ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

Cost-Benefit Analysis of Replacing versus Stabilizing Expansive Soils in Road Construction (Case study for Gambella-Alwero-Rice-Project)

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University
In partial fulfillment of the requirements for the degree of
Master of Science in Road and Transport Engineering

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LIST OF ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BOA	Bureau of Agriculture
BOQ	Bill of Quantities
CBR	California Bearing Ratio
Cons	Consumption
DT	Dump Truck
ERA	Ethiopian Roads Authority
GARP	Gambella Alwero Rice Project
GNP	Gambella National Park
GPNRS	Gambella Peoples National Regional State
Hrly	Hourly
hr	Hour
L + UL	Loading Plus Unloading
LL	Liquid Limit
Lub	Lubricant
MC	Moisture Content
M.D.D.	Maximum Dry Density
NESPAK	National Engineering Services Pakistan (Pvt) Limited
O.M.C.	Optimum Moisture Content
OP	Operational
PL	Plastic Limit
PI	Plastic Index
Presu	Pressure
Qty	Quantity
S	Speed
Std	Standard
TP	Test Pit
U.F.	Utilization Factor
WT	Water Truck
Wt	Weight

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ABSTRACT

Expansive soils are soils that have a property of large volumetric changes, both shrinkage and swell, due to variations in their moisture content. Their bearing capacity is poor. For road to be constructed on such soils, the subgrade should be designed to minimize subsequent changes in moisture content and consequent volume changes thereby improving bearing capacity of the soil.

The subgrade material for road construction within the project of Gambella-Alwero-Rice-Project, located in Gambella National Regional State - Abobo Wereda, is highly dominated with such type of expansive soils.

Methods applied to improve the engineering property of such soil were either to stabilize the existing soil or to replace the soil with nonexpansive impermeable soil to the depth affected by seasonal moisture changes.

The decision on which method should be used was made based on cost-benefit analysis of stabilizing versus replacing for the existing expansive soil.

To come up with the cost-benefit result, initially expansive soil samples from different road section were taken. Quality test for the collected soil samples have been made in the laboratory. The laboratory test result has indicated as the existing expansive soil needs improvement to serve as subgrade for the road within the project.

Following the test result, selection of relevant replacing material and stabilizing agent was done. Replacing material within 2km radius was found satisfying all tests and lime was selected as stabilizing agent. With those selected materials and stabilizing agent, cost-benefit analysis was carried out. Total Cost of Replacing the existing expansive soil with locally available suitable material was found to be 2,862,247.71 (Birr/Km) and total cost of stabilizing the existing expansive soil with Lime from Derba Cement Factory was found to be 1,974,821.28 (Birr/Km) amounting to a saving cost of 32%.

From the study, the result of stabilizing the existing expansive soil as compared to replacing with non-expansive soil from the nearby forest has become economical.

1 INTRODUCTION

1.1 BACKGROUND

Worldwide expansive soils occur both in temperate and tropical climates. Problems associated with these soils have been reported in Africa, Australia, Europe, India, Israel, South America, the United States as well as some regions in Canada. In the United States alone, expansive clays have been estimated to produce at least two billion dollars of damage annually. In many areas of the tropics especially Africa and India, tropical expansive soils often known as black cotton soils are the major problematic soils. These soils show very strong swelling and shrinkage characteristics under changing moisture conditions[1].

In Ethiopia like many other countries, lands which are fertile, suitable for agriculture and covered by Forest are highly dominated with expansive soils. Gambella-Alwero-Rice-Project, located in Gambella National Regional State - Abobo Wereda, is also dominated by expansive soils especially in areas of forest and fertile lands.

As the lands are fertile and good for agriculture as well as rainfall is high during summer season lasting from July to October, good mechanized irrigation systems is on its way. Though good road network is a basic requirement for the all-round development of the region, those soils available within the project area are unsuitable for laying long-lasting roads which has an impact on the transport cost of the project.

Expansive soils are soils that has a property of large volumetric changes, both shrinkage and swell, due to variations in their moisture content. Their bearing capacity is poor. For road construction to be constructed on such soils, the subgrade should be designed to minimize subsequent changes in moisture content and consequent volume changes thereby improving bearing capacity of the soil.

Currently applied methods here in Ethiopia to improve the engineering property of such soil are either to stabilize the existing soil or to replace the soil with nonexpansive impermeable soil to the depth affected by seasonal moisture changes.

These expansive soils could be stabilized with different technique/option to make them suitable for road construction where this processes will be in place if it is economical in such a way that the cost of overcoming the existing problem in the expansive soils with selected stabilizer is less than the cost of importing another material which is satisfactory without stabilization. In so doing, reduction in the cost of transport of the project will be achieved.

1.2 STATEMENT OF THE PROBLEM

Agricultural investment is now underway in many regions of Ethiopia. Gambella is one of the region where this investment is taking place in which case Gambella-Alwero-Rice-Project is one among other investment in the region dominated by fertile soil and forest.
In agricultural sector the parameters, such as road construction, which has influence in deforestation requires close inspection during construction in areas of fertile and forest lands

where expansive soil dominates much of the terrain. Though expansive soils are good for agriculture, they are not suitable for road construction. To make expansive soils suitable for road construction, their engineering property has to be improved through stabilizing process or replacement where the decision depends on cost-benefit analysis of the methods.

In GARP project there is around 2000km of gravel road which is going to be constructed. These roads will be constructed on soil where much of the area is dominated by expansive soil. These soil is not suitable for such road construction because of its expansiveness property when it gets contact with water. As a result of this problem the existing expansive soil is now being removed and replaced with selected material obtained from nearby forest and fertile soil section without making any cost benefit analysis for which method to apply. This current practice exercised on this project is now aggravating loss of fertile soil, forest, wild animals and birds which could have been protected through the decision made from cost benefit analysis of replacing versus stabilizing.

1.3 SCOPE OF INVESTIGATION

Soil samples of expansive soil from different section of the project roads were collected for the investigation in the laboratory. Samples of soils from 5 test pit has been taken from 0.5 m depth below the ground surface after clearing has been done since cross section of the design indicate such a depth to be improved [2].

For the collected sample, tests have been conducted if the existing expansive soil needs improvement or not. Based on the laboratory result the existing expansive soil needs improvement where the improvement is made using replacing with locally available material and stabilizing agent. Final decision was reached on which of the two methods to apply, after a cost-benefit analysis was done.

1.4 OBJECTIVE OF THE STUDY

General Objective

To protect the removal of existing expansive soil in the farm where the road is going to be constructed thereby reducing loss of fertile soil, forest, wild animals and birds resulting from development of selected material for replacement of the existing expansive soil.

Specific Objective

- To develop a Model that can show cost-benefit analysis for decision making in using either replacing or stabilizing of the existing soil.
- To generate a sound indicator for the use of either option in areas of road construction where there is expansive soil.

2 STUDY AREA

2.1 GENERAL

As per the Design Report made by NESPAK [2], the Gambella Peoples National Regional State of the Federal Democratic Republic of Ethiopia exhibits suitable agro-climatic characteristics and geophysical features for agriculture. The region's average annual rainfall is high and lands are fertile. Most part of the state is covered with dense forests.
Saudi Star Agricultural Development Plc has acquired about 11,690 ha in Gambella valley about 45 km from Gambella city near Abobo village. Major part of the area has fine and moderately fine textural soils.

2.2 CLIMATE

As per the Design Report made by NESPAK [2], the project area is characterized by abundant precipitation in the wet season from May to October. Most of the annual precipitation (80-90%) occurs during the wet months. Scanty precipitation is recorded in the dry season from November to April. The average annual rainfall is about 1280 mm.

The mean annual temperature is 27.8 °C with maximum and minimum annual temperatures of 44.9 °C, and 10.3 °C, respectively. Maximum mean monthly humidity varies from 69-79%in wet season while minimum mean monthly humidity varies from 45-48% in dry season.

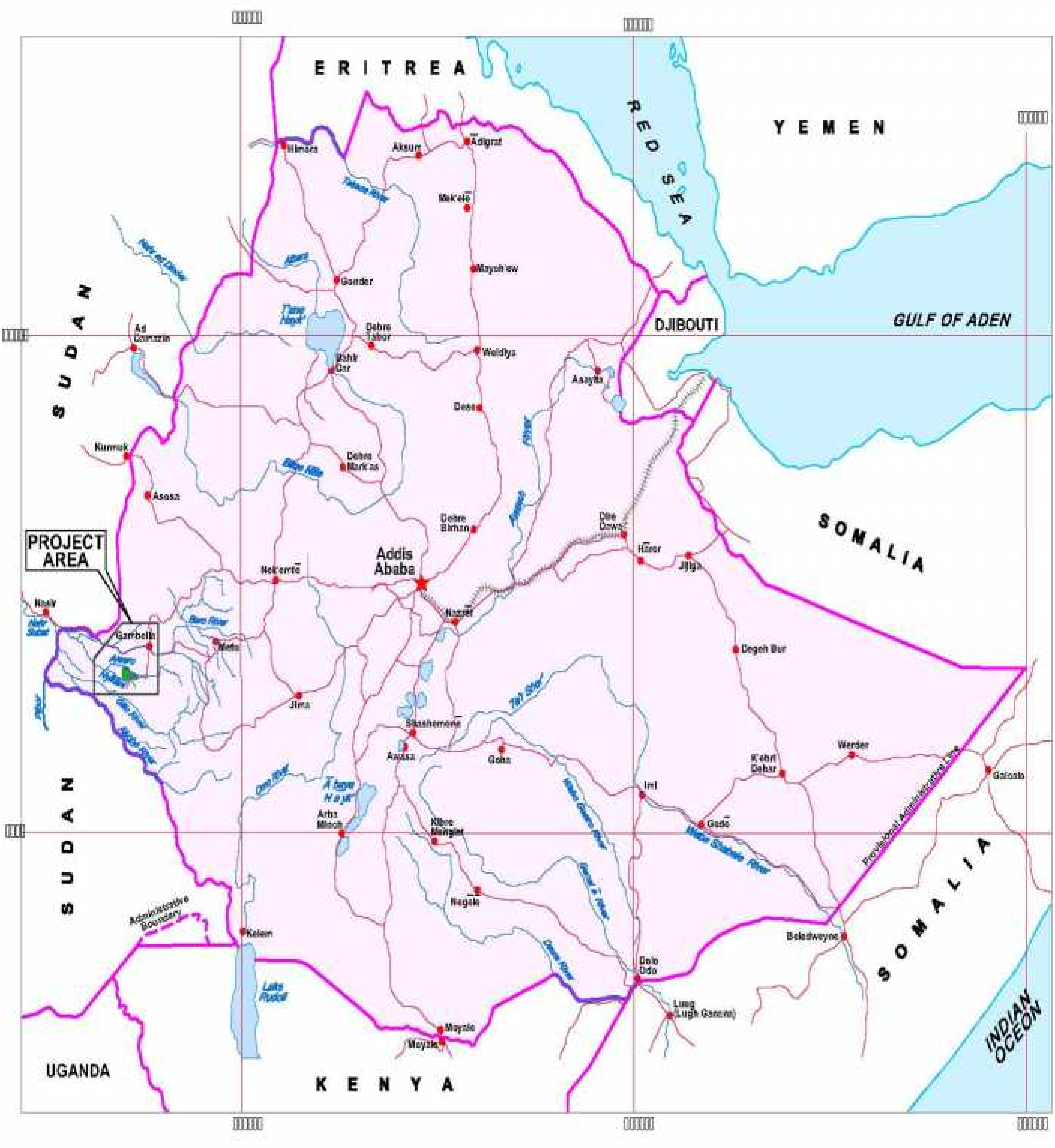
2.3 LOCATION AND EXTENT OF THE PROJECT AREA

As per the Design Report made by NESPAK [2], the Project is located at about 45 km from Gambella city in the south-western Gambella Peoples National Regional State. The area to be irrigated is located at a distance of 20 km towards downstream of Abobo dam and lies in the northern territory between the Alwero and Nyikani rivers at elevations varying from 450 to 425 meters. The location of project is shown in Fig. 2.1.

2.4 DESCRIPTION OF ROADS ON THE PROJECT AREA

As per the Design Report made by NESPAK [2], the main canal has been provided 4.5m wide service road, whereas branch canals have 5m wide road on right embankment and 7m wide on left embankment, which also serves as unit boundary. Distributaries, minors and watercourses have been provided with 5m wide service roads. Furthermore 10m wide roads connect the unit centres. Project boundary has been provided with 5m wide road, which also serves as flood protection embankment. Total road lengths and related covering area are as follows;

- 10 m roads 20.948 km Covering area 20.948 ha
- 7 m roads 24.340 km Covering area 17.038 ha
- 5 m roads 1,598.157 km Covering area 799.079 ha


ERITREA
YEMEN
RED SEA
DJIBOUTI
GULF OF ADEN
SUDAN
SOMALIA
PROJECT AREA
Addis Ababa
KENYA
UGANDA
INDIAN OCEAN
Gambella
Metu
Jima
Nek'emte
Asosa
Kurmuk
Gonder
Bahir Dar
Aksum
Adigrat
Mek'ele
Weldiya
Dese
Nazret
Dire Dawa
Harer
Jijiga
Degeh Bur
Shashemene
Awasa
Goba
Arba Minch
Negele
Kibre Mengist
Werder
K'ebri Dahar
Gode
Imi
Dolo Odo
Moyale
Beledweyne
Galcaio
Kelem
Lake Rudolf
Administrative Boundary
Provisional Administrative Line

2.5 DETAILS OF THE PROJECT AREA

Gambella-Alwero-Rice-Project owned by Saudi-Star-Agricultural-Development plc., located in Gambella National Regional State - Abobo Wereda is dominated by expansive soil especially in areas of forest and fertile lands. The Abobo Wereda where the project is located has the following features,

Location,

- It is located in the south-western part of Ethiopia and borders Godere Wereda to the East, Itang Wereda to the West, Gambella town and Wereda to the North and Gog Wereda to the South.

Existing terrain,

- Topography of the Wereda is flat which is dominated by red clay soil of 50%, light grey soil of 30% and sandy soil of 20%.

Rivers,

- Alwero and Seru are the rivers available within the Wereda.

Population,

- a total population of 19,458 [3].

Area,

- has an estimated area of 243,775.62 Ha. [4].

Area of Forest,

- 109,699.03 ha of the area is covered by natural forest, 68.3 ha covered by manmade forest. It also owns wet grassland and swamps where the native grasses grow over 3 meters in height [3].

Weredas Wildlife,

- Wildlife reported as living here include populations of elephant, African Buffalo, lion, roan antelope, tiang, Lelwel Hartebeest, olive baboon, and guereza monkey. Several birds only found in this area include the shoebill stork, the Long-tailed Paradise Whydah and the Red-throated and Green Bee-eaters [4].

People's Food,

- Particularly maize and sorghum are the common food widely practiced by Anyuaa people. As the region is generally not cereal self-sufficient, alternative income sources such as fishing are important sources of food.
- Wild food consumption is part of the daily dietary intake from the untouched bush land and natural forest resources [4].

Map of the Region,

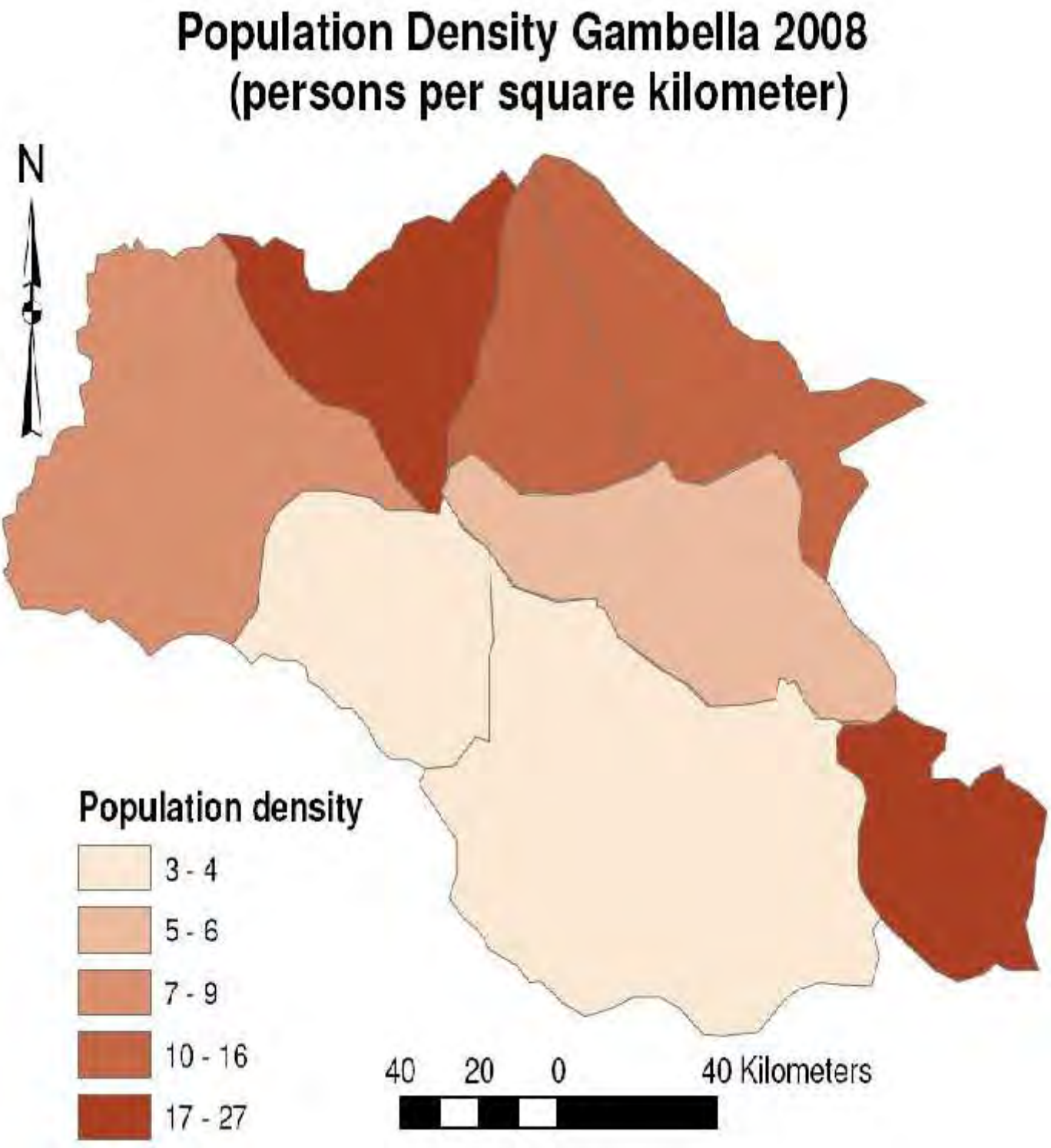
- Gambella zone was divided into nine Weredas until recently: Akobo, Jikawo, Itang, Gambella, Abobo, Jor, Gog, Dimma and Godere.

Study Area within the Region,

- Abobo Wereda is one of the nine Weredas where this study is trying to focus. It is in this Wereda that the Gambella-Alwero-Rice-Project is located [3]

Gambella Wereda's in decreasing order of:

Wereda	Population Size	Population Density
Jicawo	58,218.0	26.5
Godere Special Wereda	45,057.0	23.2
Gambella	44,953.0	15.7
Akobo	34,196.0	14.3
Itang	26,344.0	8.9
Gog	21,225.0	5.5
Abobo	19,458.0	3.8
Jor	9,548.0	3


Population Density Gambella 2008
(persons per square kilometer)
N
Population density
3 - 4
5 - 6
7 - 9
10 - 16
17 - 27
40 20 0 40 Kilometers

3.1

expansive soils or to replace the soil with nonexpansive impermeable soil to the depth affected by seasonal moisture changes where the former is not widely used in our country while the later is widely used(leaving aside the impact/damage of developing such selected material from the nearby forest) [12].

As per Ethiopian Roads Authority (ERA) Standard Technical Specifications [7], stabilization of materials is used in the construction of the in-situ subgrade by the addition of a chemical stabilizing agent or by the mechanical modification of the material by mixing various materials or by treating the material with a bituminous stabilizing agent. It includes the furnishing, spreading and mixing of the stabilizing agent or soil binder. In the case of chemically stabilized material, the layer is given a curing treatment.

Material to be stabilised shall be any naturally occurring cohesive or non-cohesive soil or processed material, the properties of which can be permanently improved by the process of stabilisation to comply with the requirements of the Specification for the relevant material.
Stabilizing the existing expansive soils includes;

- the process of mixing materials with the soil to improve certain properties of the soil,
- the blending of soils with other materials to achieve a desired gradation or
- the mixing of commercially available additives that change the gradation, texture or plasticity of the soil.

Methods which are currently available for stabilizing light grey expansive soils include;

- Remoulding and Compaction
- Surcharge Loading
- Prewetting
- Moisture Control
- Chemical Admixtures [9].

3.3.1 REMOULDING AND COMPACTION

The swell potential of the soil can be reduced by decreasing the dry density of expansive soils. Using standard proctor test, compaction at low densities and at water contents above the optimum water content provides less expansion potential than compaction at high densities and low water contents.

Advantages of remoulding and compacting include;

- Avoiding of cost of importing selected material.
- Proper compaction of the soil minimize infiltration of water into underlying soils.
- It is economically feasible to scarify, pulverize, and re-compact such expansive soils.

Some disadvantages of remoulding and compaction include ;

- The lower bearing capacity of the low density compaction may not be adequate.
- Some soils have such high potential for volume change that compaction control doesn’t reduce swell potential significantly and replacement may be necessary.
- Compacting at specified densities and water contents may necessitate frequent testing to maintain quality control, which may increase the cost of the project[9].

3.3.2 SURCHARGE LOADING

The swell property of an expansive soil can be prevented using surcharge load which is large enough to counteract the expected swell pressures. This method is most effective when swell pressures are low. However, many soils exhibit swell pressure too high to be controlled by normal surcharge loads alone[9].

3.3.3 PREWETTING

Prewetting is based on the theory that increasing the moisture content in the expansive foundation soils will cause heave to occur prior to construction and there by eliminate problems afterward. If the high moisture content is maintained, there will be no appreciable increase in soil volume to damage the pavement structure.

The procedure has serious drawbacks that limit its application. Expansive soils typically exhibit low hydraulic conductivity and the time required for adequate wetting can be up to several years. Furthermore, after the water has been applied for long periods of time serious loss of soil strength can result causing reductions in bearing capacity[9].

3.3.4 MOISTURE CONTROL

Soil expansion problems are primarily the result of fluctuations in water content. Non uniform heave will result from either non uniform water content changes, non-uniform soil conditions, or both. If fluctuations in water content over time can be minimized and if the water content in the subsoil can be made uniform, a major part of the expansion problem can be mitigated.

The placement of a structure or pavement on the ground surface will change the evapo-transpiration from the surface. Changes in land use, such as irrigation, will change the potential for infiltration. These changes will, in turn, change the water content and its distribution in the subsoil's.

If the change in water content can be made to occur slowly and if the water content distribution can be made uniform, differential heave can be minimized[9].

3.3.5 CHEMICAL ADMIXTURES

Expansive soils undergo modification when a catalyst agent is introduced into the soil. In turn, the chemical reaction converts the engineering properties of the material which was unsuitable to suitable for roadbed materials[9].
Examples of Chemical Stabilization,

3.3.5.1 LIME STABILIZATION

With proper design and construction techniques, lime treatment chemically transforms unstable soils into usable materials.

Fig.3.4 Lime-stabilized layer (see arrow) bridging an erosion failure illustrates strength.[14]

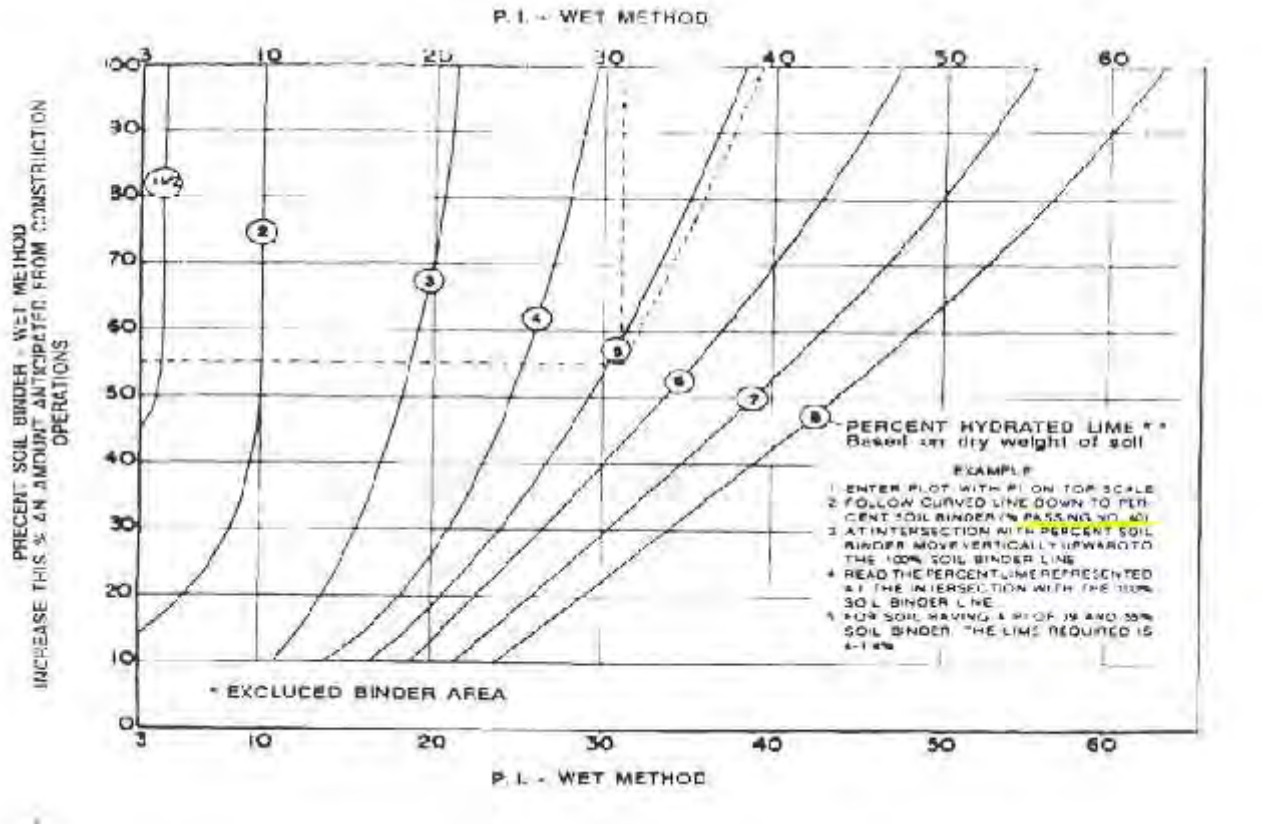
- Lime treatment of expansive soils

Expansive soils are characterized by heaving of a pavement or road when water is imbibed in their clay minerals. The plasticity characteristics of a soil are a good indicator of the swell potential as indicated in table 3-1. If it has been determined that a soil has potential for excessive swell, lime treatment will be appropriate. Lime will reduce swell in an expansive soil to greater or lesser degrees depending on the activity of the clay minerals present.[9]
In general, fine-grained clay soils (with a minimum of 25 percent passing the #200 sieve (74mm) and a Plasticity Index greater than 10) are considered to be good candidates for stabilization. Lime can permanently stabilize fine-grained soil employed as a subgrade to create a layer with structural value in the pavement system. The treated soils may be in-place (subgrade). Subgrade stabilization usually involves in-place “road mixing,” and generally requires adding 3 to 6 percent lime by weight of the dry soil.[14]

The amount of lime to be added is the minimum amount that will reduce swell to acceptable limits based on the parameters of plasticity index and percent of material passing the No. 40 sieve as shown in fig. 3.5.[9]

Table 3.1 Swell potential of soils [9]

Liquid limit	Plasticity Index	Potential Swell
> 60	> 35	High
50 - 60	25 - 35	Marginal
< 50	< 25	Low


P. I. - WET METHOD
PERCENT SOIL BINDER - WET METHOD
INCREASE THIS % AN AMOUNT ANTICIPATED FROM CONSTRUCTION OPERATIONS
3
10
20
30
40
50
60
100
90
80
70
60
50
40
30
20
10
0
PERCENT HYDRATED LIME **
Based on dry weight of soil
EXAMPLE
1 ENTER PLOT WITH PI ON TOP SCALE
2 FOLLOW CURVED LINE DOWN TO PER-
CENT SOIL BINDER (% PASSING NO. 40)
3 AT INTERSECTION WITH PERCENT SOIL
BINDER MOVE VERTICALLY UPWARD TO
THE 100% SOIL BINDER LINE
4 READ THE PERCENT LIME REPRESENTED
AT THE INTERSECTION WITH THE 100%
SOIL BINDER LINE
5 FOR SOIL HAVING A PI OF 19 AND 35%
SOIL BINDER, THE LIME REQUIRED IS
4-1 4%
* EXCLUDED BINDER AREA
P. I. - WET METHOD

- Disadvantages:

Quicklime requires 32 percent of its weight in water to convert to hydrated lime and there can be significant additional evaporation loss due to the heat of hydration. Care must be taken with the use of quicklime to ensure adequate water addition, mellowing, and mixing. These greater water requirements may pose a logistics or cost problem in remote areas without a nearby water source. Quicklime may require more mixing than dry hydrated lime or lime slurries because the larger quicklime particles must first react with water to form hydrated lime and then be thoroughly mixed with the soil[14].

Construction Overview

The construction steps involved in stabilization include

a) scarifying or partially pulverizing soil,

b) spreading lime,

c) adding water and mixing,

d) compacting to maximum practical density, and

e) curing prior to placing the next layer

f) dry lime - bags

a) Scarification and Pulverization

After the soil has been brought to line and grade, the subgrade can be scarified to the specified depth and width (Figure 3.6) and then partially pulverized. It is desirable to remove non-soil materials, such as stumps, roots, turf, and aggregates.

A scarified or pulverized subgrade offers more soil surface contact area for the lime at the time of lime application. If the slurry method is being employed, scarification will also lessen runoff from the treatment area.

In the past it was common practice to scarify before spreading. Today, because of the availability of superior mixers, lime is often applied without scarification. Lime trucks can also negotiate the roadway more readily if it is compacted, rather than scarified, particularly on wet soils. The main disadvantage of this procedure, however, pertains to weather conditions; when lime is placed on a smooth surface, there is greater chance for loss due to wind and runoff, particularly if mixing is not started immediately[14].

The subgrade can be uneven or scarified for this type of application. This application works well in very wet soil conditions.

To insure that the correct quantity of lime is spread, a pan or cloth of known area can be placed on the ground between the wheels of the spreader truck as it drives across the site. The collection container with the lime in it is weighed to insure that the quantity of lime is correct.

A second way that dry quicklime is applied is through a gravity drop into a windrow. Bottom dump tankers and clam shell bottom drop trailers are commonly used. A motor grader/ maintainer is used to spread the quicklime evenly. Larger-size lime up to ¾" can be used. This method requires the area be level and dry enough so that the soil will not rut under the truck tires, which prevents uniform spreading. It is difficult to measure the application rate of lime when it is spread using a motor grader. The best method is to mark off an area in which a known quantity of lime will be spread and observe the grader to insure that it is spread evenly.

Dry Hydrated Lime

Hydrated lime should be uniformly spread at the specified percentage from suitably equipped trucks (Figure 3.7). An approved spreader is preferable for uniform distribution. The application rate of dry hydrated lime can be measured using the same method as described above for quicklime.

Dry hydrated lime should not be spread under windy conditions because of excessive dusting. Under windy conditions, in populated areas, or adjacent to heavy vehicle traffic, slurry application or proper quicklime applications can minimize dust related problems.

