



## **SECTION 1: EXECUTIVE SUMMARY**

## 1.0 Background

Upon successful submission of the Technical and Financial Proposals, Ochieng Abuodha & Associates Consulting Engineers were commissioned by the Government of Kenya, through the Kenya National Highway Authority (KeNHA), to undertake Consultancy Services for Feasibility Study, Environmental and Social Impact Study, Preliminary and Detailed Engineering Design of Maralal-North Horr Road A4 (Formerly C77) Lot 1: Maralal – Baragoi.

### 1.1 Terms of Reference

#### 1.1.1 Study Objectives

The main objective of the project is to provide the decision makers in the Government of Kenya, with sufficient information to construct the road to all-weather bitumen road..

##### 1.1.1.1 Scope of Work

###### a) General

The Consultant shall perform all assignments as detailed in these Terms of Reference including but not limited to Economic feasibility Studies, all Technical Studies, Field Investigations and related services. In carrying their work, the Consultant shall co-operate fully with the concerned agencies of the Government of Kenya, in particular the Design and Construction Department of the Kenya National Highways Authority, Ministry of Transport, Infrastructure, Housing and Urban Development (MoTIHUD), County and National Governments, Ministry of Lands amongst others. The Consultant shall provide the necessary support services related to and necessary for the completion of the assignment. The work shall cover but not be limited to the aspects outlined in these Terms of Reference.

#### 1.1.2 Project Description

The road is primarily located in Samburu County. It measures approximately 100 kilometres and starts at the Maralal, proceeds in a northerly direction and ends at Baragoi.

The study for design shall incorporate design for all access roads to Government institutions including but not limited to schools, colleges, Administrative headquarters and other Government offices. Major loop roads through townships and bypasses or market centres along the project road shall also be included.

The road is located within Samburu County; the location map is presented as figure **Fig 1.1-1: Project Location**.

Samburu County lies within the Arid and Semi-Arid parts of Kenya and has an area of 21,022.1 sq. Km. It is situated in the northern part of the Great Rift Valley. Samburu is bordered by Turkana to the Northwest, Baringo to the Southwest, Marsabit to the Northeast, Isiolo to the East and Laikipia to the South. The county lies between latitudes 0°30' and 2° 45' north of the equator between longitudes 36°15' and 38° 10' east of the Prime Meridian.

### 1.2 Soils and Materials Investigations

#### 1.2.1 Alignment Soils

In order to obtain an idea of the type of materials encountered along the alignment, the soils along the alignment were sampled from test pits dug to a depth of about 1.5m at approximately

500 metres intervals.

The RDM Part III Clause 6.1.2 (v) recommends that for any one section of a road the average CBR should be higher than or equal to the mean of the subgrade class selected and no individual CBR result should be below the lowest value of the class range.

This formed the basis of subgrade design for the project road.

### 1.2.2 Proposed Design Subgrade Class

**Subgrade Class S3** has been proposed for the entire length of the project road with section having S1 and S2 class improved to S3 subgrade class.

The homogenous sections and their respective Subgrade Class are presented below in table below.

**Design Subgrade.**

Project Road Homogeneous Section	Total Length (km)	Native Subgrade Class	Improved Subgrade	Design Subgrade Class
Km 0+000 – 5+250	5.25	S2	300	S3
Km 5+250 – 6+750	1.5	S1	425	S3
Km 6+750 – 13+750	7	S2	300	S3
Km 13+750 – 15+750	2	S1	425	S3
Km 15+750 – 21+250	5.5	S1	425	S3
Km 21+250 – 25+250	4	S2	300	S3
Km 25+250 – 26+250	1	S1		S3
Km 26+250 – 35+750	9.5	S2	300	S3
Km 35+750 – 41+250	5.5	S2	300	S3
Km 41+250 – 54+250	13	S3		S3
Km 54+250 – 59+250	5	S2	300	S3
Km 59+250 – 74+250	15	S2	300	S3
Km 74+250 – 94+250	20	S3		S3
Km 94+250 – 95+250	1	S1	425	S3
Km 95+250 – 101+000	5.75	S3		S3

The shaded sections are proposed for improvement by a layer of 425mm (11km) and 300mm (51km) of S3 quality material to the design subgrade class of S3.

### 1.2.3 Design Pavement Loading;

The design EFs was developed based on 85<sup>th</sup> percentile for 5-6 axle trucks and mean EFs for the rest of the commercial vehicles. Within the sections that the Traffic Class changes due to the two considerations, the values from the Mean EFs are on the upper border of the classes. The pavements were therefore design for Traffic Cass T3.

### 1.2.4 Gravel Sources

In total 8 material sites meet the base quality at 3% cement treatment and 10 sited meet subbase qualities at 1% cement treatment. Material site MS14 and MS7 are the two sites that meet subbase quality and not base of the 10 material sites submitted for treatment.

#### Analysis of the Results for Cement treated materials

	CBR %			PI %			%age Meeting Requirement				Proposed Use
	Cement			Cement			S/base		Base		
	1%	2%	3%	1%	2%	3%	CBR (60%)	PI (15%)	CBR (160%)	PI (6%)	
MS1	114	151	193	8	NP	NP	1%C	1%C	3%C	1%C	Base 3%, Subbase 1%
MS5	106	139	182	12	9	6	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS7	98	122	150	10	7	NP	1%C	1%C	Not	3%	Subbase 1%
MS8	117	146	178	12	6	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS9	107	141	190	11	NP	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS10	101	134	172	12	6	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS11	107	143	179	16	10	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS12	103	135	167	14	9	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS13	101	134	172	13	7	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS14	111	145	148	16	10	NP	1%C	1%C	Not	3%	Subbase 1%

### 1.2.5 Hard Stone Sources

Hard stones were sourced at:

- Lpartuk km 4+400 6
- Lorian km 43+900
- Mbukoi km 50+000
- Marti km 60+000
- Marti 2 km 60+00
- Charada km 65+500

The aggregates were therefore evaluated for their quality to be used for GCS, AC and Concrete works.

The results indicate the stones qualify as follow:

- Lpartuk km 4+400, Lorian km 43+900 and Mbukoi km 50+000
  - **GCS:** stone class B
  - **Concrete works:** the sample meets all the criteria for aggregates for concrete works
  - **Asphalt Concrete:** the samples qualify for AC aggregate class B.
- Marti km 60+000, Marti 2 km 60+00
  - **Concrete works:** the sample meets all the criteria for aggregates for concrete works
- Charada km 65+500
  - Fail all proposed uses due to flakiness

### 1.2.6 Sand Sources

Sand source investigations yielded two river sand sources, one 54km away along Maralal – Wamba road and the second at Baragoi. The sand deposits are expansive in both the sites. The sand samples were subjected to laboratory testing and the results are as **Appendix VII**.

#### Sand Sample Results

Variable	Requirement	Result	
		R. Lodongokwe 54 km from Maralal	R. Gwelgwel km 99+00 at Baragoi
The Clay, Silt and dust content	Max – 2.4%	1.8	2.0

The samples are well graded and within the grading envelop with 1.8% and 2% silt and clay contents respectively. These sites qualify for use as sources for construction sand.

### 1.2.7 Water for construction use

Samburu County receive high rainfall of about 700-1000 mm/year in the mountain ranges that recharges springs in the lowlands. Most rivers in Samburu flow for short periods after rain. There are no perennial rivers along the project road. Surface water is available in small quantities from River Ewaso Ngiro, the only major perennial river, averagely 30 km away at the southern Samburu border. Due to the scarcity of water and sensitivity that comes with it within the region, no consideration has been made for abstraction of the river water for construction.

Hydrogeological surveys were carried out at predetermined locations along the project road. The table below indicate the extraction potential of the proposed well sites.

#### Borehole details and yield

Name	Location	Proposed Depth	Estimated Yield
Mbukoi	240033E,155862N	180	5 m <sup>3</sup> /hr
Marti	247442E,161721N	180	5 m <sup>3</sup> /hr
Baragoi	254626E,196327N	160	5 m <sup>3</sup> /hr

Detailed hydrogeological reports are attached as **Appendix VIII**.

Considerations will also be made to ensure the existing community wells are not interfered with. Additional wells where possible will be considered for the communities in addition to any existing wells. This will go a long way to minimise conflicts with the pastoralist communities.

The hydrogeological study indicates sufficient ground water for abstraction for construction works. Chemical analyses for the wells operational within the proposed locations were conducted and the results analysed. The quality of the water was found to be within required limits. Water pans will also be provided for augmentation during rainy seasons. All social and environmental considerations will be made in locating, constructing and utilising the pans.

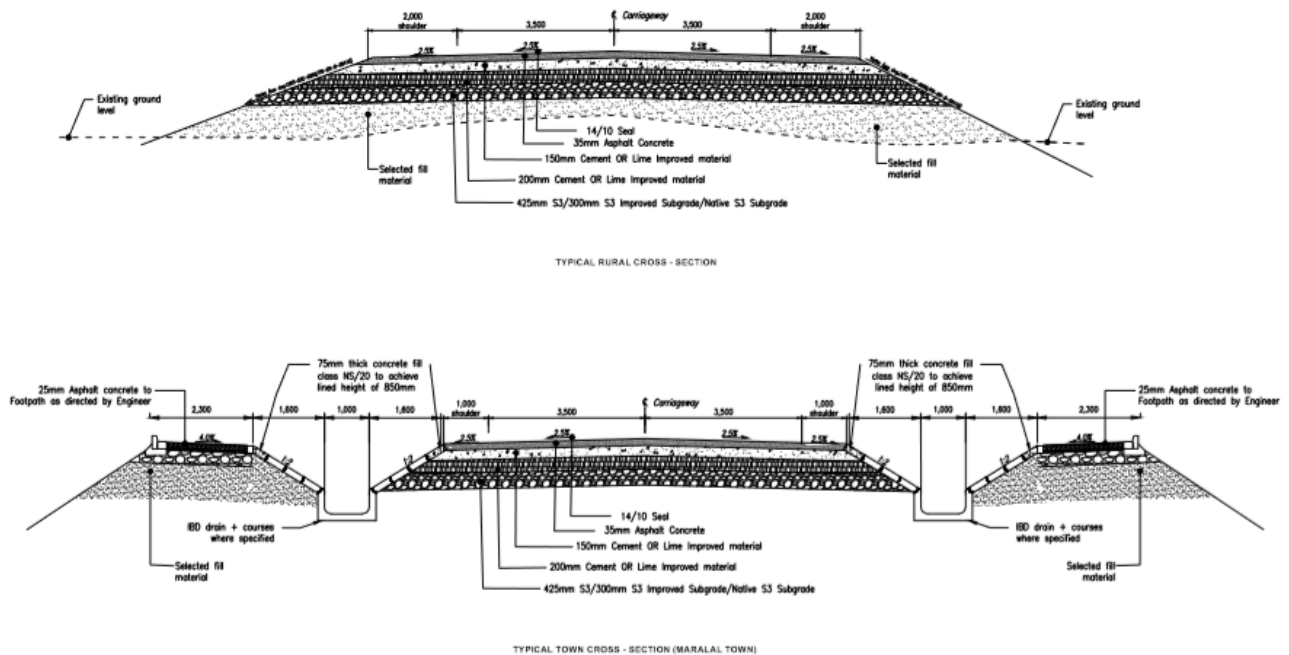
### 1.2.8 Pavement Choice

The detailed assessment of viable pavement options was made based on quality and availability of construction materials, their technical suitability and the implications on the pavement construction cost for the selected cross-section type.

Pavement type 1, 2 and 6 were eliminated earlier at the preliminary stage based on the limitations of suitable natural gravel materials for either base or subbase.

The quality of materials and availability as presented above favoured Pavement Type 3 and 7. The two pavement types were subjected to feasibility evaluation. The feasibility studies (presented separately) indicated that: pavement Type 3 composed of treated gravel material for both base and subbase was more robust compared to Type 7.

### Pavement Cross Section



## TABLE OF CONTENTS

<b>SECTION 1: EXECUTIVE SUMMARY.....</b>	<b>I</b>
<b>1.0 BACKGROUND.....</b>	<b>II</b>
1.1 TERMS OF REFERENCE.....	II
1.1.1 STUDY OBJECTIVES .....	II
1.1.2 PROJECT DESCRIPTION.....	II
1.2 SOILS AND MATERIALS INVESTIGATIONS .....	II
1.2.1 ALIGNMENT SOILS .....	II
1.2.2 PROPOSED DESIGN SUBGRADE CLASS .....	III
1.2.3 DESIGN PAVEMENT LOADING; .....	IV
1.2.4 GRAVEL SOURCES .....	IV
1.2.5 HARD STONE SOURCES.....	IV
1.2.6 SAND SOURCES .....	V
1.2.7 WATER FOR CONSTRUCTION USE .....	V
1.2.8 PAVEMENT CHOICE .....	VI
<b>SECTION 2: TECHNICAL REPORT.....</b>	<b>III</b>
2.0 INTRODUCTION.....	5
2.1 BACKGROUND .....	5
2.2 TERMS OF REFERENCE.....	5
2.2.1 STUDY OBJECTIVES .....	5
2.2.2 SCOPE OF WORK.....	5
2.1.2 PROJECT DESCRIPTION.....	6
2.4.1 GENERAL .....	6
2.4.2 THE PROJECT ROAD.....	11
3.0 SOILS AND MATERIALS INVESTIGATIONS .....	13
3.1 GENERAL.....	13
3.2 EARTHWORKS .....	13
3.3 ALIGNMENT SOILS.....	13
3.3.1 ALIGNMENT SUBGRADE STRENGTH .....	13
3.4 PAVEMENT DESIGN .....	18
3.4.1 DESIGN PAVEMENT LOADING; .....	18
3.4.2 DESIGN PAVEMENT .....	18
3.5 GRAVEL SOURCES.....	19

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3.5.1	GENERAL .....	19
3.5.2	THE SPECIFICATIONS FOR NEAT MATERIALS FOR SUB-BASE AND BASE; ..	19
3.5.3	NEAT MATERIALS TEST RESULTS AND ANALYSIS .....	19
3.5.4	EVALUATION OF THE QUALIFICATION OF THE NATURAL MATERIALS FOR TREATMENT .....	20
3.5.5	TESTS AND ANALYSIS OF CHEMICALLY TREATED MATERIALS .....	21
3.6	HARD STONE SOURCES .....	24
3.7	SAND SOURCES .....	29
3.8	WATER FOR CONSTRUCTION USE .....	31
3.9	BASIS OF DESIGN AND MATERIALS ASSESSMENT .....	33
3.9.1	BASIS OF DESIGN .....	33
3.10	DESIGN PAVEMENT.....	38
3.10.1	SURFACING .....	38
3.10.2	ROAD CROSS-SECTION .....	38
4.0	APPENDICES .....	39
4.1	APPENDIX I: ALIGNMENT SOIL LOGS .....	40
4.2	APPENDIX II: ALIGNMENT SOIL TEST RESULTS .....	41
4.3	APPENDIX III: MATERIAL SITE DISTRIBUTION .....	49
4.4	APPENDIX IV: GRAVEL SITE LAYOUTS AND LOGS.....	50
4.5	APPENDIX V: GRAVEL SITES TEST RESULTS.....	51
	NEAT TEST RESULTS .....	52
	TREATED MATERIALS TEST RESULTS .....	55
4.6	APPENDIX VI: HARD STONE TEST RESULTS .....	61
4.7	APPENDIX VII: SAND TEST RESULTS .....	63

## **SECTION 2: TECHNICAL REPORT**



## 2.0 INTRODUCTION

### 2.1 Background

Upon successful submission of the Technical and Financial Proposals, Ochieng Abuodha & Associates Consulting Engineers were commissioned by the Government of Kenya, through the Kenya National Highway Authority (KeNHA), to undertake Consultancy Services for Feasibility Study, Environmental and Social Impact Study, Preliminary and Detailed Engineering Design of Maralal-North Horr Road A4 (Formerly C77) Lot 1: Maralal – Baragoi.

The contract agreement was finalised and signed on the 15<sup>th</sup> of June 2018. The following contract dates were accordingly derived:

Deliverables	Submission Date
Commencement Date	13 <sup>th</sup> August, 2018
Inception Report	28 <sup>th</sup> August, 2018
Receive Clients Comments and Approval	28 <sup>th</sup> September, 2018
Preliminary Report	13 <sup>th</sup> June, 2019
Receive Clients Comments and Approval	13 <sup>th</sup> July, 2019
Draft Final Report	13 <sup>th</sup> December, 2019
Receive Clients Comments and Approval	13 <sup>th</sup> January, 2019
Final Report	13 <sup>th</sup> February, 2020

The Consultant is to render all technical support services, which may be deemed relevant to this study.

### 2.2 Terms of Reference

#### 2.2.1 Study Objectives

The main objective of the project is to provide the decision makers in the Government of Kenya, with sufficient information to construct the road to all-weather bitumen road.

#### 2.2.2 Scope of Work

##### a) General

The Consultant shall perform all assignments as detailed in these Terms of Reference including but not limited to Economic feasibility Studies, all Technical Studies, Field Investigations and related services. In carrying their work, the Consultant shall co-operate fully with the concerned agencies of the Government of Kenya, in particular the Design and Construction Department of the Kenya National Highways Authority, Ministry of Transport, Infrastructure, Housing and Urban Development (MoTIHUD), County and National Governments, Ministry of Lands amongst others. The Consultant shall provide the necessary support services related to and necessary for the completion of the assignment. The work shall cover but not be limited to the aspects

outlined in these Terms of Reference.

## b) Description

### **Stage 1 – Preliminary Engineering Design and Feasibility Study**

- a) Review of the existing data on the proposed road project and social and economic activities in the project study area and producing an economic feasibility study report;
- b) Collection of social, environmental, and physical data that is necessary to assist in the design of the project road;
- c) Preliminary Materials Investigations for Pavement Design using design standards including preliminary costs estimates and implementation schedule;
- d) Preliminary Engineering survey and design work for the optimum alignment and design standards including preliminary costs estimates and implementation schedule;
- e) Carrying out an environmental and social impact assessment study of the project area in relation to the proposed project.

