33	118
		Toilet	79	10	19
		Livestock	65	22	86
		Others	14	8	19
	Water supply connectivity	Connected	102	32	36
		Not connected	48	18	164
	Water supply status	Number of faucets	1127	141	152
	Water meter	installed	63	14	33
		Not installed	39	18	3
	Function of water meter	working	63	14	31
		Not working	0	0	2
	If water meter working	Reliable	55	8	23
		Not reliable	8	6	8
	Supply hour	Hours/day	24	3.8	1.5
	Water volume	Sufficient	40	3	5
Insufficient		53	21	23	
Insufficient always		9	8	5	
Others		0	0	0	
Water quality	Good	45	8	20	
	Having turbid sometimes	52	24	10	
	Having turbid always	3	5	0	

		Having smell	1	1	1
		Having unpleasant taste	1	2	2
		Others	3	0	0
	Water pressure	Sufficient	35	5	10
		Low pressure sometimes	63	19	23
		Low pressure always	4	8	0
		Others	0	0	0
	Water supply	Satisfied	24	2	12
		Insufficient supply hour	35	17	11
		Low water pressure	10	12	9
		Poor water quality	8	7	1
		Expensive water charge	45	9	15
		Poor service from water provider	15	10	7
		Others	5	0	0
	Use of water	Exclusively own use	79	25	19
		Communal use With neighbours	21	6	13
		Others	0	1	0
	Where there is no piped water supply - Water source	Neighbour	12	9	19
		Public faucet	6	0	2
		Private own well	6	2	16
		Public/neighbours Well	3	2	26
		Spring water	5	8	37
		Water vendor	0	4	56
		Others	21	0	30
	If piped water is availed - Key benefits	Mitigation of water fetching burdens	34	16	47
		Less morbidity, less	30	7	21

		cost for medical care			
		more time for productive activities	68	21	82
		More time to study	14	4	15
		others	4	3	1
	Water quality check by interviewer - Colour/Turbidity Having deep colour.	None (Clear)	70	28	94
		Having colour/Turbidity	61	18	81
		Deep colour	50	5	23
		Brown	37	5	44
		Yellow	0	0	1
		Red	0	0	1
		White	5	0	8
		Others	9	0	0
	Having Light colour	Having light colour	46	14	33
		Brown	41	11	40
		Yellow	6	0	2
		Red	0	0	0
		White	3	2	9
		Black	0	0	0
	Smell	Others	3	1	0
		None	113	34	104
	If having smell	Having smell	33	12	73
		Muddy	21	7	41
		Musty	6	3	22
	Taste	Others/ chlorine	11	0	27
		No unpleasant taste	102	20	87
	If with Unpleasant taste	With unpleasant taste	41	28	86
		Salty	6	9	77
		Metallic	0	10	6
		Muddy	38	12	34
	Hygiene Infection route	Others	1	1	1
		Oral	56	36	105
		Contagion	16	19	22

		Environment	83	42	85
		Others	10	0	3
Cause of sickness		Average sick days per year per family	27	20	31
		Water	54	28	132
		Food	17	21	23
		Sewerage	5	5	6
		Unknown	46	10	49
		Other	36	8	14

Table 3.
Individual Institutions by Region and Related Variables

Sub region	Name	Population size	Number of sick days per population per year	Monthly income in Kenya shillings	Monthly general expenditure in Kenya shillings	Monthly water expenditure in Kenya shillings	Medical expenditure in Kenya shillings	Preferred monthly water charge in Kenya Shillings
EMBU REGION								
Gatirui	Gatirui Primary School	367 pupils	-	68,000	60,638	3,300	-	500
Nthambo	Kangaro Hosp'	7 employees	35	250,000	100,000	1,500	-	-
	Nthambo Sec School	250 students	120	160,000	100,000	645	-	200
	Nthambo Pri School	549 pupils	90	14,300	14,300	315	-	200
Dallas	Dallas Dispensary	5 employees	5	25,000	23,000	2,000	12,000	900
	Bonanza School	400 students	100	1,080,000	1,000,000	30,000	40,000	20,000
Njukiri	St Michael Primary School	700 pupils	30	10,800	10,800	4,000	54,000	3,000
	By Grace Academy	300 students	100	300,000	300,000	20,000	45,000	10,000
	Njukiri East College	550 students	-	1,000,000	1,000,000	90,000	-	30,000
Kamin	Victory Academy	90 pupils	90	45,000	35,000	2,000	10,000	2,000
	ACK Academy	265 pupils	365	170,000	65,000	-	90,000	-
Itabua	St. Peters Primary School	300 pupils	50	150,000	80,000	500	27,000	-
	Itabua Primary School	872 pupils	108	25,000	25,000	200	4,500	200
Gatunduri	Gatunduri Dispensary	6 employees	5	35,000	14,000	200	10,000	200
	Kiangima Secondary School	330 students	15	98,000	98,000	700	90,000	150
TOTALS			1,113	3,431,100	2,925,738	155,360	382,500	07,350
Average per month			74	228,740	195,049	10,357	9,563	5,613
GACHOKA REGION								
Kiamuringa	Kiamuringa	317 students	15	-	-	-	-	-

	secondary School							
	Dispensary	100 patients per month	360	-	-	1,000	-	1,000
Gachuriri	A.I.C Berain	100	36	7,000	6,000	1,000	27,000	600
	Dispensary	270 patients per month	365	40,000	20,000	10,000	100,000	5,000
Kirima	St. Mary Primary	168 pupils	-	41,667	25,000	25,000	-	30,000
Gachoka	Rwika Dispensary	6 employees	21	-	-	500	1,000	500
	Ngenge Secondary School	162 students	3	455,230	400,000	6,000	180,000	6,000
	Rwika Institute	600 students	7	583,333	616,667	26,598	180,000	26,598
Mbita	-	-	2 a week	-	-	24,000	12,000	24,000
Nyangwa	Karanduri Sub District Hospital	10 staffs 13 students	Through out the year	20,000	30,000	2,000	-	400
	Nyangwa Primary School	486 students	45	-	-	700	27,000	700
	Betty academy	334 pupils	30	200,000	110,000	26,000	180,000	10,000
	Min of Agriculture-Mbeere South	6 staffs	2	00,000	60,000	-	48,000	350
	Nyangwa Boys Secondary School	667 students	Through out	291,667	166,667	58,206	100,000	10,000
Kitbunthul	School	380 student	45	163,000	153,000	22,150	99,000	21,000
Mavuria	Triamuni Girls secondary School	310 students	100	62,500	50,000	40,000	-	15,000
Gichiehe	Gichiehe Primary School	190 pupils	340	36,000	36,000	0	-	6,000
Kiambere	Kiambere Mixed Boarding	140 students	50	297,330	267,600	50,000	30,000	16,000
Gacabari	Gacabari Primary School	207 pupils	60	4,000	3,000	200	5,400	300
Riachina	Primary School	280 pupils	15	5,000	5,000	2,000	9,000	500
TOTALS			1,408	2,266,727	1,948,934	295,354	998,400	173,948

Average per month			70	113,336	97,446	14,768	71,314	8,697
NEMBURE REGION								
Eta East	Nembure Primary School	434 pupils	30	20,000	10,000	500	9,000	1,000
Eta West	Rukira Dispensary	1,000 patients per month	30	50,000	40,000	1,300	13,500	700
Kirigi	-	-	-	-	-	-	-	-
Nembure	Nembure Health Centre	1,070 patients per month	-	113,000	74,500	1,050	-	1,000
Kiangoria	St. Mary Secondary School	400 students	150	791,667	500,000	36,000	108,000	20,000
Gatundari	M. Teni Secondary School	230 students	144	366,667	366,667	22,000	41,280	10,000
TOTALS			354	1,341,534	991,167	60,850	171,780	32,700
Average per month			70	268,266	198,233	12,170	57,260	6,540