Equipment for dry hydrated lime application: For truck shipments, self-unloading bulk tanker trucks are most efficient for transporting and spreading lime because no rehandling is involved.

c) Initial Mixing and Watering

Preliminary mixing is required to distribute the lime throughout the soil and to initially pulverize the soil to prepare for the addition of water to initiate the chemical reaction for stabilization. This mixing can begin with scarification (Figure 3.8). Scarification may not be necessary for some modern mixers, however. During this process or immediately after, water should be added (Figure 3.9).

f) Final Curing

Before placing the next layer, the compacted subgrade should be allowed to harden until loaded dump trucks can operate without rutting the surface. During this time, the surface of the lime treated soil should be kept moist to aid in strength gain[14].

g) Dry Lime – Bags

In bagged lime process, bags are delivered in dump or flatbed trucks and evenly spaced for the required distribution. Generally, with windrow mixing by a grader, one or two lines of bags are used. After the bags are properly placed, they are slit with a knife or shovel and the lime is dumped into piles or into transverse windrows across the roadway. The lime is then leveled by using a motor grader to ensure uniform spreading of the predetermined spacing. Immediately thereafter, the lime is sprinkled with water and follow the above procedures[14].

3.3.6 REMOVAL AND REPLACEMENT OF EXPANSIVE SOILS

Removing the existing expansive soils and replacement with non expansive soils is another method to provide stable foundation material. In some cases the expansive soil may be entirely removed. Generally, the expansive layer extends to a depth too great to economically allow complete removal and replacement.
Whenever a soil experiences a value of CBR $\leq$ 3% the material needs to be replaced with other selected material used for road construction with a value of CBR > 3%.

One mechanism by which the removal and replacement method mitigates expansive potential of the soil is by the control of the moisture content in the underlying clay layer.

The basic requirements concerning soil replacement are;

- the type of replacement material,
- the depth of replacement, and
- the extent of replacement.

Advantages of improvement by removal and replacement are;

- Non expansive soils can be compacted at higher densities, yielding higher bearing capacities than can be produced by Prewetting the expansive soil or compacting it at low densities.
- Removal and replacement require less delay to construction than some other procedures such as Prewetting[9].

Disadvantages of removing and replacing the expansive soils are;

- Non expansive, which is impervious, fill material must be obtained. This can have a significant cost factor if the fill material must be imported from long distance.

- The required thickness of the non expansive fill material may be too great to be practical.
- Granular fill may serve as a reservoir and provide long term sources of water to foundation or subgrade soils.
- Environmental impact on the existing environment that results from developing those selected materials.
- Historical cases indicate that when roads are placed in forested areas, it speeds up deforestation, endangering biodiversity and loss of fertile soil.

From the suggestion, road construction on such area and soil type poses a trade- off between economic development and environmental damage[10].

3.4 GENERAL USES OF STABILIZATION

Generally stabilization is applied to improve the quality of the existing soil thereby allowing a reduction in pavement thickness. The layers in pavement structure are so designed to resist shearing, avoid excessive deflections and prevent excessive permanent deformation through densification. As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is increased so that a reduction in the required thickness of the pavement will be achieved[9].

a) QUALITY IMPROVEMENT

Through stabilization the most common improvements achieved include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and strength[4].

b) THICKNES REDUCTION

The strength and stiffness of a soil layer can be improved through the use of additives to permit a reduction in design thickness of the stabilized material compared with an unstabilized or unbound material[9].

3.5 RECENT EXPERIENCE IN COST- BENEFIT ANALYSIS

Millions of dollars can be saved by soil subgrade stabilization in comparison to cutting out and replacing the unstable subgrade soil. When included in pavement design, stabilizing the subgrade can result in reducing the thickness of other pavement layers. In one case 5 inches of bituminous base course and 2 inches of granular crushed stone base were eliminated[15].

- In the late 1990's, PennDOT District 12 (southeast of Pittsburgh) and the Pennsylvania Turnpike Commission treated the subgrade during the reconstruction of two major highway sections: I-79 south of Washington, Pa. and 9 miles of Turnpike near New Stanton, PA. In addition, the hot mix asphalt industry in Pennsylvania has discussed a subgrade design and construction philosophy to assure a strong foundation for "Perpetual Pavement".

The Pennsylvania Turnpike specified a "lime-pozzolan" by-product (LKD) from lime

production for subgrade stabilization. After complete removal of the existing roadway,

LKD treatment was used to stabilize the subgrade in lieu of undercutting and removing two feet of existing soil and backfilling with shot rock. The LKD application rate was reported to be between 6% and 8%. The cost of lime-pozzolan treatment was reported to be about $4.28/m2 for lime treatment as compared to $28/m2 for undercutting and backfilling.

In one of their current reconstruction projects, the Pennsylvania Turnpike design has shown that the stabilization subgrade attains adequate strengths to substantially reduce the total pavement section[15].

- The City of Indianapolis has permitted lime-fly ash for subgrade stabilization for nearly 15 years. The increased subgrade strength can be used in design, reducing the overall pavement design thickness. The City of Columbus and some Ohio counties have recently approved similar guidelines[15].

- Recently a project to reconstruct a portion of the Pennsylvania Turnpike included chemical stabilization with lime kiln dust as well as removal and replacement of unsuitable subgrade material. The comparative costs, about $3.50/sq.yd. for lime stabilization compared to about $23.50/sq.yd. for remove and replace, showed a significant savings for stabilization[15].

- Another example is described in a report based on Kentucky DOT bid data from 1997. Eight inches of lime stabilized soil is compared to the cost of replacing the soil with 8 inches of crushed stone.

Eight inches stabilized soil:	Eight inches crushed stone plus fabric:
1. soil mixing = $1.49/sq.yd.	1. excavation @ $2.90/cu.yd. = $0.64 sq.yd.
2. hydrated lime @ 5% = $1.46/sq.yd.	2. rushed stone @ $16.33/ton = $4.85/sq.yd.
3. bituminous curing seal = $0.26/sq.yd.	3. geotextile fabric = $1.41/sq.yd.
$3.21 sq.yd.	$6.90/sq.yd.[15]

- The permanent improvement to pavement subgrade from lime-fly ash stabilization can realize substantial reduction of the total required pavement thickness. For example, Illinois DOT studies show by increasing the CBR from 2 to 8, the pavement granular base thickness can be reduced from 15 to 7 inches[15].

- On the reconstruction project of the Somerset County section of the Pennsylvania Turnpike, stabilization allowed for the reduction of 5 inches of bituminous concrete base course and 2 inches of granular base aggregate, savings more than $4 million. This is equivalent to over 20% of the cost of the pavement design based on untreated subgrade[15].

4 METHODOLOGY AND DATA SAMPLING

4.1 GENERAL

The under listed methodology were adopted for developing the model as well as for analysing cost of replacing versus stabilizing.

4.1.1 METHODOLOGY FOR COST ANALYSIS OF REPLACING

Cost for replacing the existing expansive soils with borrow material was done from the computation of the following parameters which were classified as Quantitative and Qualitative cost;

4.1.1.1 PARAMETERS USED FOR QUANTITATIVE COST ANALYSIS

I. Road Prism/Road Section (Annex 1)

- Clearing
  - Top Soil
- Undercut /Unsuitable Material Excavation
- Disposal of Undercut Excavation/Unsuitable Material
- Reinstating of Undercut Disposal site

II. Preparation for Suitable/Borrow Material Development

- Clearing
  - Top Soil Excavation/Overburden Excavation

III. Suitable/Borrow Material Development

- Production of Suitable/Borrow Materials
- Transportation of Suitable Material

IV. Placing of Suitable/Borrow Material

- Placement of Suitable/Borrow Material

V. Reinstatement of Suitable/Borrow areas

- Reinstate the excavated section of Suitable Material area with Overburden

VI. Cleared forest or grass

- Measuring the type and quantity of lost forest or grass

4.1.1.2 PARAMETERS USED FOR QUALITATIVE COST ANALYSIS

I. Loss of wild animals and birds
II. Loss of food from forest used by local people
III. Loss of herbal medicine from forest used by local people

4.1.2 METHODOLOGY FOR COST ANALYSIS OF STABILIZING

Cost for stabilizing the existing light grey expansive soil was carried out using the following procedures;
Samples from four different road section, were collected and the following tests were done for the light grey expansive soil without stabilizing agent in the laboratory;

1. Atterberg Limit
2. Sieve Analysis
3. Proctor Density + CBR one point
4. Volumetric Shrinkage Limit

After this test is over, same type of collected soil sample with stabilizing agent(lime) has undergo the same test done above.
Following completeion of the above tests, the following parameters were used for quantitative cost analysis of stabilizing;

4.1.2.1 PARAMETERS USED FOR QUANTITATIVE COST ANALYSIS OF STABILIZED SOIL

I. Road Prism/Road Section (Section attached in Annex 1)

- Clearing
  - Top Soil

II. Transportation of Stabilizer

- Purchase of Stabilizer
- Transportation of Stabilizer
- Stocking of Stabilizer

III. Placing of Stabilizer

- Dumping of Stabilizer
- Mixing of Stabilizer
- Placement of Stabilizer

4.2 DATA COLLECTION

Data collection is carried out in two phases, Primary data collection and Secondary data collection.

Primary data are collected on actual site taking physical measurement of the existing parameters described above and from local people through interview while secondary data were taken from different Organization. All actual site measurement of each parameter is taken from 1000 ha area of the project as these area were the only accessible site during this study. The method adopted during data collection were;

4.2.1 PRIMARY DATA

1. Selection of representative section from different types of roads
2. Selection of representative section of borrow site
3. Marking of selected representative section
4. Examining of the existing natural vegetation, soil characterstics, wild animals and birds
5. Taking representative soil sample and transporting to laboratory
6. Conducting laboratory test and recording laboratory test result
7. Recording performance of all the resources applied for those parametrers within the representative section

4.2.2 SECONDARY DATA

1. Examining previously recorded data from different Organization
2. Recording all relevant data

4.3 SAMPLING

Since Non-probability sampling represents a group of sampling techniques that help researchers to select units sample from a population that they are interested in studying, this sampling method is adopted. Procedures followed for sampling were;

4.3.1 PRIMARY DATA

1. Survey of existing original ground condition
2. Selection of representative section of different types of roads
3. Selection of representative section of borrow site
4. Marking of selected representative section
5. Examining of the existing soil characterstics, natural vegetation, wild animals and birds
6. Taking representative soil sample, natural vegetation, wild animals and birds

4.4 SAMPLE SIZE

Soil samples of light grey expansive soils from different road sections of Gambella-Alwero-Rice-Project have been collected for the investigation.

Since the nature and distribution of the existing soil do have same property within this particular project location , samples of soils from 4 test pit from each road section were taken from 0.5m depth below the ground surface (because the construction of a road could affect the subgrade soil up to such depth).

5 COST-BENEFIT ANALYSIS OF REPLACING VERSUS STABILIZING

5.1 GENERAL

The decision to use either method depends on how much cost and benefit will be applied. To show the cost-benefit analysis of these two methods separate analysis of each method is done here under.

5.2 COST- BENEFIT ANALYSIS FOR REPLACING

Removing the existing expansive soils and replacing with non expansive soils to provide stable foundation material is a common practice in Ethiopia.
The mechanism for providing stable foundation through removal and replacement method is achieved through moisture content control of the underlying clay layer which results in mitigating expansive potential of the soil.

5.2.1 BASIC REQUIREMENT

To overcome the expansive potential of the soil with replacement of the nearby non-expansive soil selected from cost effective distance, the basic requirements which were examined before proceeding with replacement are;

- Soil characterstics of the existing expansive soil
- the type of replacement material required,
- the depth of replacement required,
- the extent of replacement
- the avaialability of replacement material and
- its disadvantage in relation to the environment
- its advantage to the project
- its disadvantage to the project

5.2.1.1 CHARACTERISTICS OF EXPANSIVE SOIL

Soil sample of the existing expansive soil from different road section were taken to examine their characteristics in the laboratory. The laboratory result from 5 test pit revealed that the expansive soil experiences the following properties listed hereunder Table 5.1. Detail of Test Results are annexed on annex 5.

From the table above, the test indicate as most of the soil have a value of CBR < 3% and Medium Swell Potential with a value of Liquid Limit 50-60 as well as Plastic limit 25-35. These value of laboratory test indicates as the existing material is expansive soil which needs to be replaced with other selected material used for road construction.

Table 5.1 Laboratory test result for existing soil

Sr. No	Test Pit No	Sieve Analysis, % Passing (AASHTO T27-84)				Atterberg Limits		AASHTO Classification	OMC %	Max. Dry Density g/cm^3	CBR Value (%)		Swell %	Linear Shrinkage Limit
		4.75 mm	2.0 mm	0.425 mm	0.075 mm	LL %	PI %				at 2.54	at 5.08		
1	TP1	100	99	90	71.8	44	22	A-7-6(17)	16.00	1.703	2.5	2.8	2.19	12.86
2	TP2		100	87	60.5	51	27	A-7-6(13)	13.01	1.802	4.6	4.7	1.62	13.57
3	TP3	100	97	87	68.1	54	25	A-7-6(15)	13.40	1.792	1.6	1.3	3.02	17.50
4	TP4		100	88	66.6	51	24	A-7-6(13)	12.65	1.808	2.3	2.2	2.53	17.14

5.2.1.2 TYPE OF REPLACEMENT MATERIAL REQUIRED

Type of replacement material to be used should exhibit CBR value of > 3% and very low Swell potential (LL<50 and PI < 25 or Percent Swell < 3%).

To satisfy the requirements, samples from different borrow pits from a depth of 2m were taken for laboratory test at site. Selection of these different borrow pits were made taking into account the following criteria;

- quality
- quantity
- average distance
- accessebility
- its relation with the environment

Table 5.2 shows summary of laboratory test result conducted at site laboratory for selected material from different test pit. Details are annexed on annex 6.

Table 5.2 Test result for selected materials

Sr. No	Test Pit No	CBR Value (%)		Swell %
		at 2.54	at 5.08	
1	TP1	9	10	0.4
2	TP2	6	5	2.5
3	TP3	11	12	0.5
4	TP4	9	9	0.9
5	TP5	8	8	1.4

From the test result obtained and with those criteria set above, test pit 1 (TP1) was selected for the analysis of this investigation.

- DEPTH OF REPLACEMENT MATERIAL REQUIRED

As per the design made by the designer of the project NESPAK [2], the depth of replacement for the existing expansive soil is 50 cm.

- EXTENT OF REPLACEMENT MATERIAL REQUIRED

From the designer report of NESPAK [2], though the depth of replacement for the existing expansive soil is 50 cm, the extent of replacement is the whole width of the road section.

- AVAILABILITY OF REPLACEMENT MATERIAL

Though different selected material pits are available at site, taking into account the shortest distance and the criteria under the specification, TP1 which is located at an average radius of 2 km is selected for this analysis. Also the project is now exercising replacing from this source.

- DISADVANTAGE IN RELATION TO ENVIRONMENT

As the borrow material is developed, the environment encountered loss of forest or grass, loss of fertile soil, loss of wild animals and birds, loss of food and herbal medicine from forest used by local people.

- ADVANTAGE TO THE PROJECT

The process of removing and replacing the existing expansive soil will not have any delay to construction as it could be started immediately.

- DISADVANTAGE TO THE PROJECT

Since non expansive, which is impervious, fill material must be obtained, this has a cost factor in relation to distance from which the material is imported. The distance less than 2 km radius could provide better cost saving than 2km radius.[4]

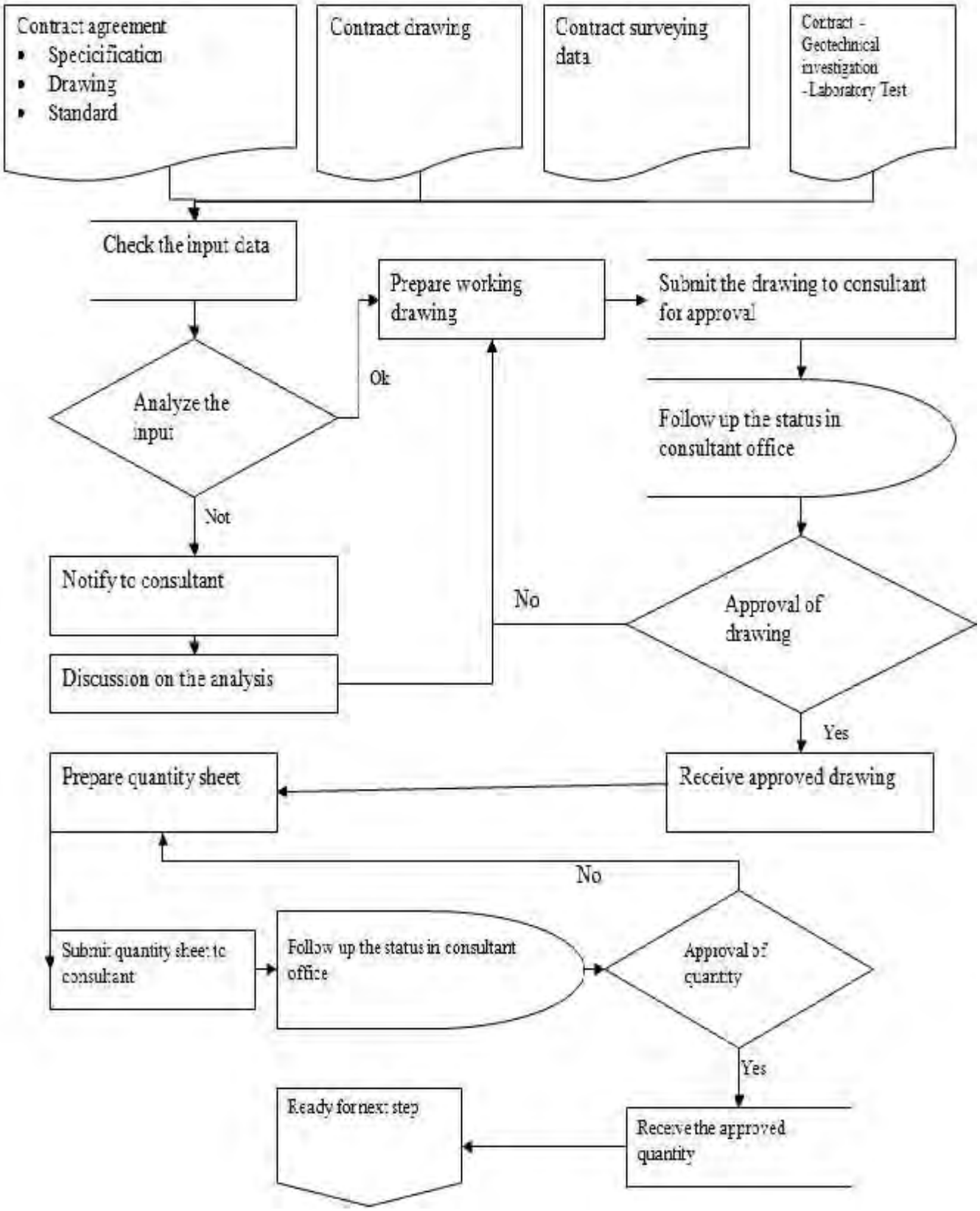
5.2.2 COST- BENEFIT ANALYSIS OF REPLACING

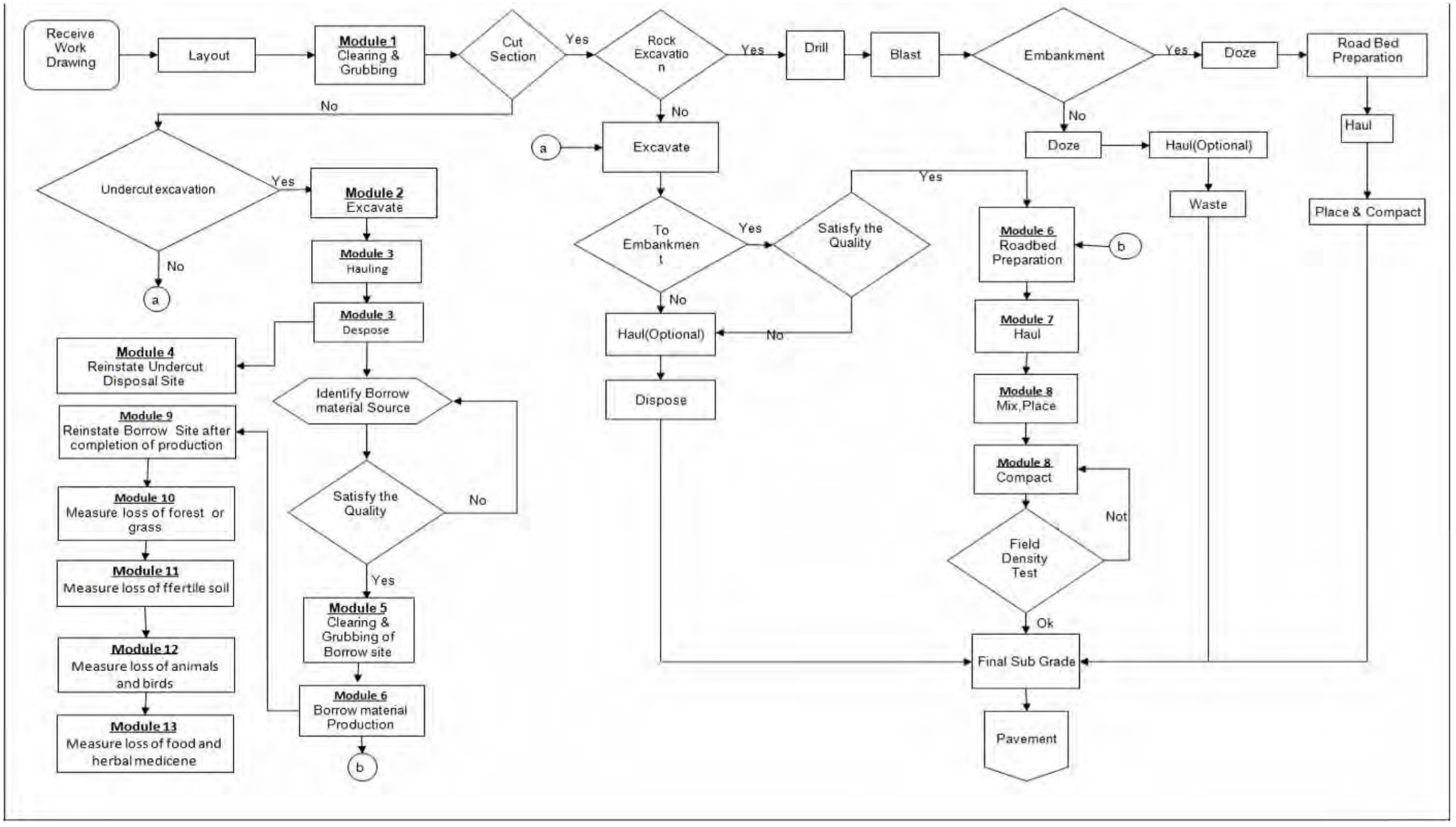
The process for cost-benefit analysis of replacing is shown using the following work breakdown structures.

5.2.2.1 WORK BREAKDOWN STRUCTURE FOR WORKING DRAWINGS

Fig. 5.1 shows the work breakdown structure before the start of replacing the existing expansive soil. The information's obtained from this diagram were;

- exact location of road section
- identification of the overall soil type within the project area
- volume of work
- preliminary geotechnical investigation and laboratory test
- contractual obligation


Contract agreement
• Specicification
• Drawing
• Standard
Contract drawing
Contract surveying data
Contract -
Geotechnical investigation
-Laboratory Test
Check the input data
Prepare working drawing
Submit the drawing to consultant for approval
Analyze the input
Ok
Follow up the status in consultant office
Not
Notify to consultant
No
Approval of drawing
Discussion on the analysis
Yes
Prepare quantity sheet
Receive approved drawing
No
Submit quantity sheet to consultant
Follow up the status in consultant office
Approval of quantity
Yes
Ready for next step
Receive the approved quantity


Receive Work Drawing
Layout
Module 1 Clearing & Grubbing
Cut Section
Yes
Rock Excavation
Yes
Drill
Blast
Embankment
Yes
Doze
Road Bed Preparation
No
No
No
Undercut excavation
Yes
Module 2 Excavate
a
Excavate
Haul
Doze
Haul(Optional)
Waste
Place & Compact
No
a
Module 3 Hauling
To Embankment
Yes
Satisfy the Quality
Yes
Module 6 Roadbed Preparation
b
Module 3 Despose
No
Haul(Optional)
No
Module 7 Haul
Module 4 Reinstate Undercut Disposal Site
Dispose
Module 8 Mix,Place
Identify Borrow material Source
Module 8 Compact
Module 9 Reinstate Borrow Site after completion of production
Satisfy the Quality
No
Not
Field Density Test
Module 10 Measure loss of forest or grass
Yes
Ok
Module 11 Measure loss of ffertile soil
Module 5 Clearing & Grubbing of Borrow site
Final Sub Grade
Module 12 Measure loss of animals and birds
Module 6 Borrow material Production
Pavement
Module 13 Measure loss of food and herbal medicene
b

Since this research focused on partial section of the flow chart of Fig. 5.1, description of some of those activities for cost analysis were discussed hereunder as per ERA Standard Technical Specifications while for some of the others, Population and species composition of Vegetation were examined as per the existing condition on the site.

A. Description of activities as per ERA Standard Technical Specifications;

I.Road Prism/Road Section

1. Clearing [8]

Clearing is defined as the removal of all trees, brush, other vegetation,rubbish, fences and all other objectionable material including the disposal of all material resulting from the clearing.

1.1 Top Soil [8]

Top soil is defined as the soil to be removed after clearing and grubbing of the natural ground surface within the width of the road prism is completed. The depth of top soil to be removed could be be either zero or an average depth between 150 mm and 400 mm. Stckpiling of topsoil is in heaps where the height is not more than 3 meters.

2. Undercut Excavation/Removal of Unsuitable Material [8]

Undercut is the removal of any material, occurring below the existing ground surface which is considred as unsuitable for road construction. The excavated section of the road is then be backfilled with approved imported material compacted to the required density.

3. Disposal of Undercut Excavation/Unsuitable Material [8]
It is the disposal of those excavated soil which are unsuitable for use in the works in specially designated areas assigned for this disposal.

II.Prepartion for Borrow Development [8]

Preparation of borrow development is the excavation of the necessary trial holes, taking of such samples in laboratory for necessary tests to be conducted so as to satisfy the required specification requirement.

4. Clearing [8]

Clearing is defined as the removal of all trees, brush, other vegetation,rubbish, fences and all other objectionable material including the disposal of all material resulting from the clearing.

4.1 Top Soil [8]

Top soil is defined as the soil to be removed after clearing and grubbing of the natural ground surface within the width of the road prism is completed. The depth of top soil to be removed could be be either zero or an average depth between 150 mm and 400 mm. Stckpiling of topsoil is in heaps where the height is not more than 3 meters.

III.Suitable/Borrow Material Development

5. **Production of Suitable/Borrow Materials** [8]

This is the development of borrow material using heavy duty machine where special care is needed when excavating near the floor and outer boundaries of borrow areas so as to reduce as far as possible the amount of earthmoving that will be necessary for the finishing-off of borrow pits. Indiscriminate excavation without due regard for the desired final shape of the borrow pit will not be permitted.

6. **Transportation of Suitable/Borrow Material**

It is the transporation of Borrow material from its source to the place where the material is intended to be dumped through appropriate service road.

IV.Placing of Suitable/Borrow Material

7. **Placement of Suitable/Borrow Material** [8]

Placing of fill material is the process of depositing the material on the compacted underlying surface, and evenly spread over the whole of the designated area.

V.Reinstatement of Suitable/Borrow areas

8. **Reinstatement of Suitable/Borrow Material pit** [8]

On completion of development of borrow in areas of borrow pits, the borrow pit needs reinstate with top soil so as allow the re-establishment of vegetation where the borrow pit will be shaped to even contours.

B. POPULATION AND SPECIES COMPOSTION OF VEGETATION

While taking the representative sample, areas with no or minimum human interference or deforestation and as well as clearing was never practised were selected nearby TP1. Three sites with a total area of 625 m2 was marked and the population of Shrubs and Trees were counted.

All those plants measuring below 8m height were considered as Shrubs while those above 8m were counted as Tree. As per the query made on the site for the local people, the use of these vegetation by the local people is also annexed on annex 4.