### **Stage 2 – Detailed Engineering Design**

After comments and approval of the preliminary design by the Director (Highway Planning and Design), the Consultant shall carry out a detailed engineering survey and design including engineering cost estimates, materials investigations and tender documents for the selected alignment and design standards for the road and any town/market roads.

## **2.1.2 Project Description**

### **2.4.1 General**

The road is primarily located in Samburu County. It measures approximately 100 kilometres and starts at the Maralal, proceeds in a northerly direction and ends at Baragoi.

The study for design shall incorporate design for all access roads to Government institutions including but not limited to schools, colleges, Administrative headquarters and other Government offices. Major loop roads through townships and bypasses or market centres along the project road shall also be included.

The road is located within Samburu County; the location map is presented as figure **Fig 1.1-1: Project Location**.

Samburu County lies within the Arid and Semi-Arid parts of Kenya and has an area of 21,022.1 sq. Km. It is situated in the northern part of the Great Rift Valley. Samburu is bordered by Turkana to the Northwest, Baringo to the Southwest, Marsabit to the Northeast, Isiolo to the East and Laikipia to the South. The county lies between latitudes 0°30' and 2° 45' north of the equator between longitudes 36°15' and 38° 10' east of the Prime Meridian.

### **Administrative Units**

The County is administratively divided into three sub-county, 7 divisions, 14 locations and 106 sub-locations. **Table 2.4.1-1** shows the administrative areas of the county.

**Table 2.4.1-1: Samburu County Administrative Units**

Sub-county	Division	Area (km <sup>2</sup> )	No. of Locations	No. of Sub-locations
Samburu Central	Lorroki	1,399.30	6	17
	Kirisia	1,237.70	5	18
	Malasso	1,300.30	3	11
Samburu East	Wamba	4,670.80	8	19
	Waso	5,378.90	4	10
Samburu North	Baragoi	4,024.40	7	17
	Nyiro	3,010.70	6	16
<b>Total</b>		<b>21,022.10</b>	<b>39</b>	<b>108</b>

Source: County Commissioner’s Office, Samburu, 2012



Source: Kenya National Bureau of Statistics, 2013

**Fig 2.4 -1: Samburu County Location**

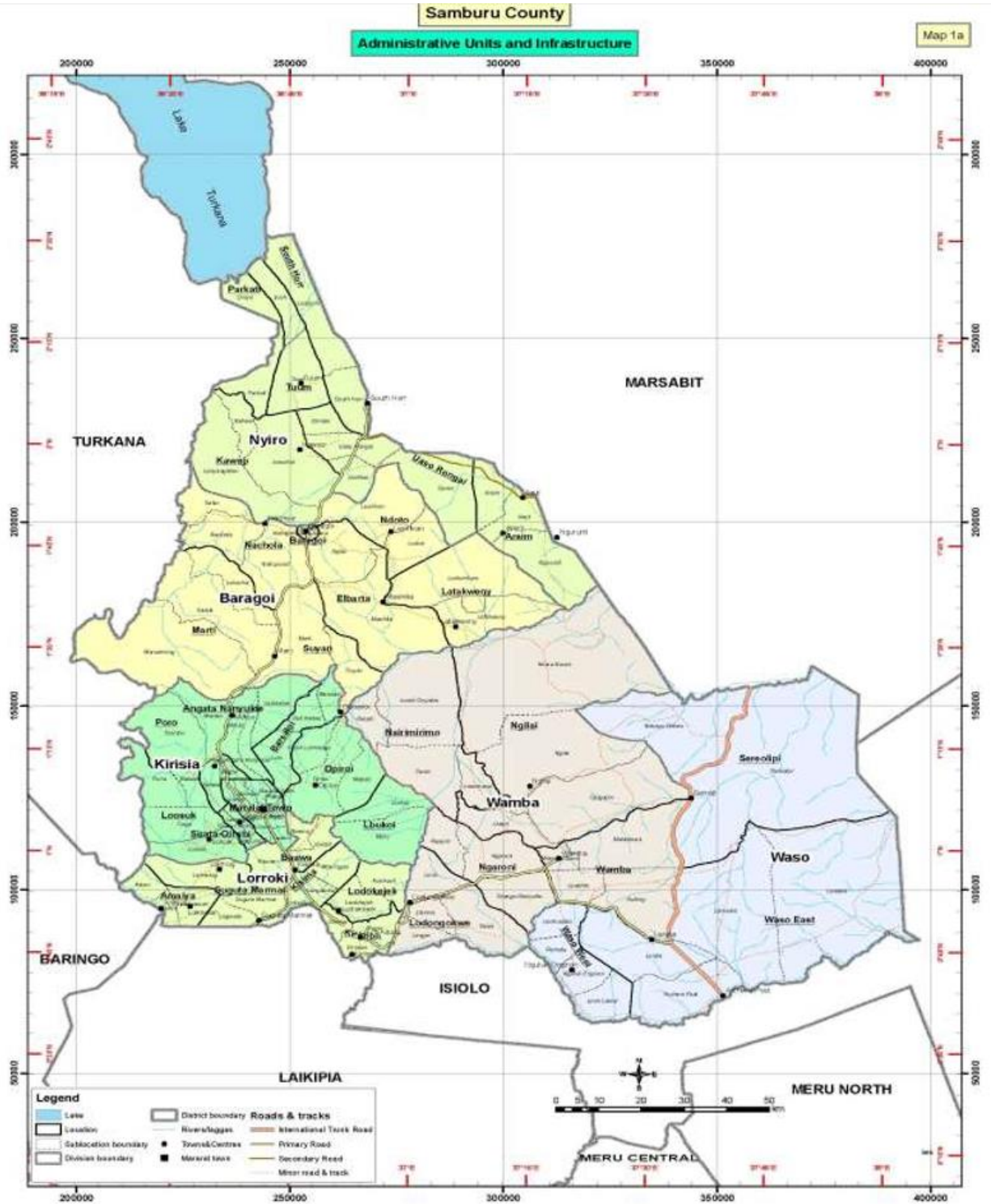


Fig 2.4-1: Samburu Administrative Units

## Existing Road Network

The County has a total road length of 1,449 kilometres most of which are rural access roads whose management falls under the Kenya Rural Roads Authority. The road A4 Rumuruti-Maralal-Baragoi which is considered the gateway to the county, and which falls under the management of the Kenya National Highways Authority is in a bad condition. Laying tarmac on this road will not only improve accessibility to the County but will also play a role in improving the elusive security situation while at the same time open up the region to potential investors. Good road network will enable the vast resources of the county to be exploited for the benefit of resident communities and the nation at large. The County is expecting a total of 60 km of road network under tarmac planned as part of Lamu Port–Southern Sudan–Ethiopia Transport (LAPSSET) Corridor project. LAPSSET is a flagship project under Vision 2030. Once implemented, the road will unlock the development potential of Samburu County. The link to Juba under this project is also expected to cut across the county covering a significant section thereby enhancing connectivity within the county and also between the county and the neighbouring counties.

## Economic Activities and Land Use

Land ownership in Samburu falls into four categories namely; Trust, communal, Government and Private. Communal land is managed by the communities while private land encompasses group ranches. The bulk of the land is not registered a situation that affects its full potential exploitation. The primary land use practices are pastoralism and wildlife conservation. These practices account for over 90 percent of the total land holding in the county. Farming is also undertaken in favourable areas like Poro in Kirisia Division, Baragoi and South Horr and Tuum in Nyiro divisions. Gazetted forests occupy 15% of land area. These forests provide habitat and foliage for both wildlife and livestock.

The main livestock found in the county are the indigenous cows, goats, sheep, camels, and donkeys. The main breeds of cattle kept are the Zebu and the Boran while those of goats include: the Small E.A, the crosses of Torggenburg, Gerryman-alphine and Gala exotic breeds. Sheep breeds include the Borpers and the Red Maasai while those of camels include the Somali, the Rendile and Turkana. Milk and meat are the main livestock products in the county. Persistent drought has over the years remained a challenge to livestock keeping. Interventions such as livestock off take by the government in collaboration with development partners, has assisted in mitigating the effects of these adverse climatic conditions. A herds-boy with a goat: Livestock is a key sub-sector in the county.

The county has a total 139,892 ha arable land which is mainly concentrated in Samburu Central highland. Main food crops grown in this area are maize, beans and wheat. Barley is also grown in small quantities. The total area under crops is 4,000 ha and 3,200 ha for food and cash crops respectively. The main cash crops grown are barley, and wheat which are grown in high altitude areas of Poro.

The County boasts of having the largest number of wildlife outside the game reserve. Some of the wild animals found in the County include; giraffes, the endangered bevy zebra, lions, elephants, and buffalos in addition to the small wildlife. Below is a picture of elephants a constant feature in Samburu County. A herd of Elephants in a game reserve: wildlife is a major tourist attraction in the county.

## Labour

The total labour force (population aged 15-64) in the county is estimated to be 118, 879 in 2012 and is expected to have grown to 135,811 by 2017. This age group has a critical role to play in

the socio-economic development of the County. Thus, imparting appropriate skill through effective training and employment of this population group will significantly determine the future of Samburu County.

The county has at about 45 percent of its population unemployed majority of whom are youths aged between 18-35 years. There is need for appropriate urgent mitigation measures to be put in place to ensure that this large number in considerably reduced otherwise the majority will turn into vices like cattle rustling, prostitution, and theft to make ends meet.

## **Ecology**

The county is divided into five ecological zones as follows: Tropical Aphine Zone: This zone covers an altitude of 1,980 to 2,040 m above sea level with an annual average rainfall of between 600 mm and 800 mm. Temperatures range from 21.0oC to 25oC making it too cold for growing crops. It is used for sheep and cattle grazing. Upper Highland zone:

This zone covers an altitude of between 2,150 m to 2,600 m above sea level and receives an annual average rainfall of 900 mm to 1,000 mm. Temperatures range from 15.5 oC to 19 0C. The zone is suitable for Sheep, dairy cattle rearing as well as wheat and barley and forestry farming.

### **Lower Highland Zone:**

This zone covers an altitude of 1,800 m to 1,980 m above sea level and receives an annual average rainfall of 750 mm. Temperature varies between 14.80 C and 17.50C. The dominant land use practices are agriculture and the dormant crops are maize and sorghum cultivation and also livestock keeping.

### **Lower Midland Zone**

It covers an altitude of below 1,300 m above sea level and has an annual rainfall of 720 mm and annual mean temperatures ranging from 22oC to 27oC. Sorghum, millet, and livestock farming are important land uses partners in the area.

### **Lowlands Zone**

This zone comprises of an altitude of 600 m and 1,450 m above sea levels and an annual rainfall of below 700 mm with annual mean temperatures of between 30oC and 33oC. This zone is the largest and covers up to 80 percent of land in the county. The zone is mainly used as grazing fields for wildlife and livestock by pastoralist communities living in the county.

## **Climate**

Rainfall in the County follows a fairly erratic pattern varying significantly both in temporal and spatial scale. The County experiences both short and long rains. The driest months are January and February. The long rainy season falls in the months of March, April and May. A part from South Horr and Wamba areas, short rains occur during the months of July and August, sometimes extending into September. At Wamba and South Horr areas, the short rainy season is usually delayed and occurs in October and November and sometimes extends into December. This short rainy season succeeds a fairly dry spell during the month of June. Rain distribution varies across the county. The southwest plains and the Lorroki Plateau receive between 500 mm and 700 mm of rain annually. The Nyiro and Ndoto Mountains and Matthews range, however, receive the highest amount of rainfall between 750 mm and 1250 mm per annum. The central basin and the plains east of the Matthews Range are the driest parts of the county with annual rainfall of between 250 mm and 500mm. Temperatures in the County vary with altitude and mean temperatures generally range between 24 0C and 33 0C. The central

plains and the region east of the Matthews Range have the highest temperatures while the highland belts in the North Eastern side of Lorroki Plateau are cooler. The county has a mean temperature of 29°C. The fast blowing winds, especially in the lowlands areas of the county like the Nyiro division, is a great resource especially if tapped for renewable power generation. The month of January experienced the highest temperature of 33 °C and the month of July is the coldest month with 24 °C.

## **Water Resources**

Samburu is generally classified as water deficit region. The main sources of water for domestic and livestock use are from water pans, dams and shallow wells. Other water sources are protected and unprotected springs, boreholes and roof catchments. Water quality in the county is generally poor. Most water sources in the county are not protected hence contaminated. Human habitation along catchment areas, lack of proper sanitation and sewerage services in the major urban centres are major source of water contamination.

The average distance to the nearest watering point for is approximately five kilometres in rural areas but it becomes much shorter in most urban and market centres to about 0.5 km.

### **2.4.2 The Project Road**

#### **2.4.2.1 Alignment**

The Existing road alignment presents a typical un-engineered gravel road with narrow width mostly below 6m wide, with sharp curves falling below the standards, occasionally long straights (particularly towards project end), numerous broken curves, curves in the same direction with relatively short straights between them and very poor sight distances.

It is expected that a lot of horizontal alignment elements will be improved so as to comply with the standards at the chosen design speed.

The existing road lies in a rolling terrain with the existing profile showing occasional rises and falls with relatively steep gradients. These relatively high gradients are observed in the initial sections of the project road while towards the project end, the road profile is relatively flat in spite of being slightly lower than the abutting ground levels.

#### **2.4.2.2 Pavement**

The road is a Gravel/Earth road running about 100 km long. The first 20 km show indications of some maintenance works. The remaining portion deteriorates as you move towards Baragoi.

The subgrade is generally composed of shallow silty clays and loams overlaying rock stratum. Rock outcrops are evident along the road as most sections have no pavement material above the parent rock subgrade. It is clear there will be no pavement materials recovered for use during construction stage.

#### **2.4.2.3 Traffic**

Traffic along the proposed roads are generally low. The poor road conditions are a possible cause of the low traffic. Opening of these roads will result in reduced travel times, reduced VOC and possibly incite generated traffic. The traffic along the road mainly operates between Maralal and Baragoi.

#### **2.4.2.4 Environmental and Social Setting**

Over 90 percent of Samburu County lies within the fragile arid and semi-arid ecological zone. Given that over 80 percent of the population of the county relies on land to support livelihoods, activities such as Charcoal burning, overstocking and crop cultivation in the catchment areas

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and wetlands has contributed greatly to the destruction of the environment. The above practices coupled with low environmental education, weak enforcement of legislations, poor community participation as well as weak institutions at local level has contributed heavily to environmental degradation in the County.

Samburu County has not been spared impacts of the vagaries of Environmental degradation. The county has witnessed repeated droughts, occasional floods and reduced vegetation cover and diminishing surface water volumes overtime.

These has greatly affected crop farming and livestock rearing leading to complete loss of property, livestock and crops for majority of the county's population consequently worsening the poverty situation in the county.

## 3.0 SOILS AND MATERIALS INVESTIGATIONS

### 3.1 General

The materials investigation for this project consisted of locating, sampling and testing the locally available materials and the sub grade soils along the alignment.

For purposes of the design, the principal objective was to locate existing sources of construction materials as near as possible to the road alignment and establish their quality. Detailed stage looked deeper into the material sources, their suitability and quantity. Where necessary, more sources were identified and available quantities for all sources established during the detailed design stage.

### 3.2 Earthworks

Earthworks are defined in terms of cuttings and embankments or fills. Earthworks are carried out to meet geometric needs and may adopt the use of materials of lower quality than subgrade material qualities. Sections of deep cuts (over 5m) and high fills are always accorded specific studies after confirmation and affirming of the alignment geometry.

The main elements of study include assessment of:

- Water tables in cut sections
- Slope stability
- Appearance
- Fill foundation and settlement assessment
- Fill materials availability

The fill materials, as provided in the RDM Part III shall:

- Contain no more than 5% by weight of organic matter
- Have swell of 3% or less
- For clays, shall not have plasticity index of more than 50%

Generally, all the native materials along the project alignment meet the requirement for fill materials.

### 3.3 Alignment Soils

In order to obtain an idea of the type of materials encountered along the alignment, the soils along the alignment were sampled from test pits dug to a depth of about 1.5m at approximately 500 metres intervals. The logs of these test pits are attached as **Appendix I** of this report. The soil samples were subjected to Laboratory testing as per the TOR. The test results from the alignment samples are also attached as **Appendix II**.

Each sample was subjected to the following laboratory tests:

- Atterberg Limits and Linear shrinkage
- Sieve analysis to 0.075 mm size.
- Standard compaction Test ( Light compaction)
- Determinations of four days soak CBR at 100% MDD and OMC

#### 3.3.1 Alignment subgrade strength

### 3.3.1.1 General

The RDM Part III Clause 6.1.2 (v) recommends that for any one section of a road the average CBR should be higher than or equal to the mean of the subgrade class selected and no individual CBR result should be below the lowest value of the class range.

This formed the basis of subgrade design for the project road.

### 3.3.1.2 Homogeneous Subgrade Design

#### a) General

The proposed alignment is mainly composed of loam soils, silty clays, sandy soils and lateritic gravels with a few short sections of black cotton soils and clayey loams. The **Table 3.3-1** below indicate some values derived from the results.

**Table 3.3-1: Proposed General subgrade attributes**

Project Road Section	Total Length (km)	Max. CBR (%)	Min. CBR (%)	Mean. CBR (%)	%age above Mean CBR
Maralal – Baragoi	109	41	2	12.7	54%

#### b) Analysis

A four period moving average was plotted along the alignment chainage, representing 1.5 km segments along the alignments. This moving average, indicating the average of every subsequent 1.5 km of each alignment was used in assessing the trend of the average CBR of each subsequent 1.5 km segments and the entire alignment.

A CUSUM trend was also plotted over the same graph. The CUSUM trend indicates the trend of each point value about a group mean. This enabled discerning of sections with conforming trend about the mean and hence homogenous sections.

The moving average trend within the homogenous sections was employed in determining the prevailing section mean. The minimum individual CBR within the sections were then checked in accordance with the provision of the RDM Part III Clause 6.1.2 (v) stated above and with the prevailing mean, appropriate subgrade class assigned.