Table 4.
Individual Commercial Uses by Region and Related Variables

SUB REGION	Number of Questionnaires Administered	Name of Institution	Population Size	Number of sick days	Monthly Income in Kenya Shillings	Monthly General Expenditure in Kenya Shillings	Annual Medical expenditure in Kenya shillings	Preferred Monthly water charge in Kenya Shillings	Monthly Water expenditure in Kenya Shillings
ENDU REGION									
Gallioi	1	Commercial	5	14	6,500	3,000	3,000	200	200
	2	Commercial	1	30	10,000	8,500	4,000	300	200
	3	Commercial	4	8	8,000	6,000	2,000	200	200
	4	Commercial	3	40	8,000	6,500	6,000	250	1,500
	5	Commercial	4	40	5,000	5,200	8,500	100	400
Thaba	1	Commercial	8 Customers	90	21,000	12,000	500	200	270
	2	Kangari Clinic	6 Employees	60	10,000	2,500	-	300	200
	3	Bar	3	5	20,000	21,000	10,000	500	3,000
	4	Commercial	0	-	6,000	6,000	2,000	-	-
	5	Butchery	1	5	25,000	18,000	3,000	400	-
Dalla	1	Commercial	24	10	400,000	130,000	8,000	20,000	30,000
	2	Commercial	8 Customers	15	60,000	45,000	12,000	10,000	13,000
	3	Commercial	14 Customers	20	2,000,000 Per annum	500,000 Per annum	60,000	1,000	3,000
	4	Commercial	18 Customers	10	90,000	80,000	5,000	4,000	10,000
	5	Commercial	18 Customers	8	350,000	260,000	12,000	4,000	10,000
	6	Commercial	12 Customers	15	100,000	80,000	6,000	3,000	5,000
	7	Kiosk	6 Customers	15	250,000 Per annum	120,000 Per annum	12,000	3,000	4,000
	8	Commercial	31 Customers	10	2,000,000 Per annum	500,000 Per annum	30,000	12,000	20,000
	9	Besta Food Processor	11 Employees	8	350,000	250,000	80,000	1,000	5,000
	10	Commercial	20	20	200,000	120,000	10,000	2,500	4,000
Njohoi	1	Commercial	3	36	5,000	5,500	4,000	500	800
	2	Commercial	4	24	40,000	36,000	12,000	5,000	12,000
	3	Commercial	3	45	30,000	35,000	-	3,000	3,000
	4	Commercial	4	-	20,000	20,000	-	1,500	4,000
	5	Commercial	3	8	10,000	9,000	10,000	100	100
	6	Commercial	4	30	10,000	4,000	20,000	500	100
	7	Isaki Water Board	-	4	-	6,000,000	-	100,000	100,000
	8	Commercial	1	1	1,000	1,000	100	200	250

Koroba	1	Terry Shopping Complex	-	110	600,000	100,000	300,000	-	10,000
	2	MacNuts	6	30	600,000	100,000	10,000	20,000	15,000
	3	Mama Rich Eats	6	150	45,000	25,000	40,000	350	1,000
	4	Commercial	4	90	20,000	14,000	10,000	2,000	15,000
	5	Commercial	5	90	50,000	45,000	0,000	900	600
	6	Commercial	5	180	50,000	20,000	30,000	100	300
	7	Mama Kinyua Shop	5	210	30,000	20,000	15,000	300	800
Babau	1	Commercial	2	3	6,000	3,000	1,000	200	900
	2	Shop	1	5	20,000	5,000	2,000	300	300
	3	Commercial	2	48	3,000	6,000	10,000	400	200
	4	Commercial	1	180	15,000	0,000	1,000	200	300
	5	Shop	2	90	900	2000	700	700	900
Gatunduri	1	Commercial	2	5	15,000	0,000	1,000	300	200
	2	Fringe Coffee Factory	15	10	195,000	135,000	-	150	-
	3	Commercial	5	12	10,000	8,000	2,000	150	200
	4	Gatunduri Coffee Fact	12	35	180,000	110,000	-	300	200
	5	Commercial	3	2	24,000	5,000	3,000	200	200
TOTALS	45			1,813	3,699,334	1,813,201	677,844	200,788	320,120
Average per month				42	84,075	41,209	17,320	4,667	7,621
GACHOKA REGION									
Kiamuraga		Hotel	13 Customers	3	300	300	-	250	-
		Butchery	50 Customers per day	5	15,000	12,000	10,000	200	1,000
		Market stall	10	3	3,000	500	3,000	100	100
		Shop	3	3	3,400	400	3,000		200
Gachuri	1	Commercial	15 Customers	80	40,000	10,000	80,000	1,000	2,000
	2	Commercial	150 Customers	40	20,000	10,000	14,000	1,000	3,000
	3	Commercial	100 Customers	40	20,000	8,000	10,000	1,000	3,000
	4	Commercial	70 Customers	50	30,000	40,000	-	500	800
	5	Commercial	0 Customers	30	30,000	40,000	20,000	3,000	3,000
	6	Commercial	20 Customers	36	3,000	3,000	20,000	300	1,000
Kirima	1	Hotel	100 Customers	20	15,000	2,000	10,000	8,000	9,000
	2	Hotel	150 Customers		25,000	12,000		10,000	3,000
	3	Cafe	50 Customers	5	12,000	700	1,800	8,000	8,000

	4	Hotel	250 Customers	10	10,000	9,000	2,000	14,000	2,000
	3	Hotel	80 Customers	3	12,000	7,300	2,000	10,000 per annum	8,500
	6	Hotel	150 Customers	10	18,000	8,000	3,000	10,000 per annum	12,000
Gachoka	1	Salon	1	3	3,000	2,300	400	230	290
	2	Commercial	6	6	8,000	7,000	1,500	500	-
	3	Commercial	5	30	24,000	6,000	3,000	200	-
	4	Commercial	4	8	16,000	10,000	2,000	1,000	1,200
	5	Commercial	9	24	20,000	14,000	3,000	2,000	5,000
	6	Commercial	2	8	5,000	6,000	1,400	250	-
Mbita	1	Shop	3 Customers	3	25,000	18,000	1,000	3,000	2,500
	2	Butchery	150 Customers	2	30,000	20,000	1,000	3,000	2,000
	3	Hotel	200 Customers	2	40,000	25,000	3,000	5,000	5,000
	4	Hotel	100	1 week	30,000	15,000	-	5,000	5,000
Nyungu	1	Commercial	1	6	15,000	5,000	1,000	200	1,200
	2	Shop	1	4	8,000	65,000	8,000	500	700
	3	Restaurant	5	2	40,000	35,000	1,000	250	1200
	4	Mixed commercial	5	10	200,000	150,000	10,000	4,000	3,000
	5	Utensils shop	4	3	50,000	40,000	5,000	250	700
	6	Pharmacy	10 Customers	15	100,000	70,000	6,000	5,000	9,500
	7	Agrovet	3	10	60,000	20,000	4,000	3,000	1,575
	8	Green grocer	3	10	50,000	24,000	1,200	300	500
Kilimbarizi	1	Commercial	40 Customers	-	10,000	6,000	1,000	2,000	2,500
	2	Commercial	24 Customers	7	10,000	5,000	1,500	1,500	800
	3	Commercial	16 Customers	-	12,000	3,000	1,500	1,000	500
	4	Commercial	170 Customers	12	28,000	7,000	2,000	2,000	600
Mavuria	5	Shop	12 Customers	15	21,000	15,000	20,000	2,000	4,000
	6	Bar	1	2	10,000	5,000	2,000	3,000	2,000
	7	Salon	7	7	9,000	10,000	2,000	300	2,000
	8	Hotel	30 per days	8	20,000	11,000	1,700	2,000	9,000
Gichilele	1	Shop	1	1	2,000	1,500	300	400	900
	2	Tulse	1	36	2,000	2,000	250	100	-
	3	Shop	1	24	4,000	3,000	500	100	450
	4	Shop	1	3	3,000	3,200	100	300	-
Kilimbari	1	Shop	2	16	12,000	10,000	7,000	3,000	3,000
	2	Hotel	20	5	16,000	24,000	8,000	900	9,000