Table 5.3 shows the type and volume of vegetation obtained after investigation carried out on the marked section of the borrow area;

Table 5.3 Type and volume of vegetation available on the borrow site of the project

Sample	Type of Vegetation		Total (Pcs/ 625M^2)	Total (Pcs/ M^2)	Total (Pcs/ha)
	Shrubs	Trees			
1	60	1	61	0.0976	976
2	46	11	57	0.0912	912
3	78	3	81	0.1296	1,296
Average	**61**	**5**	**66**	**0.1061**	**1,061**

C. TYPE AND NUMBER OF WILD ANIMALS

As per the information we have from Ethiopian Wildlife Conservation Authority, the type of wild animals are listed hereunder table 5.4

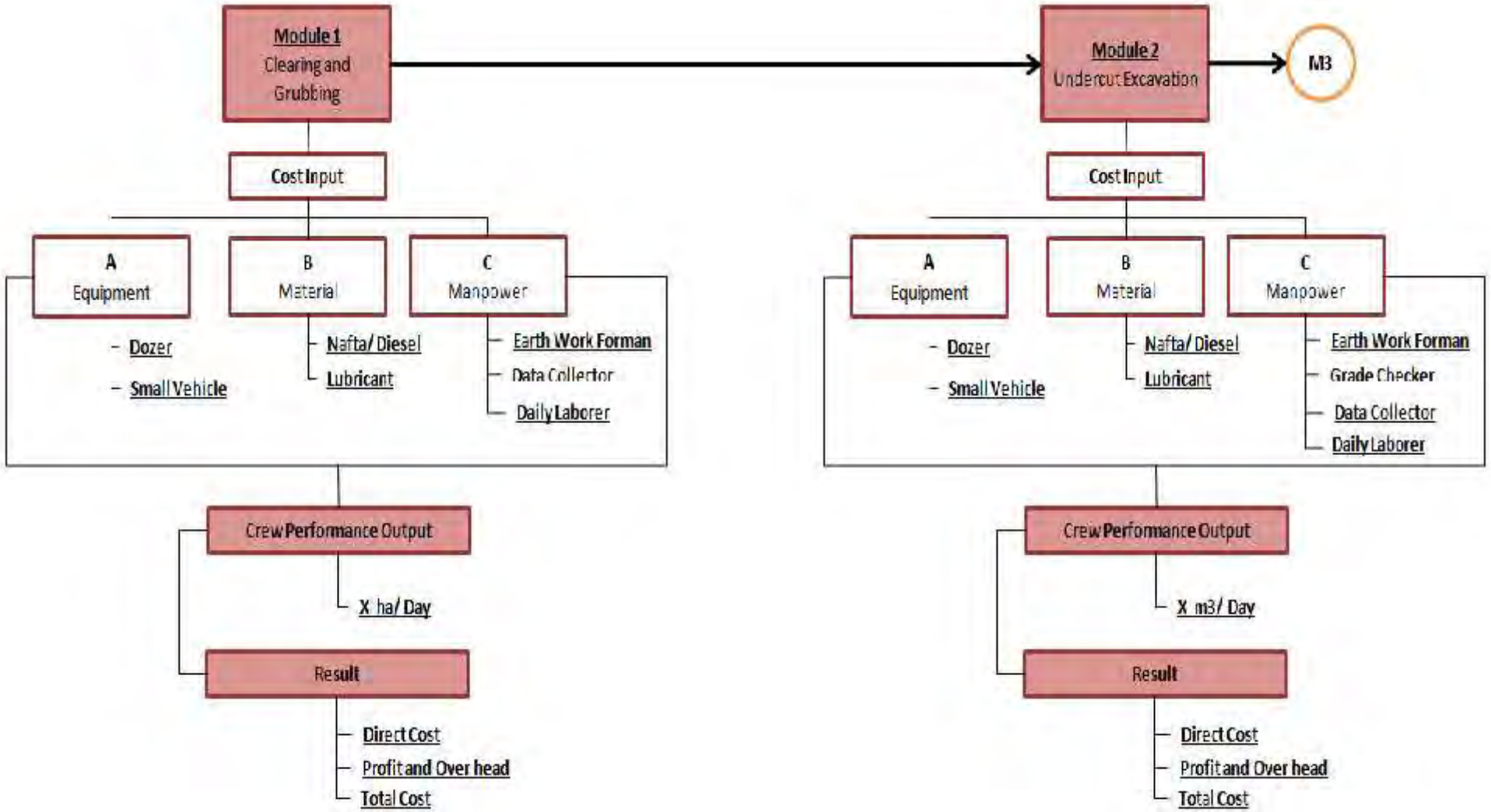
Table 5.4 Type of Wild Animals on project

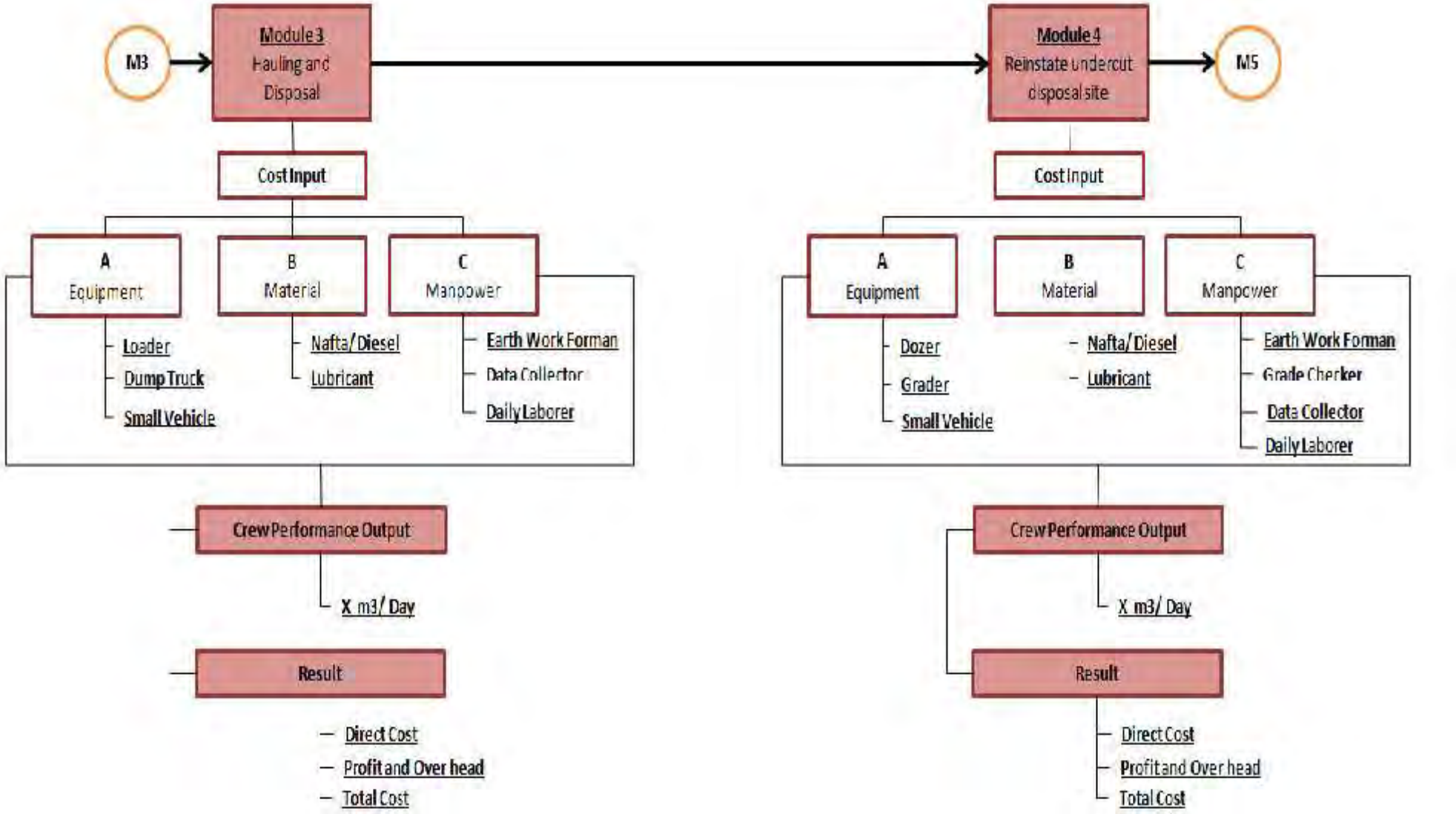
No	Type of Wild Animals
1	White Eared Kob
2	Leopard
3	Lion
4	Monkey
5	Baboon
6	Duiker
7	Elephant
8	Buffalo
9	Nile leechwe
10	Different types of Birds

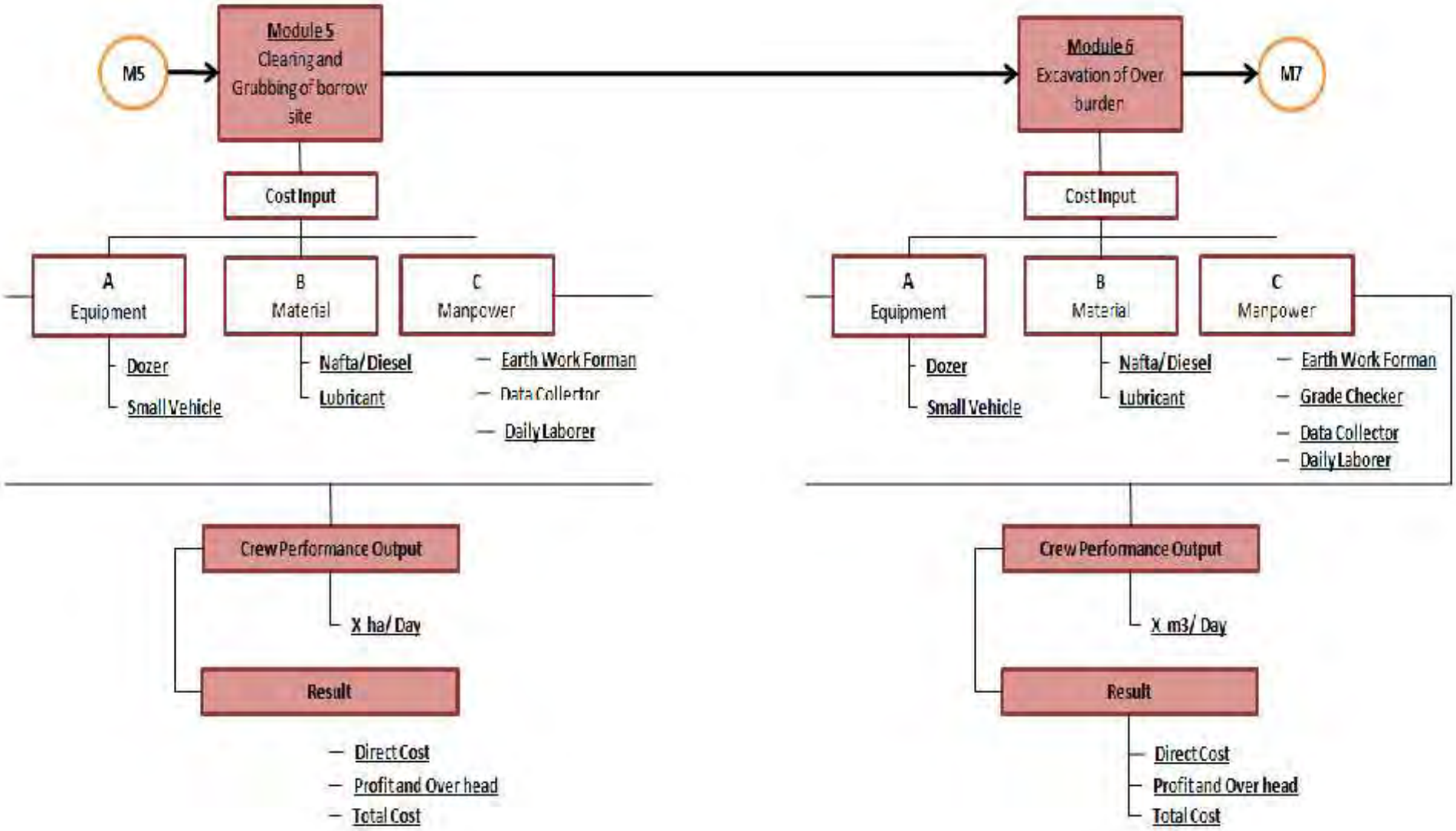
With those description of the activities, the cost incurred in each activity was computed dividing the cost parameters into quantitative and qualitative cost where the parameters are discussed under item 4.1.1.1and 4.1.1.2.

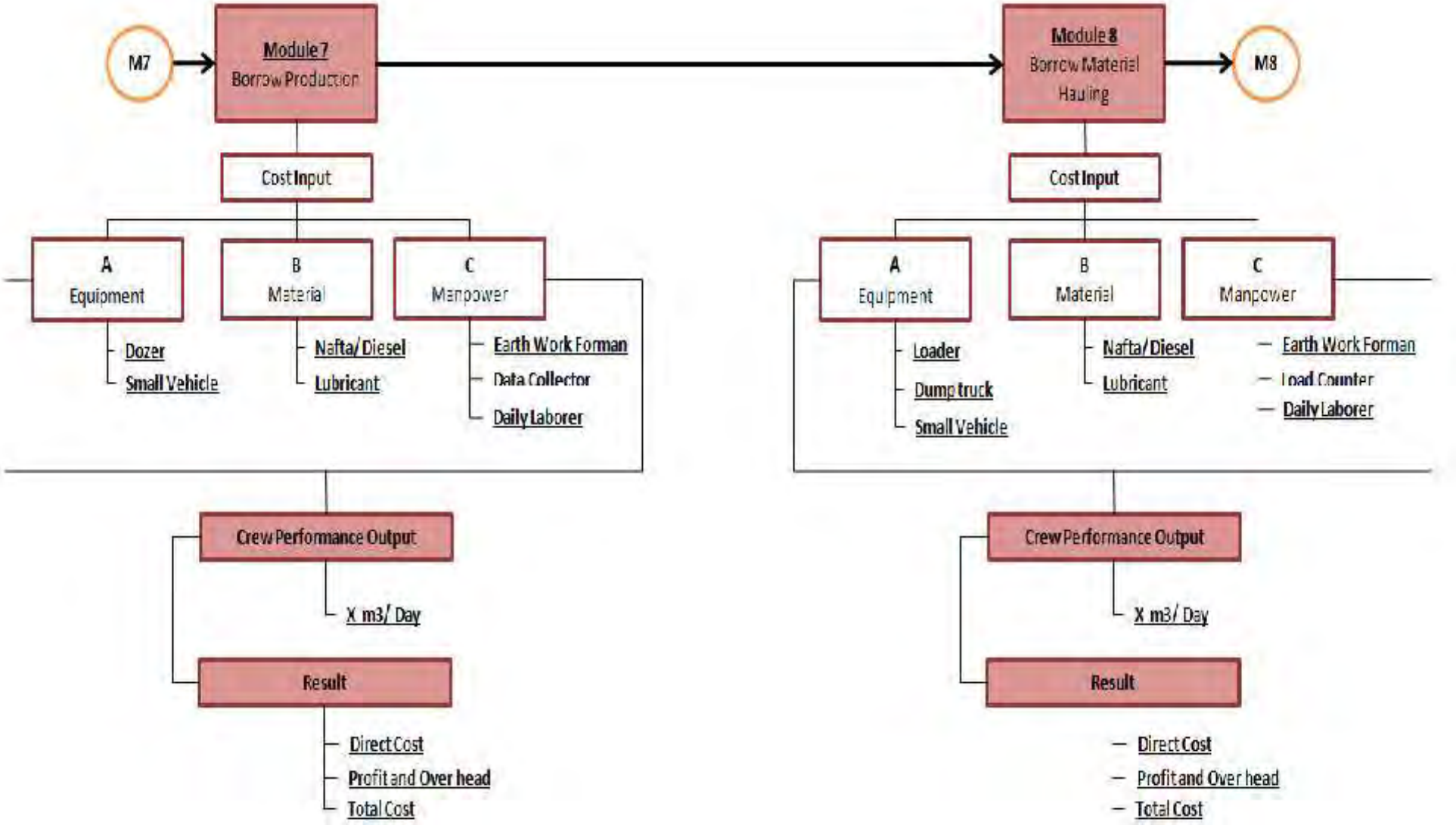
5.2.2.3 COST OF REPLACING

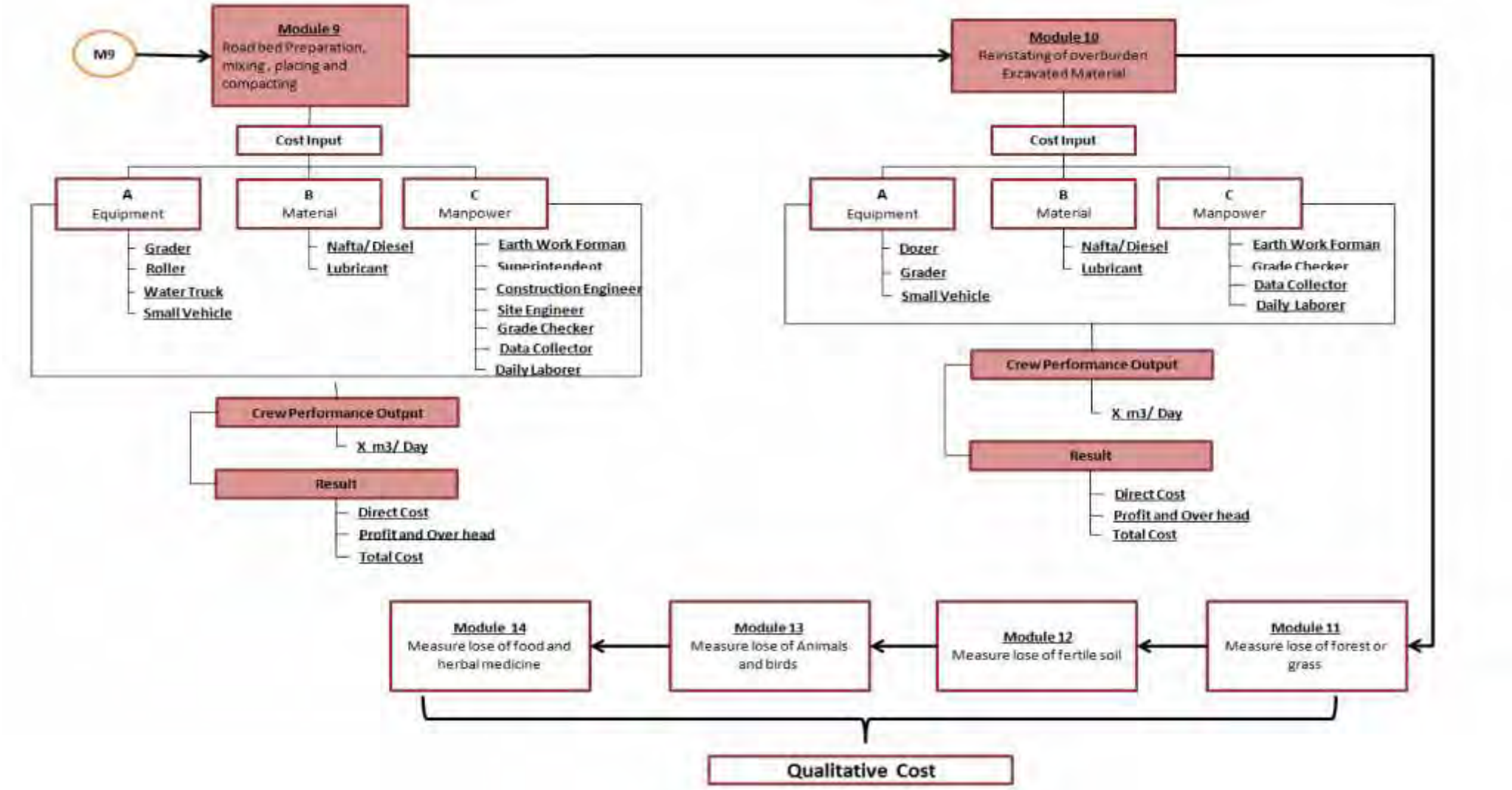
Cost breakdown structure for replacing the existing expansive soil is shown in fig.5.3.


Module 1
Clearing and Grubbing
Module 2
Undercut Excavation
M3
Cost Input
Cost Input
A
Equipment
B
Material
C
Manpower
A
Equipment
B
Material
C
Manpower
Dozer
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Data Collector
Daily Laborer
Dozer
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X ha/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost


M3
Module 3
Hauling and Disposal
Module 4
Reinstate undercut disposal site
M5
Cost Input
Cost Input
A
Equipment
B
Material
C
Manpower
Loader
Dump Truck
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Data Collector
Daily Laborer
A
Equipment
B
Material
C
Manpower
Dozer
Grader
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X m3/ Day
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Result
Direct Cost
Profit and Over head
Total Cost


M5
Module 5
Clearing and Grubbing of borrow site
Module 6
Excavation of Over burden
M7
Cost Input
Cost Input
A
Equipment
B
Material
C
Manpower
A
Equipment
B
Material
C
Manpower
Dozer
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Data Collector
Daily Laborer
Dozer
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X ha/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost


M7
Module 7
Borrow Production
Module 8
Borrow Material
Hauling
M8
Cost Input
Cost Input
A
Equipment
B
Material
C
Manpower
Dozer
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Data Collector
Daily Laborer
A
Equipment
B
Material
C
Manpower
Loader
Dump truck
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Load Counter
Daily Laborer
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost


M9
Module 9
Road bed Preparation, mixing , placing and compacting
Cost Input
A
Equipment
Grader
Roller
Water Truck
Small Vehicle
B
Material
Nafta/ Diesel
Lubricant
C
Manpower
Earth Work Forman
Superintendent
Construction Engineer
Site Engineer
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Module 10
Reinstating of overburden Excavated Material
Cost Input
A
Equipment
Dozer
Grader
Small Vehicle
B
Material
Nafta/ Diesel
Lubricant
C
Manpower
Earth Work Forman
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Module 11
Measure lose of forest or grass
Module 12
Measure lose of fertile soil
Module 13
Measure lose of Animals and birds
Module 14
Measure lose of food and herbal medicine
Qualitative Cost

Following the above examined data and the procedures, an excel plate is developed to analyze the cost of replacing. The Cost analysis for quantitative and qualitative parameters are annexed on annex 2.

A. RESULT OF QUANTITATIVE COST ANALYSIS

Result of quantitative cost is tabulated in Table 5.5 hereunder;

Table 5.5 Quantitative unit cost for replacing

No	Activity	Unit Price (Birr/M^2)	Unit Price (Birr/Km)
	I. Road Prism/Road Section		
1	Clearing and Grubbing within Road Prism	4,29	34.326,01
2	Under Cut Excavation	44,85	358.819,00
3	Disposal of Under Cut Excavation	95,69	294.431,25
4	Reinstating of Undercut Disposal Site	4,29	422.394,20
	II. Preparation for Suitable/Borrow Material Development		
5	Clearing and Grubbing for Borrow Production	44,85	34.326,01
5,1	Excavation of Overburden	44,85	358.819,00
	III. Suitable/Borrow Material Development		
6	Borrow Production	13,18	263.601,75
7	Transportation of Borrow material	57,22	176.061,63
	IV. Placing of Suitable/Borrow Material		
8	Road bed preparation & Placing of Borrow Material	17,81	356.276,60
	V. Reinstatement of Suitable/Borrow areas		
9	Reinstating of Overburden Excavated material	70,40	563.192,26
	VI. Cleared forest or grass		
10	Cost for lost forest or grass	-	***
	VI. Loss of fertile soil,		
11	Cost for lost fertile soil	-	****
	Total Quantitative Cost	**397.44**	**2,862,247.71**

****

During the study of this research, it was difficult to get unit price for those lost forest during borrow development at national level. And hence it is assumed to have high benefit for the local people. However it is hoped the unit price to be investigated by other investigator who have the knowledge and access to this field.

****

Though it has become difficult to put the loss in Birr/M^2, the income that is expected per year as a result of loss of wild animals is annexed on annex 2 to show the possible benefit that the local administration could lose.

B. RESULT OF QUALITATIVE COST ANALYSIS

Result of qualitative cost is tabulated in Table 5.6 hereunder;

Table 5.6 Qualitative unit cost for replacing

No	Activity	Unit Price (Birr/M^2)	Unit Price (Birr/Km)
1	Lost Food Cost used from Forest by local people		**
2	Lost Herbal Medicine Cost used from Forest by local people		***
3	Loss of trees having spiritual value		****
	Total Qualitative Cost		

****,***,******

Since it was difficult to get the quantity and unit price for those qualitative parameters it is assumed to have high benefit for the local people which will be investigated further by other investigator.

TOTAL COST OF REPLACING = A (QUANTITATIVE COST) + B (QUALITATIVE COST)

= <u>397.44</u> Birr/M^2

= <u>2,862,247.71</u> Birr/Km

5.3 COST- BENEFIT ANALYSIS FOR STABILIZING

As per the book of the department of the army, the navy, and the air force October 1994 [9], to stabilize a soil so as to improve its engineering properties, there are a number of stabilizers applicable for one soil type, however, there are some general guidelines that make specific stabilizers more desirable based on soil granularity, plasticity, or texture.[9]

5.3.1 BASIC REQUIREMENT

Using the book of department of the army, the navy, and the air force October 1994 [9], in the selection of a stabilizer, the basic requirement that must be considered are;

- the type of soil to be stabilized,
- the purpose for which the stabilized layer will be used,
- the type of soil improvement desired, the required strength and durability of the stabilized layer,
- the depth of Stabilizing required,
- the extent of Stabilizing
- disadvantage to the project

    - TYPE OF SOIL TO BE STABILIZED

Type of soil to be stabilized is shown in table 5.1 where the soil is classified as expansive soil which needs improvement before permanent road is built on it.

    - PURPOSE OF STABILIZED LAYER

The purpose of the stabilized layer is to serve as a subgrade material below the pavement.

    - TYPE OF SOIL IMPROVEMENT DESIRED

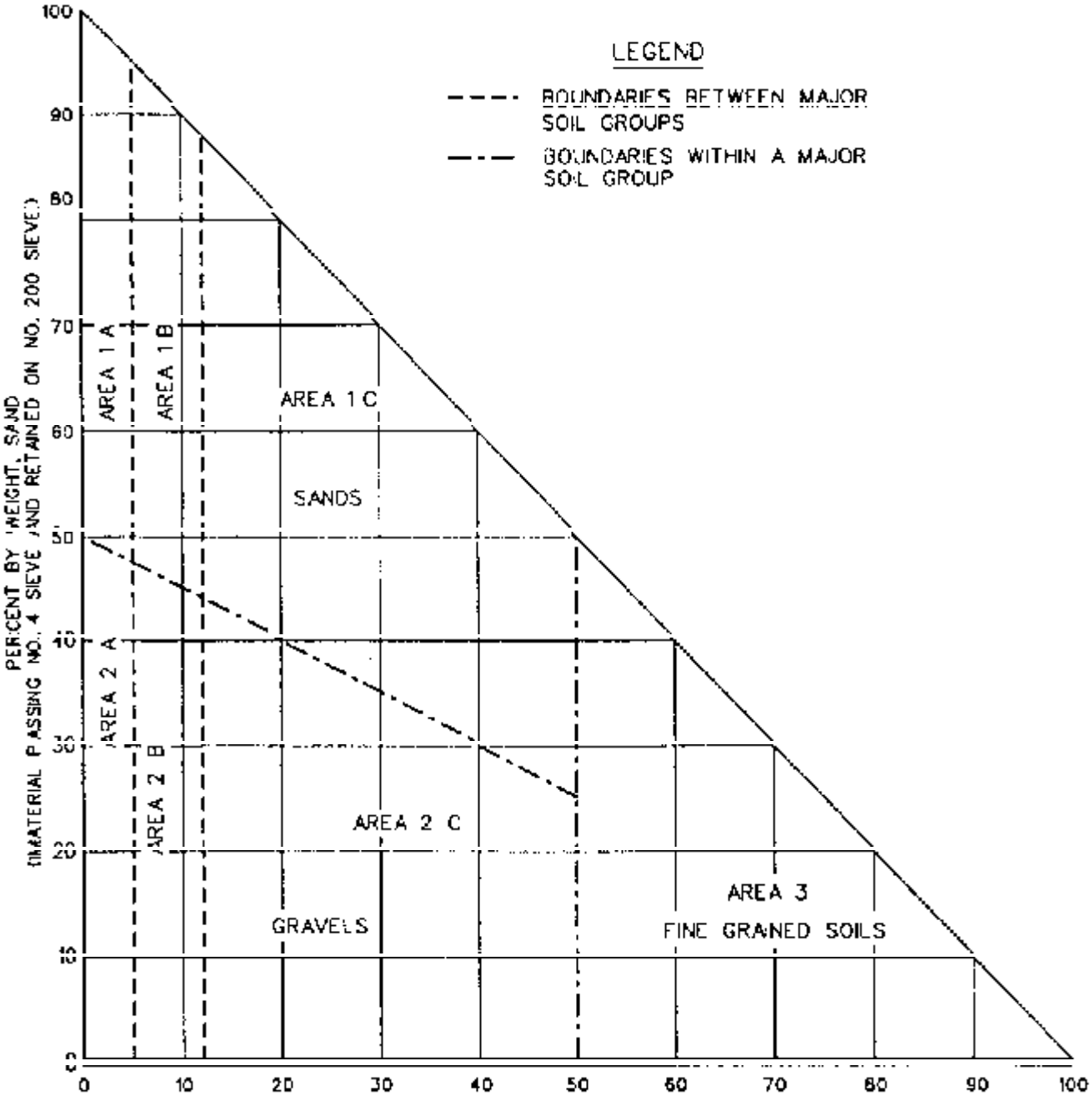
Since the existing soil tested in the laboratory exhibit expansive property, the soil needs improvement where the improvement needed were its liquid limit, plasticity index and CBR value.

    - DEPTH OF STABILIZING AGENT REQUIRED

As per the book of department of the army, the navy, and the air force October 1994 [9], the depth to which lime should be incorporated into the soil is generally limited by the construction equipment used but 2 feet (60cm) to 3 feet (91cm) is the maximum depth that the existing soil can be treated directly without removal of the soil. However, the design made by the designer of the project, NESPAK, the depth of stabilizing for the existing expansive soil is 50 cm which is below the limit of 60-91 cm.

    - EXTENT OF STABILIZING

As per the design made by the designer of the project NESPAK [2], the extent of stabilizing is the whole width of the road section.


LEGEND
BOUNDARIES BETWEEN MAJOR SOIL GROUPS
BOUNDARIES WITHIN A MAJOR SOIL GROUP
PERCENT BY WEIGHT, SAND (MATERIAL PASSING NO. 4 SIEVE AND RETAINED ON NO. 200 SIEVE)
AREA 1 A
AREA 1 B
AREA 1 C
SANDS
AREA 2 A
AREA 2 B
AREA 2 C
GRAVELS
AREA 3
FINE GRAINED SOILS
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100

Area	Soil Class.[a]	Type of Stabilizing Additive Recommended	Restriction on LL and PI of Soil	Restriction on Percent Passing No. 200 Sieve[a]	Remarks
1B	SW-SM or SP-SM or SW-SC or SP-SC	(1) Bituminous	PI not to exceed 10		
		(2) Portland cement	PI not to exceed 30		
		(3) Lime	PI not to exceed 12		
		(4) Lime-cement-fly ash	PI not to exceed 25		
1C	SM or SC or SM-SC	(1) Bituminous	PI not to exceed 10	Not to exceed 30% by weight	
		(2) Portland cement	--[b]		
		(3) Lime	PI not less than 12		
		(4) Lime-cement-fly ash	PI not to exceed 25		
2A	GW or GP	(1) Bituminous			Well-graded material only
		(2) Portland cement			Material should contain at least 45% by weight of material passing No. 4 sieve
		(3) Lime-cement-fly ash	PI not to exceed 25		
2B	GW-GM or GP-GM or GW-GC or GP-GC	(1) Bituminous	PI not to exceed 10		Well-graded material only
		(2) Portland cement	PI not to exceed 30		Material should contain at least 45% by weight of material passing No. 4 sieve
		(3) Lime	PI not less than 12		
		(4) Lime-cement-fly ash	PI not to exceed 25		
2C	GM or GC or GM-GC	(1) Bituminous	PI not to exceed 10	Not to exceed 30% by weight	Well-graded material only
		(2) Portland cement	--[b]		Material should contain at least 45% by weight of material passing No. 4 sieve
		(3) Lime	PI not less than 12		
		(4) Lime-cement-fly ash	PI not to exceed 25		
3	CH or CL or MH or ML or OH or OL or ML-CL	(1) Portland	LL less than 40 and PI less than 20		Organic and strongly acid soils falling within this area are not susceptible to stabilization by ordinary means
		(2) Lime	PI not less than 12		

[a] Soil classification corresponds to MIL-STD-619B. Restriction on liquid (LL) and plasticity index (PI) is in accordance with Method 103 in MIL-STD-621A.

[b] $PI \leq 20 + \frac{50 - \text{percent passing No. 200 sieve}}{4}$

Data required to enter table 5.7 are;

- the area determined from figure 5.4 is then found in the first column of table 5.7 and
- also provided in the second column of table 5.7 is a listing of soil classification symbols applicable to the area determined from figure 5.4.
- the selection process is continued with table 5.7 which indicates for each area shown in figure 5.4 candidate stabilizers and restrictions based on grain size and/or plasticity index (PI).

5.3.1.2 TYPE OF STABILIZING MATERIAL REQUIRED

Based on the procedures stated above and the test result obtained from laboratory, the stabilizer selection was done and tabulated under table 5.8.

Table 5.8 Stabilizer Selection

Sr. No	Test Pit No	Sieve Analysis		Area determined from Fig. 5.4	Atterberg Limits	Candidate Stabilizer from Fig. 5.4
		% Passing #200 (AASHTO T27-84)	% Passing #4 and Retained on #200 (AASHTO T27-84)		PI %	
1	TP1	71.8	28.2	Area 3	22	Lime
2	TP2	60.5	39.5	Area 3	27	Lime
3	TP3	68.1	31.9	Area 3	25	Lime
4	TP4	66.6	33.4	Area 3	24	Lime

From table 5.8, it is known that Lime is the appropriate stabilizer for the existing expansive soil.

5.3.1.3 QUANTITY OF STABILIZING MATERIAL REQUIRED

Quantification of quantity of Lime required for stabilization was based on either quicklime or hydrated lime since they act upon clay soils to make the existing soils suitable for highway construction.[9] However it was impossible to get those lime in the market. What was found was crushed Lime obtained from High Grade Limestone which was produced by Derba Cement Factory. As this crushed lime was readily available, a number of tests were conducted to check if it brings improvement on the engineering property of the existing expansive soil thereby to exploit its existence as opportunity. The amount of stabilizer (Lime) needed for the existing expansive soil was done in the laboratory taking different lime treatment levels such as 6, 8 and 10 percent lime for each soil sample taken from site. Summary of the laboratory result for those key points are shown in Table 5.9 hereunder while detail test result is annexed on annex 7.

Table 5.9 Summary of test result for blended lime-soil material

Sr. No	Test Pit No	% Lime	Sieve Analysis, % Passing (AASHTO T27-84)				Atterberg Limits		AASHTO Classification	OMC %	Max. Dry Density g/cm^3	CBR Value %		Swell %	Linear Shrinkage Limit
			4.75 mm	2 mm	0.425 mm	0.075 mm	LL %	PI %				at 2.54	at 5.08		
1	TP1	6	99	97	85	65.4	52	27	A-7-6(15)	15.4	1.856	2.5	2.5	1.95	17.86
		8	98	97	85	66.8	52	27	A-7-6(15)	11.47	1.827	2.7	2.6	1.95	17.14
		10	99	97	84	65.8	48	24	A-7-6(13)	15.85	1.799	2.86	2.96	1.89	16.43
2	TP2	6	99	98	84	61.1	49	25	A-7-6(12)	13.22	1.845	2.6	2.4	1.23	16.43
		8	98	97	83	60	49	27	A-7-6(10)	11.83	1.897	2.7	3.8	1.29	15.71
		10	97	95	83	59.9	48	26	A-7-6(11)	12.25	1.867	2.9	2.6	1.48	15
3	TP3	6	98	96	84	63.5	56	31	A-7-6(16)	14.42	1.803	2.1	2.6	2.23	18.57
		8	99	96	84	63.4	49	27	A-7-6(14)	13	1.829	2.3	2.2	2.92	17.86
		10	95	92	82	62.2	48	24	A-7-6(12)	14.59	1.795	4.1	3.4	1.64	15.71
4	TP4	6	99	97	86	62.6	53	29	A-7-6(14)	14.29	1.763		1.9	2.7	19.29
		8	98	96	85	62.1	52	28	A-7-6(13)	15.02	1.793	2.3	2.2	2.71	18.21
		10	97	95	83	60.9	52	29	A-7-6(14)	11.5	1.807	2.3	2.2	2.63	16

As can be seen from the test result above, there was no significant improvement on the existing expansive soil with different percentage of lime application, rather on some of the lime-soil combination the property tends to worsen than improvement. This was because of the nature of the lime used for stabilization.