Ninety percent (90%) of the alignment have mean CBR above 10% corresponding to S3 subgrade class group mean. However the minimum CBR values vary within the homogeneous sections from as low as 2% to 8%. These minimum values affect the final subgrade class. The subgrade means, minimum values and the respective subgrade classes are presented in **Table 3.3-2** below. The fourth column presents the section subgrade class based on the section's group mean. Given provisions of the RDM Part III Clause 6.1.2 (v), the minimum CBR values within these sections were also assessed as presented in column five. The resultant subgrade class for each of the homogeneous sections are presented in the sixth column.

**Table 3.3-2: Homogeneous subgrade sections' attributes**

Project Road Homogeneous Section	Total Length (km)	Mean. CBR (%)	Mean CBR Subgrade	Min. CBR (%)	Subgrade Class
Km 0+000 – 5+250	5.25	13.0	S3	5.0	S2
Km 5+250 – 6+750	1.5	3.3	S1	2.0	S1
Km 6+750 – 13+750	7	11.1	S3	5.0	S2
Km 13+750 – 15+750	2	9.5	S2	2.0	S1
Km 15+750 – 21+250	5.5	9.3	S2	3.0	S1
Km 21+250 – 25+250	4	17	S4	5.0	S2
Km 25+250 – 26+250	1	3.5	S1	3.0	S1
Km 26+250 – 35+750	9.5	13.4	S3	5.0	S2
Km 35+750 – 41+250	5.5	11.45	S3	5.0	S2
Km 41+250 – 54+250	13	14.2	S4	7.0	S3
Km 54+250 – 59+250	5	10.0	S3	5.0	S2
Km 59+250 – 74+250	15	10.9	S3	5.0	S2
Km 74+250 – 94+250	20	14.4	S3	7.0	S3
Km 94+250 – 95+250	1	4.0	S1	2.0	S1
Km 95+250 – 101+000	5.75	18.9	S4	8.0	S3

A homogeneous subgrade class S3 is only limited by short sections having CBR values less than 7%. In general terms, S3 represents the subgrade for the entire alignment with pockets of weaker subgrade. Seven homogeneous sections, accounting about 67 km, have a group mean falling within subgrade class S3 with the limiting minimum CBR, however, falling within subgrade class S1 and S2. Similarly S4 homogeneous sections with limiting minimum CBRs within S2 and S1 account for 22 km of the alignment. This implies that sections that are outright S2 are 8 km long and S1 4 km long.

The cumulative lengths of these sections with CBR less than 7% (less than S3 limiting minimum) within each homogeneous section are as presented in **Table 3.3-3** below.

**Table 3.3-3: Subgrade section with CBR less than 7%**

Project Road Homogeneous Section	CBR (%) and respective sectional lengths					
	2	3	4	5	6	TOTAL
Km 0+000 – 5+250				0.5	0.5	1

Project Road Homogeneous Section	CBR (%) and respective sectional lengths					
Km 5+250 – 16+250	0.5	1.0	1.0	0.5	0.5	3.5
Km 16+250 – 21+250		1.0	0.5	0.5	1.0	3
Km 21+250 – 44+250		0.5	1.5	1.0	1.0	4
Km 44+250 – 54+250						0
Km 54+250 – 74+250		1.0	1.0	1.5	2.5	6
Km 74+250 – 96+250	0.5			1.0	0	1.5
Km 96+250 – 101+000						0
<b>Total</b>	<b>1</b>	<b>3.5</b>	<b>4</b>	<b>5</b>	<b>5.5</b>	<b>19</b>

In the instance above (**Table 3.3-3**) where within a homogeneous section, some individual CBR values were below the Subgrade Class group minimum values, the following solutions were considered depending on the technical and economic implications:

a) Subgrade Improvement

The sections with CBR lower than the selected design group minimum CBR values were proposed for improvement to meet the group minimums. The schedule of subgrade improvement is presented in the later section 5.7.1.

b) Lowering the Subgrade Class

The section having Subgrade Class higher than design subgrade class may be lowered to the design subgrade class where the technical reasons for continuity and ease of implementation warrants. This in essence is an over-design and the economic implication must be commensurate to the technical reasons adopted.

**Subgrade Class S3** has therefore been proposed for the entire length of the project road with section having S1 and S2 class improved to S3 subgrade class.

**3.3.1.3 Proposed Subgrade Class**

The homogenous sections and their respective Subgrade Class are presented below in **Table 3.3-4**.

**Table 3.3-4: Design Subgrade.**

Project Road Homogeneous Section	Total Length (km)	Native Subgrade Class	Improved Subgrade	Design Subgrade Class
Km 0+000 – 5+250	5.25	S2	300	S3
Km 5+250 – 6+750	1.5	S1	425	S3
Km 6+750 – 13+750	7	S2	300	S3
Km 13+750 – 15+750	2	S1	425	S3
Km 15+750 – 21+250	5.5	S1	425	S3
Km 21+250 – 25+250	4	S2	300	S3
Km 25+250 – 26+250	1	S1		S3
Km 26+250 – 35+750	9.5	S2	300	S3
Km 35+750 – 41+250	5.5	S2	300	S3
Km 41+250 – 54+250	13	S3		S3
Km 54+250 – 59+250	5	S2	300	S3
Km 59+250 – 74+250	15	S2	300	S3
Km 74+250 – 94+250	20	S3		S3
Km 94+250 – 95+250	1	S1	425	S3
Km 95+250 – 101+000	5.75	S3		S3

The shaded sections are proposed for improvement by a layer of 425mm (11km) and 300mm (51km) of S3 quality material to the design subgrade class of S3.

### 3.4 Pavement Design

#### 3.4.1 Design Pavement Loading;

The Pavement Traffic Classes for the project road, in accordance with the Road Design Manual Part III, Table 2.5.1 is as presented in the **Table 3.4-1** below.

**Table 3.2.2-1: Design Pavement Traffic**

	Description	Year 20 CENSAs Based on Mean EFs	Traffic Loading Class (Y15)	Year 20 CENSAs Based on Design EFs	Traffic Loading Class (Y20)
HS 1	Urban-Section 1	6,661,426	T3	7,242,565	T3
HS 2	Urban-Section 2	11,531,611	T2	12,186,837	T2
HS 3	Urban-Section 3	2,966,464	T4	3,433,959	T3
HS 4	Maralal -Suyiani	2,890,966	T4	3,376,034	T3
HS 5	Suyiani - Marti	2,673,557	T4	3,158,626	T3
HS 6	Marti - Baragoi Boys School	2,468,544	T4	2,987,733	T3
HS 7	Baragoi Boys School - Baragoi Town	9,478,290	T3	14,565,066	T2

The design EFs was developed based on 85<sup>th</sup> percentile for 5-6 axle trucks and mean EFs for the rest of the commercial vehicles. Within the sections that the Traffic Class changes due to the two considerations, the values from the Mean EFs are on the upper border of the classes. The pavements were therefore design for Traffic Cass T3.

#### 3.4.2 Design Pavement

The selection of the pavement was based on subgrade class **S3** and Traffic class **T3**.

##### 3.4.2.1 Pavement Alternatives

The Roads Design Manual, **Table 9.1.1** propose Pavements Type 1, 2, 3, 6, 7, 8 and 9 as technically suitable and economically justified for the Traffic Class T3 on Subgrade Class S3. These options were studied during the preliminary design stage.

In addition, pavement types 4, 5, 12, 13 and 14 were also analysed based on T2 Traffic Class that was reviewed in the detailed stage based on additional information on LAPSET route.

The pavement options were reduced to Pavement Type 3 and type 7 for the detailed design stage evaluations. These two options were analysed as presented under **Section 3.9.2** pavement choice.

### 3.5 Gravel Sources

#### 3.5.1 General

In all, a total of eight (8) material sources were preliminarily investigated as prospective borrow areas for fill, sub-base, base and shoulder material. The section between km 50+000 and km 70+000, despite showing indications of quality gravel deposits, was not sampled during to security reasons. This section was investigated during the design stage. An additional 8 sites were investigated.

The materials are mainly of lateritic gravel, sandy gravels, quartzite gravels and mixture of these ranging from light brown, brown to dark brown/reddish brown in colour. The map showing distribution of the material sites is attached as **Appendix IV**. The average rainfall experienced by the area is between 700 mm and 100 mm. The CBR tests were therefore carried on soaked samples.

At the previously worked sites depths of the overburden and that of the gravel materials layers were measured on the worked face of the borrow area, where necessary pits were dug to a certain full extent of usable gravel. At the new borrow areas, the utilizable area was assessed visually and several test pits dug to a depth of about 2 metres or shallower where the material was too hard to excavate by hand (refusal). A sample of each usable layer was taken over the whole depth of the layer as indicated above.

Each gravel sample was subjected to the following laboratory tests:

- Atterberg Limits
- Sieve analysis to 0.075 mm size
- BS heavy compaction to determine dry density / water content relationship
- CBR test at 95% MDD and OMC and after 4 days soak

#### 3.5.2 The Specifications for Neat Materials for Sub-base and Base;

The Ministry of Roads Design Manual, Part III specify the limits for materials to be used as **neat materials** for sub-base and base. These are summarised below in **Table 3.5-1**.

**Table 3.5-1: Specifications for neat materials for base and sub base**

	PI (%) (MAX)	PM (%) (MAX)	CBR (MIN)
SUBBASE	15	250	30
BASE	15	250	80

#### 3.5.3 Neat materials test results and analysis

The material sites were subjected to tests as described above. The synthesis of the results based on the CBR and Plasticity Index is as illustrated below.

**Table 3.5-2: Qualification of Neat Materials**

	CBR %			PI %			PM (%)			Remarks
	CBR %	CBR% (Min)	CBR% (Min)	PI %	PI (%) Max	PI (%) Max	PM (%)	PM (%) (Max)	PM (%) (Max)	
	MS	S/base 30	Base 80	MS	S/base 15	Base 15	MS	S/base 250	Base 250	
MS1	38	Pass	Fail	14	Pass	Pass	1410	Fail	Fail	Not Qualified
MS2	7	Pass	Fail	30	Fail	Fail	1885	Fail	Fail	Not Qualified
MS3	7	Fail	Fail	29	Fail	Fail	851	Fail	Fail	Not Qualified
MS4	6	Fail	Fail	23	Fail	Fail	800	Fail	Fail	Not Qualified
MS5	32	Pass	Fail	20	Fail	Fail	820	Fail	Fail	Not Qualified
MS6	22	Fail	Fail	20	Fail	Fail	504	Fail	Fail	Not Qualified
MS7	25	Fail	Fail	14	Pass	Pass	432	Fail	Fail	Not Qualified
MS8	19	Fail	Fail	18	Fail	Fail	400	Fail	Fail	Not Qualified
MS9	37	Pass	Fail	16	Fail	Fail	374	Fail	Fail	Not Qualified
MS10	34	Pass	Fail	17	Fail	Fail	660	Fail	Fail	Not Qualified
MS11	35	Pass	Fail	20	Fail	Fail	589	Fail	Fail	Not Qualified
MS12	39	Pass	Fail	19	Fail	Fail	540	Fail	Fail	Not Qualified
MS13	34	Pass	Fail	18	Fail	Fail	609	Fail	Fail	Not Qualified
MS14	38	Pass	Fail	18	Fail	Fail	1410	Fail	Fail	Not Qualified

From the schedule in the table above it can be concluded that all the material sites did not qualify as neat materials for either base or sub-base. The materials were therefore proposed for treatment to improve their road making qualities.

### 3.5.4 Evaluation of the qualification of the natural materials for treatment

The requirement from tables **SB1**, **SB2**, **B1**, **B2** and **B3** of the Roads Design Manual Part III indicating the specifications for roads construction materials before treatment and after treatment and are as summarised below in **Table 3.5-3**.

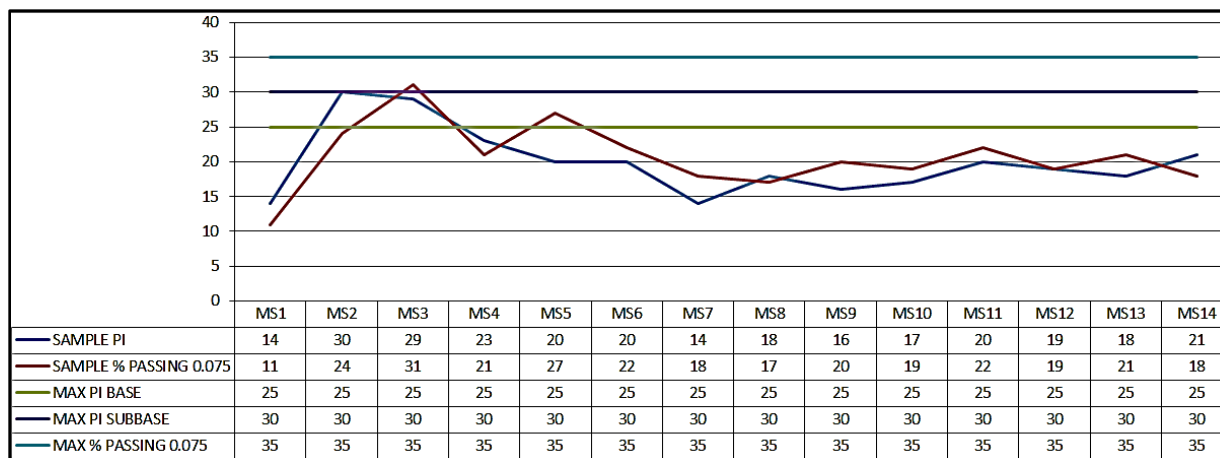
**Table 3.5-3: Materials specifications before and after treatment**

	Requirement for Base material		Requirement for Subbase material	
	Before treatment	After treatment	Before treatment	After treatment
Max size	10-50 mm		10-50 mm	
Passing 0.075	5-35%		40%	
Plasticity index	Max 25%	Max 6%	Max 30%	Max 15%
Plasticity modulus	Max 2000	Max 250 (calc)	Max 2500	Max 250
Organic content	Max 1%		Max 2%	
Soaked CBR		Minimum 160%		Minimum 60%

All the materials that qualified for treatment were proposed for treatment with cement at 1%, 2 and 3% and a combination of lime and cement at 1% respectively.

The critical criteria being PI, percentage passing 0.075 and PM for the samples tested in the neat state. The graphs below present the relationship of the material sample values and the requirement before treatment.

All the material sites pass the requirement for treatment based on PI, PM and percentage passing 0.075 sieve apart from MS2 and MS3 having PI above the 25% qualification required for base material treatment.



Though not limiting, MS4 with CBR of 6% was also not proposed for treatment. The CBR value was too low to achieve desired strength with economic and practical dosage.

The remaining sites were treated with both cement and lime as reported below.

### 3.5.5 Tests and Analysis of chemically treated materials

The materials from the qualified material sites were submitted for treatment with cement at 1%, 2 and 3%. Cement and lime was also considered at combination of 1%C+1%L. The samples were subjected to the following tests:

- Atterberg Limits after CBR testing.
- BS heavy compaction to determine dry density / water content relationship
- CBR test at 95% MDD and OMC and after 7 days cure and 7 days soak

The results of the treated materials are as presented in **Table 3.5-4** below. The certified results are attached as **Appendix V** of this report.

**Table 3.5-4: Analysis of the Results for Cement treated materials**

	CBR %			PI %			%age Meeting Requirement				Proposed Use
	Cement			Cement			S/base		Base		
	1%	2%	3%	1%	2%	3%	CBR (60%)	PI (15%)	CBR (160%)	PI (6%)	
MS1	114	151	193	8	NP	NP	1%C	1%C	3%C	1%C	Base 3%, Subbase 1%
MS5	106	139	182	12	9	6	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS7	98	122	150	10	7	NP	1%C	1%C	Not	3%	Subbase 1%
MS8	117	146	178	12	6	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS9	107	141	190	11	NP	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS10	101	134	172	12	6	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS11	107	143	179	16	10	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS12	103	135	167	14	9	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS13	101	134	172	13	7	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS14	111	145	148	16	10	NP	1%C	1%C	Not	3%	Subbase 1%

In total 8 material sites meet the base quality at 3% cement treatment and 10 sited meet subbase qualities at 1% cement treatment. Material site MS14 and MS7 are the two sites that meet subbase quality and not base of the 10 material sites submitted for treatment.

**Table 3.5-5: Analysis of the Results for Cement and Lime treated materials**

	CBR %	PI %	%age Meeting Requirement				PROPOSED USE
	Cement + Lime		S/base		Base		
	1%C+1%L	1%C+1%L	CBR (60%)	PI (15%)	CBR (160%)	PI (6%)	
MS1	114	7	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS5	106	7	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS7	98	8	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS8	117	9	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS9	107	9	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS10	101	10	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS11	107	9	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS12	103	8	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS13	101	8	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%
MS14	111	11	1%+1%	1%+1%	Not	1%+1%	Subbase 1%+1%

All the 10 material sites meet subbase quality at a combination of 1% Cement and 1% lime. However, none meets base quality. Given the prevailing temperatures in the project area, scarcity of water and the cost component, cement treatment at 1% is proposed for subbase in favour if the combination treatment.

### 3.6 Hard Stone Sources

Hard stones were sourced at:

- Lpartuk km 4+400
- Km 30+400
- Lorian km 43+900
- Mbukoi km 50+000
- Marti km 60+000
- Marti 2 km 60+00
- Charda km 65+500

The location is attached as **Appendix VI**. The samples were subjected to the following tests;

- Los Angeles Abrasion (L.A.A.)
- Aggregate Crushing Value (A.C.V.)
- Sodium/Magnesium Sulphate Soundness (S.S.S.)
- Plasticity index on L.A.A. fines
- Relative density and water absorption

The results are attached as **Appendix VI** and are reproduced here as **Table 3.6-1** below.