			Customers						
	3	Hotel	24 Customers	22	10,000	10,000	15,000	1,500	9,000
	4	Lodging	5	5	12,000	20,000	2,000	5,000	3,000
	5	Lodging	8	20 members	25,000	25,000	6,000	10,000	10,000
	6								
Gatunduli	1	Commercial	7	3	6,000	200	720	300	600
	2	Commercial	22 Customers	19	30,000	25,000	500	500	1,000
	3	Commercial	8	24	9,000	6,000	450	100	200
	4	Commercial	8	12	12,000	18,000	500	1,000	1,200
Itackina	1	Commercial	13	2	4,000	3,000	1,000	500	1,500
	2	Commercial	20 Customers	2	8,000	4,000	1,000	500	1,000
	3	Commercial	10	2	5,000	4,000	2,000	200	500
	4	Commercial	25 Customers	3	10,000	5,000	1,500	500	2,000
TOTALS	40			128	1,313,700	677,600	327,120	119,576	156,175
Average per month				12	21,893	14,626	5,738	1,993	2,602
NEMBURE REGION									
Ena East	1	Commercial	6	30	16,000	14,300		400	300
	2	Commercial	6	30	16,000	14,300	100	400	300
Ena West	1	Commercial	4	20	6,000	4,800	1000	200	300
	2	Commercial	5	30	17,200	6,400	1500	300	400
Kirigi	1	Slaughter house	-	5	40,000	30,000	2,000	500	8,000
	2	Hotel	3,000 (customers)	2	60,000	51,000	300	150	5,000
	3								
	4	Coffee factory	1,400 (members)	?	20,000,000 Per annum	5,000,000 Per annum	-	2,000	
Nembury	1	Hotel	100 Customers per day		80,000	50,000	-	500	2,000
	2	Slaughter house	3	20	20,000	8,000	15,000	500	2,000
	3	Coffee factory	1629 Members	20	270,000	158,000	17,000	4,300	8,500
Niangima	1	Hotel	50		20,000	7,000		300	200
	2	Shop	80	20	30,000	12,000	3,000	100	200
Gatunduli	1	Commercial	17	-	15,600	10,000	72	100	200
	2	Commercial	51 Customers	-	12,700	1,800	36	300	500
	3	Commercial	5	-	17,000	6,300	4	200	130
TOTALS	15			179	1,289,967	760,667	40,612	16,356	27,850
Averaged totals per month				14	152,531	60,711	3,384	1,360	2,320

The above tables were used to create analytical charts and graphs which are discussed below. It is to be noted that the tables hold a wealth of information all of which can not be dealt with in detail in this brief report. Selective analysis of the most important variables is made in the following pages. For purposes of comparative analysis, percentages of average statistics have been widely used.

4 DATA ANALYSIS

The data as tabulated above was analyzed through a combination of water related variables to determine the prevailing social economic conditions for the improvement of water supply system in Embu and the surrounding areas of Nembure and Gachoka. The report findings are grouped by clusters of variables for ease of relative comparisons.

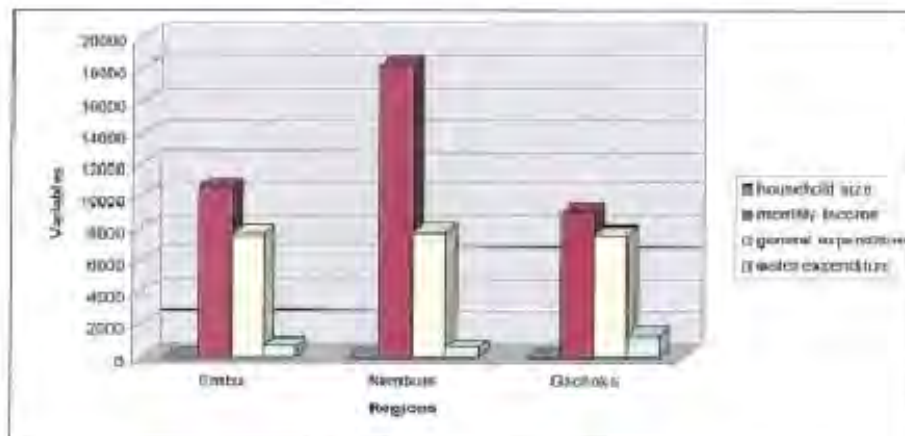
One fact of special significance is the general shortage of piped water supply in the three regions under study. Of the 384 persons who responded to the question of piped water supply, 217 (57%) have no such supply. Only 43% (167) confirmed connectivity to some form of piped water supply even of a communal nature. The Government's vision to provide all Kenyans with piped water by 2030 need to be speeded up in these regions especially since river water is readily available particularly close to the mountains. Its transportation to the end users is entirely through gravity and is therefore cost effective.

It is also noteworthy that 399 respondents want more piped water even at higher costs. It is only Izaac Walton Inn who would want their water charges reduced downwards. The hotel heavily relies on its borehole water which had dried up in the recent drought. The water supplied by the vendors may end up being more expensive than the regular supply.

4.1 Household sizes and monthly incomes

Embu and Nembure have similar average household sizes of five persons as opposed to Gachoka which has an average of six persons per household. Average household incomes substantially differ with those in Nembure being twice as high as those in Embu and Gachoka. As noted earlier, the region is better climatically and agriculturally endowed. The region also has flowing rivers which the residents advantageously utilized for irrigation during the recent drought period. This points to the fact that these regions can enjoy better and healthier lives if provided with adequate and affordable water.

Figure 1
Household size by monthly income, general and water expenditure

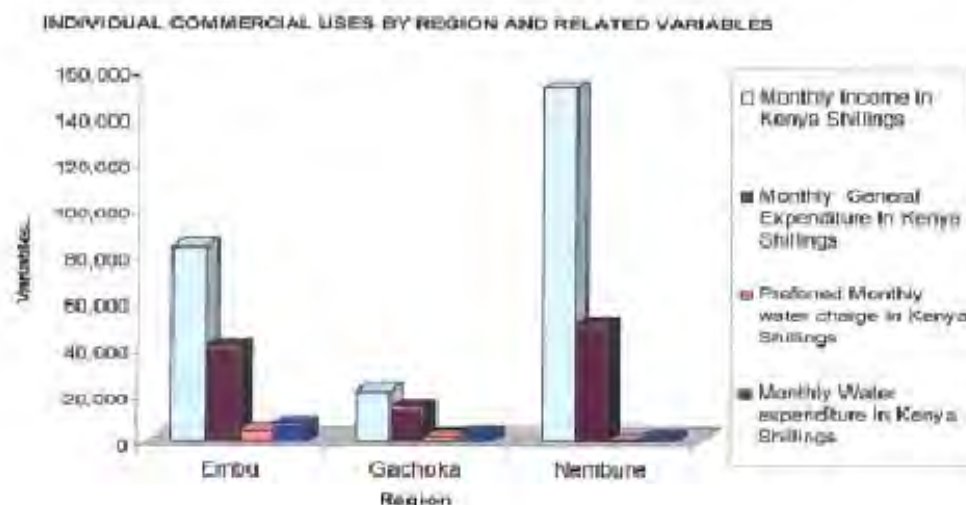


Although Gachoka is the poorer region of the three, it has both the highest general purposes and water expenditures. Households on average spend four times the money spent by the other two regions on water alone. This is due to the critical shortage of water, the long distances travelled to get the water and the mode of transporting water to users either on human or donkey backs. A twenty litre gallon of water in Gachoka costs 5 shillings if drawn from the EWASCO water pipes and 20 shillings if drawn from the river or a well.