The lime that should be used for stabilization was either quicklime or hydrated lime. Following the problems encountered in getting either quicklime or hydrated lime at national level during this investigation, the analysis has focused in using figure 3.5 for determination of design lime content required for stabilization. The lime to be use as per figure 3.5 is hydrated lime. Besides, Derba Cement Factory has installed the factory for production of hydrated lime in the near future. Taking into account its future availability, this investigation proceeds with application of figure 3.5.

Table 5.10 Lime content determination

Sr. No	Test Pit No	Sieve Analysis	Atterberg Limits	Lime required from Fig. 3.5 (%)
		% Passing #40 (AASHTO T27-84)	PI %	
1	TP1	90	22	3.1
2	TP2	87	27	3.8
3	TP3	87	25	3.6
4	TP4	88	24	3.5
			Average Value	3.5

Using the test result of table 5.1 and figure 3.5, the average design lime content used for stabilizing the existing expansive soil was estimated to be 3.5%, as seen on table 5.10.

Hence the 3.5% lime by weight was considered for cost analysis. As the cost analysis is done based on volume, the 3.5% by weight was changed to volume as follows;

- 3.5% by weight was defined as;

  from 100Kg of Lime-Soil material we need 3.5 Kg of lime for stabilization and 96.5 Kg of expansive soil where,

  Specific gravity of soil = Unit weight of soil / Unit weight of water
  Unit weight of soil = Specific gravity of soil X Unit weight of water

  Specific gravity of soil = 2.53
  Unit weight of water = 1000 Kg/M^3

  Unit weight of soil = 2.53 X 1000 Kg/M^3 = 2,530 Kg/M^3

  $1M^3$ of Soil = 2,530 Kg of soil
  1Kg of soil = 0.000395 M^3

  Specific gravity of hydrated Lime = Unit weight of hydrated Lime / Unit weight of water
  Unit weight of Lime = Specific gravity of hydrated Lime X Unit weight of water

  Specific gravity of hydrated Lime = 2.35
  Unit weight of water = 1000 Kg/M^3

  Unit weight of hydrated Lime = 2.35 X 1000 Kg/M^3 = 2,350 Kg/M^3

  $1M^3$ of hydrated Lime = 2,350 Kg of Lime
  1Kg of Lime = 0.000426 M^3

But we have, for 96.5 kg of soil we need 3.5 kg of hydrated lime

i.e. 96.5 kg of soil --- 3.5 kg of hydrated lime

1 kg of soil = 0.000395 M^3

96.5 kg of soil = ? = 0.0381 M^3 of soil.

1 kg of lime = 0.000426 M^3

3.5 kg of soil = ? = 0.00149 M^3 of hydrated lime.

so, 96.5 kg of soil = 0.0381 M^3 of soil -- 3.5 kg of lime = 0.00149 M^3 of lime.

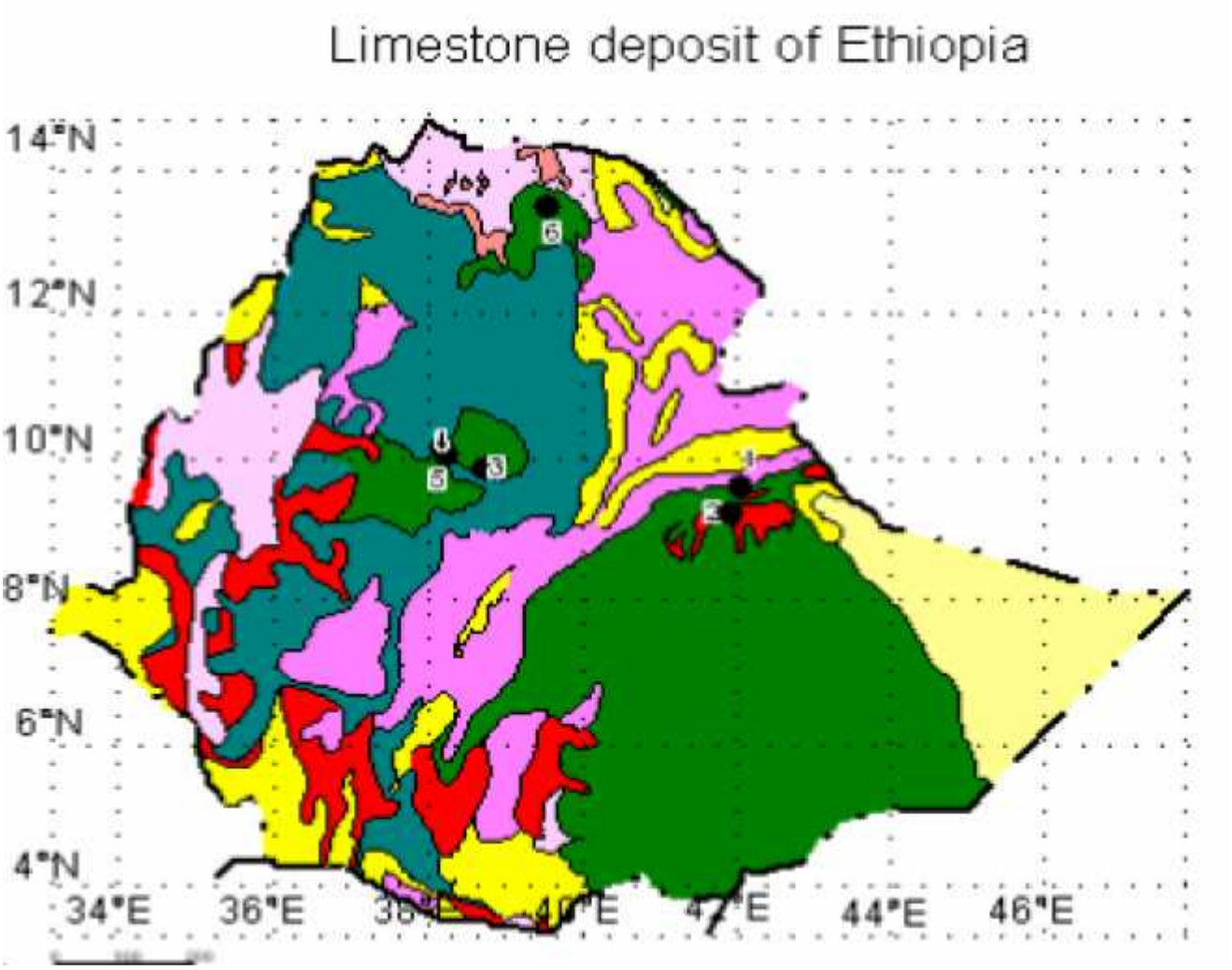
0.0381 M^3 of soil = 0.00149 M^3 of lime.

1 M^3 of soil = ? = 0.039 M^3 of lime

So from the discussion above, for 1M^3 of expansive soil it was found 0.039 M^3 of hydrated Lime to be used as stabilizing agent.

5.3.1.4 AVAILABILITY OF STABILIZING MATERIAL

The stabilizing material selected under item 5.3.1.2 is lime. As per the promotion made by investment opportunities in limestone resources development of Ethiopia [11], in Ethiopia, Limestone makes up about 10% of the total volume of all sedimentary rocks available in the country. The limestone are mainly exposed in the Blue Nile Basin, the Mekele outlier, Hararghe, Denakil, and the Ogaden Basin. Fig. 5.5 and Fig. 5.6 shows known limestone deposits of Ethiopia.


Limestone deposit of Ethiopia
14°N
12°N
10°N
8°N
6°N
4°N
34°E
36°E
44°E
46°E
GENERALIZED GEOLOGY
Quaternary Cover (Undifferentiated)
Quaternary-Tertiary Rift Sediments & Volcanics
Tertiary Sediments
Tertiary Highland Volcanics
Mesozoic Sediments
Paleozoic Sediments
Proterozoic Metamorphic Rocks
Archean
Limestone deposit of Ethiopia
1 Degachebsi Limestone
2 Hakime Gara Limestone
3 Wonchit & Jema Limestone
4 Dejen Limestone
5 Filiklik Limestone
6 Mosobo Limestone

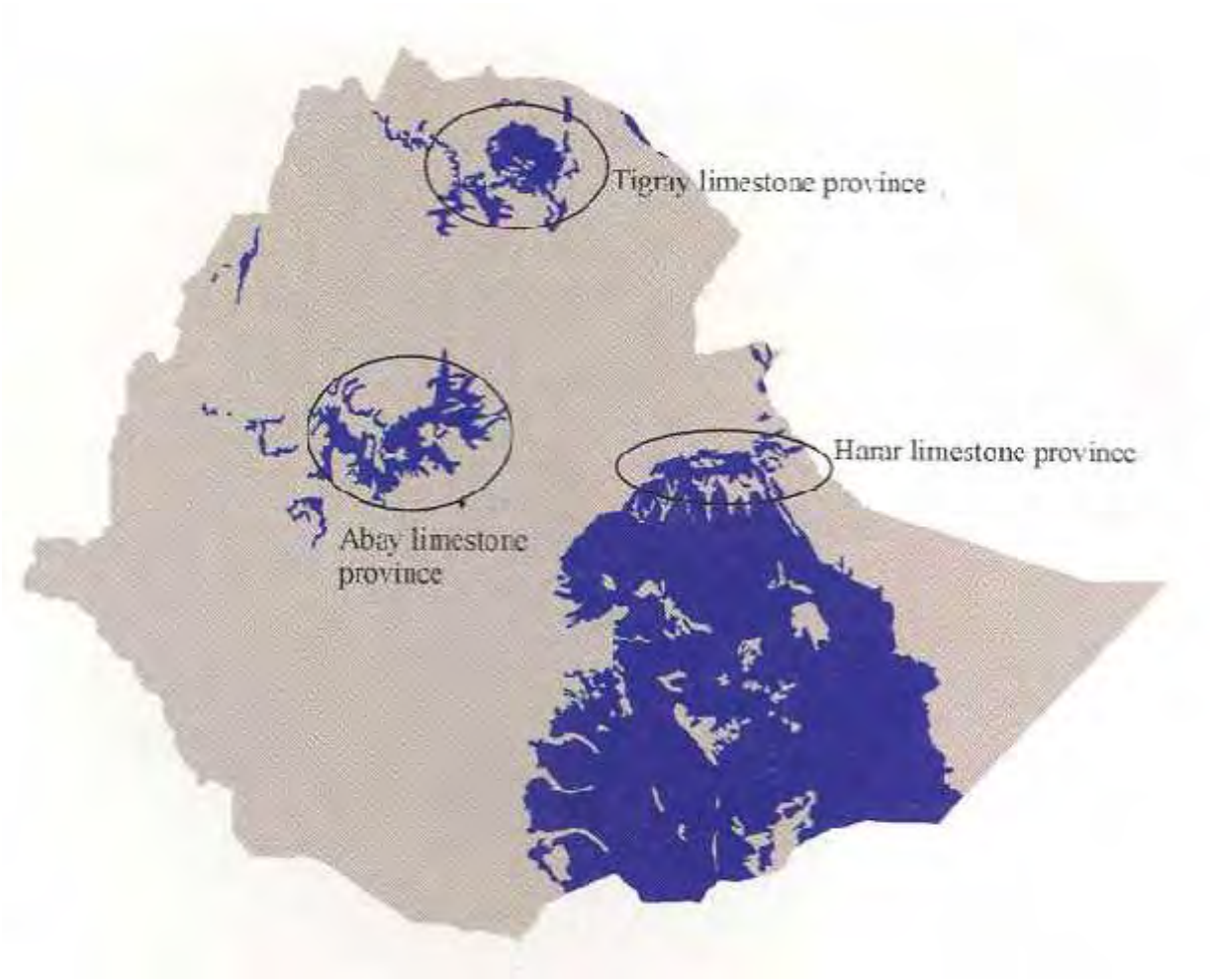


Fig. 5.6 Location Mesozoic sediments and limestone resources of Ethiopia. [11]

Comparing utilization of Limestone in the country, the limestone of Mossobo and Mugher are the potential sources which have been explored for cement production.[11]

5.3.2 SOURCE SELECTION OF LIME

From the discussion made above there is no any lime source within the vicinity of the project that could be used for stabilizing. Hence taking into account the following criteria;

- quality
- quantity
- average distance and
- accessebility,

Comparison for lime supply from Muger Cement Factory, Derba Cement Factory, Mossobo Cement Factory and Dire Dawa Cement Factory was done. The Muger Cement Factory and Derba Cement Factory were found feasible to the project from distance point of view. However hydrated lime was expected to be found only from Derba Cement Factory where the factory for production of hydrated lime was built to start production within few months.

Since the factory didn't start production and selling for any customer sofar, for the purpose of this study, Derba Cement Factory has given the provisional cost of hydrated lime and details of the procedure on the process of production. But the comparison for the two Cement Factory, Muger Cement Factory and Derba Cement Factory, from distance point of view is tabulated hereunder to check which of the two will be feasible;

Table 5.11 Comparison for Lime Supply

No	Source	Type of Lime	Quality	Quantity	Access	Unit Cost (Birr/Qtl)	Transport Cost upto Gambela (Birr/Qtl)	Shortest Distance From Project (Km)	Distance to be covered
A	B	C	D	E	F	G	H	I	J
1	Muger Cement Factory	Hydrated Lime	Very good	Tens of millions of tons	Accessible	-	160.0	985.0	Muger-Holeta-Ambo-Weliso-Jima-Abobo-Project
2	Derba Cement Factory	Hydrated Lime	Very good	Tens of millions of tons	Accessible	181.1***	70.0	968.0	Derba-Addis Ababa-Jima-Abobo-Project

From the above tabulated data hydrated lime from Derba Cement Factory is selected to be used as a stabilizer based on the cost and proximity to the project.

*** The unit price given by Derba Cement Factory which is indicated in the above table is provisional unit price.

5.3.3 COST- BENEFIT ANALYSIS OF STABILIZING

The process for cost-benefit analysis of Stabilizing is shown using work breakdown structure.

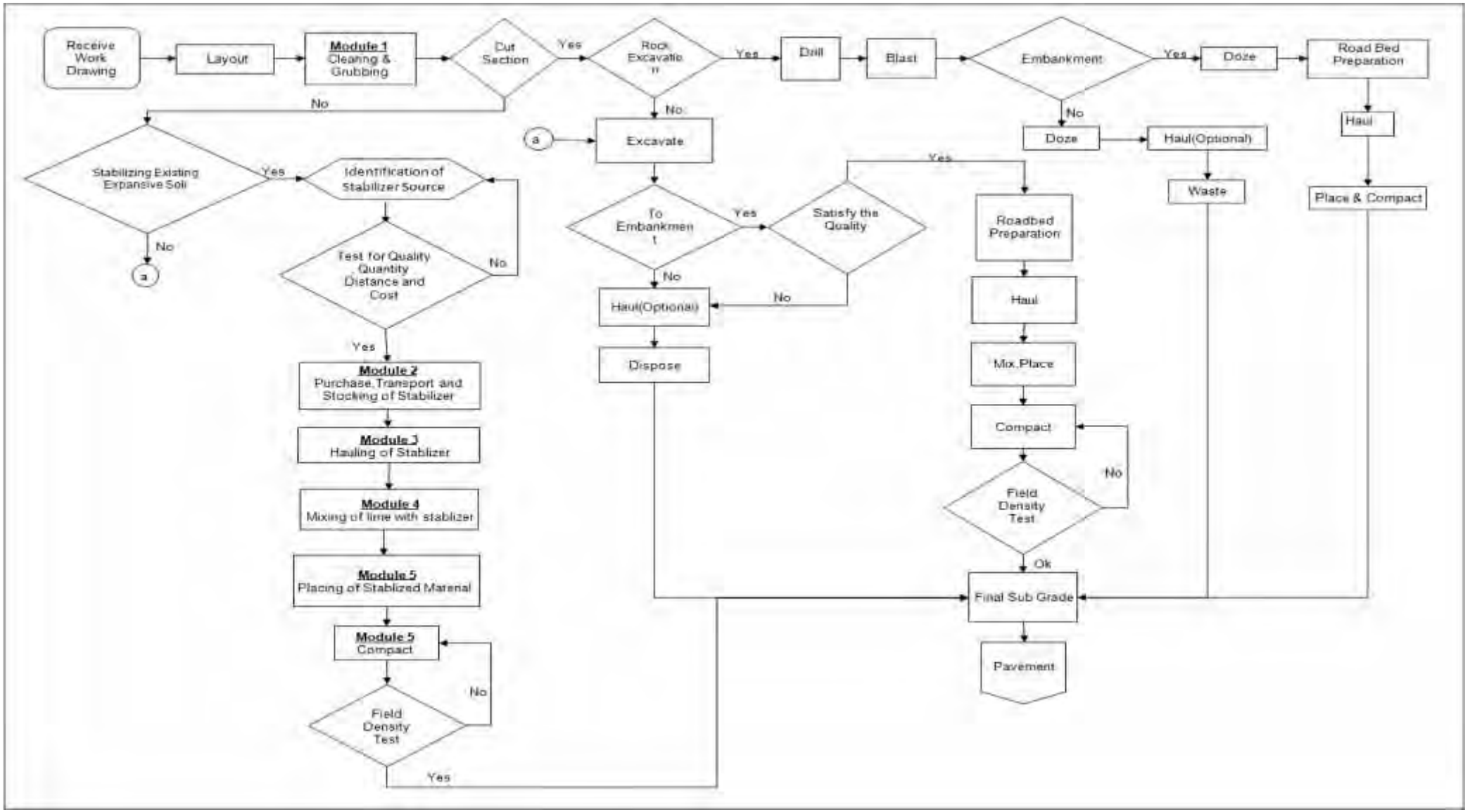
5.3.3.1 WORK BREAKDOWN STRUCTURE FOR WORKING DRAWING

Before the start of Stabilizing the existing expansive soil, we need to know the input data required which are explained hereunder. The flow chart of Fig. 5.1 is also used here to get those listed here under;

- exact location of road section
- identification of the overall soil type within the project area
- volume of work
- preliminary geotechnical investigation and laboratory test
- contractual obligation

5.3.3.2 WORK BREAKDOWN STRUCTURE FOR STABILIZING

Process for Stabilizing was summarized using the following work break down structure (Fig. 5.7).


Receive Work Drawing
Layout
Module 1 Clearing & Grubbing
Cut Section
Yes
Rock Excavatio n
Yes
Drill
Blast
Embankment
Yes
Doze
Road Bed Preparation
No
No
Haul
Stabilizing Existing Expansive Soil
Yes
Identification of Stabilizer Source
a
Excavate
Doze
Haul(Optional)
No
Waste
Place & Compact
No
a
Test for Quality Quantity Distance and Cost
No
To Embankmen t
Yes
Satisfy the Quality
Yes
Roadbed Preparation
Yes
No
No
Haul(Optional)
Haul
Yes
Module 2 Purchase,Transport and Stocking of Stabilizer
Dispose
Mix,Place
Module 3 Hauling of Stablizer
Compact
Module 4 Mixing of lime with stablizer
No
Field Density Test
Module 5 Placing of Stablized Material
Ok
Final Sub Grade
Module 5 Compact
No
Field Density Test
Pavement
Yes

Description of some of those activities used for this study of cost analysis were discussed hereunder as per ERA Standard Technical Specifications;

A. Description of activities as per ERA Standard Technical Specifications;

I.Road Prism/Road Section

1. Clearing; [8]

Clearing is defined as the removal of all trees, brush, other vegetation,rubbish, fences and all other objectionable material including the disposal of all material resulting from the clearing.

1.1 Top Soil [8]

Top soil is defined as the soil to be removed after clearing and grubbing of the natural ground surface within the width of the road prism is completed. The depth of top soil to be removed could be be either zero or an average depth between 150 mm and 400 mm. Stckpiling of topsoil is in heaps where the height is not more than 3 meters.

II.Transportation of Stabilizer

2. Purchase and Transportation of Stabilizer

Since the lime to be used was selected from Derba Cement Factory, purchase and transport of lime was conducted from Derba Cement Factory.

3. Stocking of Stabilizer [8]

Stocking needs tto be carried out in such a way that, from the time of purchase to the time of use, all stabilizing agents shall be kept under proper cover and protected from moisture.

III.Placing of Stabilizer [8]

ERA Standard Technical Specifications [8] specifies the following activities to be done carefully before final placing is performed;

4. Application of Stabilizing Agent

Application of stabilizing agent is done using mechanical spreader or usin hand where the stabilizer is over the full width of the layer.
Spreading of stabilizer by hand requires pockets or bags of stabilizing agent to be accurately spaced at equal intervals along the section to be stabilized so as to provide the specified rate of application. Those spotted stabilizing agent by hand could spread using motor grader.

5. Mixing of stabilizing agent

Following the spread of stabilizing agent, mixing will be carried out continiously until a thorough, uniform and intimate mix of the soil and stabilizing agent over the full width and depth of material to be treated is attained. Motor grader could be used for mixing.

6. Watering

Watering is done to keep optimum moisture content of the mix to the required level. To apply watering, the moisture content of the mixture shall be determined. The amount of water required to be added shall be sufficient to bring the mixed material to the optimum moisture content for the compaction equipment used and the density required for sub grade.

7. Compaction

Before compaction is done, a sufficient number of compacting units shall be employed to the site to ensure that from the time the stabilizing agent is first applied to the layer, the process of mixing, applying water, compaction, shaping and final finishing, is completed within the periods specified hereunder item 10. Vibrating rollers could be used as required.

8. Finishing at Junctions

Works which were under construction are stopped to continue on the other day which adjacent to new work shall be provided with a protective cover of soil or gravel at least 100 mm in thickness over a sufficient length to prevent damage to work already completed.

9. Curing of Stabilized Work

Any completed portion of the road shall be protected against rapid drying out for at least seven days. Curing could be done by an effective fogspraying system that will not damage the surface of the layer or by any other system.

10. Construction Limitations

When applying the stabilizing agent, all processing, watering, compacting and finishing can be completed within the period stated hereunder:

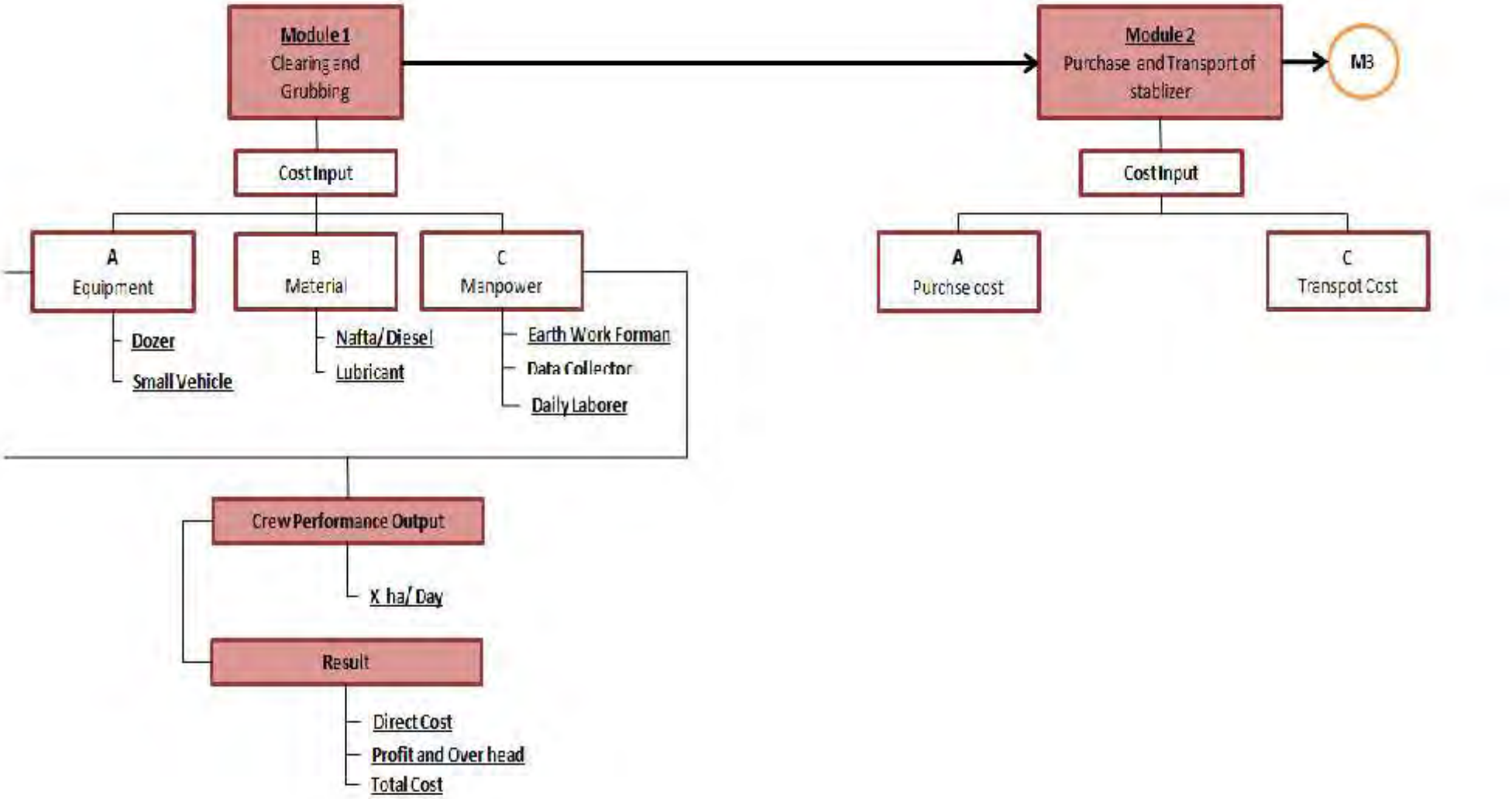
Table 5.12 Maximum time for completion in stabilization [8]

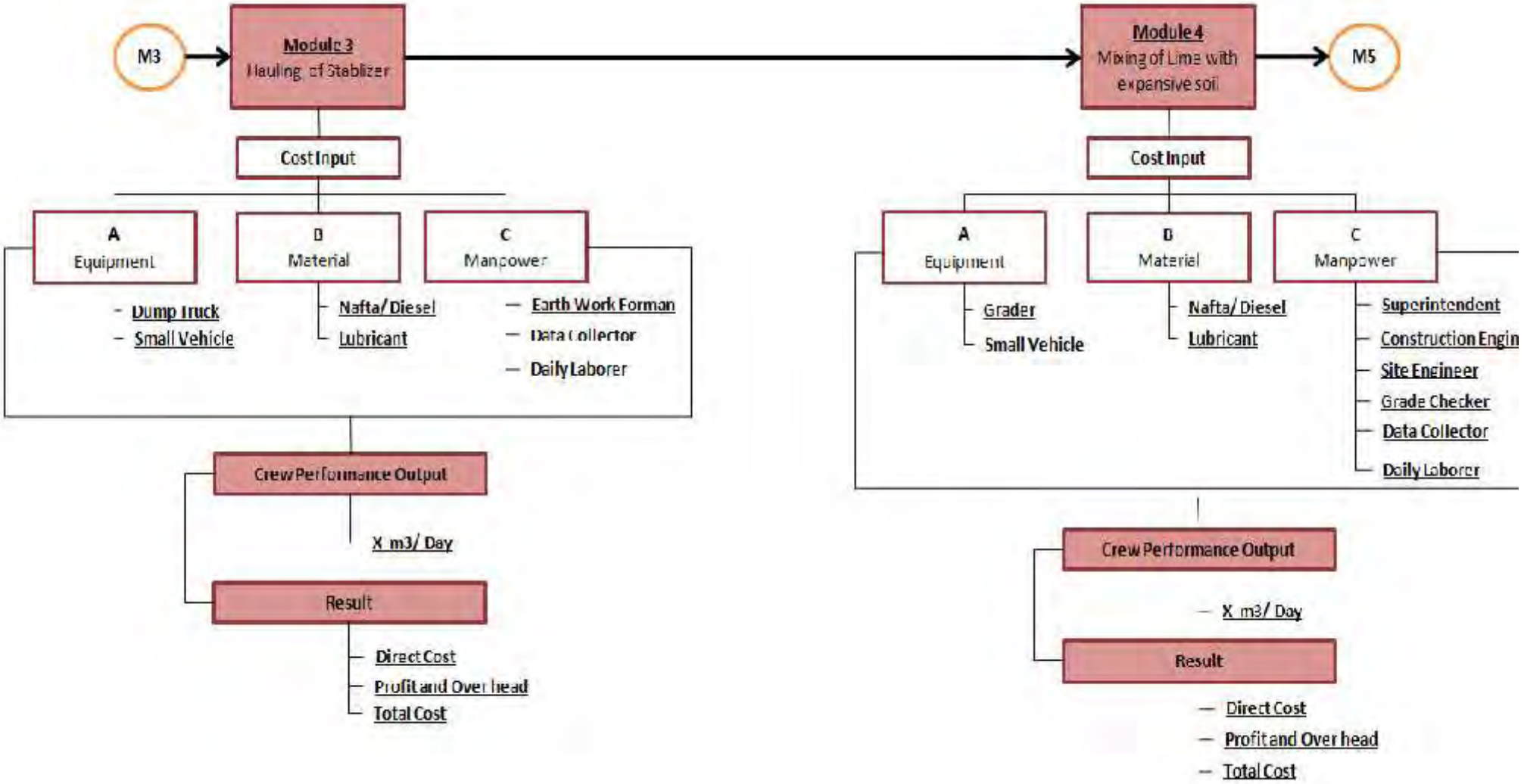
Stabilizing agent	**Maximum time for completion after stabilizing agent comes into contact with the material to be stabilized**
Lime	10 hours

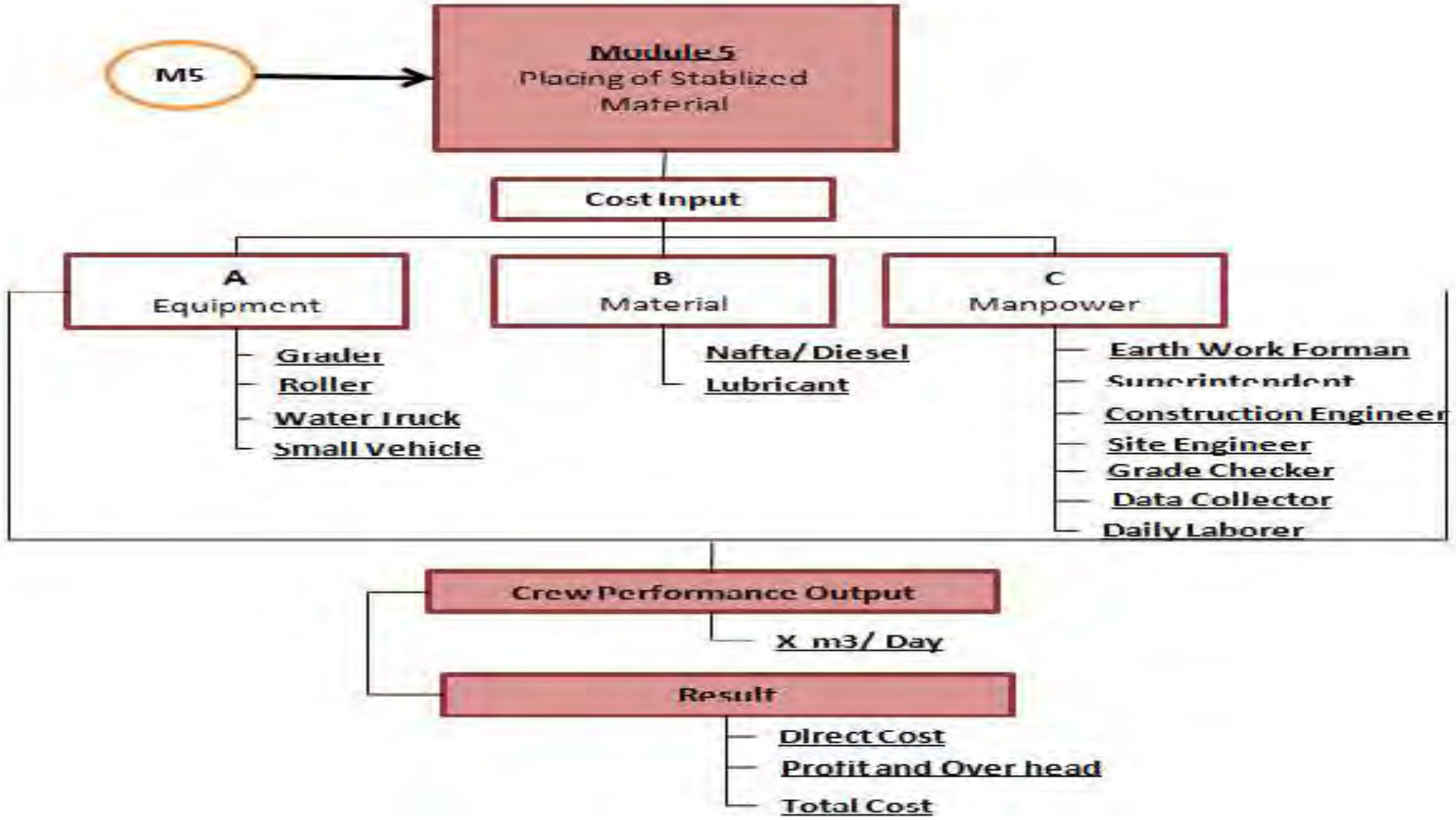
Any traffic or any equipment are not allowed to pass over the freshly spread stabilizing agent.