**Table 3.6-1: Hard stone sample test results**

Parameter	Source	Source	Source	Source	Source	Source	Source
	4+400	30+400	43+900	50+000	60+000	60+000	65+500
L.A.A (%)	12.8	26.2	21.0	20.9	16.2	17.6	19.2
A.C.V (%)	25.3	28.7	24.8	28.6	26.2	27.8	24.8
S.S.S (%)		1.9	2.9	5.6	1.2	1.6	1.0
P.I. on L.A.A Fines	NP	NP	NP	NP	NP	NP	NP
SG (OD)	2.59	2.67	2.55	2.57	2.64	2.61	2.66
Water Absorption	2.2	1.2	1.6	1.5	.66	0.79	0.38
FI	22.6	22	23.6	23.6	28.6	32	36.6

The pavement options evaluated propose the use of treated gravel and a combination of treated gravel and GCS. The aggregates were therefore evaluated for their quality to be used for GCS, AC and Concrete works.

**Table 3.6-2: Hard stone sample test evaluation**

Parameter	Source	Specification for aggregates			Recommendations for use	
1	Km 4+400 Result	GCS Stone Class		AC class B	Concrete Works	
		A	B			
LAA (%)	12.8	30	35	35	50 max	GCS (A), AC (B), Concrete works
ACV (%)	25.3	25	28	28	35 max	GCS (A), AC (B), Concrete works
S.S.S (%)		12	12	12	12 max	GCS (A), AC (B), Concrete works
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works
SG (OD)	2.59	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works
Water Absorption	2.2	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works
Flakiness Index (%)	22.6	25	25	25	35	GCS (A), AC (B), Concrete works
2	Km 30+400 Result	GCS Stone Class		AC class B	Concrete Works	
		A	B			
LAA (%)	26.2	30	35	35	50 max	GCS (A), AC (B), Concrete works
ACV (%)	28.7	25	28	28	35 max	GCS (A), AC (B), Concrete works
S.S.S (%)	1.9	12	12	12	12 max	GCS (A), AC (B), Concrete works
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works
SG (OD)	2.67	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works
Water Absorption	1.2	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works
Flakiness Index (%)	22	25	25	25	35	GCS (A), AC (B), Concrete works

Parameter	Source	Specification for aggregates				Concrete Works	Recommendations for use
2	Km 43+900 Result	GCS Stone Class		AC class B			
		A	B				
LAA (%)	21.0	30	35	35	50 max	GCS (A), AC (B), Concrete works	
ACV (%)	24.8	25	28	28	35 max	GCS (A), AC (B), Concrete works	
S.S.S (%)	2.9	12	12	12	12 max	GCS (A), AC (B), Concrete works	
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works	
SG (OD)	2.55	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Water Absorption	1.6	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Flakiness Index (%)	23.6	25	25	25	35	GCS (A), AC (B), Concrete works	
Parameter	Source	Specification for aggregates				Concrete Works	Recommendations for use
3	Km 50+000 Result	GCS Stone Class		AC class B			
		A	B				
LAA (%)	20.9	30	35	35	50 max	GCS (A), AC (B), Concrete works	
ACV (%)	28.6	25	28	28	35 max	GCS (A), AC (B), Concrete works	
S.S.S (%)	5.6	12	12	12	12 max	GCS (A), AC (B), Concrete works	
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works	
SG (OD)	2.57	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Water Absorption	1.5	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Flakiness Index (%)	23.6	25	25	25	35	GCS (A), AC (B), Concrete works	

Parameter	Source	Specification for aggregates				Concrete Works	Recommendations for use
4	Km 60+000 Result	GCS Stone Class		AC class B			
		A	B				
LAA (%)	16.2	30	35	35	50 max	GCS (A), AC (B), Concrete works	
ACV (%)	26.2	25	28	28	35 max	GCS (B), AC (B), Concrete works	
S.S.S (%)	1.2	12	12	12	12 max	GCS (A), AC (B), Concrete works	
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works	
SG (OD)	2.64	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Water Absorption	.66	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Flakiness Index (%)	28.6	25	25	25	35	Concrete works	
Parameter	Source	Specification for aggregates				Concrete Works	Recommendations for use
5	Km 60+000 Result	GCS Stone Class		AC class B			
		A	B				
LAA (%)	17.6	30	35	35	50 max	GCS (A), AC (B), Concrete works	
ACV (%)	27.8	25	28	28	35 max	GCS (B), AC (B), Concrete works	
S.S.S (%)	1.6	12	12	12	12 max	GCS (A), AC (B), Concrete works	
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works	
SG (OD)	2.61	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Water Absorption	0.79	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Flakiness Index (%)	32	25	25	25	35	Concrete works	
Parameter	Source	Specification for aggregates				Concrete Works	Recommendations for use
6	Km 65+500 Result	GCS Stone Class		AC class B			
		A	B				
LAA (%)	19.2	30	35	35	50 max	GCS (A), AC (B), Concrete works	
ACV (%)	24.8	25	28	28	35 max	GCS (A), AC (B), Concrete works	
S.S.S (%)	1.0	12	12	12	12 max	GCS (A), AC (B), Concrete works	
P.I. on L.A.A Fines	NP	N/P	N/P	N/P	25 max	GCS (A), AC (B), Concrete works	
SG (OD)	2.66	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Water Absorption	0.38	O.K	O.K	O.K	O.K.	GCS (A), AC (B), Concrete works	
Flakiness Index (%)	36.6	25	25	25	35	None	

The results indicate the stones qualify as follow:

- 
- Lpartuk km 4+400, km 30+400, Lorian km 43+900 and Mbukoi km 50+000
    - **GCS:** stone class B
    - **Concrete works:** the sample meets all the criteria for aggregates for concrete works
    - **Asphalt Concrete:** the samples qualify for AC aggregate class B.
  - Marti km 60+000, Marti 2 km 60+00
    - **Concrete works:** the sample meets all the criteria for aggregates for concrete works
  - Charda km 65+500
    - Fail all proposed uses due to flakiness

The traffic loading class **T3** require GCS stone class B (0/20) and AC class B. The criteria for the proposals for GCS and AC indicate availability of qualifying hard stones from 3 sites. In total 4 sites qualify for concrete works.

### 3.7 Sand Sources

Sand source investigations yielded two river sand sources, one 54km away along Maralal – Wamba road and the second at Baragoi. The sand deposits are expansive in both the sites. The sand samples were subjected to laboratory testing and the results are as **Appendix VII**.

**Table 3.7-1: Sand Sample Results**

Variable	Requirement	Result	
		R. Lodongokwe 54 km from Maralal	R. Gwelgwel km 99+00 at Baragoi
The Clay, Silt and dust content	Max – 2.4%	1.8	2.0

The grain size analysis is presented below:

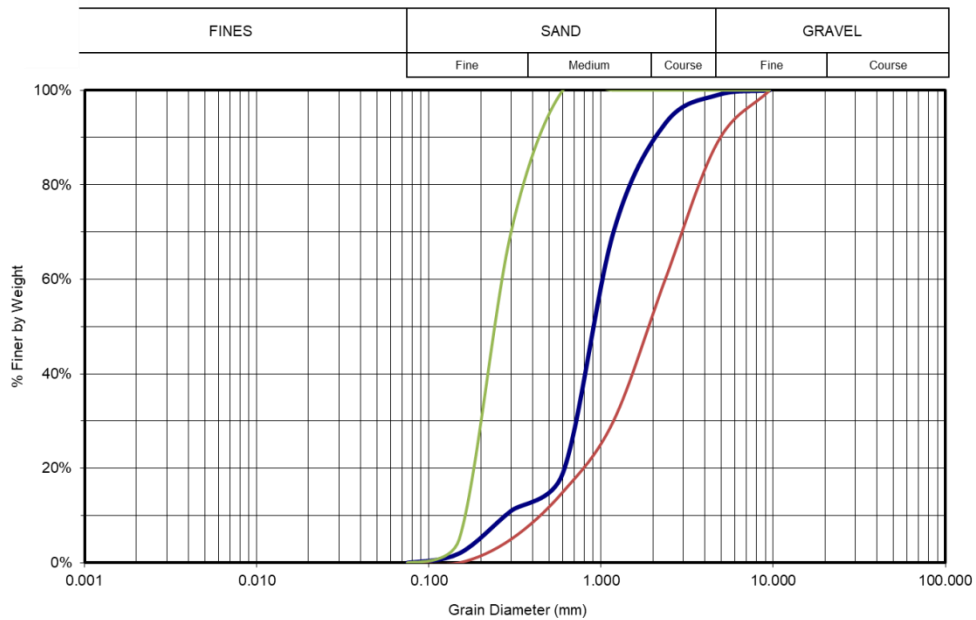
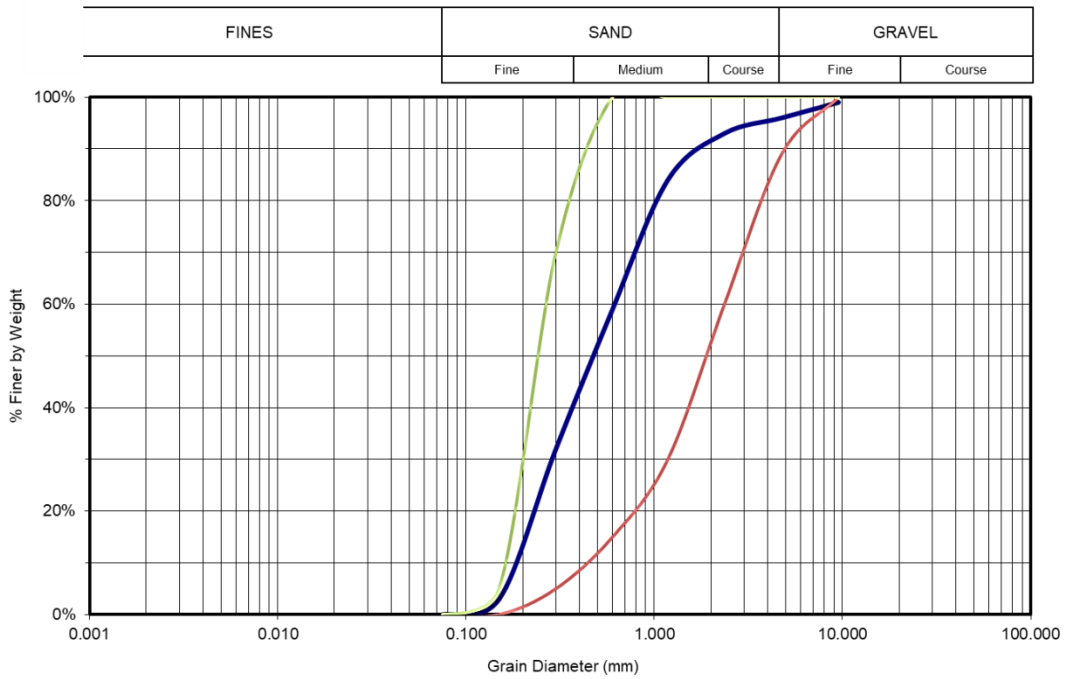


Figure 1: Grain size analysis

**Fig. 3.7-1: Grain size analysis Lodongokwe river sand**



**Fig. 3.7-2:** Grain size analysis Baragoi Gwelwel river sand

The samples are well graded and within the grading envelop with 1.8% and 2% silt and clay contents respectively. These sites qualify for use as sources for construction sand.

### 3.8 Water for construction use

Samburu County receive high rainfall of about 700-1000 mm/year in the mountain ranges that recharges springs in the lowlands. Most rivers in Samburu flow for short periods after rain. There are no perennial rivers along the project road. Dams and pans are common but their storage capacities have been reduced by siltation. Surface water is available in small quantities from River Ewaso Ngiro, the only major perennial river, averagely 30 km away at the southern Samburu border. Due to the scarcity of water and sensitivity that comes with it within the region, no consideration has been made for abstraction of the river water for construction. [1]

Hydrological literature review indicate boreholes sited near rivers or laggas, yield about 1.4-2.5 m<sup>3</sup>/hour and about 4 m<sup>3</sup>/hour in volcanic rocks. The areas with potential ground water sources along the project road include Lorian around km 40+000, Marti and Charda areas around km 60+000 and around Baragoi covering from km 89+000 to 101+000.

Bearing this in mind, hydrogeological surveys were carried out at predetermined locations along the project road. **Table 3.8-1** indicate the extraction potential of the proposed well sites.

The boreholes in the area produce average yields between 1.8 - 4.98 m<sup>3</sup>/hr at depths varying between 102 m to 131 m.

BH No. C-	Owner	Location (X km dir)	Depth (m bgl)	WSL (m bgl)	WRL (m bgl)	Q (m <sup>3</sup> /hr)	PWL (m)
1626	-	15.2SW	131	119	46	1.8	-
1639	-	3.6NW	102	69	60	4.32	-
4063	-	20.6SW	110	85	49	4.98	86
<b>Range</b>			<b>102 - 131</b>	<b>69 - 119</b>	<b>46 - 60</b>	<b>1.8 – 4.98</b>	<b>-</b>

**Table 3.8-1: Borehole details and yield**

Name	Location	Proposed Depth	Estimated Yield
Mbukoi	240033E,155862N	180	5 m <sup>3</sup> /hr
Marti	247442E,161721N	180	5 m <sup>3</sup> /hr
Baragoi	254626E,196327N	160	5 m <sup>3</sup> /hr

Detailed hydrogeological reports are attached as **Appendix VIII**.

Considerations will also be made to ensure the existing community wells are not interfered with. Additional wells where possible will be considered for the communities in addition to any existing wells. This will go a long way to minimise conflicts with the pastoralist communities.

The hydrogeological study indicates sufficient ground water for abstraction for construction works. The water from the boreholes adjacent to the proposed sites is palatable and provides potable water for the communities around. No chemical tests were conducted for the proposed wells. However chemical analyses for the wells operational within the proposed locations were conducted and the results presented in **Table 3.8-2** below. The quality of the water was found to be within required limits. Water pans will also be provided for augmentation during rainy

seasons. All social and environmental considerations will be made in locating, constructing and utilising the pans.

**Table 3.8-2: Water quality**

PARAMETERS	UNIT	RESULTS BARAGOI WELL	RESULTS GWELGWEL WELL	WHO STANDARDS	KEBS STANDARDS (KS 459-1:2007)	STANDARD SPEC FOR ROAD AND BRIDGE CONSTRUCTION	RECOMMENDATION
pH	pH Scale	7.43	7.72	6.5-8.5	6.5-8.5		Suitable
Chlorides	mg/L	11.8	14.75	-	-	1000	Suitable
Sulphate	mg/L	3.32	9.85	-	-	2000	Suitable

### 3.9 Basis of Design and Materials Assessment

#### 3.9.1 Basis of Design

The pavement design was carried out in accordance with the “Ministry of Transport and Communication, Road Design Manual, Part 3, Materials and Pavement design for New Roads” of 1987, hereafter referred to as the Design Manual. In general, the design considers the pavement loading expected during the design life, sub grade soil strength, and materials available for pavement construction including base, sub base and surfacing.

The cross section used for this road is selected from the standard Ministry of Roads and Public Works Road Design Manual Part I- Geometric Design of Rural Roads. The selected cross section has a carriageway width of 6.5 m and 1.5 m shoulders.

##### 3.9.1.1 Pavement Design Traffic

The pavement design period of the road was taken as 20 years as stipulated in the Terms of Reference. The road has been designed based on **T3 Traffic Class**.

##### 3.9.1.2 Sub grade and Improved Sub grade

The characteristics of the sub grade soils found along the alignment are as shown in the figure of CBR against chainage and the trial pit logs attached in **Appendix I**. The road is designed for subgrade class **S3** for the entire alignment.

#### 3.9.2 Pavement Choice

The assessment of viable pavement options was further made based on quality and availability of construction materials, their technical suitability and the implications on the pavement construction cost for the selected cross-section type.

Pavement type 1, 2 and 6 were eliminated earlier at the preliminary stage based on the limitations of suitable natural gravel materials for either base or subbase.

The quality of materials and availability as presented above favoured Pavement Type 3 and 7. The two pavement types were subjected to feasibility evaluation. The feasibility studies (presented separately) indicated that: The feasibility studies (presented separately) indicated that: pavement Type 3 composed of treated gravel material for both base and subbase was more robust compared to Type 7.

##### 3.9.2.1 Material Quality and proposed use

Based on the materials analysis presented above, 8 Material sites meet the base quality at 3% cement treatment and 10 material sites meet subbase quality at 1% cement treatment.

**Table 3.9-1: Treated materials proposed use**

	CBR %			PI %			%age Meeting Requirement				Proposed Use
	Cement			Cement			S/base		Base		
	1%	2%	3%	1%	2%	3%	CBR (60%)	PI (15%)	CBR (160%)	PI (6%)	
MS1	114	151	193	8	NP	NP	1%C	1%C	3%C	1%C	Base 3%, Subbase 1%
MS5	106	139	182	12	9	6	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%

	CBR %			PI %			%age Meeting Requirement				Proposed Use
	Cement			Cement			S/base		Base		
MS7	98	122	150	10	7	NP	1%C	1%C	Not	3%	Subbase 1%
MS8	117	146	178	12	6	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS9	107	141	190	11	NP	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS10	101	134	172	12	6	NP	1%C	1%C	3%C	2%C	Base 3%, Subbase 1%
MS11	107	143	179	16	10	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS12	103	135	167	14	9	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS13	101	134	172	13	7	NP	1%C	1%C	3%C	3%C	Base 3%, Subbase 1%
MS14	111	145	148	16	10	NP	1%C	1%C	Not	3%	Subbase 1%

### 3.9.2.2 Material Availability

The land use is sparse for most of the alignment. Large tracts of land are still unoccupied or not engaged in economical extractions. Environmental and safety considerations have to be taken into full consideration before exploitation of any materials. The land ownership is largely communal at the location of the proposed sites. Due process must be followed before acquisition and use of the material sites.