4.2 Commercial and institutional income by related variables

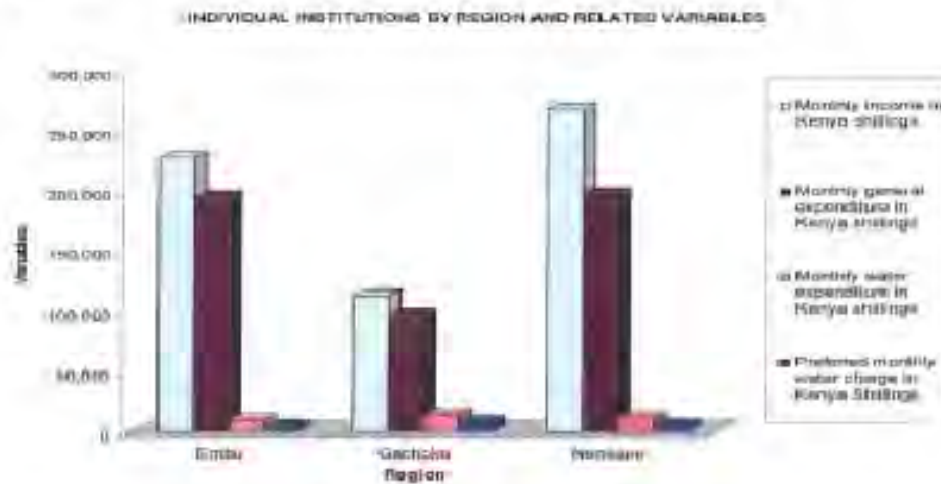
Of the three regions, commercial outlets and institutions in Nembure have the highest incomes and also the highest general expenditure. On average institutions spend more money on water than commercial uses since they have a higher population.

Figure 2



In terms of medical expenditure, the commercial use has higher medical expenditure than the other regions. Institutions in Nembure and Embu have fairly high medical expenditure compared to Gachoka. This does not tie up well with the reported water related higher incidence of ill health in Gachoka.

Figure 3



The only possible explanation to this variance may be the higher poverty levels in Gachoka as is even reflected in the Figure 2 and 3 above even within institutions and commercial outlets.

4.3 Piped water supply by region and user satisfaction

As can be seen on Figure 2 below Gachoka is very poorly supplied with piped water. EWASCO does supply the areas close to Embu Municipality and quite a number of institutions. The need for wider water supply in Gachoka is quite real. It is interesting to note that although water is four times more expensive in Gachoka than in the other two regions, 78% of those who complained of high water costs are from Embu while 10% and 12% are from Nembure and Gachoka respectively.

Figure 4
Piped water supply by region

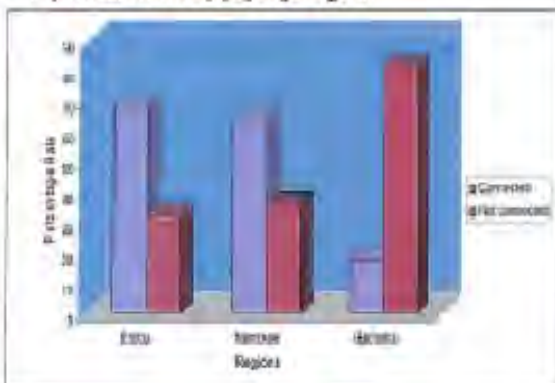
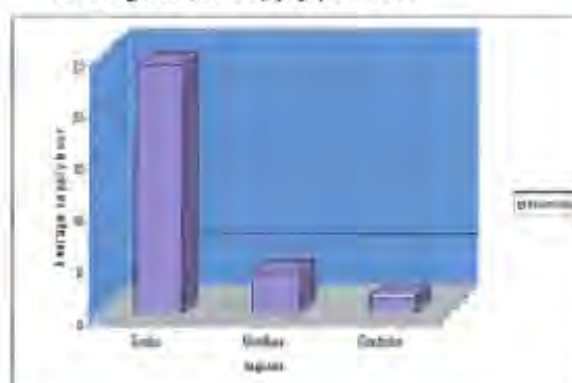
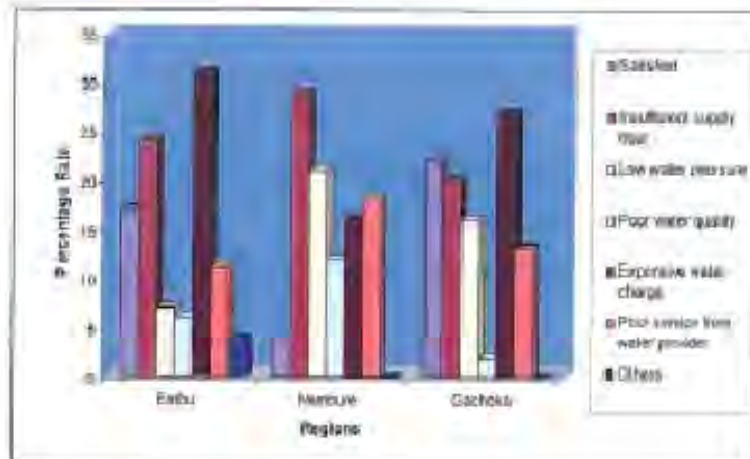


Figure 5
Average water supply per hour



In addition to getting the largest share of piped water in the three regions, Embu also has the most reliable supply enjoying almost a 24 hour 7 day piped water flow according to the available statistics. Gachoka and Nembure report limited daily average water flow of roughly two to four hours respectively. Water satisfaction is highest in Embu.

Figure 6
Water user satisfaction



Due to frustrations occasioned by inadequate water supply, user satisfaction for all user categories is fairly low as can be seen on Figure 4 above. Insufficient supply hour and costly water are reported as serious problems in Embu. In view of the reported 24 hour 7 days supply, this seems like a contradiction. However 32% of the Embu respondents have no piped water connection. This shows that EWASCO has as yet not had 100% coverage of the area and needs to increase its capacity at least to serve all categories of users in the region.

There are general complaints of expensive water. Although 24 hour daily water supply for 12 months in a continuous cycle involves up to date infrastructure, high degree of maintenance and efficient management, the level of cost dissatisfaction might warrant a review. However, those who are complaining loudest are the most favoured both in terms of water sufficiency and cost. It is truly unreasonable for the Gachoka households to spend 18% of their monthly income on water while those in Embu and Nembure pay only 7% and 6% respectively. And households in Gachoka are amazingly willing to pay more if only they could be supplied with wholesome piped water.

Many users in Nembure complain of low water pressure and poor water quality than in the other two regions. This makes sense in view of the poor water quality at the Kapingazi intake dam. Gachoka and Nembure also report high incidence of poor service from water providers.

Figure 7

Status of water supply by region

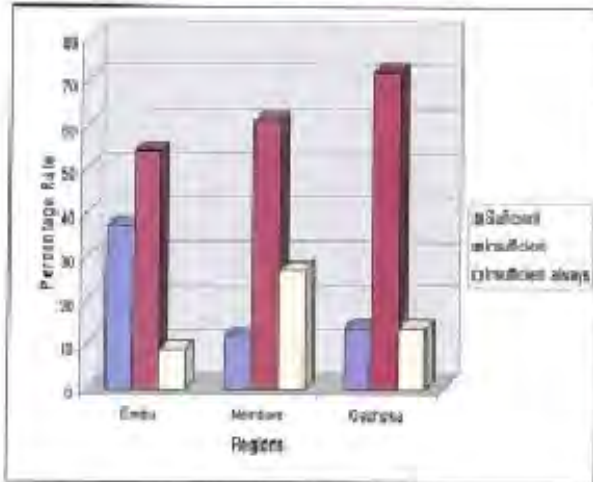
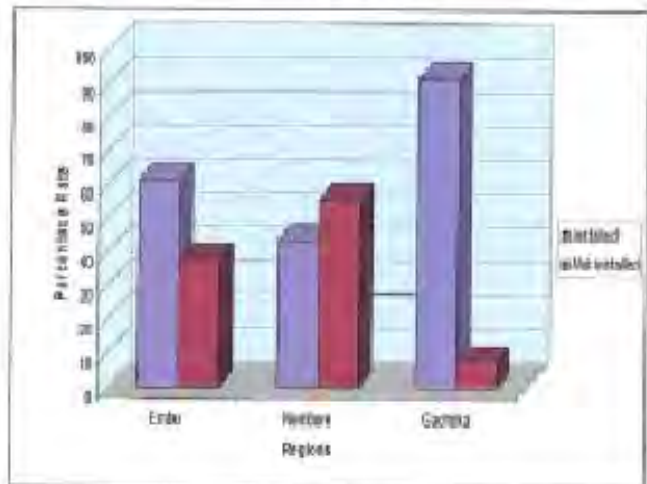


Figure 8

Water meter installation by region



Many people in the three regions report that the water provided is not sufficient. Gachoka is the most deficiently supplied both with water and water meters. The meters in all the three regions are said to be in good working condition as can be seen in Figure 7 below. Nembure might need to give more attention to its meter maintenance.