5.3.3.3 COST OF STABILIZING

Cost breakdown structure for stabilizing the existing expansive soil is shown in fig.5.8.


Module 1
Clearing and Grubbing
Module 2
Purchase and Transport of stablizer
M3
Cost Input
Cost Input
A
Equipment
B
Meterial
C
Manpower
A
Purchse cost
C
Transpot Cost
Dozer
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Data Collector
Daily Laborer
Crew Performance Output
X ha/ Day
Result
Direct Cost
Profit and Over head
Total Cost


M3
Module 3
Hauling of Stablizer
Cost Input
A
Equipment
B
Material
C
Manpower
Dump Truck
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Data Collector
Daily Laborer
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost
Module 4
Mixing of Lime with expansive soil
M5
Cost Input
A
Equipment
B
Material
C
Manpower
Grader
Small Vehicle
Nafta/ Diesel
Lubricant
Superintendent
Construction Engin
Site Engineer
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost


M5
Module 5
Placing of Stablized Material
Cost Input
A
Equipment
B
Material
C
Manpower
Grader
Roller
Water Truck
Small Vehicle
Nafta/ Diesel
Lubricant
Earth Work Forman
Superintendent
Construction Engineer
Site Engineer
Grade Checker
Data Collector
Daily Laborer
Crew Performance Output
X m3/ Day
Result
Direct Cost
Profit and Over head
Total Cost

Following the above examined data and the procedures, an excel plate is developed to analyze the cost of stabilizing. The Cost analysis for quantitative parameters are annexed on annex 3.

A. RESULT OF QUANTITATIVE COST ANALYSIS

Result of quantitative cost is tabulated in Table 5.11 hereunder;

Table 5.13 Quantitative unit cost for stabilizing

No	Activity	Unit	Unit Price	Unit	Unit Price
	I. Road Prism/Road Section				
1	Clearing and Grubbing within Road Prism	Birr/M^2	4.29	Birr/Km	34,326.01
	II. Transportation of Stabilizer				
2**	Purchase Cost of Stabilizer from Derba Cement Factory (Hydrated Lime)	Birr/Qtl	181.12		
		Birr/M^3	4,256.32		
	For 1M3 of Expansive soil we need 0.04 M3 of Lime	Birr/M^3	166.2		
	Purchase Cost of Stabilizer (Hydrated Lime)	Birr/M^2	83.1	Birr/Km	664,794.86
3***	Transport Cost of Stabilizer from Derba Cement Factory (Hydrated Lime)	Birr/Qtl	70		
		Birr/M^3	1,645.0		
	For 1M3 of Expansive soil we need 0.04 M3 of Lime	Birr/M^3	64.23		
	Purchase Cost of Stabilizer (Hydrated Lime)	Birr/M^2	32.11	Birr/Km	256,932.64
	III. Placing of Stabilizer				
4	Hauling of Stabilizer	Birr/M^2	39.05	Birr/Km	120,156.13
5	Mixing of Stabilizer	Birr/M^2	64.02	Birr/Km	512,193.16
6	Placing of Stabilizer	Birr/M^2	48.30	Birr/Km	386,418.49
	Total Quantitative Cost		**270.87**		**1,974,821.28**

Note

****: Details of purchase cost of stabilizer**

Depth of Lime Placing = 0.5 M

1 M^2 of Lime Placing = 1M X 1M = 1M^2

1 M^2 of Lime Placing = 1M X 1M X 0.5M = 0.5 M^3

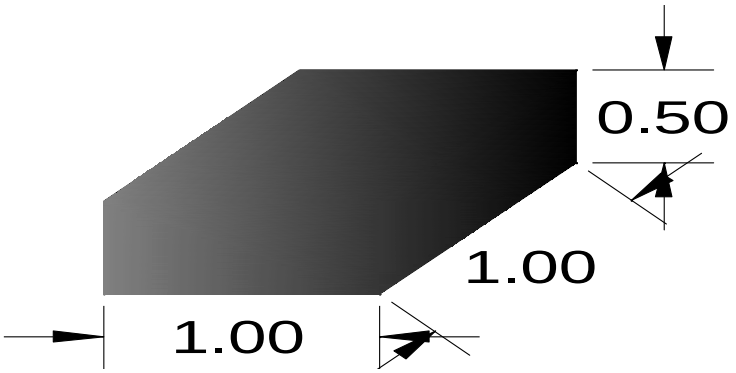
1 M^2 of Lime Placing = 0.5 M^3

COST

1 M^3 of Lime Purchase = 166.2 Birr

1 M^2 of Lime Purchase = 0.5 M^3 = ? Birr

1 M^2 of Lime Purchase = 0.5 M^3 = 83.1 Birr



*****: Details of transport cost of stabilizer**

Depth of Lime Placing = 0.5 M

1 M^2 of Lime Placing = 1M X 1M = 1M^2

1 M^2 of Lime Placing = 1M X 1M X 0.5M = 0.5 M^3

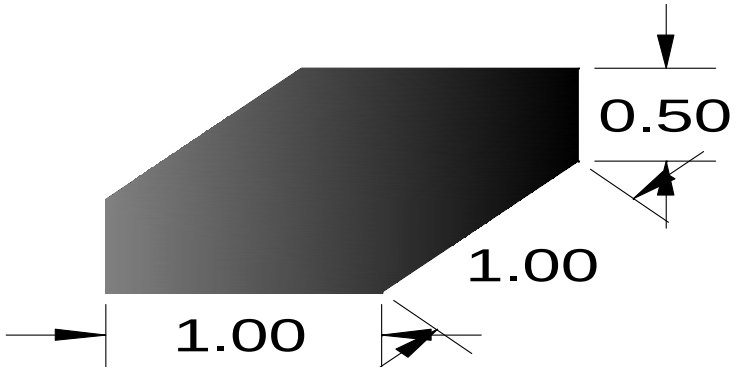
1 M^2 of Lime Placing = 0.5 M^3

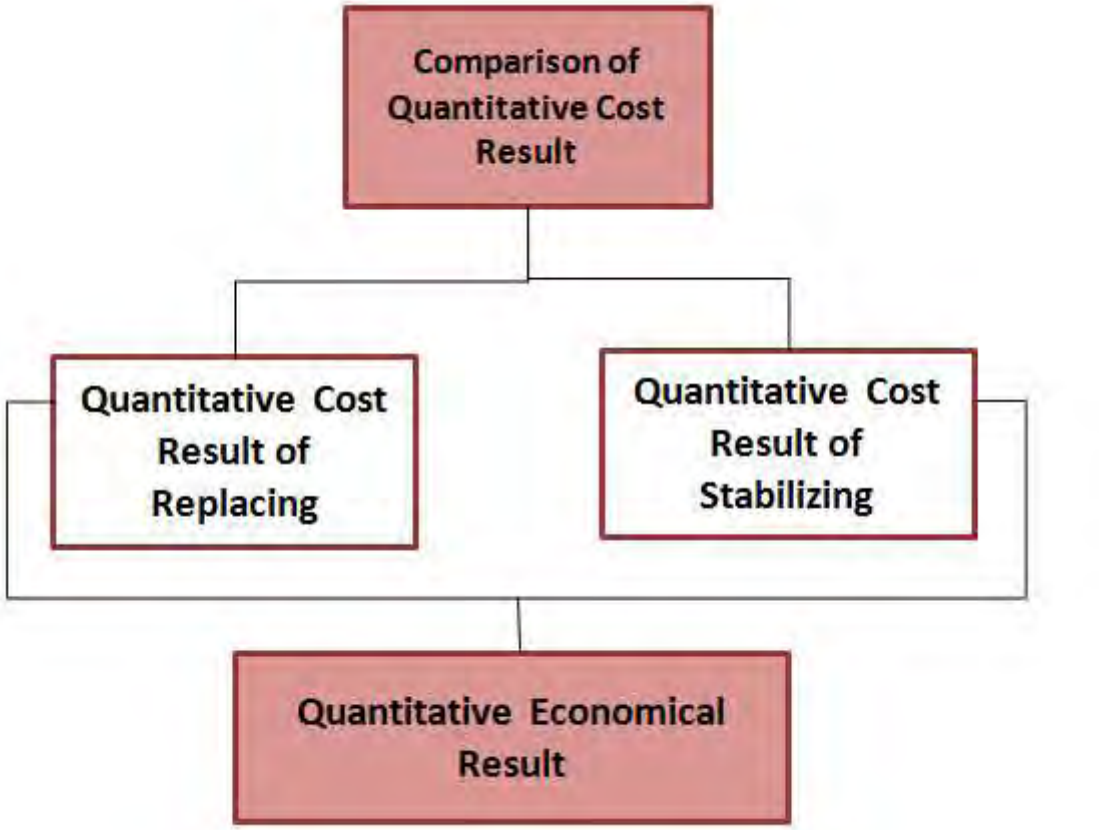
COST

1 M^3 of Lime Transport = 64.23 Birr

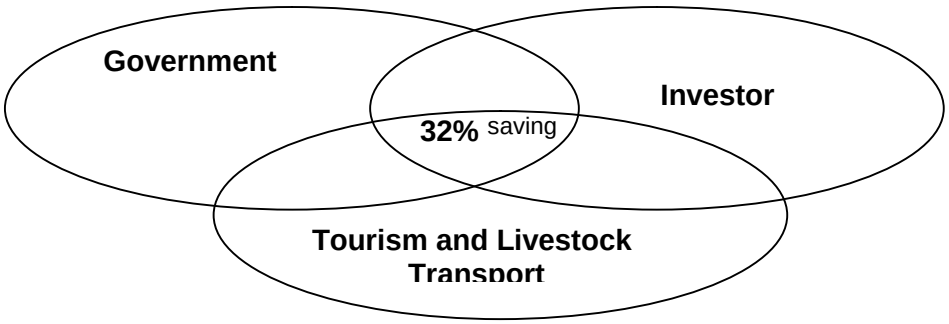
1 M^2 of Lime Transport = 0.5 M^3 = ? Birr

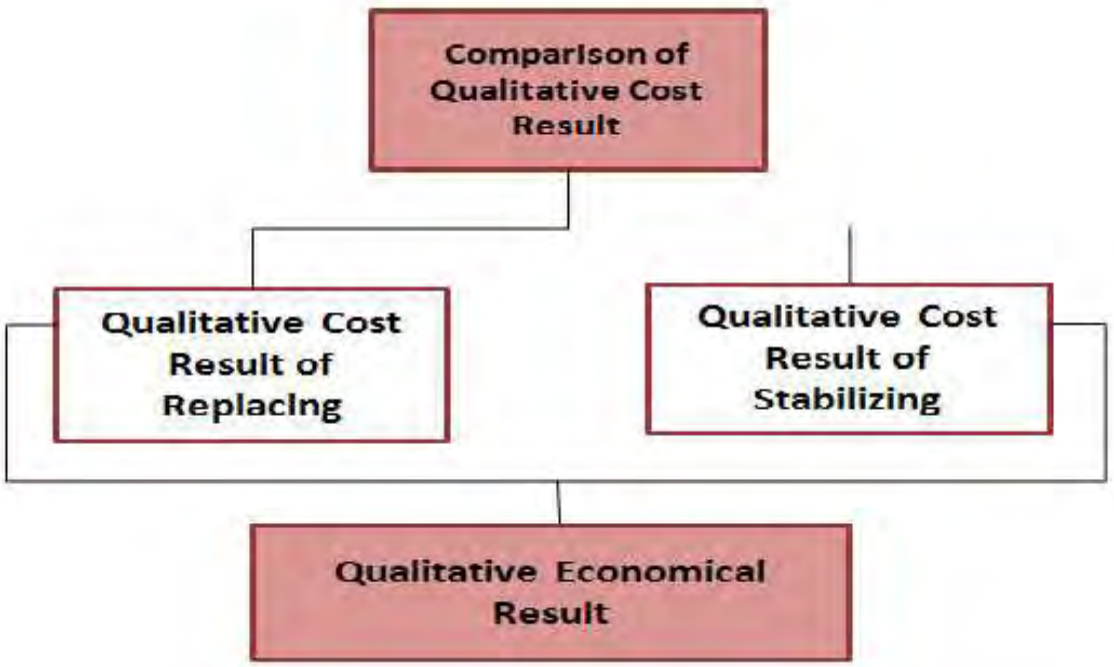
1 M^2 of Lime Transport = 0.5 M^3 = 32.11 Birr


0.50
1.00
1.00



No	Description	Unit Cost (Birr/M^2)	Unit Cost (Birr/Km)	Percent Saving (%)
1	Total Cost of Replacing the existing expansive soil with locally available suitable material	397.44	2,862,247.71	32%
2	Total cost of stabilizing the existing expansive soil with Lime from Derba Cement Factory	270.87	1,974,821.28	


Government
Investor
32% saving
Tourism and Livestock Transport


Comparison of Qualitative Cost Result
Qualitative Cost Result of Replacing
Qualitative Cost Result of Stabilizing
Qualitative Economical Result

7 CONCLUSION AND RECOMMENDATION

7.1 CONCLUSION

From the present investigation, it is observed that:

- The engineering property of the existing expansive soil studied revealed as it needs improvement to its engineering property to serve as subgrade for the road construction.
- Replacing of the existing expansive soil with non-expansive soil from locally available materials or stabilizing with stabilizing agent were the options adopted to improve the engineering property of the soil.
- Selection of the appropriate replacing material or stabilizing agent were carried out taking into account all laboratory test required, relevant table and chart, availability, accessebility, location, and enviromental relation.
- Quantitative and qualitative cost-benefit analysis for both replacing and stabilizing were conducted.
- Following the model stabilished, from quantitative cost-benefit analysis, stabilizing the existing expansive soil with lime is found to be economical than replacing.
- However from qualitative cost-benefit analysis, though the qualitative cost of replacing was not found interms of unit price cost, it has been examined to negatively affect the cost of replacing.
- Inaddition qualitative cost of stabilizing and its negative impact was considered in the cost of selling the lime by Derba Cement Factory in which case it was not included in this study to avoid duplication.

So it is concluded that before any construction is commenced such cost benefit analysis on different options to improve those expansive soils have to be made. Though this study reveals the use of lime stabiliztion to be more economical than replacing for this case study, such analysis was not done before which otherwise could have protect the loss of extra cost, loss of fertile soil, forest, wild animals and birds.

In addition it is concluded that the saving obtained as a result of proper decision in selecting the right option benefits, Federal Democratic Republic of Ethiopia (FDRE), Ethiopian Roads Authority (ERA), Contractor, Ministry of Health, the Woredas, Potential Local Private Investors, Potential Foreign Private Investors, Existing businesses involved in tourism (tour operators, hotel and restaurant owners), Livestock traders doing business with pastoralist communities, Transport users and operators in the project area.

7.2 RECOMMENDATION

- As this investigation was done for specific area, it is recommended as more investigation on different parts of the country with similar nature is mandatory to develop a representative model to the nation.

- As per the promotion made by Investment Opportunities In Limestone Resources Development Of Ethiopia [11], though lime production and sale for market to be used as a stabilizing agent for road construction is not available at the moment, there is a potential source of lime nationwide which can be developed and processed for market.

- Following the development of limestone resources of the country, there will be a huge contribution to the development of the nation in areas of:

    - creating employment opportunity,
    - the development of industry, and

- As per the Health Policy of the Transitional Government of Ethiopia [13], protection of the existing vegetation will serve the nation to benefit from Traditional Medicine through the measures taken by the Government in areas of:

    - identifying and encouraging utilization of its beneficial aspects [13]
    - coordinating and encouraging research including its linkage with modern medicine[13] and
    - developing appropriate regulation and registration for its practice.[13]

And finally, as this study follows the procedures using quantitative and qualitative cost parameters for the model to run effectively, the qualitative cost for replacing and stabilizing needs more investigation in collaboration with different governmental and non-governmental organization to establish a sound indicator that could help in making a decision in using either replacing or stabilizing.

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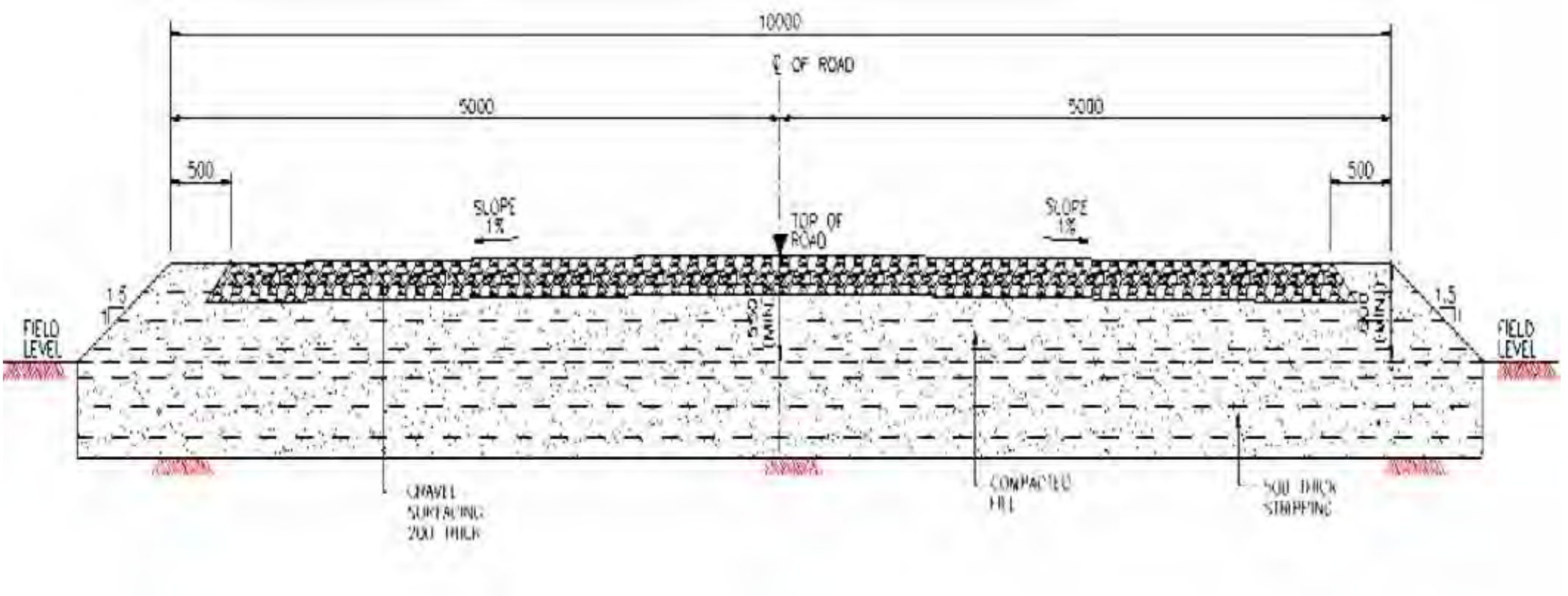
ANNEX 1

Typical cross section of the road.[2]



Module 1 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Clearing and Grubbing within Road Prism

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	0,13	1	Ha/Day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
A	B	C	D	E	F=B*C*D*E
Dozer	1	1	2.800,0	8	22.400,0
S/Vehicle	1	0,25	90,0	8	180,0
					-
TOTAL (A) BIRR					22.580,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
M	N	O=B1/V(Total)	P	Q=O*P
Nafta	Lit	407,00	17,79	7.240,53
Lubricants	***	***	***	-
				-
TOTAL (B)				7.240,53

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
G	H	I	J	K	L=H*I*J*K
Dozer - Operator	0	1	-	1,6	-
S/Vehicle - Driver	0	0,25	-	1,6	-
E/Work Forman	1	1	7.000,0	1,6	11.200,00
Data Collector	1	1	1.800,0	1,4	2.520,00
Daily Labourer	4	1	1.500,0	1,3	7.800,00
					-
TOTAL (C) BIRR					21.520,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 22.580,0

2. MATERIAL COST = TOTAL (B) = 7.240,5

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 827,7

I. DIRECT COST (1+2+3) =	30.648	Birr/Ha
II. PROFIT + OVERHEAD (40%) =	12.259	Birr/Ha
III. TOTAL COST (I + II) =	42.908	Birr/Ha
IV. TOTAL COST (Birr/M^2) =	4,29	Birr/M2
V. TOTAL COST (Birr/Km) =	34.326	Birr/Km

Module 1 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Clearing and Grubbing within Road Prism PAGE 2 OF 2

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
R	S=B*C	T	U=E	V=S*T*U
Dozer	1,00	50	8,00	400,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				407,00

Lubricants consumption in Amount per day

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
W	X=S	Y	Z=Y*V*P(constant)
Dozer	1,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-

NOTE

1 Ha of Clearing = 10.000 M^2

1 M^2 of Clearing = 1M X 1M = 1M^2

COST

1 Ha of Clearing (10,000 M^2) =	42.907,51	Birr
1 M^2 of Clearing =	?	Birr
1 M^2 of Clearing =	4,29	Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Area =	8000	m^2
1km length road =	8000,0	m^2
IF for 1 m2 =	4,29	Birr
8000,0	?	Birr
1km length road =	34.326,01	Birr

Module 2 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Under Cut Excavation

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	60	480	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
A	B	C	D	E	F=B*C*D*E
Dozer	1	1	2.800,0	8	22 400,00
S/Vehicle	1	0,25	90,0	8	180,00
					-
TOTAL (A) BIRR					22.580,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
M	N	O=B1/V(Total)	P	Q=O*P
Nafta	Lit	0,85	17,79	15,08
Lubricants	***	***	***	-
				-
TOTAL (B)				15,08

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
G	H	I	J	K	L=H*I*J*K
Dozer - Operator	-	1	-	1,6	-
S/Vehicle - Driver	-	0,25	-	1,6	-
E/Work Forman	1	1	7.000,0	1,6	11 200,00
Grade Checker	1	1	2.000,0	1,4	2 800,00
Data Collector	1	1	1.800,0	1,4	2 520,00
Daily Labourer	4	1	1.500,0	1,3	7 800,00
TOTAL (C) BIRR					24.320,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 47,04

2. MATERIAL COST = TOTAL (B) = 15,08

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 1,95

I. DIRECT COST (1+2+3) =	64,07	Birr/M3
II. PROFIT + OVERHEAD (40%) =	25,63	Birr/M3
III. TOTAL COST (I + II) =	89,70	Birr/M3
IV. TOTAL COST (Birr/M^2) =	44,85	Birr/M2
V. TOTAL COST (Birr/Km) =	358.819	Birr/Km

Module 2 - COST ANALYSIS

ACTIVITY :- Under Cut Excavation

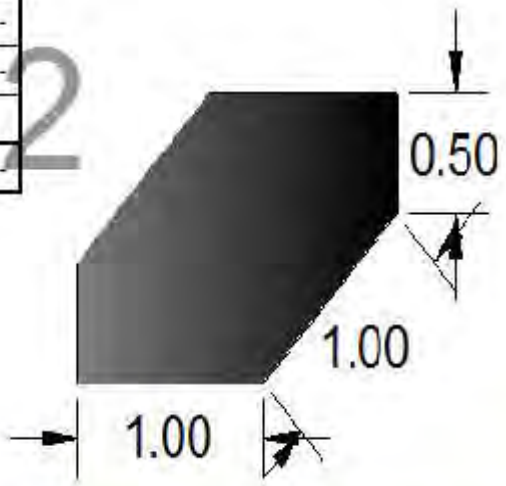
DATE May,2013

PAGE 2 OF 2

Equipment Type	Nc* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
R	S=B*C	T	U=E	V=S*T*U
Dozer	1,00	50	8,00	400,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				407,00

Lubricants consumption in Amount per day

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
W	X=S	Y	Z=Y*V*P(constant)
Dozer	1,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-



1M x 1M x 0.5M Strip of Undercut Excavation

NOTE

Depth of Undercut excavation = 0,5 M

1 M^2 of Undercut excavation = 1M X 1M = 1M^2

1 M^2 of Undercut excavation = 1M X 1M X 0.5M = 0.5 M^3

1 M^2 of Undercut excavation = 0.5 M^3

COST

1 M^3 of Undercut excavation = 89,70 Birr

1 M^2 of U/excavation = 0.5 M^3 = ? Birr

1 M^2 of U/excavation = 0.5 M^3 = 44,85 Birr

4000

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	89,70	Birr
4000,0	?	Birr
1km length road =	358.819	Birr

Module 3 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Disposal of Uncer Cut Excavation

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	100	800	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
A	B	C	D	E	F=B*C*D*E
Loader	1	1	800,0	8	6.400,0
D/Truck	5	1	500,0	8	24.000,0
S/Vehicle	1	0,25	30,0	8	180,0
					-
TOTAL (A) BIRR					30.580,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
M	N	O	P	Q
Nafta	Lit	0,76	17,79	13,50
Lubricants	***	***	***	-
				-
				-
TOTAL (B)				13,50

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
G	H	I	J	K	L=H*I*J*K
Loader - Operator	1	1	-	1,6	-
D/Truck - Driver	6	1	-	1,6	-
E/Work Forman	1	0,5	7 000	1,6	5.600,00
Data collector	1	1	2 000	1,4	2.800,00
Daily Labourer	4	1	1.800	1,3	9.360,00
					-
TOTAL (C) BIRR					17.760,0

1. EQUIPMENT COST	= TOTAL (A) / OUTPUT	=	38,23
2. MATERIAL COST	= TOTAL (B)	=	13,50
3. MAN POWER COST	= TOTAL (C) / OUTPUTx26	=	0,85

I. DIRECT COST (1+2+3)	=	52,58 Birr/M3
II. PROFIT + OVERHEAD (40%)	=	21,03 Birr/M3
III. TOTAL COST (I + II)	=	73,61 Birr/M3
IV. TOTAL COST (Birr/M^2)	=	95,69 Birr/M2
V. TOTAL COST (Birr/Km)	=	294.431 Birr/Km

Module 3 - COST ANALYSIS

ACTIVITY :- Disposal of Under Cut Excavation

DATE May,2013

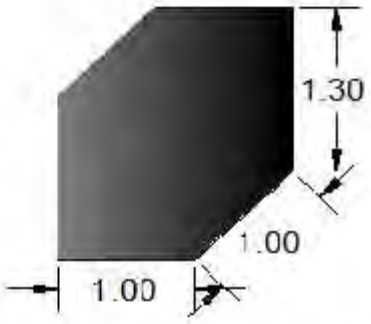
PAGE 2 OF 2

Nafta Consumption per day (lt)

Equipment Type	Nc* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
R	S	T	U	V
Loader	1,00	15	8,00	120,00
D/Truck	6,00	10	8,00	480,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				607,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
W	X=S	Y	Z=Y*V*P(constant)
Loader	1,00	0,00%	
D/Truck	6,00	0,00%	-
S/Vehicle	0,25	0,00%	-
-	-		-
TOTAL			-



1M x 1M x 1.3M Strip of Cartaway Material on D/Truck

Required D/Truck & W/Truck for the daily output

Type	Distance = S(Km)	Speed V(Km/Hr)	L+ UL Time (hr)	Capacity c (m3)	Hrly output (M3/hr)	Qty to be exuted=OP(m3/day)	No of DT/WT required per day
D/Truck	12	20	0,12	12	16,7	800,0	6,00

NOTE

Depth of carrier part of D/Truck = 1,3 M

1 M^2 of Cartaway Material = 1M X 1M = 1M^2

1 M^2 of Cartaway Material = 1M X 1M X 1.3M = 1.3 M^3

1 M^3 of Cartaway Material = 1.3 M^3

COST

1 M^3 of Cartaway Material = 73,61 Birr

1 M^2 of Cartaway Material=1.3M^3 ? Birr

1 M^2 of Cartaway Material=1.3M^3 95,69 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	73,61	Birr
4000,0	?	Birr
1km length road =	294.431	Birr

Module 4 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Reinstating of Undercut Disposal Site

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	80,00	640	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Dozer	1	1	2.800,0	8	22.400,00
Grader	1	1	1.900,0	8	15.200,00
S/Vehicle	1	0,25	90,0	8	180,00
TOTAL (A) BIRR					37.780,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,89	17.79	15,76
Lubricants	***	***	***	-
TOTAL (B)				15,76

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Dozer - Operator	1	1	-	1,6	-
Grader - Operator	1	1	-	1,6	-
E/Work Forman	1	0,25	7.000,0	1,6	2.800,00
Grade Checker	1	1	1.820,0	1,6	2.912,00
Data Collector	1	1	1.300,0	1,4	1.820,00
Daily Labourer	2	1	1.170,0	1,3	3.042,00
					-
					-
TOTAL (C) BIRR					10.574,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 59,03

2. MATERIAL COST = TOTAL (B) = 15,76

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 0,64

I. DIRECT COST (1+2+3) =	75,43	Birr/M3
II. PROFIT + OVERHEAD (40%) =	30,17	Birr/M3
III. TOTAL COST (I + II) =	105,60	Birr/M3
IV. TOTAL COST (Birr/M^2) =	52,80	Birr/M2
V. TOTAL COST (Birr/Km) =	422.394	Birr/Km

Module 4 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Reinstating of Undercut Dispcsal Site

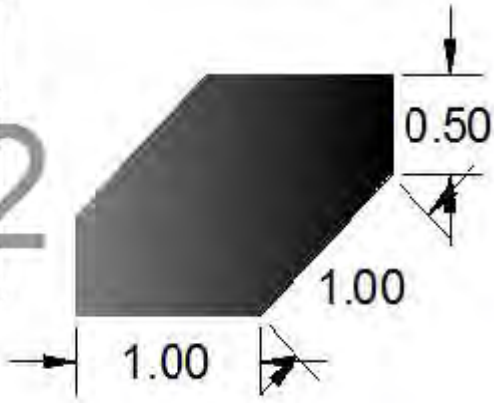
PAGE 2 OF 2

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./cay	Consumption/Day (Qty)
Dozer	1,00	50	8,00	400,00
Grader	1,00	20	8,00	160,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				567,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Dozer	1,00	-	-
Grader	1,00	-	-
TOTAL			-