The **Table 3.9-2** presented the estimated materials availability for utilisation in the project roads

**Table 3.9-2: Materials Availability**

LENGTH	PAVEMENT DEPTH				subgrade	VOLUME			
	TYPE 3		TYPE 7			TYPE 3		TYPE 7	
	subbase	base	subbase	base		subbase	base	subbase	base
103700	0.2	0.15	0.175	0.15	260,650	248,880	171,105	208,696	171,105
					S3	1% CIG	3% CIG	1% CIG	GCS (A)
							419,985	208,696	171,105
					271,250		506,800	506,800	180,000
					None		None	None	None

There is established availability of both gravel and hardstone (GCS) suitable for pavement making materials. The use of both Pavement Type 7 and 3 is feasible in terms of material availability and suitability.

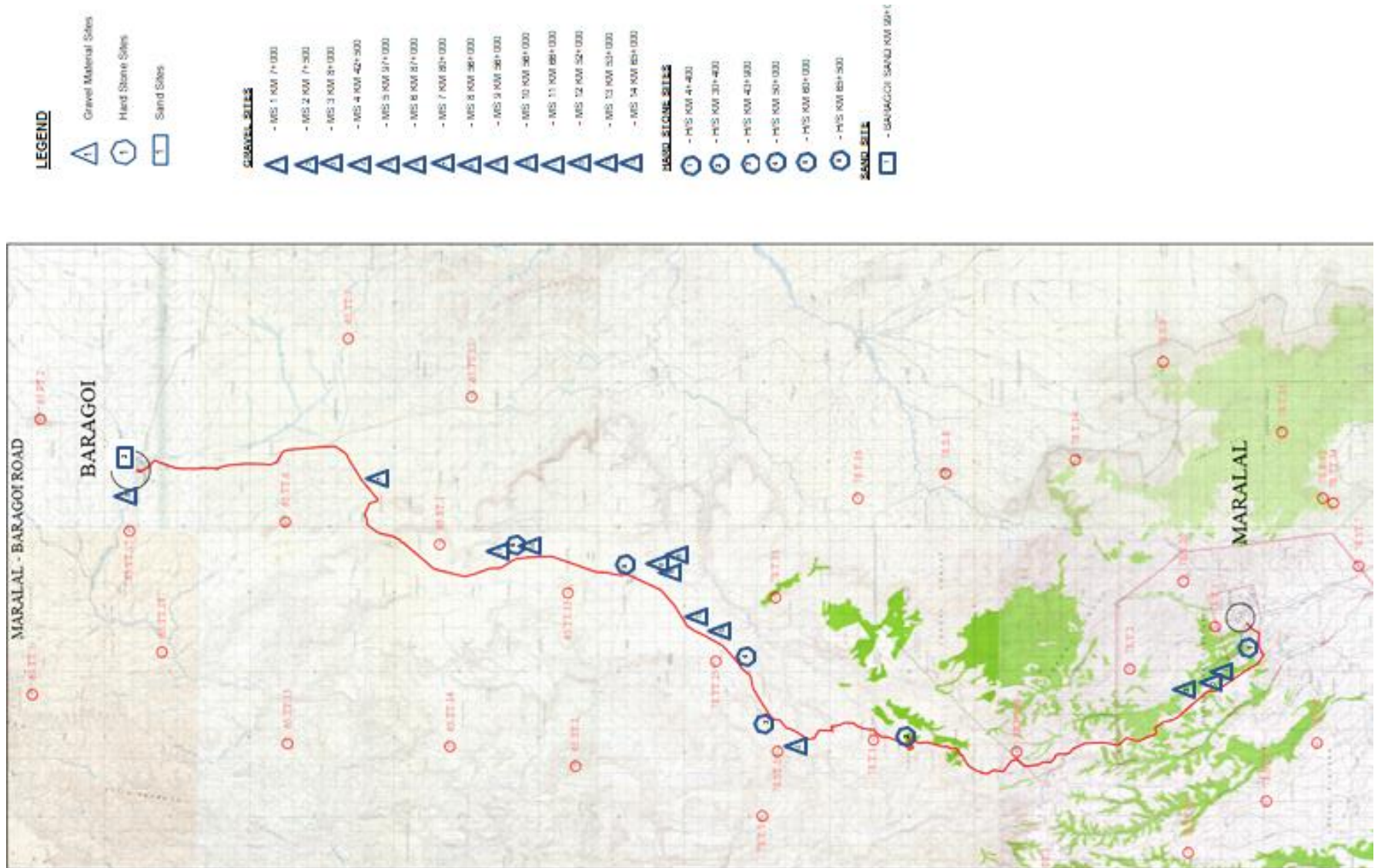
The feasibility analysis of the two options has been done using HDM4. From the analysis pavement type 3 was selected for implementation.

### **3.9.2.2 Material Utilisation**

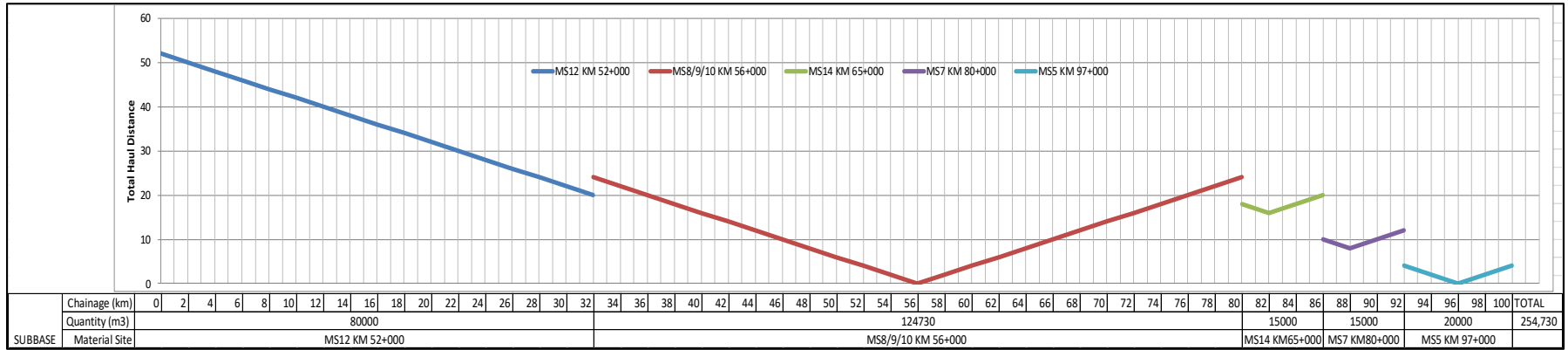
The material sites are distributed along the project road with the aim of reducing transportation costs. However, the suitable material sites are predominantly between km 30+000 to 98+000. The material sites investigated are distributed along the project road as presented in Fig. 3.9-1 below.

The materials utilisation schedule is presented in **Table 3.9-3** below.

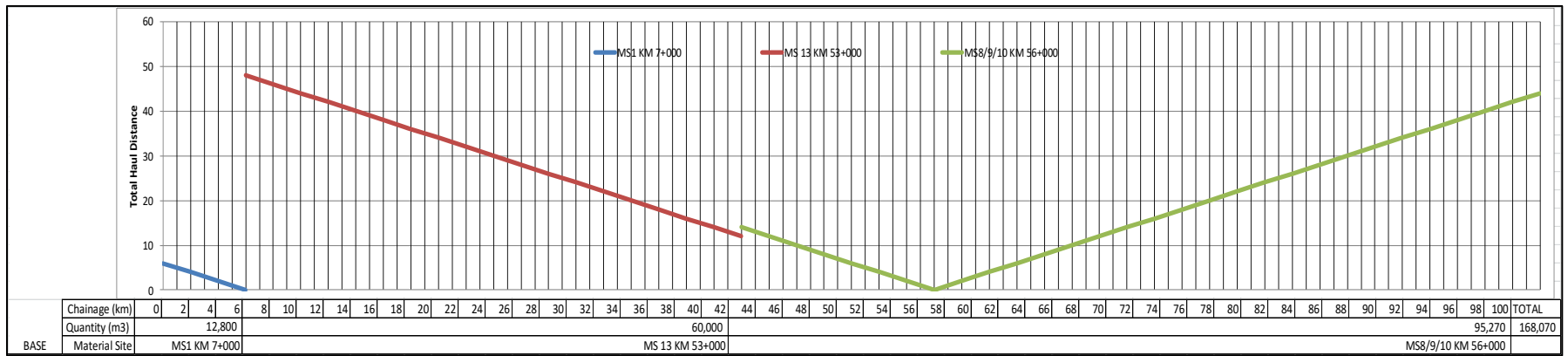
Figure 3.9-1: Material site distribution



**Table 3.9-3 (a): Material Utilisation Schedule – Subbase**



**Table 3.9-3 (b): Material Utilisation Schedule – Base**



### 3.10 Design Pavement

#### 3.10.1 Surfacing

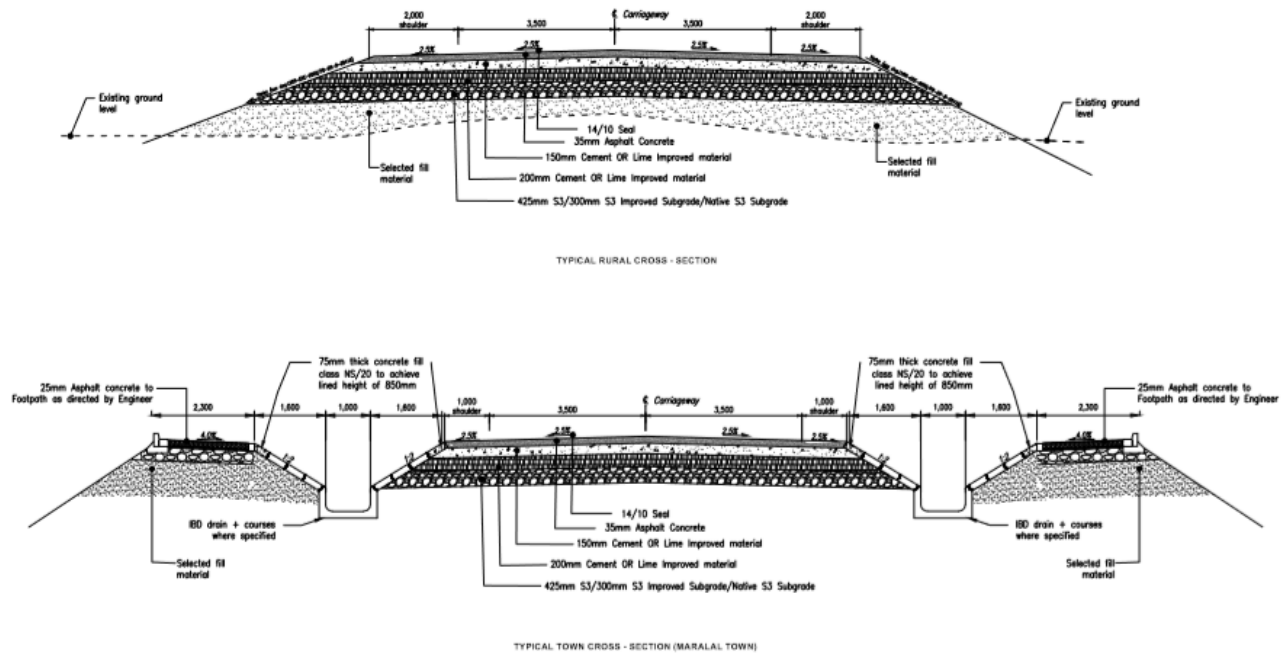
Asphalt concrete Type II 35mm with a single seal of 10/14 chippings has been provided instead of the standard Surface Dressing.

#### 3.10.2 Road Cross-Section

The RDM Part III proposes road cross-section Type A for Type 3 Standard Pavement, and cross-section Type B or D for the Standard Pavement Type 7.

Cross-section Type B has been proposed for all road sections with pavement layer extended to the shoulder. Type D shall be adopted within town centres where kerbs and walkways are provided.

**Figure 3.10-1: Proposed Pavement cross-section**




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## **4.0 APPENDICES**

#### **4.1 APPENDIX I: ALIGNMENT SOIL LOGS**

## **4.2 APPENDIX II: ALIGNMENT SOIL TEST RESULTS**



**MINISTRY OF TRANSPORT & INFRASTRUCTURE**  
**STATE DEPARTMENT OF INFRASTRUCTURE**

Telephone: Admin: 002523456789, 002523456789  
 Telephone: Public: 002523456789, 002523456789  
 Fax: 002523456789, 002523456789  
 E-mail: [info@transport.go.ke](mailto:info@transport.go.ke)

Regional Materials Office  
 Central Region  
 P.O. Box 373, Nyeri  
 51100  
 E-mail: [nyeri@transport.go.ke](mailto:nyeri@transport.go.ke)  
 DATE: 09th MAY, 2019

Ref No: M/2019/11


**Laboratory Test Report**

1. Customer's Address: OCHIENG ABUODHA & ASSOCIATES LIMITED  
 Email:  
 2. Customer Contact:  
 3. Sample Description:  
 4. Sample Submitted by: CLIENT  
 5. Date of Sample received: 25/03/2019  
 6. Additional information provided by the customer: BARAGOI - MARALAL ALIGNMENT SOILS

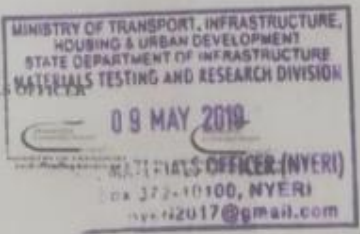
Phone:  
 a) Job Card No: 392/NY/2019/2019 S  
 b) Date fee paid: 04/04/2019  
 c) GOK MR No: 3898546  
 d) Date Analysis started: 04/04/2019

**TEST RESULTS**

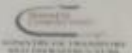
Alignment Stake Changeage (km)	Offset from Centerline (m)	Grading										Atterberg Limits					Compression Test		CBR 4 Days soak %	Swell %	
		%Passing BS Sieve Size (mm)										LL	PL	PI	LS	PM	MDD	OMC			
		28	20	10	5	2	1	0.850	0.425	0.250	0.150	0.075	%	%	%	%	%	%			
0+087	LHS	100	100	96	90	82	70	58	47	43	18	11	31	16	15	7	705	1437	23.3	10	0.2
0+200	RHS	100	100	92	84	76	65	54	47	44	19	13	45	29	16	8	752	1537	15.2	5	0.4
0+500	RHS 3.0	100	99	98	92	87	80	66	52	48	24	20	48	27	21	10	1092	1595	13.3	8	0.2
1+000	RHS 2.5	100	99	98	92	87	80	66	52	48	24	20	36	34	12	6	624	1538	16.1	7	0.2
1+500	LHS 2.5	100	100	100	100	92	82	66	55	53	27	20	44	20	24	11	1320	1498	16.6	6	0.2
2+000	RHS	100	100	100	100	93	84	69	59	56	31	25	29	13	16	8	844	1580	18.0	7	0.3
2+500	LHS 3.0	100	100	96	91	83	69	56	46	45	17	14	25	17	8	4	384	1512	17.1	5	0.3
3+000	RHS 2.5	100	100	97	90	82	65	51	43	40	12	10	40	26	14	6	602	1672	16.3	12	0.2
3+500	LHS 2.5	78	70	60	48	41	37	32	28	27	19	16	41	32	9	4	261	1515	21.5	22	0.3
4+000	LHS 2.5	80	74	66	55	48	45	42	40	38	31	29	35	NON-PLASTIC			1502	24.2	41	0.1	
4+500	RHS 3.0	98	92	79	63	50	40	33	29	27	19	15	38	32	6	3	174	1736	18.0	15	0.1
5+000	RHS 2.5	100	100	100	97	92	88	74	62	57	26	20	46	28	18	8	1116	1408	25.6	10	0.2
5+500	CL	100	100	100	98	93	87	75	63	59	25	20	45	26	19	9	1197	1327	28.8	4	0.5
6+000	RHS	100	96	91	81	74	68	62	57	54	25	18	40	26	14	6	798	1166	27.7	3	0.4
6+500	LHS 3.0	100	100	99	96	89	84	69	58	53	32	28	25	18	7	3	406	1336	21.5	4	0.4
7+000	RHS 3.0	78	72	54	44	40	35	31	28	27	17	12	33	30	3	1	84	1570	15.3	18	0.1
7+500	LHS 3.0	74	55	36	29	25	23	22	20	20	16	13	50	28	22	10	440	1599	16.5	16	0.1
8+000	LHS 3.0	100	95	79	68	58	47	39	35	33	26	25	34	16	18	9	630	1425	24.4	6	0.2
8+500	LHS	100	95	79	65	55	44	36	31	30	21	19	55	30	25	12	775	1932	13.5	8	0.2
9+500	RHS	85	82	77	71	62	54	48	43	41	23	17	20	15	5	2	215	1733	15.4	18	0.1
10+000	RHS 3.5	94	86	71	54	40	37	33	30	28	10	9	51	28	23	11	690	1334	28.2	11	0.2
10+500	LHS	84	82	77	71	62	55	49	44	42	26	19	48	28	20	9	880	1469	22.6	9	0.2
11+500	LHS 3.0	100	100	94	92	84	78	63	50	45	15	9	45	25	20	9	1000	1410	18.7	7	0.2
12+000		100	100	100	100	98	90	75	60	56	16	11	60	38	22	11	1320	1452	17.3	5	0.3
12+500	LHS 3.0	100	100	98	88	71	52	40	34	32	14	11	60	27	23	11	782	1314	25.3	11	0.2
13+000	RHS 3.0	100	100	96	87	70	51	40	34	31	20	16	18	13	5	2	170	1402	24.5	10	0.2



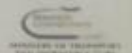
**SAMUEL K. CHEGE**  
 REGIONAL MATERIALS OFFICER  
 NYERI REGION




**MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
 HOUSING & URBAN DEVELOPMENT**  
**STATE DEPARTMENT OF INFRASTRUCTURE**  
**MATERIALS TESTING AND RESEARCH DIVISION**  
 09 MAY 2019  
 MATERIALS OFFICER (NYERI)  
 P.O. BOX 373, NYERI  
 NY. 512017@gmail.com