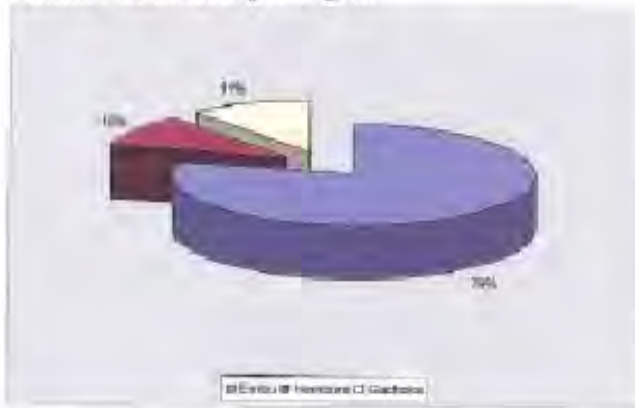
Figure 9

Condition of water meters



As is to be expected, provision of water faucets is closely related to water availability and institutional usage. Quite a number of institutions in Gachoka, including the school we were using for data collection are liberally provided with EWASCO water. Embu has the lion's share of the water faucets in the three regions.

Figure 10
Number of faucets per region

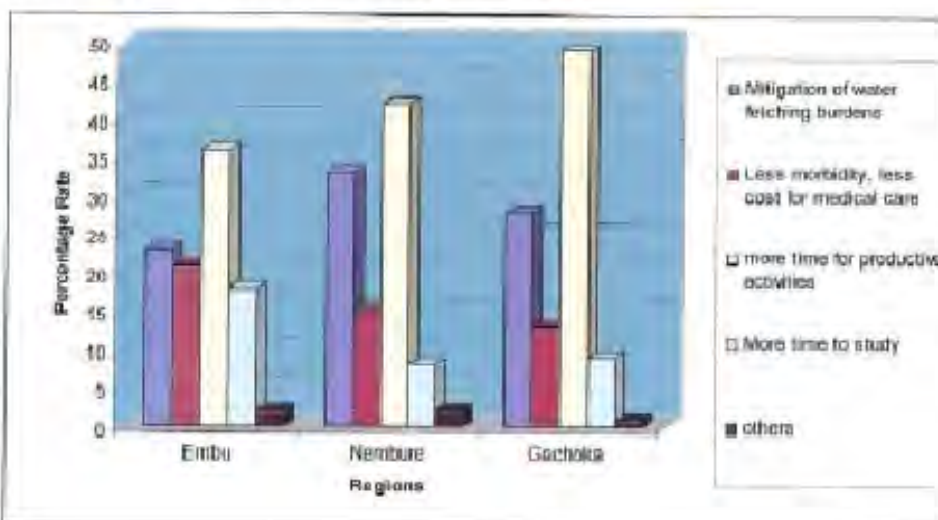


The insufficiency of water supply in the entire three regions is uniformly reported by the majority of the respondents with Gachoka taking the leading role. Many more respondents in Nembure claim that their water supply is insufficient always while the highest water sufficiency rate is reported in Embu. Ngandori-Nginda Water supply may be facing challenges that require urgent redress.

4.4 Reasons for need of wider piped water supply

Without exception, all those interviewed would want 100% piped water coverage for various reasons. The majority by far want to have more time for productive activities and to mitigate against the water fetching burdens. The respondents appear to have little knowledge of the utter significance of clean water in alleviation of many diseases.

Figure 11
Expected benefits from wider piped water supply



4.5 Sources of non-piped water and its quality

As reported area the majority of residents in the three areas are not connected to piped water. Those not served with piped water use various methods to get it.

Figure 12

Alternative means of water supply

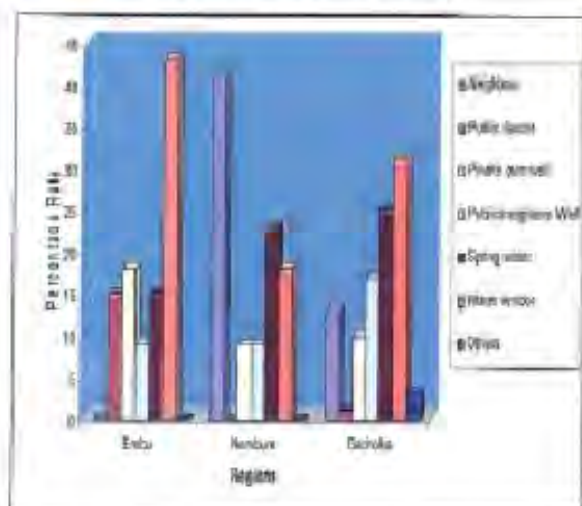
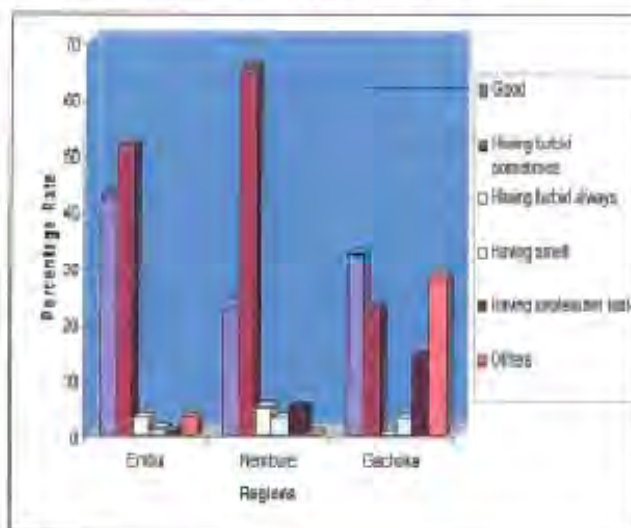


Figure 13

Interviewers' water quality report



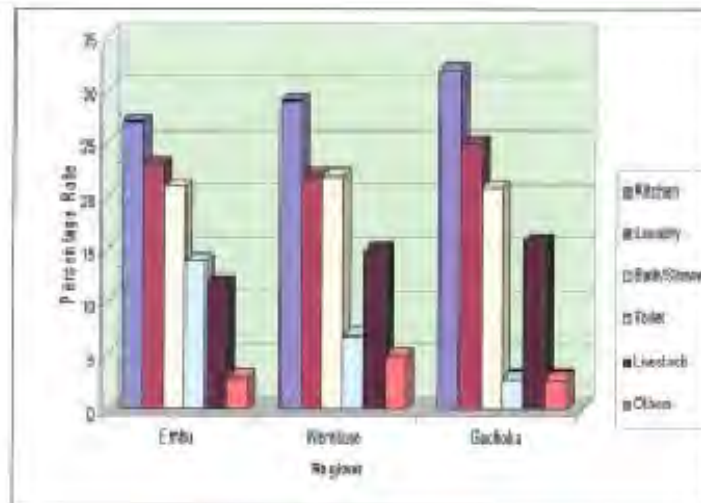
The great majority of those not connected to piped water in Embu and Gachoka use vendors for their water supply. While in Embu the use of neighbours' water supply is extremely limited probably due to the costs incurred in buying the water, the practice is very prevalent in Nembure. The reason for this community support may be that most of the water in the region is drawn from wells and springs whose water is almost practically free. The use of spring water and neighbours wells is also common in Gachoka. The spring water in Gachoka is dug from dry river beds.

The private water supply compares well with the turbidity data provided by the interviewers. The reported high turbidity rates for water in Nembure and parts of Embu not connected to piped water supply connect well with the use of community standpipes containing water drawn from the Kapingazi water intake depicted in the photograph above.