1M x 1M x 0.5M Strip of Reinstated Undercut Material

NOTE

Depth of Reinstating of disposal = 0,5 M

1 M^2 of Reinstated Material = 1M X 1M = 1M^2

1 M^2 of Reinstated Material = 1M X 1M X 0.5M = 0.5 M^3

1 M^2 of Reinstated Material = 0.5 M^3

COST

1 M^3 of Reinstated Material = 105,60 Birr

1 M^2 of Reinstated Material = 0.5 ? Birr

1 M^2 of Reinstated Material = 0.5 52,80 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	105,60	Birr
4000,0	?	Birr
1km length road =	422.394	Birr

Module 5 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Clearing and Grubbing for Borrow Productior

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	0,13	1	Ha/Day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORK[N] [G] HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
A	B	C	D	E	F=B*C*D*E
Dozer	1	1	2.800,0	8	22.400,0
S/Vehicle	1	0,25	90,0	8	180,0
					-
TOTAL (A) BIRR					22.580

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
M	N	O=B1/V(Total)	P	Q=O*P
Nafta	Lit	407,00	17,79	7.240,53
Lubricants	***	***	***	-
				-
TOTAL (B)				7.240,53

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
G	H	I	J	K	L=H*I*J*K
Dozer - Operator	0	1	-	1,6	-
S/Vehicle - Driver	0	0,25	-	1,6	-
E/Work Formar	1	1	7.000,0	1,6	11 200,00
Data Collector	1	1	1.800,0	1,4	2.520,00
Daily Labourer	4	1	1.500,0	1,3	7 800,00
					-
TOTAL (C) BIRR					21.520,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 22.580,0

2. MATERIAL COST = TOTAL (B) = 7.240,5

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 827,7

I. DIRECT COST (1+2+3) =	30.648	Birr/Ha
II. PROFIT + OVERHEAD (40%) =	12.259	Birr/Ha
III. TOTAL COST (I + II) =	42.908	Birr/Ha
IV. TOTAL COST (Birr/M^2) =	4,29	Birr/M2
V. TOTAL COST (Birr/Km) =	34.326	Birr/Km

Module 5 - COST ANALYSIS

ACTIVITY :- Clearing and Grubbing for Borrow Production

DATE May,2013

PAGE 2 OF 2

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
R	S=B*C	T	U=E	V=S*T*U
Dozer	1,00	50	8,00	400,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				407,00

Lubricants consumption in Amount per day

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
W	X=S	Y	Z=Y*V*P(constant)
Dozer	1,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-

NOTE

1 Ha of Clearing = 10.000 M^2

1 M^2 of Clearing = 1M X 1M = 1M^2

COST

1 Ha of Clearing (10,000 M^2) = 42.907,51 Birr

1 M^2 of Clearing = ? Birr

1 M^2 of Clearing = 4,29 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Area =	8000	m^2
1km length road =	8000,0	m^2
IF for 1 m2 =	4,29	0,00
8000,0	?	Birr
1km length road =	34.326	Birr

Module 6 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGICNAL STATE

ACTIVITY :- Excavation of Overburden

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	60	480	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
A	B	C	D	E	F=B*C*D*E
Dozer	1	1	2.800,0	8	22.400,00
S/Vehicle	1	0,25	90,0	8	180,00
					-
TOTAL (A) BIRR					22.580,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
M	N	O=B1/V(Total)	P	Q=O*P
Nafta	Lit	0,35	17,79	15,08
Lubricants	***	***	***	-
				-
TOTAL (B)				15,08

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
G	H	I	J	K	L=H*I*J*K
Dozer - Operator	-	1	-	1,6	-
S/Vehicle - Driver	-	0,25	-	1,6	-
E/Work Forman	1	1	7.000,0	1,6	11.200,00
Grade Checker	1	1	2.000,0	1,4	2.800,00
Data Collector	1	1	1.800,0	1,4	2.520,00
Daily Labourer	4	1	1.500,0	1,3	7.800,00
TOTAL (C) BIRR					24.320,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 47,04

2. MATERIAL COST = TOTAL (B) = 15,08

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 1,95

I. DIRECT COST (1+2+3) =	64,07	Birr/M3
II. PROFIT + OVERHEAD (40%) =	25,63	Birr/M3
III. TOTAL COST (I + II) =	89,70	Birr/M3
IV. TOTAL COST (Birr/M^2) =	44,85	Birr/M2
V. TOTAL COST (Birr/Km) =	358.819	Birr/Km

Module 6 - COST ANALYSIS

ACTIVITY :- Excavation of Overburden

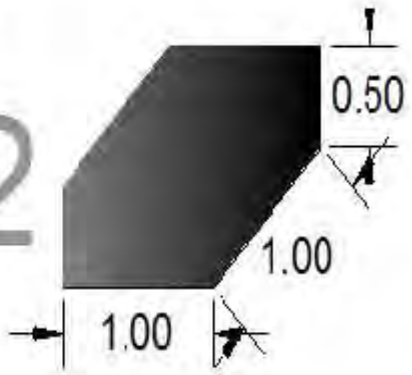
DATE May,2013

PAGE 2 OF 2

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
R	S=B*C	T	U=E	V=5*T*U
Dozer	1,00	50	8,00	400,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				407,00

Lubricants consumption in Amount per day

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
W	X=S	Y	Z=Y*V*P(constant)
Dozer	1,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-



1M x 1M x 0.5M Strip of Overburden Excavation

NOTE

Depth of Overburden 0,5 M

1 M^2 of Overburden 1M X 1M = 1M^2

1 M^2 of Overburden 1M X 1M X 0.5M = 0.5 M^3

1 M^2 of Overburden 0.5 M^3

COST

1 M^3 of Overburden excavation = 89,70 Birr

1 M^2 of Overburdenexcavation = 0.5 M^3 = ? Birr

1 M^2 of O/excavation = 0.5 M^3 = 44,85 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	89,70	Birr
4000,0	?	Birr
1km length road =	358.819	Birr

Module 7 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELA AWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELA NATIONAL REGIONAL STATE

ACTIVITY :- Borrow Procuction

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	80,00	640	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORK IN HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Dozer	1	1	2.800,0	8	22.400,00
S/Vehicle	1	0,25	90,0	8	180,00
TOTAL (A) BIRR					22.580,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,54	17,79	11,31
Lubricants	***	***	***	-
TOTAL (B)				11,31

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Dozer - Operator	1	1	-	16	-
S/Vehicle - Driver	1	0,25	-	16	-
E/Work Forman	0,5	1	7.000,0	16	5.600,00
Daily Labourer	1	1	1.800,0	13	2.340,00
TOTAL (C) BIRR					7.940,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 35,28

2. MATERIAL COST = TOTAL (B) = 11,31

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 0,48

I. DIRECT COST (1+2+3) =	47,07	Birr/M3
II. PROFIT + OVERHEAD (40%) =	18,83	Birr/M3
III. TOTAL COST (I + II) =	65,90	Birr/M3
IV. TOTAL COST (Birr/M^2) =	13,18	Birr/M2
V. TOTAL COST (Birr/Km) =	263.602	Birr/Km

Module 7 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Borrow Production

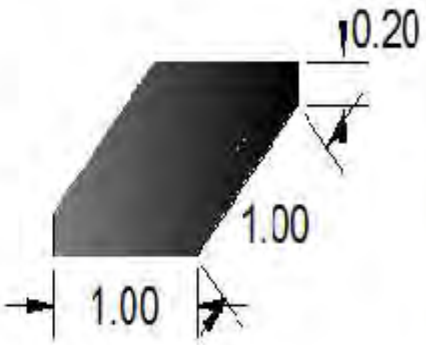
PAGE 2 OF 2

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
Dozer	1,00	50	8,00	400,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				407,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Dozer	1,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-



1M x 1M x 0.2M Strip of Borrow Material to be placed

NOTE

Depth of Borrow to be placed = 0,2 M

1 M^2 of Borrow to be placed = 1M X 1M = 1M^2

1 M^2 of orrow to be placed = 1M X 1M X 0.5M = 0.2 M^3

1 M^2 of Borrow to be placed = 0.5 M^3

COST

1 M^3 of Borrow to be placed = 65,90 Birr

1 M^2 of Borrow to be placed = 0.2 M^3 = ? Birr

1 M^2 of Borrow to be placed = 0.2 M^3 = 13,18 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	65,90	Birr
4000,0	?	Birr
1km length road =	263.602	Birr

Module 8 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA A.WERO RICE PROJECT PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL FEGIONAL STATE

ACTIVITY :- Transportation of Borrow material

ITEM No :-

CUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	100,00	800	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Loader	1	1	800,0	8	6.400,00
D/Truck	3	1	500,0	8	12.000,00
S/Vehicle	1	0,25	90,0	8	180,00
TOTAL (A) BIRR					18.400,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,46	17,79	8,16
Lubricants	***	***	***	-
TOTAL (B)				8,16

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Loader - Operator	1	1	-	1,6	-
D/Truck - Driver	3	1	-	1,6	-
S/Vehicle - Driver	1	0,25	-	1,4	-
E/Work Forman	1	0,25	7.000,0	1,4	2.450,00
Load Counter	1	1	1.300,0	1,4	1.820,00
Daily Labourer	1	1	1.170,0	1,3	1.521,00
TOTAL (C) BIRR					5.791,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 23,00

2. MATERIAL COST = TOTAL (B) = 8,16

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 0,28

I. DIRECT COST (1+2+3) =	31,44	Birr/M3
II. PROFIT + OVERHEAD (40%) =	12,58	Birr/M3
III. TOTAL COST (I + II) =	44,02	Birr/M3
IV. TOTAL COST (Birr/M^2) =	57,22	Birr/M2
V. TOTAL COST (Birr/Km) =	176.062	Birr/Km

Module 8 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Transportation of Borrow material

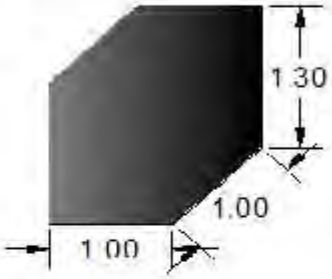
PAGE 2 OF 2

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
Loader	1,00	15	8,00	120,00
D/Truck	3,00	10	8,00	240,00
S/Vehicle	0,25	3,5	8,00	7,00
TOTAL				367,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Loader	1,00	0,00%	-
D/Truck	3,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-



1M x 1M x 1.3M Strip of Borrow Material on D/Truck

Required D/Truck & W/Truck for the daily output

Type	Distance = S(Km)	Speed V(Km/Hr)	L + UL Time (hr)	Capacity c (m3)	Hrly output (M3/hr)	Qty to be exuted=OP(m3/day)	No of DT/WT required per day
D/Truck	4	15	0,12	12	31,0	800,0	3,22

NOTE

Depth of carrier part of D/Truck = 1,3 M

1 M^2 of Borrow Material to be Transported 1M X 1M = 1M^2

1 M^2 of Borrow Material to be Transported 1M X 1M X 1.3M = 1.3 M^3

1 M^2 of Borrow Material to be Transported 1.3 M^3

COST

1 M^3 of Borrow Material Transported = 44,02 Birr

1 M^2 of Borrow Material Transported -1.3M^3 ? Birr

1 M^2 of Borrow Material Transported =1.3M^3 57,22 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	44,02	Birr
4000,0	?	Birr
1km length road =	176.062	Birr

Module 9 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Road bed preparation & Placing of borrow Material

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	60,00	480	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Grader	1	1	1.900,0	8	15.200,00
Roller	1	1	500,0	8	4.800,00
W/Truck	1	1	140,0	8	1.120,00
S/Vehicle	1	0,25	90,0	8	180,00
TOTAL (A) BIRR					21.300,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,75	17,79	13,31
Lubricants	***	***	***	-
TOTAL (B)				13,31

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Grader - Operator	1	1	-	1,6	-
Roller - Operator	1	1	-	1,6	-
W/Truck - Driver	1	1	-	1,6	-
E/Work Forman	1	1	7.000,0	1,6	11.200,00
Supperintendent	1	0,5	12.000,0	1,6	9.600,00
Construction Engireer	1	0,25	20.000,0	1,6	8.000,00
Site Engineer	1	0,5	10.000,0	1,6	8.000,00
Grade Checker	2	1	1.820,0	1,4	5.096,00
Data Collector	1	1	1.300,0	1,4	1.820,00
Daily Labourer	20	1	1.170,0	1,3	30.420,00
TOTAL (C) BIRR					74.136,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 44,38

2. MATERIAL COST = TOTAL (B) = 13,31

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 5,94

I. DIRECT COST (1+2+3) =	63,62	Birr/M3
II. PROFIT + OVERHEAD (40%) =	25,45	Birr/M3
III. TOTAL COST (I + II) =	89,07	Birr/M3
IV. TOTAL COST (Birr/M^2) =	17,81	Birr/M2
V. TOTAL COST (Birr/Km) =	356.277	Birr/Km

Module 9 - COST ANALYSIS

DATE May,2015

ACTIVITY : Road bed preparation & Placing of Borrow

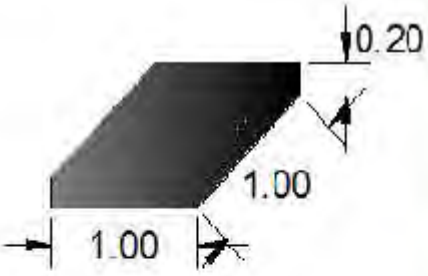
PAGE 2 OF 2

Natta Consumption per day (lit)

Equipment Type	No* Of	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
Grader	1,00	20	8,00	160,00
Roller	1,00	14	8,00	112,00
W/Truck	1,00	10	8,00	80,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				359,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Grader	1,00	-	-
Roller	1,00	-	-
W/Truck	1,00	-	-
TOTAL			-



1M x 1M x 0.2M Strip of Borrow Placing

Required D/Truck & W/Truck for the daily output

Type	Distance = S(Km)	Speed V(Km/Hr)	L + UL Time (hr)	Capacity c (m3)	Hrly output (M3/hr)	Qty to be exuted=QP(m3/day)	No of DT/WT required per day
D/Truck							
W/Truck	40	20	1,5	13	5,7	144,0	0,97

NOTE

Depth Borrow placing – 0,2 M

1 M^2 of Borrow Placing – 1M X 1M – 1M^2

1 M^2 of Borrow Placing = 1M X 1M X 0.2M = 0.2 M^2

1 M^3 of Borrow Placing – 0.2 M^3

COST

1 M^3 of Borrow Placing – 89,07 Birr

1 M^2 of Borrow Placing = 0.2 M^3 = ? Birr

1 M^2 of Borrow Placing = 0.2 M^3 = 17,81 Birr

Cost for 5m width road		
Bottom Width =	5	m
Length =	1000	m
Depth –	0,5	m
Volume –	4000	m^3
1km length road –	4000,0	m^3
IF for 1 m^3 =	89,07	Birr
4000,0	?	Birr
1km length road =	356.277	Birr

Module 10 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Reinstating of Overburder Excavated material

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	60,00	480	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Dozer	1	1	2.800,0	8	22.400,00
Grader	1	1	1.900,0	8	15.200,00
S/Vehicle	1	0,25	90,0	8	180,00
TOTAL (A) BIRR					37.780,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	1,18	17,79	21,01
Lubricants	***	***	***	-
TOTAL (B)				21,01

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Dozer - Operator	1	1	-	1,6	-
Grader - Operator	1	1	-	1,6	-
E/Work Forman	1	0,25	7.000,0	1,6	2.800,00
Grade Checker	1	1	1.820,0	1,6	2.912,00
Data Collector	1	1	1.300,0	1,4	1.820,00
Daily Labourer	2	1	1.170,0	1,3	3.042,00
					-
					-
TOTAL (C) BIRR					10.574,0

1 EQUIPMENT COST = TOTAL (A) / OUTPUT = 78,71

2 MATERIAL COST = TOTAL (B) = 21,01

3 MAN POWER COST = TOTAL (C) / OUTPUT*26 = 0,85

I. DIRECT COST (1+2+3) =	100,57	Birr/M3
II. PROFIT + OVERHEAD (40%) =	40,23	Birr/M3
III. TOTAL COST (I + II) =	140,80	Birr/M3
IV. TOTAL COST (Birr/M^2) =	70,40	Birr/M2
V. TOTAL COST (Birr/Km) =	563.192	Birr/Km

Module 10 - COST ANALYSIS

DATE May,2013

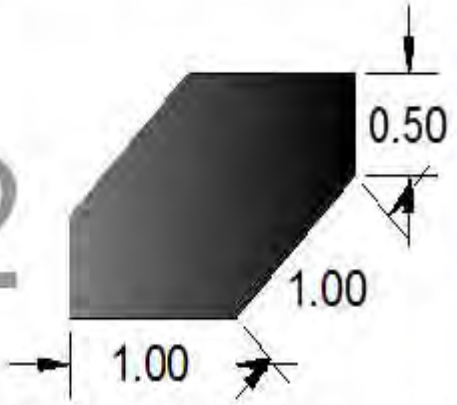
ACTIVITY :- Reinstating of Overburden Excavated material

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
Dozer	1,00	50	8,00	400,00
Grader	1,00	20	8,00	160,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				567,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Dozer	1,00	-	-
Grader	1,00	-	-
TOTAL			-



1M x 1M x 0.5M Strip of Reinstated Overburden Material

NOTE

Depth of Reinstating of disposal = 0,5 M

1 M^2 of Reinstated Material = 1M X 1M = 1M^2

1 M^2 of Reinstated Material = 1M X 1M X 0.5M = 0.5 M^3

1 M^2 of Reinstated Material = 0.5 M^3

COST

1 M^3 of Reinstated Material = 140,80 Birr

1 M^2 of Reinstated Material = 0.5 ? Birr

1 M^2 of Reinstated Material = 0.5 70,40 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	140,80	Birr
4000,0	?	Birr
1km length road =	563.192	Birr

A*. Loss of income related to loss of wild animals

No	Wild Animal Type	Unit	Hunting Unit Price (USD/No)	Hunting Unit Price (Birr/No) 1USD = 18.8628 Birr	Max. Allowed No of Hunting (No/Year)	Total Amount Expected from Hunting (Birr/Year)
A	B	C	D	E = D * 18.8628	F	G = E * F
1	White Eared Kob	No	4,000.00	75,451.20	100.00	**7,545,120.00**
2	Leopard	No	4,000.00	75,451.20	20.00	**1,509,024.00**
3	Lion	No	4,000.00	75,451.20	5.00	**377,256.00**
4	Monkey 1	No	180.00	3,395.30	200.00	**679,060.80**
5	Monkey 2	No	100.00	1,886.28	200.00	**377,256.00**
6	Duiker	No	250.00	4,715.70	50.00	**235,785.00**
7	Elephant	No	40,000.00	754,512.00	20.00	**15,090,240.00**
8	Buffalo	No	3,000.00	56,588.40	20.00	**1,131,768.00**
9	Nile leechwe	No	-	-	-	**-**
10	Birds	No		-		**-**
	TOTAL					**26,945,509.80**

B*. Loss of income related to loss of Birds

No	Birds Type	Unit	Income per Trip per Person (Pound/Trip/Person)	Income per Trip per Person (Pound/Trip/Person) 1POUND = 29.2750 Birr	Avg. No of expected visitors (No/Year)	Total Amount Expected from Vistors (Birr/Year)
A	B	C	D	E = D * 29.275	F	G = E * F
1	Birds	No	3,000.00	87,825.00	400.00	**35,130,000.00**
	TOTAL					**35,130,000.00**

Module 1 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Clearing and Grubbing for Lime stabilization

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	0,13	1	Ha/Day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
A	B	C	D	E	F=B*C*D*E
Dozer	1	1	2.800,0	8	22.400,0
S/Vehicle	1	0,25	90,0	8	180,0
					-
TOTAL (A) BIRR					22.580,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
M	N	O=B1/V(Total)	P	Q=O*P
Nafta	Lit	407,00	17,79	7.240,53
Lubricants	***	***	***	-
				-
TOTAL (B)				7.240,53

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
G	H	I	J	K	L=H*I*J*K
Dozer - Operator	0	1	-	1,6	-
S/Vehicle - Driver	0	0,25	-	1,6	-
E/Work Forman	1	1	7.000,0	1,6	11.200,00
Data Collector	1	1	1.800,0	1,4	2.520,00
Daily Labourer	4	1	1.500,0	1,3	7.800,00
					-
TOTAL (C) BIRR					21.520,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = 22.580,0

2. MATERIAL COST = TOTAL (B) = 7.240,5

3. MAN POWER COST = TOTAL (C) / OUTPUTx26 = 827,7

I. DIRECT COST (1+2+3) =	30.648	Birr/Ha
II. PROFIT + OVERHEAD (40%) =	12.259	Birr/Ha
III. TOTAL COST (I + II) =	42.908	Birr/Ha
IV. TOTAL COST (Birr/M^2) =	4,29	Birr/M2
V. TOTAL COST (Birr/Km) =	34.326	Birr/Km

Module 1 - COST ANALYSIS

ACTIVITY :- Clearing anc Grubbing for Lime stabilization

DATE May,2013

PAGE 2 OF 2

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
R	S=B*C	T	U=E	V=S*T*U
Dozer	1,00	50	8,00	400,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				407,00

Lubricants consumption in Amount per day

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
W	X=S	Y	Z=Y*V*P(constant)
Dozer	1,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-

NOTE

1 Ha of Clearing = 10.000 M^2

1 M^2 of Clearing = 1M X 1M = 1M^2

COST

1 Ha of Clearing (10,000 M^2) = 42.907,51 Birr

1 M^2 of Clearing = ? Birr

1 M^2 of Clearing = 4,29 Birr

Cost for 5m width road		
Bottom Wicth =	8	m
Length =	1000	m
Area =	8000	m^2
1km length road =	8000,0	m^2
IF for 1 m2 =	4,29	Birr
8000,0	?	Birr
1km length road =	34.326	Birr

Module 2 - COST ANALYSIS

Specific gravity of Hydrated Lime = Unit weight of H. lime / Unit weight of water

Unit weight of H. Lime = Specific gravity of H.Lime X Unit weight of water

Specific gravity of H. Lime =	2,35		
Unit weight of water =	1 000	Kg/M3	
Unit weight of H. Lime	2.350	Kg/M3	
I.e. 1M3 of H. Lime =	2.350	Kg	of H. Lime
? =	100	kg	of H. Lime
I.e. 100 kg (1qtl) of H. Lime = 100kg*1M3/2350Kg	0,0426	M3	
Purchase cost of stabilizer =	181,12	Birr/Qtl	
I.e. 100 kg (1qtl) of H. Lime = 0.0426 M3 =	181,12	Birr	
Then for 1 M3 of H. Lime = ?	4 256,32	Birr	
For 1 M3 of Soil we need	0,039	M3	of H. Lime
And hence for 0.039 M3 of H. Lime the cost will be =	166,20	Birr/M^3	
Purchase cost of stabilizer(Hydrated Lime) =	**83,10**	**Birr/M^2**	**Purchase Cost**

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Area =	8000	m^2
1km length road =	8000,0	m^2
IF for 1 m2 =	83,10	Birr
8000,0	?	Birr
1km length road =	664.795	Birr

Transport cost of stabilizer =	70	Birr/Qtl	
I.e. 100 kg (1qtl) of H. Lime 0.0426 M3	70	Birr	
Then for 1 M3 of H. Lime = ?	1.645,0	Birr	
For 1 M3 of Soil we need	0,04	M3	of H. Lime
And hence for 0.04 M3 of H. Lime the cost will be =	64,23	Birr/M^3	
Purchase cost of stabilizer(Hydrated Lime) =	**32,12**	**Birr/M^2**	**Transport Cost**

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Area =	8000	m^2
1km length road =	8000,0	m^2
IF for 1 m2 =	32,12	0,00
8000,0	?	Birr
1km length road =	256.933	Birr

Module 3 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Hauling of Lime

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	100,00	800	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
D/Truck	2	1	500,0	8	8.000,00
S/Vehicle	1	0,25	90,0	8	180,00
TOTAL (A) BIRR					8.180,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,21	17,79	3,71
Lubricants	***	***	***	-
TOTAL (B)				3,71

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
D/Truck - Driver	2	1	-	1,6	-
S/Vehicle - Driver	1	0,25	-	1,6	-
E/Work Forman	1	0,25	7.000,0	1,4	2.450,00
Load Counter	1	1	1.300,0	1,4	1.820,00
Daily Labourer	100	1	1.170,0	1,3	152.100,0
TOTAL (C) BIRR					156.370,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT = **10,23**

2. MATERIAL COST = TOTAL (B) = **3,71**

3. MAN POWER COST = TOTAL (C) / OUTPUT*25 = **7,52**

I. DIRECT COST (1+2+3) =	21,46	Birr/M3
II. PROFIT + OVERHEAD (40%) =	8,58	Birr/M3
III. TOTAL COST (I+II) =	30,04	Birr/M3
IV. TOTAL COST (Birr/M^2) =	39,05	Birr/M2
V. TOTAL COST (Birr/Km) =	120.156	Birr/Km

Module 3 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Hauling of Lime

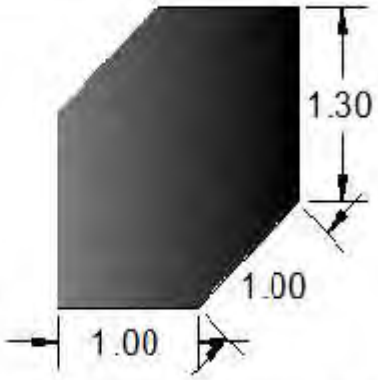
PAGE 2 OF 2

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
D/Truck	2,00	10	8,00	160,00
S/Vehicle	0,25	3,5	8,00	7,00
				-
TOTAL				167,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
D/Truck	2,00	0,00%	-
S/Vehicle	0,25	0,00%	-
TOTAL			-



1M x 1M x 1.3M Strip of Lime on D/Truck

Required D/Truck & W/Truck for the daily output

Type	Distance = S(Km)	Speed V(Km/Hr)	L + UL Time (hr)	Capacity c (m3)	Hrly output (M3/hr)	Qty to be exuted=OP(m3/day)	No of DT/WT required per day
D/Truck	1	15	0,12	12	64,3	800,0	1,56

NOTE

Depth of carrier part of D/Truck = 1,3 M

1 M^2 of Lime to be Transported = 1M X 1M = $1M^2$

1 M^2 of Lime to be Transported = 1M X 1M X 1.3M = 1.3 M^3

1 M^2 of Lime to be Transported = 1.3 M^3

COST

1 M^3 of Lime Transported =	30,04	Birr
1 M^2 of Lime Transported =1.3M^3	?	Birr
1 M^2 of Lime Transported =1.3M^3	39,05	Birr

Cost for 5m width road

Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	30,04	Birr
4000,0	?	Birr
1km length road =	120.155	Birr

Module 4 - COST ANALYSIS

DATE May 2013

PROJECT :- GAMBELLA ALWERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Mixing of Lime with Expansive Soil

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	30,00	240	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Grader	1	1	1.900,0	8	15.200,00
S/Vehicle	1	1	90,0	8	720,00
					-
					-
TOTAL (A) BIRR					15.920,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,78	17,79	13,94
Lubricants	***	***	***	-
TOTAL (B)				13,94

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Grader – Operator	1	1	-	1,6	-
S/Vehicle – Driver	1	1	-	1,6	-
E/Work Forman	1	1	-	1,6	-
Supperintendent	1	0,5	12.000,0	1,6	9.600,00
Construction Engineer	1	0,25	20.000,0	1,6	8.000,00
Site Engineer	1	0,5	10.000,0	1,6	8.000,00
Grade Checker	4	1	1.820,0	1,4	10.192,00
Data Collector	2	1	1.300,0	1,4	3.640,00
Daily Labourer	20	1	1.170,0	1,3	30.420,00
					-
TOTAL (C) BIRR					69.852,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT =	66,33	
2. MATERIAL COST = TOTAL (B) =	13,94	
3. MAN POWER COST = TOTAL (C) / OUTPUTx25 =	11,19	
I. DIRECT COST (1+2+3) =	91,46	Birr/M3
II. PROFIT + OVERHEAD (40%) =	36,59	Birr/M3
III. TOTAL COST (I + II) =	128,05	Birr/M3
IV. TOTAL COST (Birr/M^2) =	64,02	Birr/M2
V. TOTAL COST (Birr/Km) =	512.193	Birr/Km

Module 4 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Mixing of Lime with Expansive Soil

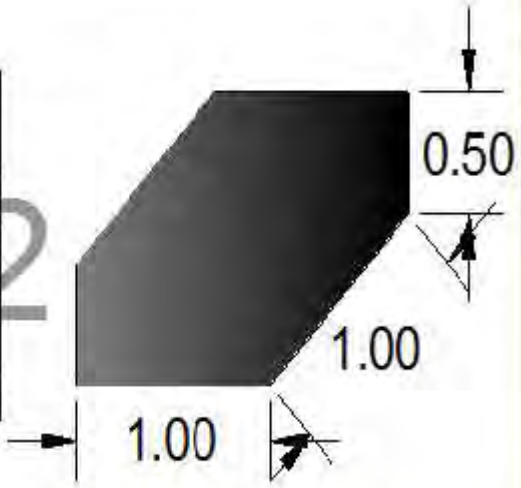
PAGE 2 OF 2

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
Grader	1,00	20	8,00	160,00
S/Vehicle	1,00	3,5	8,00	28,00
-	-		-	-
-	-		-	-
				-
TOTAL				188,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Grader	1,00	-	-
S/Vehicle	1,00	-	-
-	-	-	-
TOTAL			-



1M x 1M x 0.5M Strip of Lime Mixing

NOTE

Depth of Lime Mixing = 0,5 M

1 M^2 of Lime Mixing = 1M X 1M = 1M^2

1 M^2 of Lime Mixing = 1M X 1M X 0.5M = 0.5 M^3

1 M^2 of Lime Mixing = 0.5 M^3

COST

1 M^3 of Lime Mixing = 128,05 Birr

1 M^2 of Lime Mixing = 0.5 M^3 = ? Birr

1 M^2 of Lime Mixing = 0.5 M^3 = 64,02 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	128,05	Birr
4000,0	?	Birr
1km length road =	512.193	Birr

Module 5 - COST ANALYSIS

DATE May,2013

PROJECT :- GAMBELLA A.WERO RICE PROJECT

PAGE 1 OF 2

LOCATION :- GAMBELLA NATIONAL REGIONAL STATE

ACTIVITY :- Placing of Mixed (Stabilized) Material

ITEM No :-

OUT PUT	Perhr	Per day(8 hr)	Unit
	A1	B1	C1
	60,00	480	m^3/day

A. EQUIPMENT

TYPE	No	U.F	RENTAL RATE / HR. (BIRR)	WORKING HRS./ DAY	DAILY EQUIPMENT COST (BIRR)
Grader	1	1	1.900,0	8	15.200,00
Roller	1	1	600,0	8	4.800,00
W/Truck	1	1	140,0	8	1.120,00
S/Vehicle	1	1	90,0	8	720,00
TOTAL (A) BIRR					21.840,0

B. MATERIAL

TYPE	UNIT	REQUIRED QTY PER UNIT	UNIT RATE (BIRR)	COST PER UNIT (BIRR)
Nafta	Lit	0,73	17,79	14,08
Lubricants	***	***	***	-
TOTAL (B)				14,08

C. MANPOWER

SKILL	No	U.F	MONTHLY SALARY (BIRR)	INDEX	MONTHLY COST (BIRR)
Grader - Operator	1	1	-	1,5	-
Roller - Operator	1	1	-	1,5	-
W/Truck - Driver	1	1	-	1,5	-
E/Work Forman	1	1	7.000,0	1,5	11.200,00
Supperintendent	1	1	12.000,0	1,5	19.200,00
Construction Engineer	1	1	20.000,0	1,5	32.000,00
Site Engineer	1	1	10.000,0	1,5	16.000,00
Grade Checker	2	1	1.820,0	1,4	5.096,00
Data Collector	2	1	1.300,0	1,4	3.640,00
Daily Labourer	20	1	1.170,0	1,3	30.420,00
TOTAL (C) BIRR					117.556,0

1. EQUIPMENT COST = TOTAL (A) / OUTPUT =	45,50	
2. MATERIAL COST = TOTAL (B) =	14,08	
3. MAN POWER COST = TOTAL (C) / OUTPUTx26 =	9,42	
I. DIRECT COST (1+2+3) =	69,00	Birr/M3
II. PROFIT + OVERHEAD (40%) =	27,60	Birr/M3
III. TOTAL COST (I + II) =	96,6	Birr/M3
IV. TOTAL COST (Birr/M^2) =	48,30	Birr/M2
V. TOTAL COST (Birr/Km) =	386.418	Birr/Km

Module 5 - COST ANALYSIS

DATE May,2013

ACTIVITY :- Placing of Mixed (Stabilized) Material

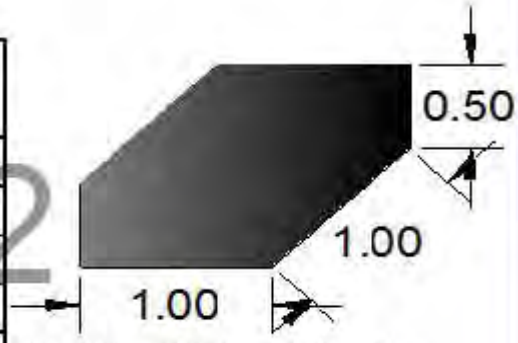
PAGE 2 OF 2

Nafta Consumption per day (lit)

Equipment Type	No* Uf	Consumption /hr.	Working hrs./day	Consumption/Day (Qty)
Grader	1,00	20	8,00	160,00
Roller	1,00	14	8,00	112,00
W/Truck	1,00	10	8,00	80,00
S/Vehicle	1,00	3.5	8,00	28,00
				-
TOTAL				380,00

Lubricants

Equipment Type	No	Lub. Cons/ Fuel Cons. (%)	Consumption/Day (BIRR)
Grader	1,00	-	-
Roller	1,00	-	-
W/Truck	1,00	-	-
TOTAL			-



1M x 1M x 0.5M Strip of Lime Placing

Required D/Truck & W/Truck for the daily output

Type	Distance = S(Km)	Speed V(Km/Hr)	L + UL Time (hr)	Capacity c (m3)	Hrly output (M3/hr)	Qty to be exuted=OP(m3/day)	No of DT/WT required per day
W/Truck	40	20	1,5	13	3,7	144,0	0,97

NOTE

Depth of Lime Placing = 0,5 M

1 M^2 of Lime Placing = 1M X 1M = 1M^2

1 M^2 of Lime Placing = 1M X 1M X 0.5M = 0.5 M^3

1 M^2 of Lime Placing = 0.5 M^3

COST

1 M^3 of Lime Placing = 96,60 Birr

1 M^2 of Lime Placing = 0.5 M^3 = ? Birr

1 M^2 of Lime Placing = 0.5 M^3 = 48,30 Birr

Cost for 5m width road		
Bottom Width =	8	m
Length =	1000	m
Depth =	0,5	m
Volume =	4000	m^3
1km length road =	4000,0	m^3
IF for 1 m^3 =	96,60	Birr
4000,0	?	Birr
1km length road =	386.418	Birr

ANNEX 4

I. Type of medicinal plant and their usage by local people

No	Type of Medicinal Plant	Usage	Process	Remark
1	*Sonegena**** (Shrub)	Arthritis, Boils	Using branch of the shrub	
2	*Duchmerachi **** (Tree)	Hepatitis	Using the roots of the tree	
3	*Hasengo**** (Shrub)	Tonsillitis, Infection	Using branch of the shrub	
4	*Beybey**** (Exotic Tree)	Malaria	Using branch of the tree	
5	*Mulukiya**** (Shrub)	Dirrhea	Using branch of the shrub	
6	*Werbebo**** (Hareg) (Shrub)	Constipation, Boils	Using branch of the shrub	
7	*Elpha**** (Shrub)	Infection, Boils	Using branch of the shrub	
8	*Towa**** (Shrub)	Infection, Boils	Using branch of the shrub	
9	*Wolo**** (Shrub)	Hepatitis	Using hard cover (Kirfit) of the shrub	

II. Type of plant used for food by local people

No	Type of Medicinal Plant	Usage	Process	Remark
1	*Mulukiya* ***(Shrub)	Food	Using branch of the shrub	
2	*Shiferaw**** (Tree)	Food	Using branch of the tree	

Note:- *** This names are local names given by local people.