MINISTRY OF TRANSPORT,  
 INFRASTRUCTURE,  
 HOUSING & URBAN DEVELOPMENT



STATE DEPARTMENT OF  
 INFRASTRUCTURE



**MINISTRY OF TRANSPORT & INFRASTRUCTURE**  
**STATE DEPARTMENT OF INFRASTRUCTURE**

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Regional Materials Office  
 P.O. Box 372-10100  
 NYERI  
 Email: rmo.nyeri2017@gmail.com  
 DATE: 9TH, MAY, 2019


Ref No: M 7632/19/1

**Laboratory Test Report**

1. Customer's Address: OCHIENG ABUODHA & ASSOCIATES LIMITED  
 Email:  
 2. Customer Contact:  
 3. Sample Description:  
 4. Sample Submitted by: CLIENT  
 5. Date of Sample received: 25/03/2019  
 6. Additional information provided by the customer: BARAGOI – MARALAL ALIGNMENT SOILS

Phone:  
 a) Job Cost No: 392/NY/2018/2019 X  
 b) Date for sale: 04/04/2019  
 c) GOK MB No: 389546  
 d) Date Analysis started: 06/04/2019

Alignment with Chainage (km)	Offset from Centreline (m)	TEST RESULTS																			
		Grading										Atterberg Limits					Compaction		CBR 4 Days soak %	Swell %	
		%Passing BS Sieve Size (mm)										LL	PL	PI	LS	PM	MDD (g/m <sup>3</sup> )	OMC (%)			
25	30	40	5	2	1	0.600	0.425	0.300	0.150	0.075	%	%	%	%	%	%	%				
13+500	LHS 3.0	100	100	94	82	69	48	39	33	28	21	14	18	13	5	2	165	1426	24.0	7	0.3
14+500	RHS	76	70	51	41	35	31	29	28	27	22	18	40	21	19	9	532	1360	23.2	2	0.6
15+000	RHS 3.0	100	98	88	76	68	61	55	50	49	34	26	62	37	25	12	1250	1395	19.4	9	0.4
15+500	LHS 3.0	81	74	67	62	57	51	43	37	35	22	18	62	38	24	11	888	1235	33.3	12	0.2
16+000	RHS	100	98	94	83	74	62	48	41	37	18	15	55	27	29	1A	1189	1295	27.0	25	0.1
16+500	LHS 3.0	100	100	100	99	94	85	62	45	41	16	13	59	28	31	14	1395	1270	26.8	10	0.2
17+000		100	100	100	90	79	70	61	48	41	32	18	62	38	24	11	1152	1314	16.5	24	0.1
17+500		100	100	100	89	83	71	64	51	45	31	21	50	27	23	11	1173	1440	24.8	3	0.4
18+000	RHS	100	100	100	99	96	82	66	56	52	29	25	42	29	13	6	728	1532	17.1	5	0.3
18+500	LHS 3.0	100	100	100	99	96	81	64	52	49	24	20	41	29	12	6	624	1664	15.2	6	0.3
19+000		100	100	98	95	80	59	47	39	34	20	16	50	27	23	11	897	1447	18.3	4	0.3
19+500		100	100	100	98	92	83	56	44	37	16	12	54	38	16	8	704	1460	18.1	6	0.3
20+000	RHS 3.0	100	100	99	94	87	77	67	57	53	28	22	35	20	15	7	855	1595	13.3	3	0.5
20+500	LHS 3.0	100	100	99	87	75	63	47	38	35	18	14	35	17	18	9	684	1580	15.3	7	0.2
21+000		100	100	89	79	63	51	45	39	33	21	16	38	29	9	5	351	1602	14.8	9	0.2
21+500	LHS 3.0	100	100	100	92	81	67	48	35	29	14	13	46	41	5	2	175	1735	14.6	33	0.1
22+000		100	100	100	100	94	80	63	51	47	14	11	40	37	3	1	153	1706	16.2	31	0.1
22+500		100	100	100	96	92	85	77	64	59	17	14	54	50	4	2	256	1514	20.7	6	0.2
23+000	RHS	100	100	100	89	77	65	53	41	38	14	11	30	26	4	2	164	1736	16.0	16	0.1
23+500	LHS 3.0	100	100	99	95	90	71	56	46	42	14	11	33	28	5	2	730	1610	17.3	8	0.2
24+000	RHS	100	100	98	95	87	70	57	46	43	18	13	40	37	3	1	138	1552	18.3	13	0.1
24+500	LHS 3.0	100	100	100	94	85	72	65	50	41	28	10	40	NON-PLASTIC			1596	20.5	11	0.2	
25+000	RHS 3.0	100	100	99	94	83	67	54	46	42	16	8	45	40	5	2	230	1607	17.1	18	0.1
25+500	LHS 3.0	100	100	100	97	93	87	77	64	59	19	16	34	17	17	8	1088	1511	15.3	4	0.4
26+000	LHS 3.0	100	100	100	97	94	88	79	67	63	26	23	53	33	20	9	1340	1247	32.5	3	0.5
27+000		93	92	89	86	82	77	72	69	68	62	57	21	17	4	2	176	1378	29.7	10	0.3

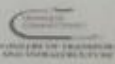
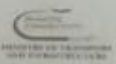


**SAMUEL K. CHEGE**  
 REGIONAL MATERIALS  
 NYERI REGION

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
 HOUSING & URBAN DEVELOPMENT  
 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION

09 MAY 2019

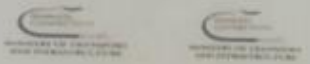
**REGIONAL MATERIALS OFFICER (NYERI)**  
 P.O. Box 372-10100, NYERI  
 Email: rmo.nyeri2017@gmail.com

MINISTRY OF TRANSPORT & INFRASTRUCTURE STATE DEPARTMENT OF INFRASTRUCTURE																					
Regional Materials Office Central Region P.O. Box 372-10100 NYERI										Regional Materials Office Central Region P.O. Box 372-10100 NYERI											
Ref No: M/NS/2019/1										DATE: 09, MAY, 2019											
Laboratory Test Report																					
1. Customer's Address: OCHIENG ABUODHA & ASSOCIATES LIMITED										Phone: 4) Job Card No: 392/NS/2018/2019 S											
Email:										5) Date for paid: 04/04/2019											
2. Customer Contact:										6) GON MR No: 1808546											
3. Sample Description:										4) Date Analysis started: 04/04/2019											
4. Sample Submitted by: CLIENT										5) Additional information provided by the customer: BARAGOI – MARALAL ALIGNMENT SOILS											
5. Date of Sample received: 28/04/2019																					
TEST RESULTS																					
Alignment Kilometre Chainage (km)	Other Soils Control (Yes)	Grading										Atterberg Limits					Compaction 25%		CBR 4 Days soak %	Swell %	
		% Passing BS Sieve Size (mm)										LL	PL	PI	LS	PS	MDD	OMC			
		25	30	40	50	60	75	100	150	200	250	300	%	%	%	%	%	%			
27+500	LHS	79	63	40	28	22	20	18	16	15	11	10	35	20	15	8	240	1412	25.3	30	0.1
28+000	LHS 2.5	84	87	81	76	72	64	57	53	51	43	40	30	16	14	6	742	1370	35.1	11	0.2
28+500	RHS 3.0	100	100	100	97	94	88	79	66	61	20	17	28	22	6	3	396	1569	12.9	5	0.3
29+000	LHS 2.5	64	49	33	27	23	21	19	18	18	14	9	40	29	11	5	198	1390	26.1	10	0.2
31+000	LHS 3.0	100	100	74	69	51	42	38	29	20	20	14	46	34	12	6	348	1690	11.0	13	0.2
31+500		100	97	88	73	69	59	51	40	37	34	23	43	33	12	6	480	1410	24.3	9	0.2
32+000	RHS 3.0	80	71	58	49	43	40	39	36	35	32	30	50	30	20	9	720	1305	28.1	30	0.1
32+500	LHS 3.0	100	100	100	100	96	90	80	70	60	44	37	45	27	18	9	1260	1308	25.9	5	0.3
33+000	RHS 3.0	100	98	79	65	54	49	45	41	42	33	29	53	45	8	4	344	1567	21.8	13	0.1
33+500	LHS	100	98	81	68	58	53	49	46	44	34	31	54	47	7	4	322	1834	17.6	15	0.1
34+000	RHS	92	87	81	71	57	43	33	26	34	12	8	37	14	23	11	599	1380	25.0	4	0.5
34+500		100	91	82	70	64	59	41	31	25	16	11	41	24	17	9	527	1560	19.2	11	0.2
35+000		100	96	84	74	66	60	55	52	51	45	37	48	29	19	9	988	1554	22.2	14	0.2
36+000	RHS	83	90	80	66	51	39	30	26	24	15	9	44	33	11	6	286	1362	20.6	3	0.6
36+500	LHS 2.5	63	56	50	43	35	30	25	21	20	10	5	46	31	15	7	315	1459	19.0	7	0.2
37+500	LHS 2.5	90	84	77	71	63	51	41	35	34	24	22	62	40	22	10	770	1270	31.5	7	0.3
38+000	RHS 2.5	83	74	45	30	21	17	15	13	13	10	9	58	40	18	9	234	1528	19.6	33	0.1
38+500	LHS	78	72	60	49	40	33	27	22	21	12	9	35	17	18	9	396	1336	25.4	4	0.5

*Samuel K. Chege*  
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MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
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 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION  
 09 MAY 2019  
 REGIONAL MATERIALS OFFICER (NYERI)  
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MINISTRY OF TRANSPORT & INFRASTRUCTURE STATE DEPARTMENT OF INFRASTRUCTURE																					
Telegraphic Address: EST/1/2008 - Nyeri Telephone/Fax: 209000/209000/2444444 Fax: 209000/209000/209000 Email: cominf@kepprac.co.ke										Regional Materials Office Central Region P.O. Box 372-10100 NYERI Email: rmo.nyeri2017@gmail.com DATE: 29TH, MAY, 2019											
Ref No: M/7632/25/17										Laboratory Test Report											
1. Customer's Address: OCHIENG ABUODHA & ASSOCIATES LIMITED Email: 2. Customer Contact: 3. Sample Description: 4. Sample Submitted by: CLIENT 5. Date of Sample received: 25/03/2019 6. Additional information provided by the customer: BARAGOI – MARALAL ALIGNMENT SOILS																					
TEST RESULTS																					
Alignment with Chainage (km)	Offset From Centerline (m)	Grading %Passing BS Sieve Size (mm)										Atterberg Limits					Liquid Limit TYP		CBR 4 Days soak %	Swell %	
		20	40	60	75	100	150	200	300	425	600	750	LL	PL	PI	LS	PM	MDD			OMC
39+500	LHS 2.0	93	89	84	74	61	47	38	32	31	19	18	50	32	18	9	576	1369	20.1	6	0.3
40+000	RHS 2.5	93	75	55	38	31	28	25	23	23	18	9	38	18	20	9	460	1440	20.7	15	0.1
40+500	LHS 2.0	93	75	54	36	29	26	23	20	19	14	13	39	21	18	9	360	1315	29.8	13	0.2
41+000	RHS 2.0	100	100	98	81	77	70	62	55	51	32	28	33	16	17	9	935	1419	23.4	8	0.2
42+500	LHS	82	71	54	41	31	27	23	21	20	15	13	50	30	20	9	420	1474	21.9	7	0.2
44+000	RHS	100	97	82	69	59	53	47	42	40	27	23	50	20	30	15	1440	1192	25.6	5	0.5
44+500		74	66	44	27	18	16	14	13	13	9	8	31	13	18	9	234	1452	23.4	15	0.1
53+500		89	78	61	48	31	25	22	17	16	14	10	33	17	16	8	272	1365	25.8	15	0.2
54+000	RHS 3.0	83	74	54	36	25	21	20	19	18	11	8	40	22	10	9	190	1428	23.5	12	0.4
54+500	LHS	84	75	57	39	27	24	22	21	21	15	12	36	17	19	9	399	1364	25.2	6	0.4
56+000	RHS 3.0	93	82	70	42	35	29	25	23	22	14	12	40	27	13	6	299	1554	21.4	4	0.4
57+500	LHS	100	96	87	57	43	37	32	27	25	14	11	38	17	21	10	567	1364	25.2	6	0.3
58+500	LHS	97	95	83	61	42	36	33	31	30	21	18	39	17	22	10	682	1431	19.0	6	0.3
59+000	RHS 3.0	98	89	75	64	64	45	53	50	49	24	17	50	27	23	11	1150	1432	22.3	8	0.2
60+500	LHS	93	85	87	64	41	37	34	31	30	13	9	39	17	22	10	682	1655	17.0	8	0.2
61+000	RHS 2.5	94	88	85	62	44	39	32	28	25	19	11	50	32	18	9	504	1564	21.6	5	0.2
61+500	LHS 2.5	83	88	83	57	38	34	32	31	30	22	18	44	29	15	7	465	1562	21.3	11	0.1
62+500	LHS 2.5	97	94	84	67	55	51	47	43	40	15	10	44	23	21	9	903	1506	23.6	4	0.3
63+000	LHS 2.5	99	95	86	64	56	49	43	39	31	19	14	44	26	18	8	702	1615	17.9	9	0.2
64+500	LHS 2.5	95	92	81	58	47	44	41	40	39	30	28	27	16	11	6	440	1590	19.2	13	0.2
65+000	RHS 2.5	94	91	77	52	38	34	32	31	30	21	19	40	17	23	11	713	1707	24.9	18	0.1
65+500	LHS	84	77	64	36	20	16	15	14	14	10	9	38	16	22	10	308	1549	19.6	5	0.4
66+000	RHS 2.5	86	80	68	45	29	25	24	23	22	19	18	31	14	17	8	391	1700	12.0	8	0.2
66+500	LHS 2.5	83	75	52	29	13	8	8	8	7	7	6	57	40	17	8	136	1538	20.5	10	0.2
67+000		63	57	51	45	38	32	28	25	23	12	8	48	33	15	7	375	1538	20.5	3	0.4
67+500	LHS	83	75	54	36	25	22	20	19	18	13	9	38	17	21	10	399	1291	27.7	3	0.4
68+000	RHS 2.5	87	82	58	26	16	15	14	13	13	10	9	36	22	14	6	182	1552	20.1	11	0.1

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MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
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STATE DEPARTMENT OF INFRASTRUCTURE  
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MINISTRY OF TRANSPORT,  
INFRASTRUCTURE,  
HOUSING & URBAN DEVELOPMENT

MINISTRY OF TRANSPORT,  
INFRASTRUCTURE,  
HOUSING & URBAN DEVELOPMENT


MINISTRY OF TRANSPORT & INFRASTRUCTURE STATE DEPARTMENT OF INFRASTRUCTURE																					
Telegraphic Address: EXECUTIVE, Nyeri Telephone: Nyeri 202660/202661/202662 Fax: Nyeri 202672/202641/202612/20 E-mail: pmc@tdi.go.ke/jan@tdi.go.ke										Regional Materials Office Central Region P.O. Box 373-10100 NYERI Email: nyeregpo2019@gmail.com DATE: 29TH, MAY, 2019											
Laboratory Test Report																					
1. Customer's Address: OCHIENG, OBOCODHA & ASSOCIATES LIMITED Email: 2. Customer Contact: 3. Sample Description: 4. Sample Submitted by: CLIENT 5. Date of Sample received: 25/03/2019 e) Additional information provided by the customer: BARAGOI – MARALAL ALIGNMENT SOILS										Phone: a) Job Card No: 392/NY/2018/2019 S b) Date fee paid: 29/05/2019 c) GOK MR No: 4231853 d) Date Analysis started: 04/04/2019											
TEST RESULTS																					
Alignment soils Chainage (km)	Offset from Centreline (m)	Grading										Atterberg Limits					Compaction T99		CBR 4 Days soak %	Swell %	
		%Passing BS Sieve Size (mm)										LL	PL	PI	LS	PM	MDD	OMC			
		28	20	10	5	2	1	0.600	0.425	0.300	0.150	0.075	%	%	%	%	kg/m <sup>3</sup>	%			
69+000	RHS 2.5	93	88	73	46	27	22	20	18	17	11	9	40	21	19	9	342	1421	19.3	13	0.2
69+500	LHS 2.5	95	92	81	58	47	44	42	40	39	30	28	27	15	12	6	480	1590	19.2	13	0.1
70+000	RHS 2.5	85	74	56	37	26	21	19	17	17	12	10	46	25	21	10	357	1252	19.0	6	0.3
73+000	LHS	96	89	56	26	14	11	10	10	10	7	7	35	20	15	7	150	1408	21.2	5	0.3
73+500		96	89	60	32	22	19	18	17	16	14	12	38	21	17	6	289	1413	20.9	6	0.3
74+500	LHS 2.5	83	77	56	31	19	17	16	16	15	14	13	47	29	18	9	288	1762	15.8	13	0.1
75+000		85	74	56	36	26	21	19	17	16	14	12	38	16	22	10	374	1790	15.1	14	0.1
75+500	RHS	91	82	59	41	30	24	21	18	16	9	6	39	17	22	10	396	1772	15.5	14	0.7
78+000	LHS 2.5	75	65	51	38	28	22	19	16	15	8	5	40	32	8	4	128	1780	12.5	5	0.6
78+500	RHS 2.5	85	80	58	54	44	35	30	27	25	17	11	27	20	7	4	189	1924	12.3	15	0.1
79+010	LHS 2.5	100	100	100	93	83	75	68	62	60	39	28	21	10	11	5	682	1574	22.5	9	0.2
79+500	LHS	71	55	28	15	10	9	9	9	7	7	7	34	31	3	1	27	1834	17.9	13	0.1
80+000	RHS 2.5	94	86	60	54	40	37	33	30	28	10	8	40	NON- PLASTIC			1980	12.7	20	0.1	
81+000	2.5	100	100	95	88	77	66	55	46	42	26	20	29	NON- PLASTIC			1877	14.5	12	0.2	
81+500	RHS 2.5	100	100	94	86	69	59	48	41	39	28	19	35	20	15	7	615	1980	11.5	23	0.1
82+000	LHS 2.5	100	100	93	84	72	62	53	47	45	24	16	25	20	5	2	235	1902	10.4	16	0.1
82+500	RHS 2.5	84	77	62	52	46	41	38	35	34	24	19	25	12	13	6	455	1420	6.0	16	0.1
83+000	LHS 2.5	100	100	93	83	75	72	69	65	63	34	25	28	12	16	8	1040	1743	15.7	5	0.4
84+000	LHS 2.5	93	87	77	57	41	35	32	30	29	15	10	27	15	12	6	450	1812	12.5	24	0.1
84+500	RHS 2.5	93	87	77	57	41	35	32	30	29	15	10	23	16	7	3	210	1700	12.0	8	0.2
85+000	LHS	92	86	75	54	37	31	28	24	22	8	2	33	17	16	8	384	1826	12.5	7	0.3
85+500	RHS 2.5	96	92	80	69	59	52	46	40	38	11	5	18	13	5	2	200	1857	10.6	12	0.1
86+000	LHS 2.5	100	89	73	66	52	45	40	35	33	13	6	37	23	12	6	492	1830	14.8	17	0.1
86+500	RHS 2.5	100	99	91	80	66	55	47	41	38	22	16	37	25	12	6	492	1707	24.9	13.2	0.2
87+000	LHS	100	100	100	99	91	85	78	70	65	20	19	54	36	18	9	1260	1355	27.0	9	0.3
87+500	RHS 2.5	91	78	60	41	29	25	22	20	19	14	11	45	24	21	10	420	1355	27.0	9	0.3
88+000	LHS 2.5	100	99	91	76	54	46	42	39	38	29	24	60	38	22	10	858	1710	16.8	12	0.1