4.6 Water usage and sewer connectivity

The study established that most water is used in the kitchen, followed by laundry and bath/shower. In Gachoka and Nembure where livestock farming is more predominant, there is high water usage in livestock farming. In Nembure, water usage is comparatively higher in the other category. This may point to higher use of water for agriculture than in other regions. This is supported by the region's reported financial capability.

Figure 14
Water usage



Nembure's low usage of water for toilets is surprising since ordinarily, provision of flush toilets even to septic or conservancy tanks increases with rising incomes and level of exposure to new ideas and technologies. Embu is understandably the most sewer connected area.

Figure 15
Sewer connectivity by region

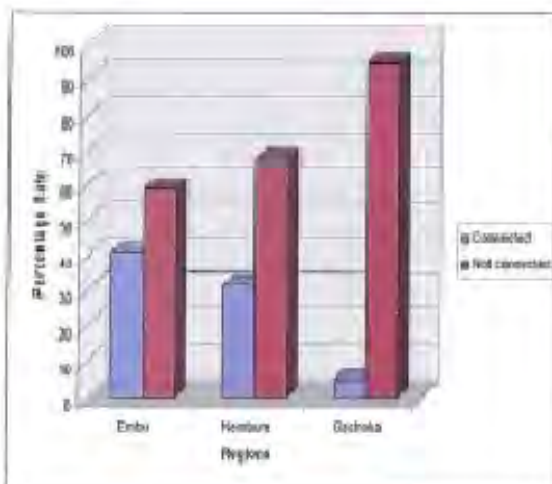
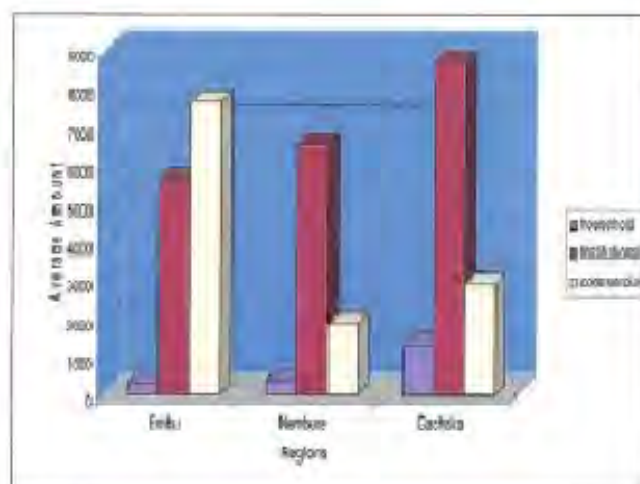


Figure 16
preferred charges for piped water



However, in all the three regions, there are more people unconnected to the sewerage system than those connected. Gachoka is by far the least connected. It is probably for reasons such as better quality of life through provision of basic services such as piped water and sewerage that support human health that the majority of those interviewed would prefer to have piped water and pay a premium for it rather than not have the service at all.

More households and institutions in Gachoka than elsewhere in the survey areas are willing to pay high water charges if only they could be offered the opportunity. All institutions interviewed in the three regions need more water than they are currently receiving and are ready to pay for it as can be seen in Figure 10 above. This is understandable as faecal matter disposal for large populations like schools and dispensaries is seriously hampered without some form of sewerage system.

All other categories of water users are willing to pay much higher costs for piped water with the exception of Izaak Walton who would want their water bill amended downwards. The hotel has its own borehole whose water could not supply the EWASCO water deficit whether real or created. The hotel has to rely on water vendors during the dry season just gone by. The piped water in the residential rooms was then both brown and particulate.

4.7 Human health and piped water provision

Water quality and human health have close interrelationships.

Figure 17
Infection route

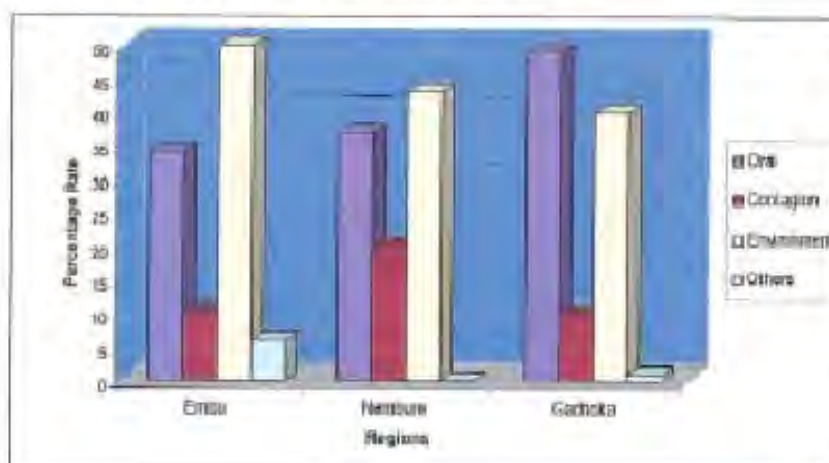
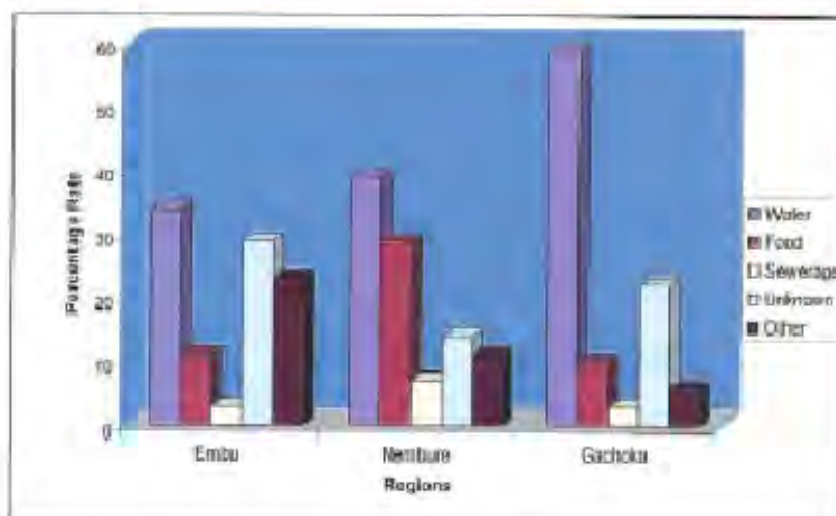


Figure 18
Causes of sickness



The sicknesses reported have a clear relationship to contaminated water usage. In Gachoka the highest reported cause of sickness is oral. In most cases, food that makes people sick is cooked under circumstances that lack adequate water. Contagion is the most prevalent cause of disease in all the three regions particularly in Embu. This again could be due to poor hygiene that may have inadequate water as the root cause or overcrowding in residential houses.

Figure 19

Reported sickness due to water

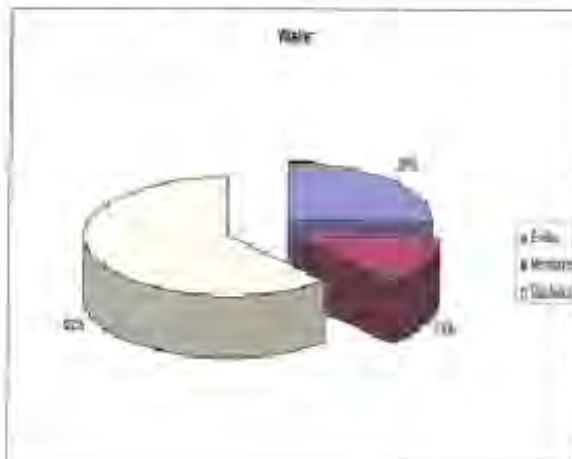
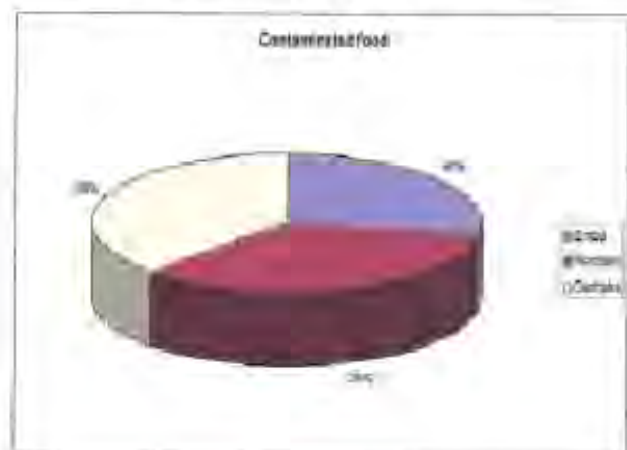


Figure 20

Reported sickness due to food intake



Water turbidity in one form or another was reported by 24% (94) of all the 400 questionnaires respondents. Of these, the largest number (57%) is from Embu. Twenty four (24%) and 17% of the respondents were from Nembure and Gachoka respectively. The worst water quality according to the interviewers is from Gachoka.