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Lab No.	:	472/13
Client	:	Saudi Star Agricultural Development (Gambella-Alwaro-Rice Project)
Project	:	Gambela Alwero-Rice-project
Sample of	:	Black Soil Blended With 6,8 and 10% Lime Stone Powder
Submitted by	:	THe Client
Test for	:	Atterbur Limit,Seive Analysis,Proctor Density + CBR Value and Linear Shrinkage Limit(AASHTO T 89-86,T 27-84, T 180-85 and T 193-81)
Sampled by	:	THe Client ON : 20/03/13
Specified by	:	THe Client ON : 20/03/13
Reported to	:	The Client ON : 10/4/2013

SUMMARY OF LABORATORY TEST RESULTS

Sr.No.	TP No	Sample of	Sample Description	Sieve Analysis,% Passing (AASHTO T 27-84) 25.0 (mm)	19.0 (mm)	12.5 (mm)	9.5 (mm)	4.75 (mm)	2.0 (mm)	0.43 (mm)	0.075 (mm)	Atterberg limits LL (%)	PI (%)	AASHTO Classification	OMC %	Max. Dry Density g/cm³	CBR Value % at 2.54	at 5.08	Swell %	Linear Shrinkage Limit
1	TP 1	Black Soil						100	99	90	71.8	44	22	A-7-6(17)	16.00	1.793	2.8	2.8	2.19	12.86
2	TP 2	Black Soil							100	87	60.5	51	27	A-7-6(13)	13.01	1.802	4.6	4.7	1.62	13.57
3	TP 3	Black Soil						100	97	87	68.1	54	29	A-7-6(18)	13.40	1.792	1.6	1.3	3.02	17.50
4	TP 4	Black Soil							100	88	66.6	51	24	A-7-6(13)	12.56	1.808	2.3	2.2	2.53	17.14
	Blended with Lime																			
5	TP1	Black Soil,Blended with 6% Lime				100	98	99	97	85	65.4	52	27	A-7-6(15)	15.40	1.856	2.50	2.5	1.56	17.86
6		Black Soil,Blended with 8% Lime					100	98	97	85	66.8	52	27	A-7-6(15)	11.47	1.827	2.7	2.6	1.56	17.14
7		Black Soil,Blended with 10% Lime				100	99	99	97	84	65.8	48	24	A-7-6(13)	15.85	1.799	2.86	2.96	1.89	16.43
8	TP2	Black Soil,Blended with 6% Lime					100	99	98	84	61.1	49	25	A-7-6(12)	13.22	1.846	2.6	2.4	1.23	16.43
9		Black Soil,Blended with 8% Lime					100	98	97	83	60.0	48	27	A-7-6(10)	11.83	1.897	2.7	3.6	1.29	15.71
10		Black Soil,Blended with 10% Lime				100	98	97	95	83	59.9	48	26	A-7-6(11)	12.25	1.867	2.9	2.6	1.48	15.00
11	TP3	Black Soil,Blended with 6% Lime					100	98	96	84	63.5	56	31	A-7-6(16)	14.42	1.803	2.1	2.5	2.23	18.57
12		Black Soil,Blended with 8% Lime					100	99	96	84	63.4	49	27	A-7-6(14)	13.00	1.829	2.3	2.2	2.92	17.86
13		Black Soil,Blended with 10% Lime				100	99	98	92	82	62.2	48	24	A-7-6(12)	14.59	1.795	4.1	3.4	1.64	15.71
14	TP4	Black Soil,Blended with 6% Lime					100	99	97	86	62.6	53	29	A-7-6(14)	14.29	1.763		1.9	2.70	19.29
15		Black Soil,Blended with 8% Lime					100	98	96	85	62.1	52	28	A-7-6(13)	15.52	1.793	2.3	2.2	2.71	18.21
16		Black Soil,Blended with 10% Lime				100	98	97	95	83	60.9	52	29	A-7-6(14)	11.50	1.807	2.3	2.2	2.63	16.00

REMARK:

REPORTED BY:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

APPROVED BY:

Ayehutsega Aygechew
Soil and Const. Mat. Testing
Dept. Manager

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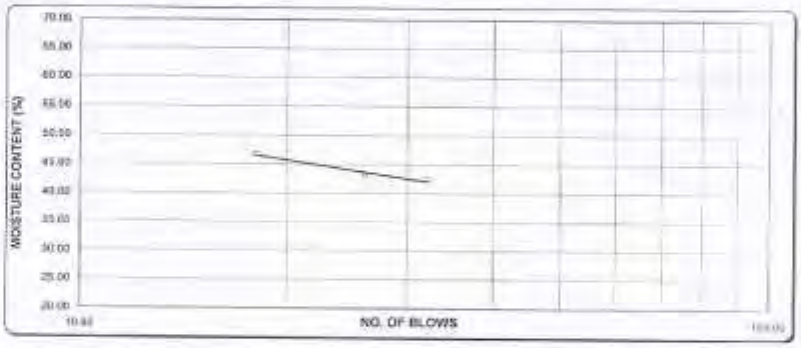
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	32	26	18		
Wt. wet soil (g.)	16.21	14.26	14.58	3.56	3.30
Wt. dry soil (g.)	17.57	9.95	9.93	3.24	3.71
Moisture content (%)	42.44	43.32	46.83	22.22	21.77
				AV. PL (%)	22.0



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SIEVE ANALYSIS, % PASS			AASHTO Soil Classification
			2 mm	0.425 mm	0.075 mm	
44	22	22	99	90	71.8	A-7-5(17)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

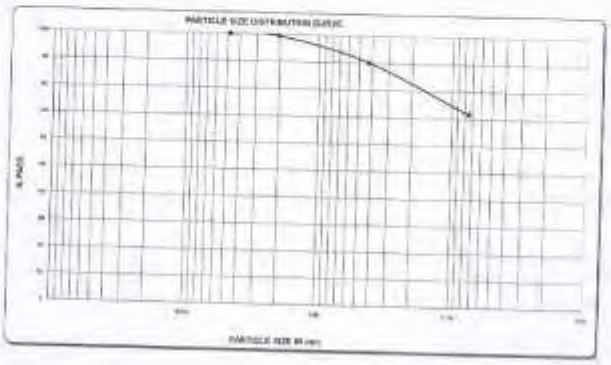
Ayahuberga Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)
TEST RESULT REPORTED TO	:	The Client ON : '05/04/13

TEST RESULT

4.75	100
2.00	90
0.425	48
0.075	11.8



REMARKS: _____

REPORTED BY :

APPROVED By:

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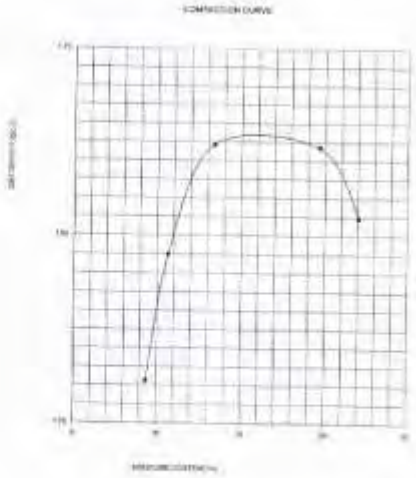
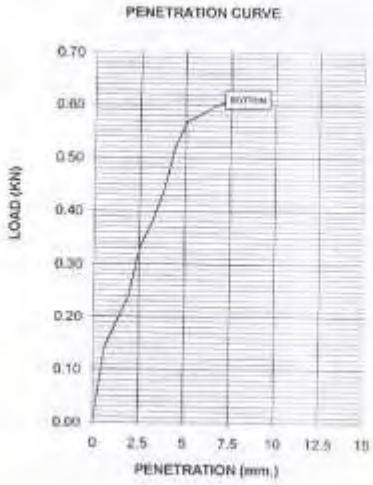
LAB. NO.	:	572/13	
CLIENT	:	Saudi Star Agricultural Development(Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 1	Depth, m :
SAMPLE OF	:	Black Cotton Soil	
SAMPLED BY	:	THe Client	
SPECIFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
With grinded	Over size
1.703	16.00

Standard Load (KN)		Load (KN) Bottom		CBR(%) Bottom		Swell (%)
2.5mm	5.0mm	2.5mm	5.0mm	2.54 (mm)	5.08 (mm)	
13.24	20	0.33	0.67	2.5	2.8	2.19

Remark :

Reported by :

Lab. Engineer

Approved by :

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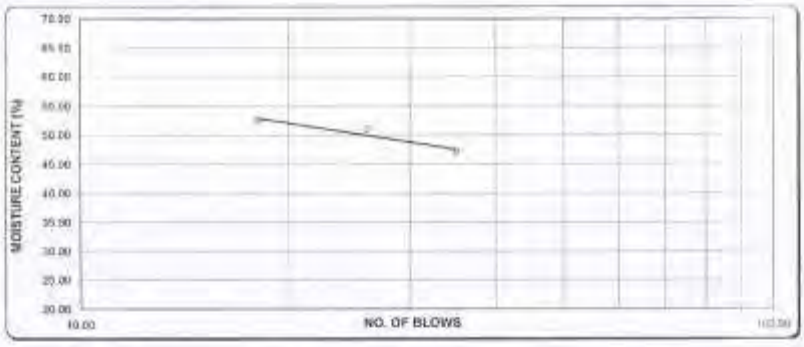
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	26	18		
Wt. wet soil (g.)	12.93	17.62	14.84	3.74	3.64
Wt. dry soil (g.)	17.57	11.87	9.73	3.01	2.94
Moisture content (%)	47.27	50.99	52.52	24.26	23.81
				AV. PL (%)	24.0



Liquid Limit	Plastic Limit	Plasticity Index	WET SEIVE ANALYSIS, % PASS			AASHTO SOIL Classification
LL(%)	PL(%)	PI	2 mm	0.425 mm	0.075 mm	
51	24	27	100	87	60.5	A-7-6(13)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

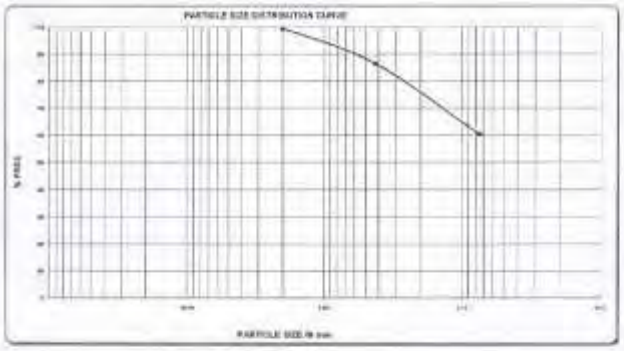
Ayshuteaga Awgachew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 2	Depth, m :
SAMPLE OF	:	Black Cotton Soil	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT

SIEVE SIZE (mm)	% PASSING
75.00	
53.00	
37.50	
25.00	
19.00	
12.50	
9.50	
4.75	
2.00	100
0.425	81
0.075	60.5



REMARKS: _____

REPORTED BY

APPROVED By:

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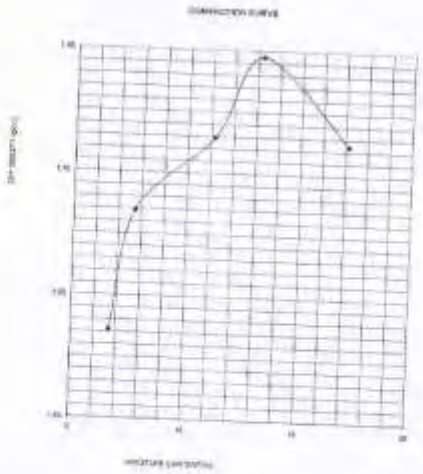
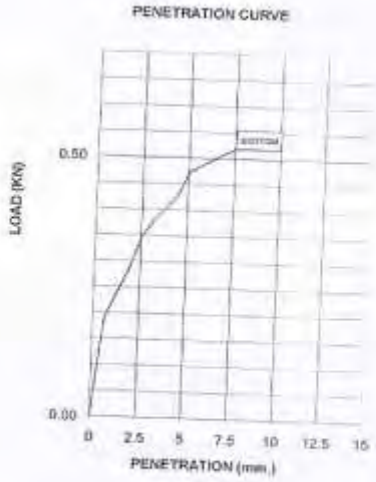
LAB. NO.	:	572/13
CLIENT	:	Saudi Star Agricultural Development (Gambella Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder
SAMPLED BY	:	The Client
SPECIEFIED BY	:	The Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193 ON :25/03/13
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD gm/cm3	OMC %
1.848	13.22

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell (%)
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	
13.24	20	8.35	9.47	2.6	2.4	1.23

Remark :

Reported by :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Approved by :

Ayehutsega Awgechew
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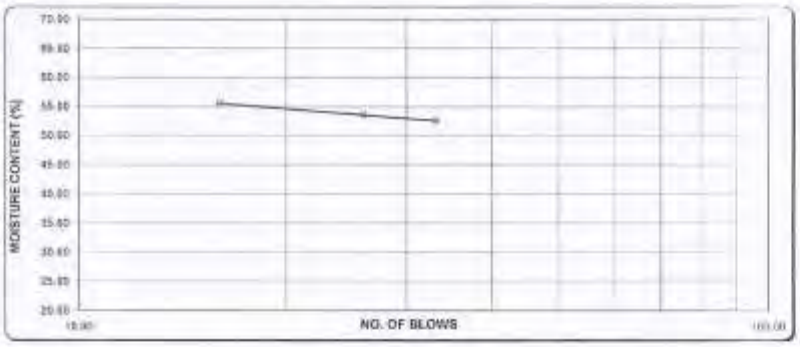
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 3 Depth, m :
SAMPLE OF	:	Black Cotton Soil
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	33	26	18		
Wt. wet soil (g.)	18.76	16.90	14.55	3.46	3.64
Wt. dry soil (g.)	17.57	11.00	9.35	2.68	2.77
Moisture content (%)	52.64	53.64	55.61	29.10	29.24
				AV. PL (%)	29.2



Liquid Limit	Plastic Limit	Plasticity Index	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
LL(%)	PL(%)	PI	2 mm	0.425 mm	0.075 mm	
54	29	25	97	87	68.1	A-7-6(15)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

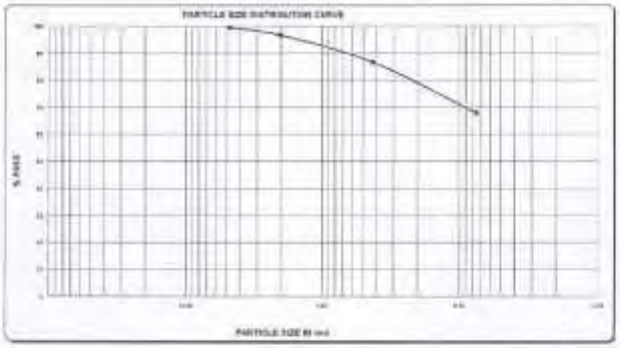
LTP3

SABA Engineering PRIVATE LIMITED COMPANY

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 3	Depth, m :
SAMPLE OF	:	Black Cotton Soil	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :26/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :26/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : '05/04/13

TEST RESULT

SIEVE SIZE (mm)	% PASSING
75.00	
63.00	
50.00	
37.50	
19.00	
13.20	
9.50	
4.75	100
2.00	97
0.425	87
0.075	68.5



REMARKS: _____

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayalneseph Awgechew
Soil and Const. Mat. Testing
Dept. Manager

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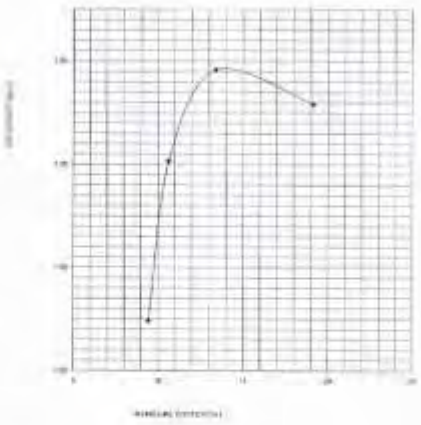
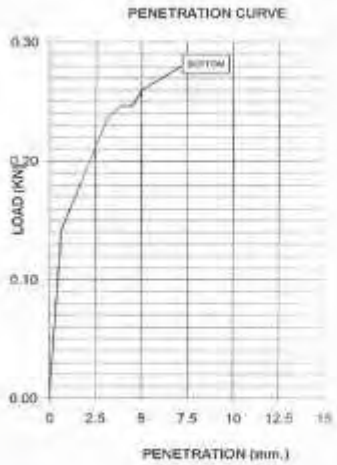
LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 3	Depth, m :
SAMPLE OF	:	Black Cotton Soil	
SAMPLED BY	:	The Client	
SPECIEFIED BY	:	The Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 193	
MDD gm/cm3	OMC (%)
1.792	13.40

Standard Load (KN)		Load (KN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.21	0.28	1.6	1.3	3.02

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

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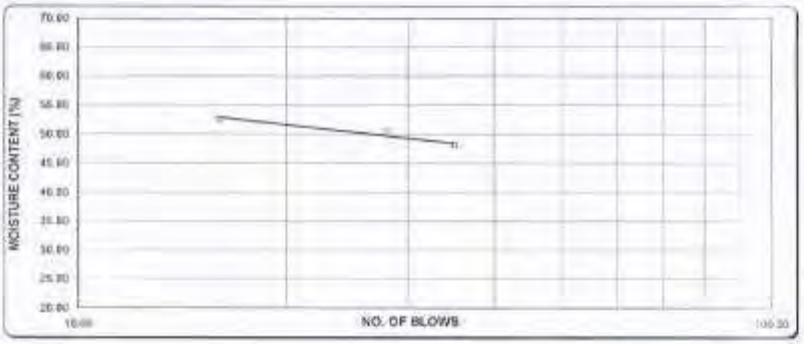
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	28	16		
Wt. wet soil (g.)	14.60	15.61	15.57	4.25	3.21
Wt. dry soil (g.)	17.57	10.36	10.20	3.34	2.54
Moisture content (%)	48.07	50.68	52.65	27.25	26.38
				AV. PL (%)	26.8



Liquid Limit	Plastic Limit	Plasticity Index	WET SEIVE ANALYSIS, % PASS			AASHTO Soil Classification
LL(%)	PL(%)	PI	2 mm	0.425 mm	0.075 mm	
51	27	24	100	88	66.6	A-7-6(13)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

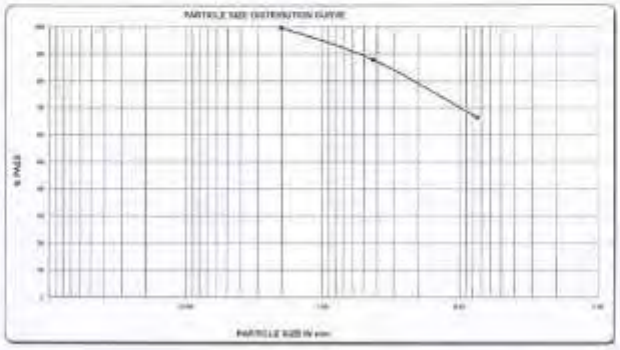
Ayalnitsega Avgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	:	672/13	
CLIENT	:	A.A University Civil Department	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 4	Depth, m :
SAMPLE OF	:	Black Cotton Soil	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSED
	100
	99
	99.4



REMARKS: _____

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

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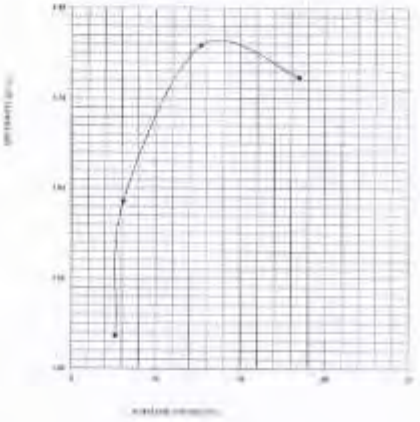
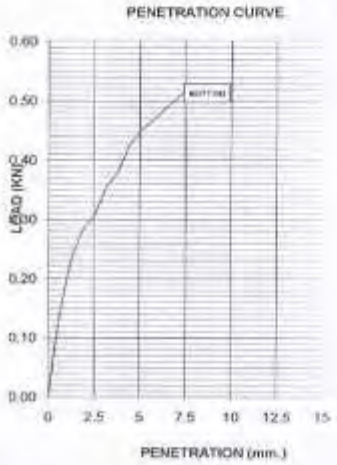
LAB. NO.	:	E72/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 4	Depth, m :
SAMPLE OF	:	Black Cotton Soil	
SAMPLED BY	:	The Client	
SPECIFIED BY	:	The Client	ON :28/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :28/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
Max. dry density (g/cm3)	OMC (%)
1.808	12.85

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell (%)
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	
13.24	20	0.31	0.45	2.3	2.2	2.83

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C.

Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

CALIFORNIA BEARING RATIO / SWELL PERCENT

GAMBELLA ALWERO RIGT PROJECT

EMPLOYER	CONSULTANT	CONTRACTOR
SAUDI STAR AGRICULTURAL DEVELOPMENT PLC	SNC LAVALINE INTERNATIONAL IN ASSOCIATION WITH TROPICS CONSULTING ENGINEERS	GHULAM RASOOL AND COMPANY PLC/SAUDI STAR AGRICULTURAL DEVELOPMENT PLC OWN FORCE

TEST METHOD: AASHTO T- 193

Station:-	Test Pit 01	Depth Sampled:-	2 m
		Surcharge Wt:-	4.5kg
Material Type:-	Borrow for Replacing	Date Sampled :-	13.03.2013
Visual Description :-	Light brown Silty Clay soil	Soaking Date:-	21/03/13
		Penetration Date :	25/03/13
Maximum Dry Density:	1,57	Optimum Moisture Content (OMC):	16,7
Mould No:-	15	Natural Moisture Content (NMC) : -	2,9
Weight of Soil Sample:-	6000 gm	Water to be added : -	808 ml

Density Determination	Before	After
Wt of mould(gm)	6344	6344
Volume of mould(cc)	2124	2124
Wt of mould+Wet soil(gm)	11345	11427
Wt of wet soil(gm)	5001	5083
Wet density(gm/cc)	2,35	2,39
Dry density(gm/cc)	2,05	2,06

Moisture Determination	Before	After
Container No.	25	26
Wt cont+wet soil	117,60	134,66
Wt cont+dry soil	105.01	118,92
Wt cont	20,04	20,33
Wt of moisture	12,590	15,74
Wt dry soil	84,970	98,59
MC %	14,8	16,0

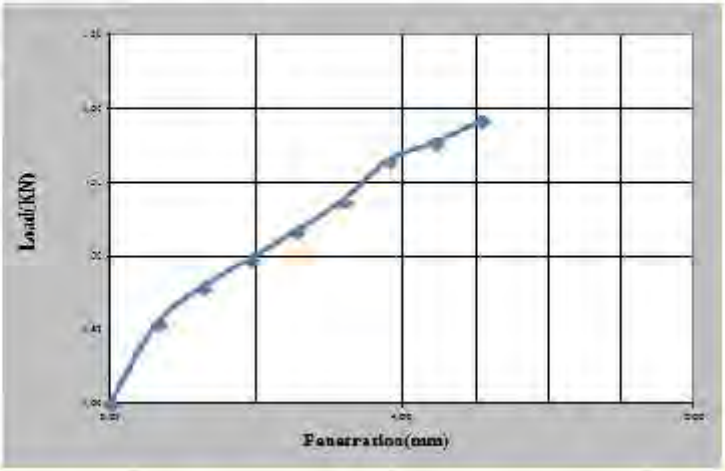
Ring Factor: 0,02082

Penetration	Dial Read.	Load (KN)	CBR (%)
0,00	0	0,00	
0,64	26	0,54	
1,27	38	0,79	
1,91	47	0,98	
2,54	56	1,17	9
3,18	66	1,37	
3,81	79	1,64	
4,45	85	1,77	
5,08	92	1,92	10
6,65			
7,62			
10,16			

Swelling Test	
Date	21/03/13
Time	3:00 PM
No of days	4
Initial reading	0
Final reading	0,56
Swell	0,56
% Swell	0,4

Std. Presu. * Piston Area
6.89 * 1.95
13.44

Std. Presu. * Piston Area
10.21 * 1.95
19.91



CALIFORNIA BEARING RATIO / SWELL PERCENT

GAMBELLA ALWERO RICE PROJECT

EMPLOYER	CONSULTANT	CONTRACTOR
SAUDI STAR AGRICULTURAL DEVELOPMENT	SNC LAVALINE INTERNATIONAL IN ASSOCIATION WITH TROPICS CONSULTING ENGINEERS	GHULAM RASCOL AND COMPANY PLC/SAUDI STAR AGRICULTURAL DEVELOPMENT PLC OWN FORCE

TEST METHOD: AASHTO T- 193

Station:-	Test Pit - 02	Depth Sampled:-	2 m
		Surcharge Wt.:-	4.5kg
Material Type:-	Borrow for Replacing	Date Sampled :-	13.03.2013
Visual Description :	Light Brown Silty Clay Soil	Soaking Date:-	21/03/13
		Penetration Date :	25/03/13
Maximum Dry Density: -	1.57	Optimum Moisture Content (OMC):-	20.5
Mould No:-	M	Natural Moisture Content (NMC) : -	3.5
Weight of Soil Sample:-	6000 gm	Water to be added : -	988 ml

Density Determination		
	Before	After
Wt of mould(gm)	6305	6305
Volume of mould(cc)	2121	2121
Wt of mould+Wet soil(gm)	10951	11134
Wt of wet soil(gm)	4673	4831
Wet density(gm/cc)	2.20	2.27
Dry density(gm/cc)	1.86	1.89

Moisture Determination		
	Before	After
Container No.	60	11
Wt cont+wet soil	110,90	108,30
Wt cont+dry soil	96,83	93,70
Wt cont.	20,25	20,18
Wt of moisture	14,070	14,84
Wt dry soil	76,580	73,52
MC %	18,1	20,2

Ring Factor: 0.02082

Penetration	Dial Read.	Load (KN)	CBR (%)
0,00	0	0,00	
0,64	10	0,21	
1,27	19	0,40	
1,91	30	0.62	
2,54	38	0.79	6
3,18	42	0.87	
3,81	44	0,92	
4,45	46	0,96	
5,08	51	1,06	5
6,35	58	1,21	
7,62	65	1,35	
10.16			

Std. Presu. * Piston Area
6.89 * 1.95
13.44

Std. Presu. * Piston Area
10.21 * 1.95
19.91

Swelling Test	
Date	21/03/13
Time	3:00 PM
No of days	4
Initial reading	0
Final reading	3,15
Swel	3,15
% Swel	2.2

CALIFORNIA BEARING RATIO / SWELL PERCENT

GAMBELLA ALWERO RICE PROJECT

EMPLOYER	CONSULTANT	CONTRACTOR
SAUDI STAR AGRICULTURAL DEVELOPMENT	SNC LAVALIN INTERNATIONAL IN ASSOCIATION WITH TROPICS CONSULTING ENGINEERS	GHULAM RASOOL AND COMPANY PLC/SAUDI STAR AGRICULTURAL DEVELOPMENT PLC OWN FORCE

TEST METHOD: AASHTO T- 193

Station:-	Test Pit 03	Depth Sampled:-	2 m
		Surcharge Wt.:-	4.5kg
Material Type:-	Borrow for Replacing	Date Sampled :-	13.03.2013
Visual Description :	Light Brown Silty CLAY Soils	Soaking Date:-	21/03/13
		Penetration Date :-	25/03/13
Maximum Dry Density: -	1,77	Optimum Moisture Content (OMC):-	16,3
Mould No:-	15	Natural Moisture Content (NMC) :	3,9
Weight of Soil Sample:-	6000 gm	Water to be added : -	717 ml