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MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
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 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION  
 29 MAY 2019

MINISTRY OF TRANSPORT  
 AND INFRASTRUCTURE  
 NYERI REGION

MINISTRY OF TRANSPORT  
 AND INFRASTRUCTURE  
 NYERI REGION



**MINISTRY OF TRANSPORT & INFRASTRUCTURE**  
**STATE DEPARTMENT OF INFRASTRUCTURE**

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Regional Materials Office  
 Central Region  
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 NYERI  
 Email: [nyeri2017@gmail.com](mailto:nyeri2017@gmail.com)  
 DATE: 19TH, MAY, 2019


Ref No: M/7622/25/1/1

**Laboratory Test Report**

1. Customer's Address: OCHIENG ABUODHA & ASSOCIATES LIMITED  
 Email:  
 2. Customer Contact:  
 3. Sample Description:  
 4. Sample Submitted by: CLIENT  
 5. Date of Sample received: 25/03/2019  
 6. Additional information provided by the customer: BARAGOI – MARALAL ALIGNMENT SOILS

Phone:  
 a) Job Card No: 152/NY/2018/2019 X  
 b) Date for paid: 25/05/2019  
 c) GOK MR No: 4231883  
 d) Date Analysis started: 04/04/2019

Alignment Stalls Change (km)	Offset from Centerline (m)	TEST RESULTS															Compaction % MDD	OMC %	CBR 4 Days soak %	Swell %		
		Grading %Passing BS Sieve Size (mm)										Atterberg Limits										
		38	60	75	100	150	200	0.075	0.150	0.300	0.600	LL	PL	PI	LS	PSI						
88+500	RHS 2.5	100	100	100	99	83	75	70	64	54	37	23	16	11	5	2	320	1733	16.5	12	0.1	
89+000	LHS 2.5	100	100	97	91	79	70	62	54	51	28	19	25	15	10	4	540	1798	14.9	14	0.1	
89+500	RHS	95	90	74	59	50	46	43	40	37	19	11	40	26	14	9	560	1846	13.6	39	0.1	
90+000	LHS 2.5	96	93	72	64	56	53	51	48	47	30	24	29	14	15	7	720	1721	13.2	7	0.5	
90+500	RHS 2.5	100	100	100	99	60	55	51	47	43	33	26	33	13	20	9	940	1810	13.6	9	0.4	
91+000	LHS 2.5	100	86	73	60	50	44	40	36	35	16	10	32	26	6	3	216	1518	13.0	5	0.3	
91+500	RHS 2.5	100	100	100	100	79	68	61	55	53	33	24	37	20	17	8	935	1762	15.8	14	0.1	
92+000	RHS 2.5	89	85	75	63	51	45	40	36	30	12	9	27	18	8	4	288	1950	11.0	17	0.1	
92+500	RHS	91	78	58	51	49	47	44	41	40	18	13	15	9	6	3	246	1810	16.0	29	0.1	
93+500	RHS 3.0	100	78	94	85	64	54	50	56	46	45	29	21	NON-PLASTIC					1672	16.0	13	0.1
94+000	LHS 3.0	100	82	69	54	41	36	34	32	31	18	14	46	20	26	12	832	1743	14.4	13	0.2	
94+500	RHS 2.5	89	78	50	38	32	29	28	26	25	13	8	33	15	18	9	488	1662	17.0	2.3	0.7	
95+000	LHS	90	78	48	36	30	27	25	23	22	11	7	26	18	8	4	184	1270	35.1	6	0.3	
95+500	2.5	100	96	91	86	79	74	68	59	53	18	12	40	22	18	9	1062	1678	18.2	13	0.1	
96+000	LHS 3.0	100	94	85	69	57	47	39	32	29	9	4	28	16	12	6	394	1768	16.6	8	0.2	
96+500	RHS	97	87	73	54	39	35	33	31	30	17	10	42	24	18	9	558	1670	18.3	39	0.1	
97+000	LHS 2.5	100	96	87	73	61	51	42	36	33	17	12	30	15	15	7	540	1824	15.2	28	0.1	
97+500	LHS 3.0	100	100	90	76	65	57	47	40	37	11	9	28	17	11	5	440	1794	10.1	12	0.1	
98+000	LHS 3.0	92	81	69	56	49	48	40	35	33	15	9	27	18	9	4	315	1932	11.5	8	0.4	
98+500	RHS 3.0	91	86	75	58	42	32	27	24	22	10	6	22	19	3	2	72	2082	10.7	16	0.1	
99+000	LHS 3.5	87	83	62	45	36	31	28	26	25	14	10	21	NON-PLASTIC					1778	14.3	16	0.1
99+500	RHS 2.0	87	82	70	61	54	40	42	37	35	11	7	32	17	15	5	555	1892	15.0	27	0.1	
100+000	LHS 2.5	97	82	59	48	38	33	30	27	26	15	10	38	29	9	4	243	1687	16.8	11	0.1	
100+500	LHS 3.0	100	100	98	93	89	87	84	81	80	22	14	21	18	8	2	243	1810	18.9	23	0.1	
101+000	LHS	91	88	75	60	48	43	40	37	36	19	13	38	22	16	8	592	1778	19.0	26	0.1	




SAMUEL K. CHEGE  
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 NYERI REGION

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
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 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION

29 MAY 2019

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 Email: rmo.nyeri2017@gmail.com.  
 DATE: 26<sup>TH</sup> APRIL, 2019

Ref No.M. 7632/35/1/1

Laboratory Test Report

- Customer's Address: OCHIENG OBUODHA & ASSOCIATES LIMITED  
 Email: Phone:
- Customer Contact: 6. Job Card No: 392/NY/2018/2019 S
- Sample Description: ALIGNMENT SOILS 7. Date fee paid: 04/04/2019
- Sample Submitted by: CLIENT 8. GOK MR No: 3898546
- Date of Sample received: 25/03/2019 9. Date Analysis started: 04/04/2019

10. Additional information provided by the customer: BARAGOI – MARALAL ALIGNMENT SOILS

		TEST RESULTS																			
Offset From Centreline (M)	Alignment Soils	Grading											Atterberg Limits					Compaction T99		CBR 4 days Soak	Swell
		% Passing BS Sieve Size (mm)											LL	PL	PI	LS	PM	MDD Kg/m <sup>3</sup>	OMC (%)		
		28	20	10	5	2	1	0.6	0.425	0.300	0.150	0.075									
LHS 2.5m	78+000	75	65	51	38	28	22	19	16	15	8	5	40	32	8	4	128	1780	12.5	5	0.3
RHS 3.0m	33+000	100	98	79	65	54	49	45	43	42	33	29	53	45	8	4	344	1567	21.8	13	0.2
LHS 3.0m	90+000	96	93	77	64	56	53	51	48	47	30	24	29	14	15	7	720	1721	15.2	7	0.3
RHS	96+500	97	87	73	54	39	35	33	31	30	17	1.0	42	24	18	9	558	1670	18.3	39	0.1
LHS 3.0m	12+500	100	100	98	88	71	52	40	34	32	14	11	60	27	23	11	782	1314	25.3	11	0.2

*[Signature]*  
 SAMUEL K. CHEGE  
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 FOR CHIEF ENGINEER (MATERIALS)

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
 NYERI HOUSING & URBAN DEVELOPMENT  
 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION  
 26 APR 2019  
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 Email: rmo.nyeri2017@gmail.com

#### **4.3 APPENDIX III: MATERIAL SITE DISTRIBUTION**

#### **4.4 APPENDIX IV: GRAVEL SITE LAYOUTS AND LOGS**

## **4.5 APPENDIX V: GRAVEL SITES TEST RESULTS**

## **NEAT TEST RESULTS**



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Email: rmo\_nyeri2017@gmail.com  
 DATE: 26TH APRIL, 2019

Ref No.M. 7632/35/I/1

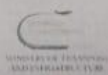
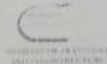
Laboratory Test Report


1. Customer's Address: OCHIENG OBUODHA & ASSOCIATES LIMITED
2. Customer Contact: Phone:
3. Sample Description: GRAVEL (MATERIAL SITES)
4. Sample Submitted by: CLIENT
5. Date of Sample received: 25/03/2019
6. Job Card No: 392/NY/2018/2019 S
7. Date fee paid: 04/04/2019
8. GOK MR No: 3898546
9. Date Analysis started: 04/04/2019
10. Additional information provided by the customer: BARAGOI – MARALAL MATERIAL SITES

Sample No.	TEST RESULTS														
	Grading						Atterberg Limits					Compaction T 99		CBR 4 days Soak	Swell
	% Passing BS Sieve Size (mm)						LL	PL	PI	LS	PM	MDD	OMC		
20	10	5	2	0.425	0.075	%	%	%	%	%	Kg/m <sup>3</sup>	(%)	(%)	(%)	
MS2 PARTUK	89	85	82	78	47	24	55	25	30	14	1410	1394	24.3	7	0.3
MS1 PARTUK 1	90	68	52	47	31	11	54	40	14	6	434	1605	17.2	38	0.1
MS4 LORIAN KM 42+500	98	86	65	41	37	21	45	22	23	11	851	1406	19.8	6	0.4
MS3 KM 8+000	100	98	97	92	65	31	58	29	29	14	1885	1376	25.4	7	0.3
MS6 KM 37+000	100	90	71	70	41	22	32	12	20	9	820	2118	9.7	22	0.1
MS 7 KM	98	84	66	45	36	18	24	10	14	6	504	1861	15.0	25	0.1
MS 5 KM 97+000 LHS	86	73	57	47	40	27	33	13	20	9	800	2166	9.5	32	0.1

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 FOR CHIEF ENGINEER

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
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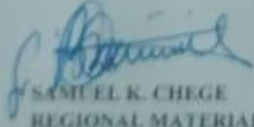
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 Nyeri, Kenya  
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 DATE: 1<sup>st</sup> JANUARY, 2020

---

**Laboratory Test Report**

1. Customer's Address: OCHIENG OBUODHA & ASSOCIATES
2. Customer Contact: \_\_\_\_\_ Phone: \_\_\_\_\_
3. Sample Description: GRAVEL (NEAT)
4. Sample Submitted by: CLIENT
5. Date of Sample received: 25/11/2019
6. Job Card No: 461 NY/2019/2020 S
7. Date fee paid: 30/12/2019
8. GOK MR No: 5308310
9. Date Analysis started: 4/12/2019
10. Additional information provided by the customer: MARALAL – BARAGOI A4 ROAD PROJECT

Sample No.	Reference CHAINAGE & OFFSET	TEST RESULTS														
		Grading						Atterberg Limits					Compaction T 180		CBR	Swell
		% Passing BS Sieve Size (mm)						LL	PL	PI	LS	PM	MDD	OMC	4 days Soak	
		20	10	5	2	0.425	0.075	%	%	%	%	%	Kg/m3	(%)	(%)	(%)
524	MS 8 KM 56+000 2KM RHS	100	80	48	29	24	17	36	18	18	9	432	1778	14.2	39	<0.1
525	MS 9 KM 56+000 RHS	100	81	50	33	25	20	37	21	16	8	400	1764	14.4	37	<0.1
526	MS 10 KM 56+000 1.5KM RHS	100	80	46	29	22	19	41	24	17	8	374	1760	14.7	34	<0.1
527	MS 11 KM 66+000 60m RHS	100	80	63	46	33	22	42	22	20	10	660	1755	14.6	35	<0.1
528	MS 12	100	86	69	41	31	19	40	21	19	9	589	1754	15.0	39	<0.1
529	MS 13 KM 63+000 30m RHS	100	89	57	42	30	21	37	19	18	9	540	1750	15.7	34	<0.1
530	MS 14 KM 65+000 60m RHS	100	85	56	40	29	18	39	18	21	11	609	1766	14.0	38	<0.1



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 MATERIALS TESTING AND RESEARCH DIVISION

09 JAN 2020

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## **TREATED MATERIALS TEST RESULTS**



REPUBLIC OF KENYA  
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 DATE: 6<sup>TH</sup> JANUARY, 2020

Laboratory Test Report

- Customer's Address: OCHIENG OBUODHA & ASSOCIATES  
 Email: Phone:
- Customer Contact: 6. Job Card No: 483/NY/2019/2020 S
- Sample Description: GRAVEL (STABILIZED) 7. Date fee paid: 30/12/2019
- Sample Submitted by: CLIENT 8. GOK MR No: 5808310
- Date of Sample received: 25/11/2019 9. Date Analysis started: 4/12/2019
- Additional information provided by the customer: MARALAL – BARAGOI A4 ROAD PROJECT

S/NO	Chainage	Reference	TEST RESULTS														
			Grading					Atterberg Limits					Compaction T 180		CBR 7 days Cure	Swell	
			% Passing BS Sieve Size (mm)					LL	PL	PI	LS	PM	MDD Kg/m <sup>3</sup>	OMC (%)			
			28	20	10	5	2								0.425	0.075	
MS 1 PARTUK 1	1% Cement	100	90	68	52	47	31	11	42	34	8	4	248	1605	17.2	114	<0.1
	2% Cement	100	90	68	52	47	31	11	NON-PLASTIC					1605	17.2	151	<0.1
	3% Cement	100	90	68	52	47	31	11	NON-PLASTIC					1605	17.2	193	<0.1
	1% Cement & 2% Cement	100	90	68	52	47	31	11	40	33	7	3		1605	17.2	132	<0.1
MS 7	1% Cement	100	98	84	66	45	36	18	32	22	10	5	360	1861	15.0	98	<0.1
	2% Cement	100	98	84	66	45	36	18	31	24	7	4	252	1861	15.0	122	<0.1
	3% Cement	100	98	84	66	45	36	18	NON-PLASTIC					1861	15.0	150	<0.1
	1% Cement & 1% Lime	100	98	84	66	45	36	18	33	25	8	4	288	1861	15.0	118	<0.1

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Email: rmo.nyeri2017@gmail.com  
DATE: 6<sup>TH</sup> JANUARY, 2020

Laboratory Test Report

- Customer's Address: OCHIENG OBUODHA & ASSOCIATES  
Email: Phone:
- Customer Contact: 6. Job Card No: 483/NY/2019/2020 S
- Sample Description: GRAVEL (STABILIZED) 7. Date fee paid: 30/12/2019
- Sample Submitted by: CLIENT 8. GOK MR No: 5808310
- Date of Sample received: 25/11/2019 9. Date Analysis started: 4/12/2019
10. Additional information provided by the customer: MARALAL – BARAGOI A4 ROAD PROJECT

S/NO	Chainage	Reference	TEST RESULTS															
			Grading						Atterberg Limits					Compaction T 180		CBR 7 days Cure	Swell	
			% Passing BS Sieve Size (mm)							LL	PL	PI	LS	PM	MDD			OMC
28	20	10	5	2	0.425	0.075	%	%	%	%	%	Kg/m <sup>3</sup>	(%)	(%)	(%)			
	MS 5 KM 97+000 LHS	1% Cement	100	86	73	57	47	40	27	42	30	12	6	396	2166	9.5	106	<0.1
		2% Cement	100	86	73	57	47	40	27	38	29	9	5	297	2166	9.5	139	<0.1
		3% Cement	100	86	73	57	47	40	27	34	28	6	3	198	2166	9.5	182	<0.1
		1% Cement & 1% Lime	100	86	73	57	47	40	27	36	29	7	4	231	2166	9.5	133	<0.1
524	MS 8 KM 56+000 2KM RHS	1% Cement	100	100	83	47	33	24	17	34	22	12	6	288	1778	14.2	117	<0.1
		2% Cement	100	100	83	47	33	24	17	35	29	6	3	144	1778	14.2	146	<0.1
		3% Cement	100	100	83	47	33	24	17	NON-PLASTIC					1778	14.2	178	<0.1
		1% Cement & 1% Lime	100	100	83	47	33	24	17	34	25	9	5	216	1778	14.2	129	<0.1

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 Email: rmo.nyeri2017@gmail.com  
 DATE: 6<sup>TH</sup> JANUARY, 2020

Laboratory Test Report

- Customer's Address: OCHIENG OBUODHA & ASSOCIATES
- Customer Contact: Email: Phone:
- Sample Description: GRAVEL (STABILIZED)
- Sample Submitted by: CLIENT
- Date of Sample received: 25/11/2019
- Job Card No: 483/NY/2019/2020 S
- Date fee paid: 30/12/2019
- GOK MR No: 5808310
- Date Analysis started: 4/12/2019
- Additional information provided by the customer: MARALAL – BARAGOI A4 ROAD PROJECT