On all variables relating to poor water quality, Gachoka had the highest score with the exception of the one on **deep colour** which Embu dominated. To compound the Gachoka problem, its water was said to be the most salty and unpleasant tasting probably because it is mainly drawn from the wells. The brown colour due to soil erosion was reported as the most predominant colour of contaminated water in all regions.

As a consequence, an average of 31 days is lost per household per annum due to sickness in Gachoka as opposed to 27 and 20 days in Embu and Nembure respectively. Overall an average loss of 78 otherwise productive days or 21% of the year due to preventable diseases is a great expense to the regional and national economics. The rate of sickness in the institutions is fairly high with an average of one sick person every four days of the month.

It is therefore not surprising to note that a fairly big share of the moderate average income goes to meet medical bills. The institutions spend about Kshs. 18,978/= on medical expenses per annum. For educational institutions this figure is not representative since parents are called to take their children to the hospital when the elementary care they give becomes ineffective. On the other hand households spend an average Kshs. 4,640/= of

their average annual income on medication. Compared to the reported number of sick days per family, there are many who fail to go to hospital on account of inability to pay and absence of medical insurance cover.

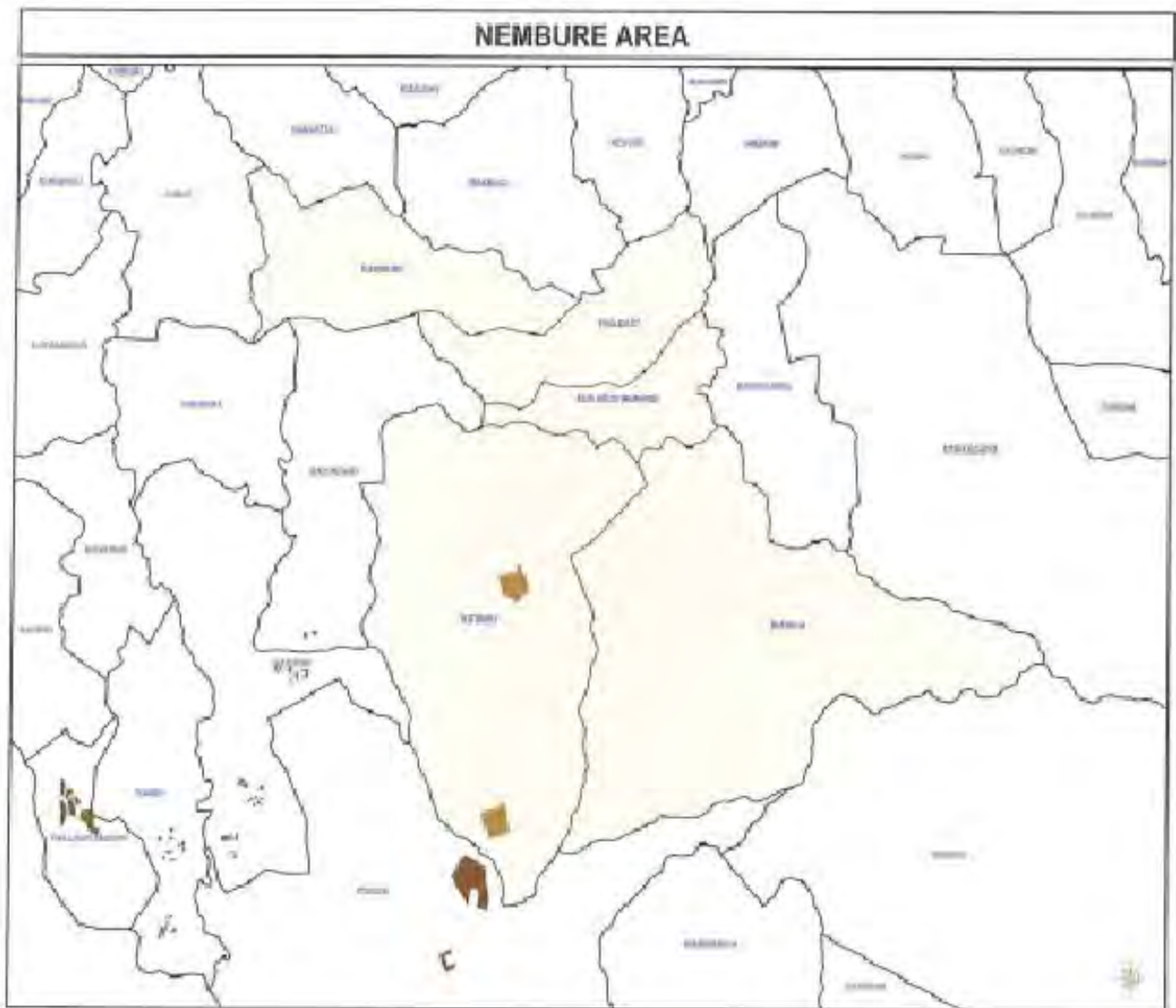
5 CONCLUSION AND RECOMMENDATION

The statistics as presented show an area of Kenya that suffers from water shortage and exacerbated poverty especially during the dry seasons. Empirical research has shown that where the water has been provided, the people are willing to pay fairly large parts of their income to get the water. Those not already connected to piped water expressed their great need both in their questionnaire answers and in their pleas to the survey team hoping that someone somewhere will this time come to their assistance and supply water not for free but at a cost. The urgent need for help has been expressed by means of avoidable diseases that result from contaminated water and food. Many sick and water fetching work days drawn from what could have been economically productive days have contributed to regional and economical poverty.