S/NO	Chainage & Offset	Reference	TEST RESULTS														
			Grading					Atterberg Limits					Compaction T 180		CBR 7 days Cure	Swel I	
			% Passing BS Sieve Size (mm)					LL	PL	PI	LS	PM	MDD	OMC			
			20	10	5	2	0.425								0.075	kg/m <sup>3</sup>	(%)
525	MS 9 KM 56+000 RHS	1% Cement	100	81	50	33	25	20	36	25	11	6	275	1764	14.4	107	<0.1
		2% Cement	100	81	50	33	25	20	NON-PLASTIC					1764	14.4	141	<0.1
		3% Cement	100	81	50	33	25	20	NON-PLASTIC					1764	14.4	190	<0.1
		1% Cement & 1% Lime	100	81	50	33	25	20	37	28	9	5	225	1764	14.4	126	<0.1
526	M 10 KM 56+000 1.5KM RHS	1% Cement	100	80	40	29	22	19	38	26	12	6	264	1760	14.7	101	<0.1
		2% Cement	100	80	40	29	22	19	36	30	6	3	132	1760	14.7	134	<0.1
		3% Cement	100	80	40	29	22	19	NON-PLASTIC					1760	14.7	175	<0.1
		1% Cement & 1% Lime	100	80	40	29	22	19	40	30	10	5	220	1760	14.7	114	<0.1

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 DATE: 3<sup>RD</sup> JANUARY, 2020

Laboratory Test Report

- Customer's Address: OCHIENG OBUODHA & ASSOCIATES
- Customer Contact:
- Sample Description: GRAVEL (STABILIZED)
- Sample Submitted by: CLIENT
- Date of Sample received: 25/11/2019
- Job Card No: 483/NY/2019/2020 S
- Date fee paid: 30/12/2019
- GOK MR No: 5808310
- Date Analysis started: 4/12/2019
- Additional information provided by the customer: MARALAL – BARAGOI A4 ROAD PROJECT

S/NO	Stabilizer	Reference CHAINAGE & OFFSET	TEST RESULTS														
			Grading						Atterberg Limits					Compaction T 180		CBR 7 days Cure	Swell
			% Passing BS Sieve Size (mm)						LL	PL	PI	LS	PM	MDD	OMC		
			20	10	5	2	0.425	0.075	%	%	%	%	%	Kg/m <sup>3</sup>	(%)	(%)	(%)
527	1% Cement	MS 11 KM 66+000 60m RHS	100	80	63	46	33	22	34	18	16	8	528	1755	14.6	107	<0.1
	2% Cement	MS 11 KM 66+000 60m RHS	100	80	63	46	33	22	35	25	10	5	330	1755	14.6	143	<0.1
	3% Cement	MS 11 KM 66+000 60m RHS	100	80	63	46	33	22	NON-PLASTIC					1755	14.6	179	<0.1
	1% Cement & 1% Lime	MS 11 KM 66+000 60m RHS	100	80	63	46	33	22	36	27	9	5	297	1755	14.6	125	<0.1
528	1% Cement	MS 12	100	86	69	41	31	19	36	22	14	7	434	1754	15.0	103	<0.1
	2% Cement	MS 12	100	86	69	41	31	19	38	29	9	5	279	1754	15.0	135	<0.1
	3% Cement	MS 12	100	86	69	41	31	19	NON-PLASTIC					1754	15.0	167	<0.1
	1% Cement & 1% Lime	MS 12	100	86	69	41	31	19	37	31	8	4	248	1754	15.0	120	<0.1

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DATE: 6<sup>TH</sup> JANUARY, 2020

Laboratory Test Report

- Customer's Address: OCHIENG OBUODHA & ASSOCIATES  
Email: Phone:
- Customer Contact: 6. Job Card No: 483/NY/2019/2020 S
- Sample Description: GRAVEL (STABILIZED) 7. Date fee paid: 30/12/2019
- Sample Submitted by: CLIENT 8. GOK MR.No: 5808310
- Date of Sample received: 25/11/2019 9. Date Analysis started: 4/12/2019
- Additional information provided by the customer: MARALAL – BARAGOI A4 ROAD PROJECT

S/NO	Stabilizer	Chainage & Offset	TEST RESULTS														
			Grading					Atterberg Limits					Compaction T 180		CBR 7 days Cure	Swel l	
			% Passing BS Sieve Size (mm)						LL	PL	PI	LS	PM	MDD			OMC
			20	10	5	2	0.425	0.075	%	%	%	%	%	Kg/m <sup>3</sup>	(%)	(%)	(%)
529	1% Cement	MS13 KM63+000 30m RHS	100	89	57	42	30	21	39	33	13	6	390	1750	15.7	101	<0.1
	2% Cement		100	89	57	42	30	21	37	30	7	4	210	1750	15.7	134	<0.1
	3% Cement		100	89	57	42	30	21	NON-PLASTIC					1750	15.7	172	<0.1
	1% Cement & 1% Lime		100	89	57	42	30	21	38	30	8	4	240	1750	15.7	119	<0.1
530	1% Cement	MS14 KM65+000 60m RHS	100	85	56	40	29	18	40	24	16	8	464	1766	14.0	111	<0.1
	2% Cement		100	85	56	40	29	18	39	29	10	5	290	1766	14.0	145	<0.1
	3% Cement		100	85	56	40	29	18	NON-PLASTIC					1766	14.0	188	<0.1
	1% Cement & 1% Lime		100	85	56	40	29	18	38	27	11	6	319	1766	14.0	130	<0.1

SAMUEL K. CHEGE  
REGIONAL MATERIALS OFFICER (NYERI)

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
HOUSING & URBAN DEVELOPMENT  
STATE DEPARTMENT OF INFRASTRUCTURE  
MATERIALS TESTING AND RESEARCH DIVISION  
06 JAN 2020  
REGIONAL MATERIALS OFFICER (NYERI)  
P.O. Box 372-10100, NYERI  
Email: rmo.nyeri2017@gmail.com

## **4.6 APPENDIX VI: HARD STONE TEST RESULTS**



## **4.7 APPENDIX VII: SAND TEST RESULTS**



MINISTRY OF TRANSPORT & INFRASTRUCTURE  
 STATE DEPARTMENT OF INFRASTRUCTURE

Telegraphic Address: "MINIWORKS", Nairobi  
 Telephone: Nairobi 554950/3/4  
 Fax: 554877  
 E-mail: chief.engineer@materials.go.ke

Regional Materials Office  
 Central Region  
 P.O. Box 372 - 10100  
 NYERI

Ref No.

DATE: 29<sup>TH</sup> MAY, 2019

Laboratory Test Report

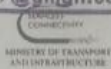
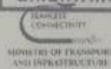
1. Customer's Address: OCHIENG ABUODHA ASSOCIATES  
 Email: Phone:
2. Customer Contact: 6. Job Card No: 868/NY/2018/2019 S
3. Sample Description: SAND (MUGURI RIVER SAND) 7. Date fee paid: 29/05/2019
4. Sample Submitted by: CLIENT 8. GOK MR No: 4231853
5. Date of Sample received: 25/03/2019 9. Date Analysis started: 20/04/2019
10. Additional information provided by the customer: BARAGOI - MARALAL

TEST RESULTS FOR SAND				
SAMPLE NO	BS Sieve size (mm)	% Passing (by wt)	Specification Limits	Remarks
	Dry Sieving			
	10	100	100	
	5	99	89-100	
	2.36	93	60-100	
	1.18	70	30-100	
	0.600	19	15-100	
	0.300	11	5-70	
	0.150	2	0-15	
	0.075			

Silt and clay contents = 1.8% (specification limits = 2-4%)

SAMUEL K. CHEGE  
 REGIONAL MATERIALS OFFICER (NYERI)  
 FOR CHIEF ENGINEER (MATERIALS)

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
 HOUSING & URBAN DEVELOPMENT  
 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION  
 29 MAY 2019  
 REGIONAL MATERIALS OFFICER (NYERI)  
 P.O. Box 372-10100, NYERI  
 E-mail: mo.tn2017@gmail.com





MINISTRY OF TRANSPORT & INFRASTRUCTURE  
 STATE DEPARTMENT OF INFRASTRUCTURE

Telegraphic Address: "MINIWORKS", Nairobi  
 Telephone: Nairobi 554950/3/4  
 Fax: 554877  
 E-mail: chief.engineer@materials.go.ke

Regional Materials Office  
 Central Region  
 P.O. Box 372 - 10100  
 NYERI.

Ref No.

DATE: 29<sup>TH</sup> MAY, 2019

Laboratory Test Report

1. Customer's Address: OCHIENG ABUODHA ASSOCIATES  
 Email: Phone:
2. Customer Contact: 6. Job Card No: 868/NY/2018/2019 S
3. Sample Description: SAND (GWEL GWEL RIVER SAND) 7. Date fee paid: 29/05/2019
4. Sample Submitted by: CLIENT 8. GOK MR No: 4231853
5. Date of Sample received: 25/03/2019 9. Date Analysis started: 20/04/2019
10. Additional information provided by the customer: BARAGOI - MARALAL

TEST RESULTS FOR SAND				
SAMPLE NO	BS Sieve size (mm)	% Passing (by wt)	Specification Limits	Remarks
	Dry Sieving			
	10	99	100	
	5	96	89-100	
	2.36	93	60-100	
	1.18	84	30-100	
	0.600	59	15-100	
	0.300	32	5-70	
	0.150	3	0-15	
	0.075			

Silt and clay contents = 2.0% (specification limits = 2-4%)

  
 SAMUEL K. CHEGE  
 REGIONAL MATERIALS OFFICER (NYERI)  
 FOR CHIEF ENGINEER (MOT&IS)  
 P.O. Box 372 - 10100, NYERI  
 Email: rmo.nyeri2017@gmail.com

MINISTRY OF TRANSPORT, INFRASTRUCTURE,  
 HOUSING & URBAN DEVELOPMENT  
 STATE DEPARTMENT OF INFRASTRUCTURE  
 MATERIALS TESTING AND RESEARCH DIVISION  
 29 MAY 2019

MINISTRY OF TRANSPORT AND INFRASTRUCTURE



## **4.8 APPENDIX VII: CONSTRUCTION WATER TEST RESULTS**

## **4.8 APPENDIX VIII: HYDROGEOLOGICAL REPORT**



**agriQ Quest Ltd.**  
**Laboratory Test Report**

Plessey House, Uhuru Highway, P.O. Box 3097 - 00506 Nairobi.  
Telephone: +254 700 321464 Fax +25420554636  
Email: info@agriq-quest.com Website: www.agriq-quest.com

Lab. Ref. No: AQ / 608856 

**Customer identification**

<b>Client name</b> Kenneth Kamau	<b>Address</b> P.O. Box Mombasa
<b>Phone</b>	

**Sample identification**

<b>Sample Type</b> Water	<b>Sampling date</b> 20/03/2019 13:26
<b>Sampler</b> Joseph Okoth	<b>Reception date</b> 20/03/2019 13:26
<b>Sampling method</b>	<b>Analysis start date</b> 03/04/2019 12:03
<b>Sample analysis</b> Client Sample	<b>Analysis finish date</b> 15/04/2019 17:22
<b>Sample ID:</b> Baragoi borehole-GwelGwel	<b>Report publication date</b> 15/05/2019 17:08

**Raw Water**

**Raw Water - Chemical Analysis**

Tests	Results	Units	Test limits	Method	Ref. Std
#pH of Water	7.43		6.5 - 8.5	AQTP 002	KS EAS 12:2014
#Conductivity	0.47	mS/cm	Max. 25	ISO 7888	EAS 12:2014
#Colour in water	1.00	TCU	Max. 50	ISO 7887	EAS 12:2014
#Turbidity	0.00	NTU	Max. 25	AQTP 7027	EAS 12:2014
#Total Dissolved Solids	250.00	mg/L	Max. 1500	ASTM D 5907	EAS 12:2014
#Total Suspended Solids	Not detectable	mg/L	Not Detectable	AQTP 007	KS EAS 12:2014
#Odour in Water	Odourless		Odourless	ISO 13301	KS EAS 12:2014
#Taste in Water	Not objectionable		Not Objectionable	ISO 13301	KS EAS 12:2014
#Chlorides as Cl- in Water	11.80	mg/l	Max. 250	AQTP 009	KS EAS 12:2014
#Fluorides as F- in Water	1.11	mg/L	Max. 1.50	AQTP 031	KS EAS 12:2014
Sulphates as SO4- in Water	3.32	mg/L	Max. 400	AQTP 004	KS EAS 12:2014
Nitrates as NO3- in Water	7.57	mg/L	Max. 45	AQTP 008	KS EAS 12:2014
Phosphates as PO4- in Water	1.97	mg/L	Max. 2.2	AQTP 013	KS EAS 12:2014
Zinc as Zn in Water	0.02	mg/L	Max. 5	AQTP 048	KS EAS 12:2014
Copper as Cu in Water	<0.01	mg/L	Max. 1.00	AQTP 047	KS EAS 12:2014
#Calcium as Ca in Water	<b>* 205.72</b>	<b>mg/L</b>	Max. 150	AQTP 061	KS EAS 12:2014
#Magnesium as Mg in Water	88.28	mg/L	Max. 100	AQTP 019	KS EAS 12:2014
#Sodium as Na in Water	12.26	mg/L	Max. 200	AQTP 042	KS EAS 12:2014
Lead as Pb in Water	<0.01	mg/L	Max. 0.01	AQTP 054	KS EAS 12:2014
#Iron as Fe in Water	0.02	mg/L	Max. 0.3	AQTP 050	KS EAS 12:2014
#Manganese as Mn in Water	0.09	mg/L	Max. 0.1	AQTP 051	KS EAS 12:2014
#Nitrites as NO2- in Water	<0.001	mg/L	Max. 0.003	ISO 6777	KS EAS 12:2014
#Free & Residual chlorine	0.00	mg/l	Absent	ISO 7393	EAS 12:2014
#Total Hardness in Water	288.00	mg/L	Max. 300	ISO 6059	KS EAS 12:2014
#Ammonia in Water	<0.01	mg/L	Max. 0.5	ISO 11732	KS EAS 12:2014



**agriQ Quest Ltd.**  
**Laboratory Test Report**

Plessey House, Uhuru Highway, P.O. Box 3097 - 00506 Nairobi.  
Telephone: +254 700 321464 Fax +25420554636  
Email : info@agriq-quest.com Website: www.agriq-quest.com

Lab. Ref. No: AQ / 608857



**Customer identification**

**Client name** Kenneth Kamau **Address** P.O. Box  
**Phone** Mombasa

**Sample identification**

<b>Sample Type</b>	Water	<b>Sampling date</b>	20/03/2019 13:29
<b>Sampler</b>	Joseph Okoth	<b>Reception date</b>	20/03/2019 13:29
<b>Sampling method</b>		<b>Analysis start date</b>	22/03/2019 16:11
<b>Sample analysis</b>	Client Sample	<b>Analysis finish date</b>	15/04/2019 18:45
<b>Sample ID:</b>	Well water-GwelGwel	<b>Report publication date</b>	15/05/2019 17:16

**Raw Water**

**Raw Water - Chemical Analysis**

Tests	Results	Units	Test limits	Method	Ref. Std
#pH of Water	7.72		6.5 - 8.5	AQTP 002	KS EAS 12:2014
#Conductivity	0.43	mS/cm	Max. 25	ISO 7888	EAS 12:2014
#Colour in water	1.00	TCU	Max. 50	ISO 7887	EAS 12:2014
#Turbidity	1.25	NTU	Max. 25	AQTP 7027	EAS 12:2014
#Total Dissolved Solids	220.00	mg/l.	Max. 1500	ASTM D 5907	EAS 12:2014
#Total Suspended Solids	* 3.00	mg/L	Not Detectable	AQTP 007	KS EAS 12:2014
#Odour in Water	Odourless		Odourless	ISO 13301	KS EAS 12:2014
#Taste in Water	Not objectionable		Not Objectionable	ISO 13301	KS EAS 12:2014
#Chlorides as Cl- in Water	14.75	mg/l	Max. 250	AQTP 009	KS EAS 12:2014
#Fluorides as F- in Water	1.57	mg/L	Max. 1.50	AQTP 031	KS EAS 12:2014
Sulphates as SO4- in Water	9.85	mg/L	Max. 400	AQTP 004	KS EAS 12:2014
Nitrates as NO3- in Water	12.34	mg/L	Max. 45	AQTP 008	KS EAS 12:2014
Phosphates as PO4- in Water	* 5.91	mg/L	Max. 2.2	AQTP 013	KS EAS 12:2014
Zinc as Zn in Water	<0.01	mg/L	Max. 5	AQTP 048	KS EAS 12:2014
Copper as Cu in Water	<0.01	mg/L	Max. 1.00	AQTP 047	KS EAS 12:2014
#Calcium as Ca in Water	145.72	mg/L	Max. 150	AQTP 061	KS EAS 12:2014
#Magnesium as Mg in Water	58.28	mg/L	Max. 100	AQTP 019	KS EAS 12:2014
#Sodium as Na in Water	23.54	mg/L	Max. 200	AQTP 042	KS EAS 12:2014
Lead as Pb in Water	<0.01	mg/L	Max. 0.01	AQTP 054	KS EAS 12:2014
#Iron as Fe in Water	0.03	mg/L	Max. 0.3	AQTP 050	KS EAS 12:2014
#Manganese as Mn in Water	0.07	mg/L	Max. 0.1	AQTP 051	KS EAS 12:2014
#Nitrites as NO2- in Water	<0.001	mg/L	Max. 0.003	ISO 6777	KS EAS 12:2014
#Free & Residual chlorine	0.00	mg/l	Absent	ISO 7393	EAS 12:2014
#Total Hardness in Water	204.00	mg/L	Max. 300	ISO 6059	KS EAS 12:2014
#Ammonia in Water	<0.01	mg/L	Max. 0.5	ISO 11732	KS EAS 12:2014