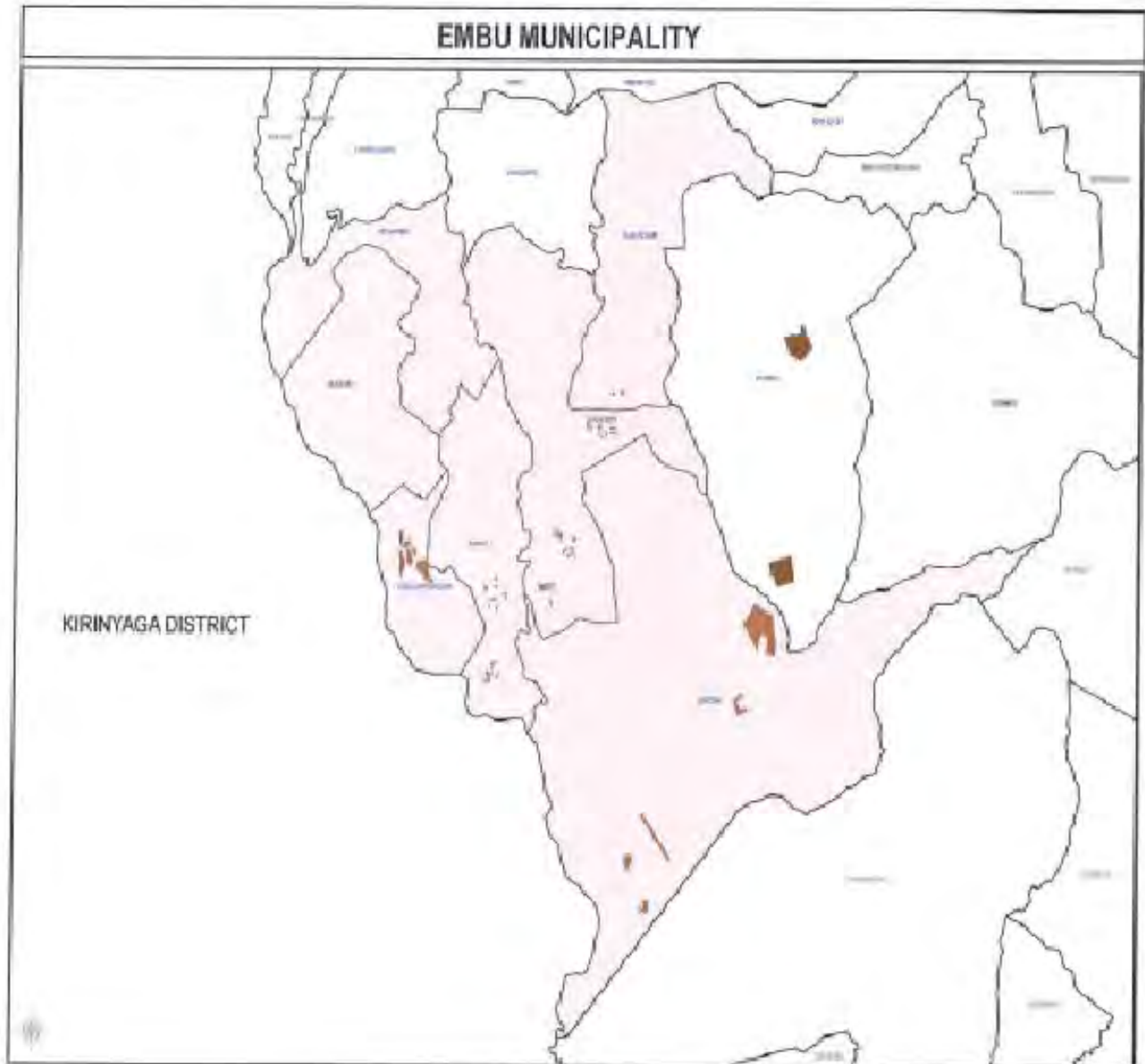
Too many girl children skip school on water fetching missions. This contributes to their failure in national examinations, early marriages and perpetuation of the poverty cycles.

The research team has developed a deep admiration for these peoples for their cooperation, industry and willingness to pay for piped water. It humbly joins its plea for any kind of assistance that may improve their lives.

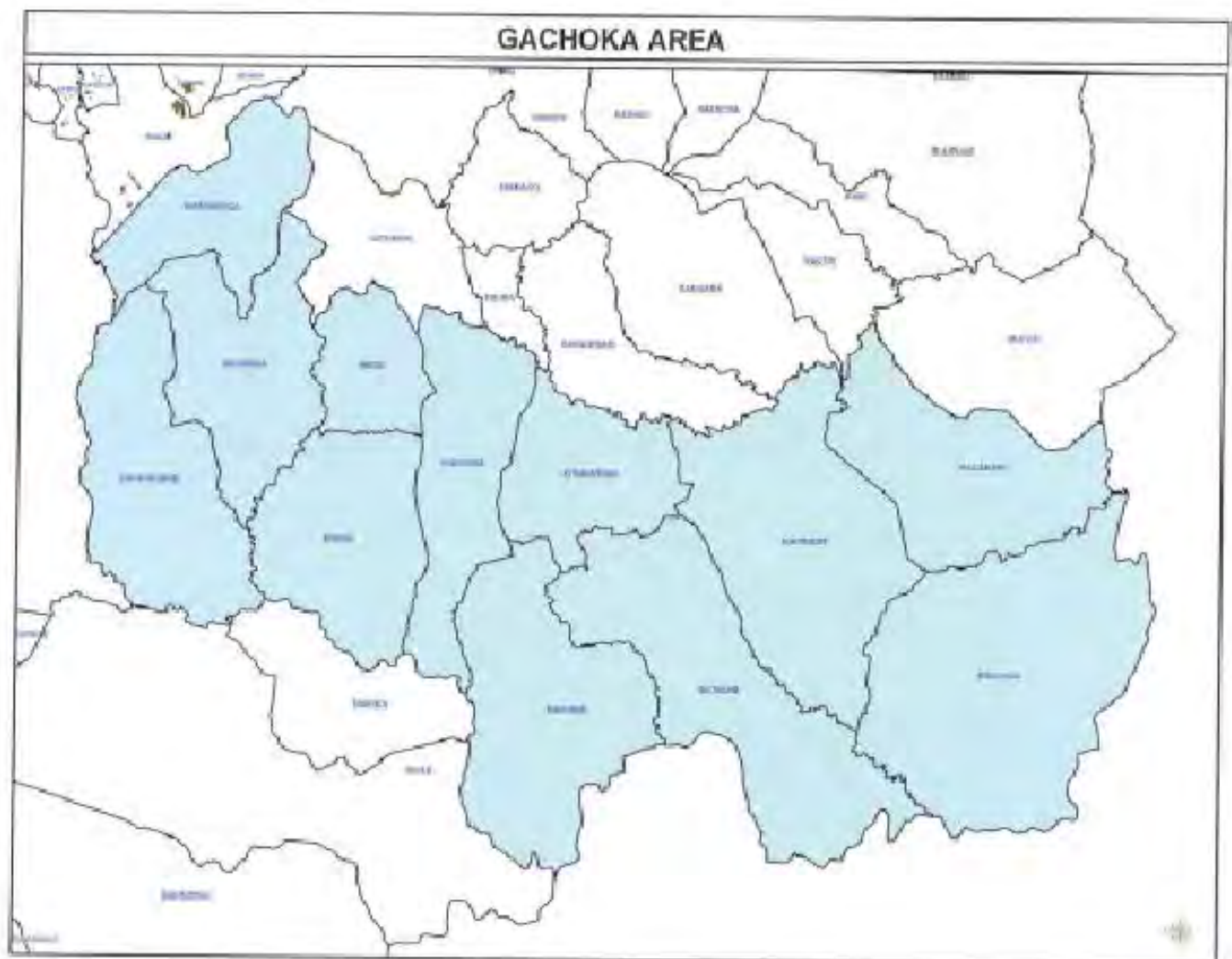
Appendix 2



Appendix 3



Appendix 4



資料-7 収集資料リスト

調査名：ケニア国エンブ市及び周辺地域給水施設改善計画準備調査

番号	名称	形態 図書・ビデオ 地図・写真等	オリジナル・コピー	発行機関	発行年
1	Contract for the water service providers contracted by Tana WSB	資料	コピー	Tana Water Service Board	?
2	Connections as at August/ September 2009	資料	コピー	Tana Water Service Board	2009.9
3	EWASCO organization charts	資料	コピー	Embu Water and Sanitation Company	2009.10
4	EWASCO NEWS	図書	オリジナル	Embu Water and Sanitation Company	2007.10
5	Tana Water Service Board Monitoring template and data capture and expenditure (EWASCO)	資料	コピー	Tana Water Service Board	2009.9
6	EWASCO Balance Sheet	資料	コピー	Embu Water and Sanitation Company	2009.7
7	水道料金表(2009,2010,2011)	資料	コピー	Embu Water and Sanitation Company	2009
8	使用水量データ(2007~2009)	資料	コピー	Embu Water and Sanitation Company	2009
9	有収水量データ(2008/9~2009/9)	資料	コピー	Embu Water and Sanitation Company	2009
10	Kangru WTP 水質データ	資料	コピー	Embu Water and Sanitation Company	2009
11	薬品使用量データ	資料	コピー	Embu Water and Sanitation Company	2009
12	水灌漑省組織図	資料	コピー	Ministry of water and irrigation	2009
13	降雨データ	資料	コピー	Ministry of Aquiculture	2009
14					
15					
16					