Density Determination			Moisture Determination		
	Before	After		Before	After
Wt of mould(gm)	6342	6342	Container No.	23	E
Volume of mould(cc)	2124	2124	Wt cont+wet soil	106,70	119,54
Wt of mould+Wet soil(gm)	11251	11363	Wt cont+dry soil	95,82	106,62
Wt of wet soil(gm)	4909	5021	Wt cont	20,05	20,25
Wet density(gm/cc)	2,31	2,36	Wt of moisture	10,880	12,92
Dry density(gm/cc)	2,02	2,06	Wt dry soil	75,77	86,37
			MC %	14,4	15.0

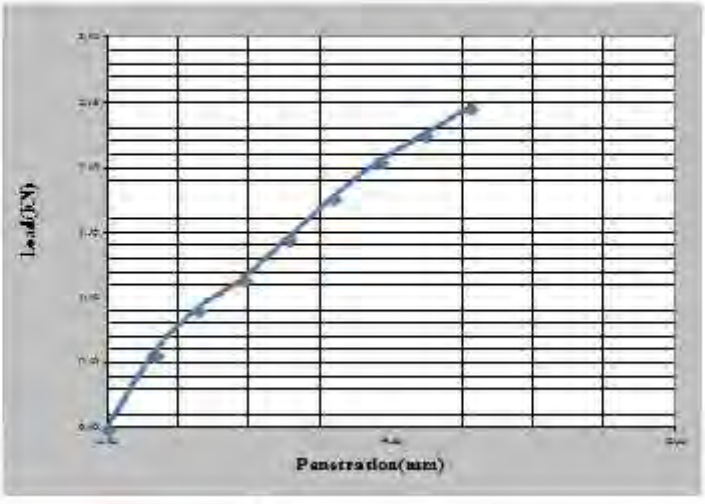
Ring Factor: 0,02082

Penetration	Dial Read.	Load (KN)	CBR (%)
0,00	0	0,00	
0,64	77	0,36	
1,27	44	0,92	
1,91	55	1,15	
2,54	70	1,46	11
3,18	85	1,77	
3,81	98	2,04	
4,45	108	2,25	
5,08	118	2,46	12
6,65			
7,62			
10,16			

Std. Presu. * Piston Area
6.89 * 1.93
17,44

Std. Presu. * Piston Area
10.21 * 1.93
19,91

Swelling Test	
Date	21/03/13
Time	2:00 PM
No of days	4
Initial reading	0
Final reading	0,65
Swell	0,65
% Swell	0,5



CALIFORNIA BEARING RATIO / SWELL PERCENT

GAMBELLA ALWERO RICE PROJECT

EMPLOYER	CONSULTANT	CONTRACTOR
SAUDI STAR AGRICULTURAL DEVELOPMENT	SNC LAVALINE INTERNATIONAL IN ASSOCIATION WITH TROPICS CONSULTING ENGINEERS	GHULAM RASOOL AND COMPANY PLC/SAUDI STAR AGRICULTURAL DEVELOPMENT PLC OWN FORCE

TEST METHOD: AASHTO T- 193

Station:-	Test Pit 01	Depth Sampled:-	2 M
		Surcharge Wt:-	4.5kg
Material Type:-	Borrow for Replacing	Date Sampled :-	13.03.2013
Visual Description :-	Light Brown Silty Clay Soils	Soaking Date:-	21/03/13
		Penetration Date :	25/03/13
Maximum Dry Density: -	1,67	Optimum Moisture Content (OMC):-	18,4
Mould No:-	B	Natural Moisture Content (NMC) :	5,1
Weight of Soil Sample:-	6000 gm	Water to be added : -	758 ml

Density Determination	Before	After
Wt of mould(gm)	6247	6247
Volume of mould(cc)	2124	2124
Wt of mould+Wet soil(gm)	10954	11120
Wt of wet soil(gm)	4707	4873
Wet density(gm/cc)	2,22	2,29
Dry density(gm/cc)	1,91	1,93

Moisture Determination	Before	After
Container No	8	15
Wt cont+wet soil	112,02	118,31
Wt cont+dry soil	99,27	102,58
Wt cont	20,31	20,47
Wt of moisture	12,750	15,73
Wt dry soil	78,960	82,11
MC %	16,1	19,2

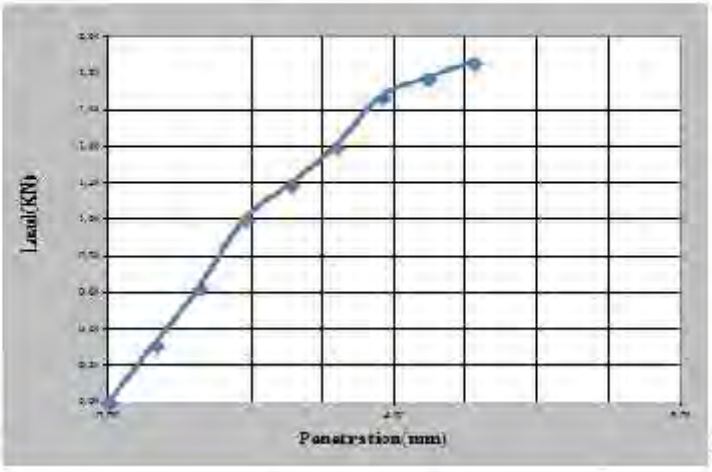
Ring Factor: 0,02082

Penetration	Dial Read.	Load (KN)	CBR (%)
0,00	0	0,00	
0,64	15	0,31	
1,27	30	0,62	
1,91	48	1,00	
2,54	57	1,19	9
3,18	67	1,39	
3,81	80	1,67	
4,45	85	1,77	
5,08	89	1,85	9
6,65			
7,62			
10,16			

Std. Presu. * Piston Area
6,89 * 1,95
13,44

Std. Presu. * Piston Area
1021 * 1,95
19,91

Swelling Test	
Date	21/03/13
Time	9:00 AM
No of days	4
Initial reading	0
Final reading	1,15
Swell	1,15
% Swell	0,9



CALIFORNIA BEARING RATIO / SWELL PERCENT

GAMBELLA ALWERO RICE PROJECT

EMPLOYER	CONSULTANT	CONTRACTOR
SAUDI STAR AGRICULTURAL DEVELOPMENT	SNC LAVALINE INTERNATIONAL IN ASSOCIATION WITH TROPICS CONSULTING ENGINEERS	GHULAM RASOOL AND COMPANY PLC/SAUDI STAR AGRICULTURAL DEVELOPMENT PLC OWN FORCE

TEST METHOD: AASHTO T 193

Station:-	Test Pit - 05	Depth Sampled:-	2 m
		Surcharge Wt.:-	4.5kg
Material Type:-	Borrow for Replacing	Date Sampled :-	13.03.2013
Visual Description :	Light Brown Silty Clay	Soaking Date:-	21/03/13
		Penetration Date :-	25/03/13
Maximum Dry Density :-	1.38	Optimum Moisture Content (OMC):-	13.5
Mould No:-	T	Natural Moisture Content (NMC) :	1,8
Weight of Soil Sample:-	6000 gm	Water to be added : -	690 ml

Density Determination	Before	After
Wt of mould(gm)	6379	6379
Volume of mould(cc)	2124	2124
Wt of mould+Wet soil(gm)	11046	11124
Wt of wet soil(gm)	4667	4745
Wet density(gm/cc)	2.20	2,23
Dry density(gm/cc)	1.84	1.80

Moisture Determination	Before	After
Container No.	11	21
Wt cont wet soil	110.49	117.95
Wt cont+dry soil	96,00	99,12
Wt cont	20,22	20,05
Wt of moisture	14,490	18,83
Wt dry soil	75.780	79.07
MC %	19,1	23,8

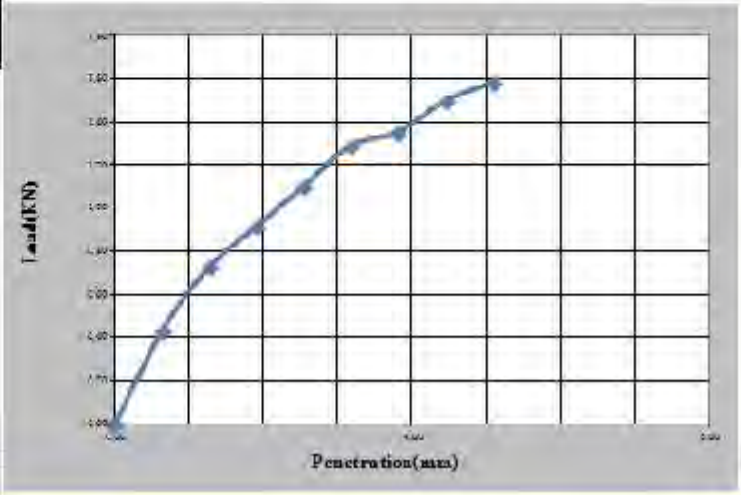
Ring Factor: 0.02082

Penetration	Dial Read.	Load (KN)	CBR (%)
0.00	0	0.00	
0,64	21	0,44	
1,27	35	0.73	
1,91	44	0.92	
2,54	53	1.10	8
3,18	62	1.29	
3,81	65	1.35	
4,45	72	1.50	
5,08	76	1.58	8
6,63			
7,62			
10,16			

Swelling Test	
Date	21/03/13
Time	9.00 AM
No of days	4
Initial reading	0
Final reading	1,85
Swell	1,85
% Swell	1,4

Std. Presu. * Piston Area
6.89 * 1.95
13,44

Std. Presu. * Piston Area
10.21 * 1.95
19,91



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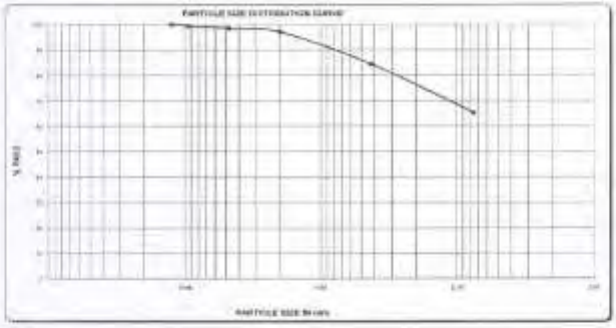
SABA Engineering

LAB. NO.	872/13	
CLIENT	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	TP 1	Depth, m :
SAMPLE OF	Black Cotton Soil Blended With 6 % Lime Stone Powder	
SAMPLED BY	THe Client	
SPECIEFIED BY	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	THe Client	ON :20/03/13
TEST FOR	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	The Client	ON : 05/04/13

TEST RESULT



REMARKS:

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

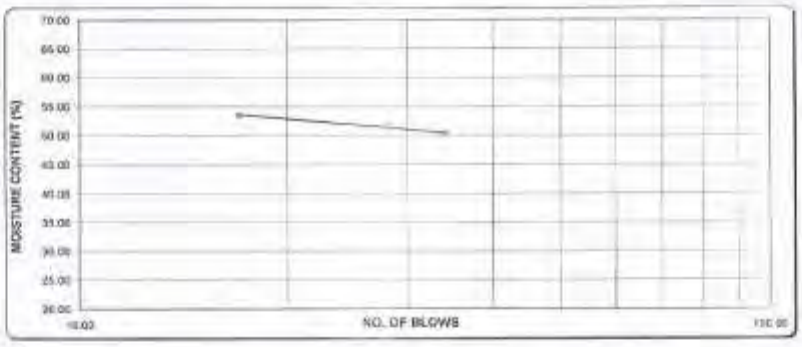
Ayehuteega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering Plc.
P.O. Box 02868 Addis Ababa, Ethiopia Tel: 28 06 90 / 39 10 65 / 39 16 17 / 39 14 99 / 39 17 73 Fax: 39 12 30 / 28 16 17 E-mail: saba.engr@telecom.net.et

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	34	28	17		
Wt. wet soil (g.)	16.13	15.95	14.94	3.25	3.08
Wt. dry soil (g.)	17.57	10.51	9.73	2.60	2.46
Moisture content (%)	50.33	51.76	53.55	25.00	25.20
				AV. PL (%)	25.1



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS: 2 mm	0.425 mm	0.075 mm	AASHTO SOil Classification
52	25	27	97	65	65.4	A-7-6(15)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

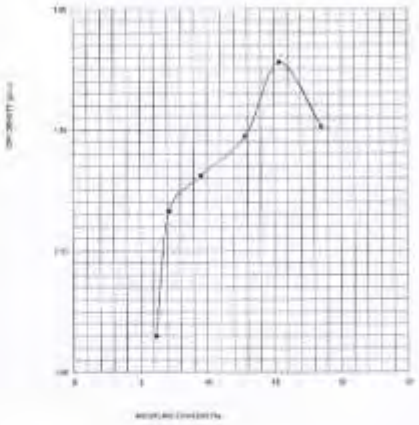
Aynalsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

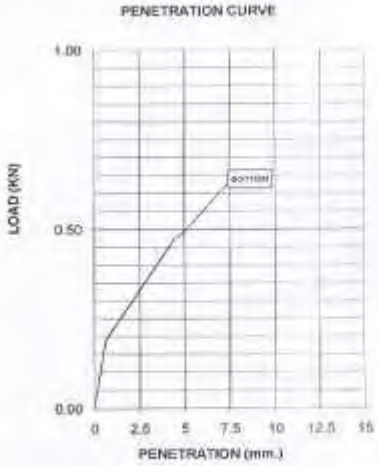
1 TP 1 Black Cotton Soil blend 6 % Lime Stone Powder ml

SABA Engineering plc.
P.O.Box 52666 Addis Ababa Ethiopia Tel: 39 08 93 / 39 10 65 / 39 16 17 / 39 17 23 Fax 391293 / 391617 E-mail saba.eng@telecom.net.et

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 1	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder	
SAMPLED BY	:	The Client	
SPECIFIED BY	:	The Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD gm/cm3	OMC (%)
1.556	15.40

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell (%)
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	
13.24	20	0.33	0.50	2.5	2.5	1.55

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

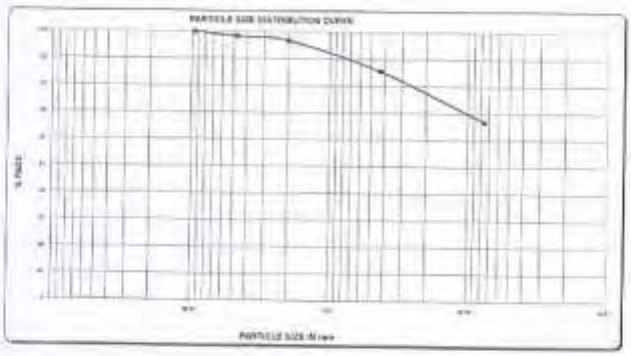
Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO TZ7-84)
TEST RESULT REPORTED TO	:	The Client ON : '05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSED
75.00	
37.50	
19.00	
9.50	100
4.75	98
2.00	91
0.425	85
0.075	60.6



REMARKS:

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

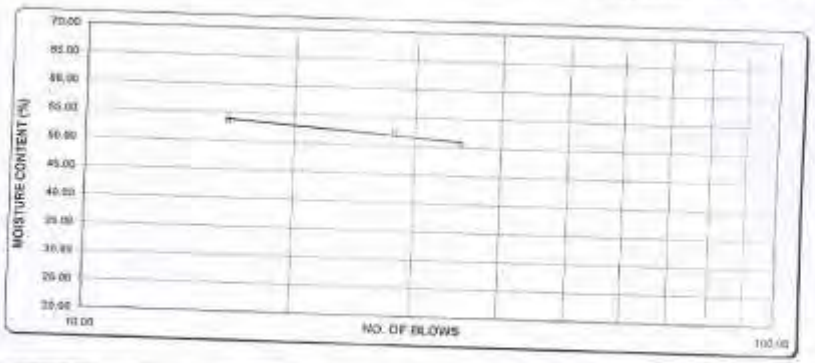
Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering Plc.
P.O. Box 62569 Addis Ababa, Ethiopia Tel: 39 06 93 / 39 10 95 / 39 16 17 / 39 14 89 / 39 1733 Fax: 39 12 30 / 39 16 17 E-mail: saba.eng@telecom.net.et

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	38	28	16		
Wt. wet soil (g.)	16.12	14.63	14.86	3.31	2.89
Wt. dry soil (g.)	17.57	9.59	9.67	2.65	2.39
Moisture content (%)	50.66	52.56	53.67	24.91	25.10
				AV. PL (%)	25.0



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
			2 mm	0.425 mm	0.075 mm	
52	26	27	97	85	66.8	A-7-6(15)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Abebutsega Awgachew
Soil and Const. Mat. Testing
Dept. Manager

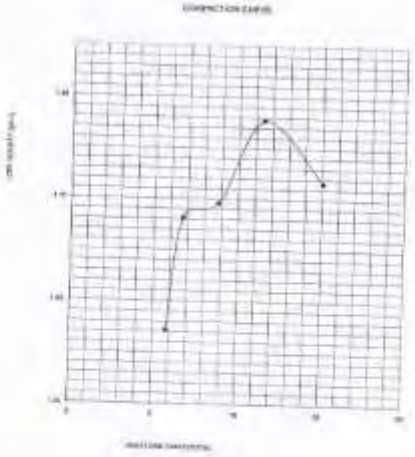
L TP 1 Black Cotton Soil And 8 % Lime Stone Powder.xls

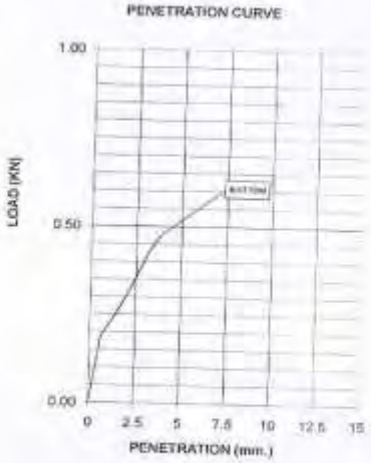
SABA Engineering plc.

P.O. Box 82665 Addis Ababa, Ethiopia Tel: 38 00 83 / 38 10 65 / 39 16 17 / 39 17 33 Fax: 391236 / 391617 E-mail: saba.eng@telecom.net.et

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder
SAMPLED BY	:	The Client
SPECIFIED BY	:	The Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD (gm/cm3)	OMC (%)
1.827	11.47

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell (%)
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	
13.24	20	0.38	0.52	2.7	2.6	1.95

Remark :

Reported by :

Approved by :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

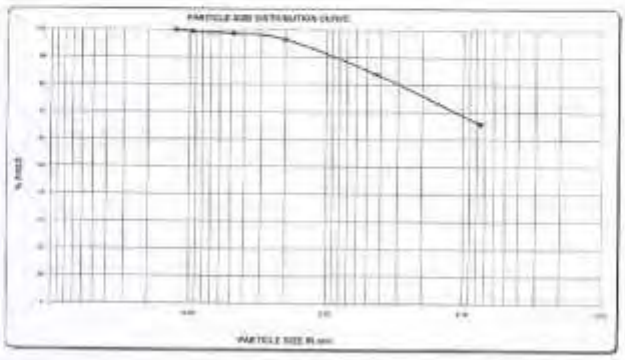
Ayelmitsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering PRIVATE LIMITED COMPANY

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 1	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSING
75.00	
63.00	
50.00	
37.50	
19.00	
12.50	100
9.50	99
4.75	96
2.00	87
0.425	64
0.075	55.8



REMARKS: _____

REPORTED BY :

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehubeza Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering Plc.

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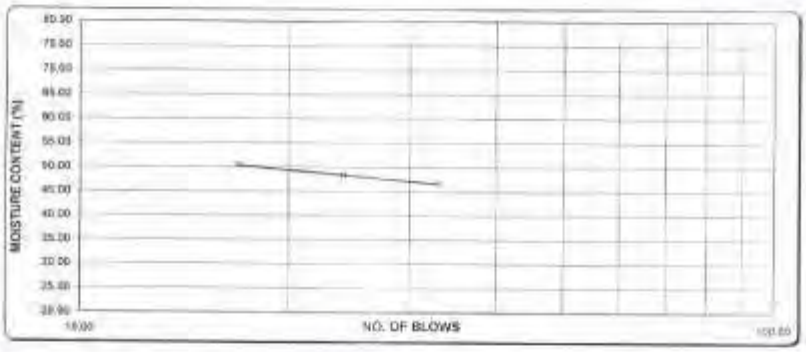
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	33	24	17		
Wt. wet soil (g.)	17.28	15.16	15.12	1.92	1.93
Wt. dry soil (g.)	17.57	10.21	10.05	1.55	1.55
Moisture content (%)	46.59	48.48	50.45	23.87	24.52
				AV. PL (%)	24.2



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
			2 mm	0.425 mm	0.075 mm	
48	24	24	97	84	65.8	A-7-6(13)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayelubelgs Awgachew
Soil and Const. Mat. Testing
Dept. Manager

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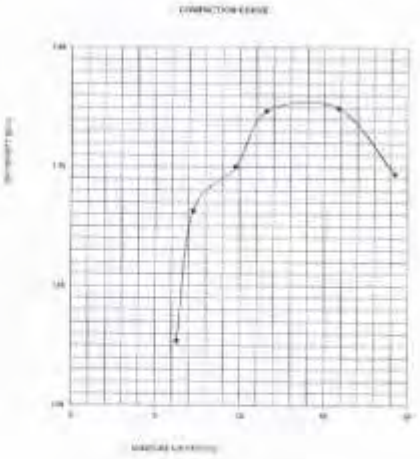
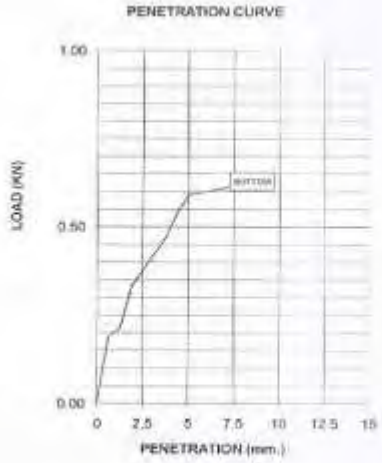
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella Alwero Rice Project
PROJECT	:	Gambela Alwero Rice project
SAMPLE SOURCE/STATION/CODE	:	TP 1 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10% Lime Stone Powder
SAMPLED BY	:	The Client
SPECIFIED BY	:	The Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT





AASHTO T - 193	
MDD gm/cm3	OMC (%)
1.799	16.85

Standard Load (KN)		Load (kN) Battery		CBR(%) Battery		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.38	0.59	2.84	2.96	1.89

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

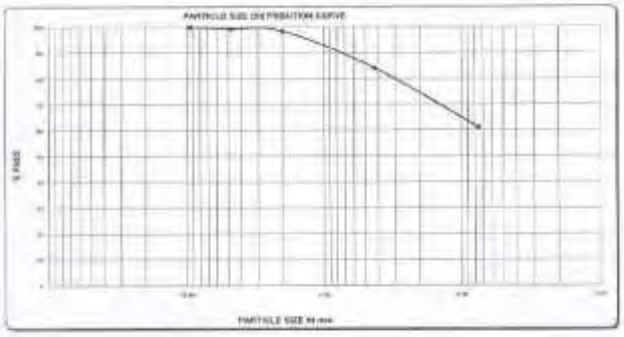
Ayahuteega Awgachew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	: 672/13	
CLIENT	: Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	: Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	: TP 2	Depth, m :
SAMPLE OF	: Black Cotton Soil Blended With 6 % Lime Stone Powder	
SAMPLED BY	: THe Client	
SPECIEFIED BY	: THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	: THe Client	ON :20/03/13
TEST FOR	: Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	: The Client	ON : 05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSED
75.00	
37.50	
25.00	
19.00	
12.50	
9.50	100
4.75	99
2.00	96
0.425	84
0.075	57.1



REMARKS:

REPORTED BY :

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ashebeaga Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering Plc.

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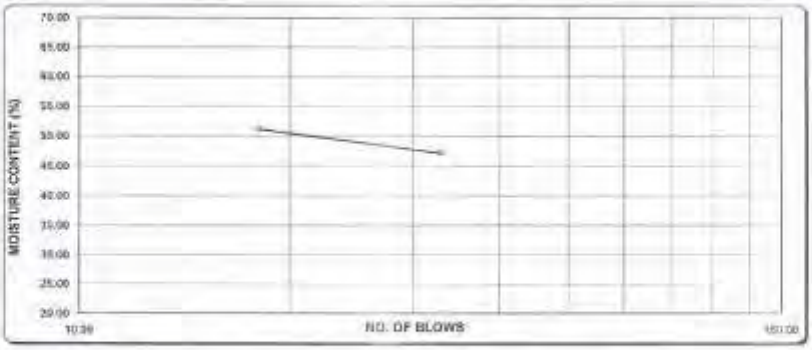
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	33	27	18		
Wt. wet soil (g.)	16.16	15.36	14.78	2.95	3.30
Wt. dry soil (g.)	17.57	10.34	9.77	2.39	2.66
Moisture content (%)	47.31	48.55	51.28	23.43	24.06
				AV. PL (%)	23.7



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
			2 mm	0.425 mm	0.075 mm	
49	24	25	98	84	61.1	A-7-6[12]

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayahuteqa Awgeschew
Soil and Const. Mat. Testing
Dept. Manager

1 TP 2 Black Cotton Soil And 6 % Lime Stone Powder.xls

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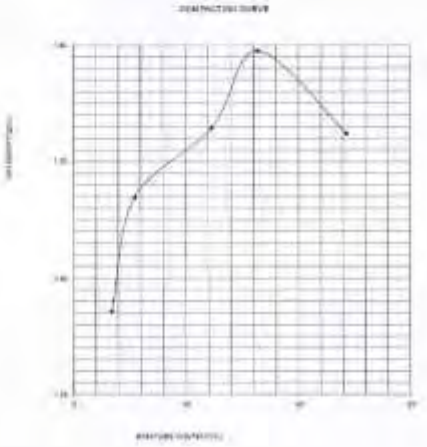
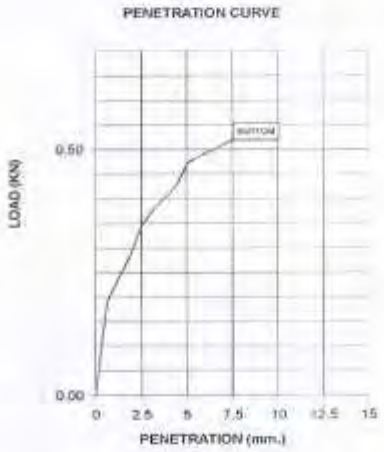
LAB. NO.	:	872/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 2	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :28/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :29/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD gm/cm³	OMC (%)
1.848	13.22

Standard Load (KN)		Load (KN) Bottom		CBR(%) Bottom		Swell (%)
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	
13.34	20	0.38	0.47	2.8	2.4	1.23

Remark :

Reported by :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Approved by :

Ayehutsegs Awgachew
Soil and Const. Mat. Testing
Dept. Manager

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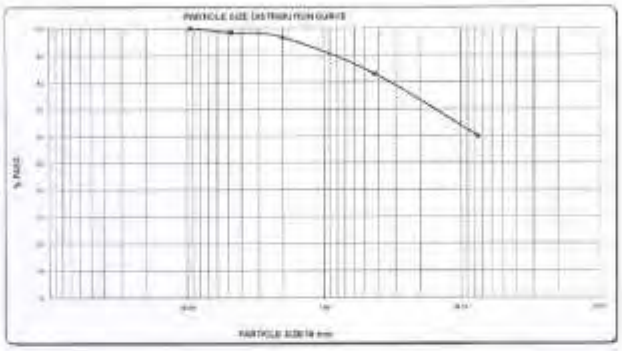
SABA Engineering

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 2	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : '05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSED
(75.00)	
(37.50)	
(19.00)	
(9.50)	
(4.75)	100
2.00	97
0.425	93
0.075	85.6



REMARKS:

REPORTED BY :

APPROVED By :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

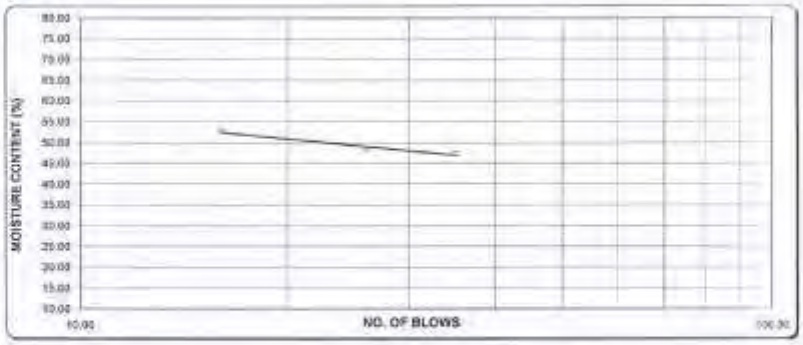
Ayenutsega Awgachew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering Plc.
P.O. Box 62668 Addis Ababa, Ethiopia Tel. 39 08 93 / 39 10 65 / 39 16 17 / 39 14 99 / 39 1733 Fax. 39 12 30 / 39 16 17 E-mail: saba.eng@ethionet.net.et

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	26	16		
Wt. wet soil (g.)	14.18	14.37	14.32	3.53	3.54
Wt. dry soil (g.)	17.57	9.67	9.37	2.89	2.91
Moisture content (%)	47.40	48.60	52.83	22.15	21.65
				AV. PL (%)	21.9



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS 2 mm	0.425 mm	0.075 mm	AASHTO SOil Classification
49	22	27	97	83	60	A-7-6(10)

REMARKS :

REPORTED BY :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

APPROVED BY :

Mehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

(TP 2 Black Cotton Soil And 8 % Lime Stone Powder

SABA Engineering plc.

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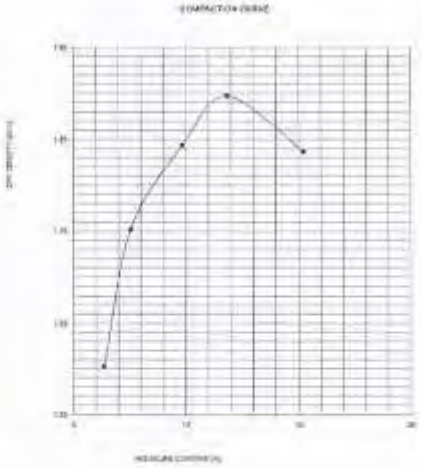
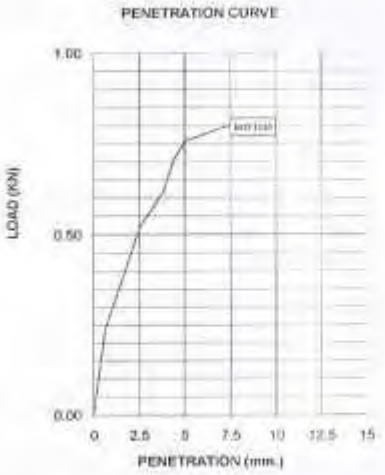
LAB. NO.	:	67/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8% Lime Stone Powder
SAMPLED BY	:	The Client
SPECIFIED BY	:	The Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT





AASHTO T - 193	
MDD (g/cm3)	OMC (%)
1.897	11.83

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.00 (mm)	(%)
13.24	20	0.52	0.76	3.9	3.8	1.29

Remark :

Reported by :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Approved by :

Yehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

I: TP 2 Black Cotton Soil and 8 % Lime Stone Powder.txt

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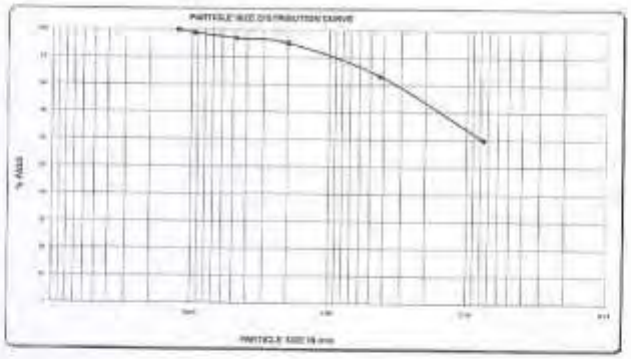
SABA Engineering PRIVATE LIMITED COMPANY

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 2	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : '05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSING
75.00	
63.00	
50.80	
25.40	
19.00	
12.70	100
4.76	93
4.75	90
2.00	85
0.425	81
0.075	69.8



REMARKS: _____

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

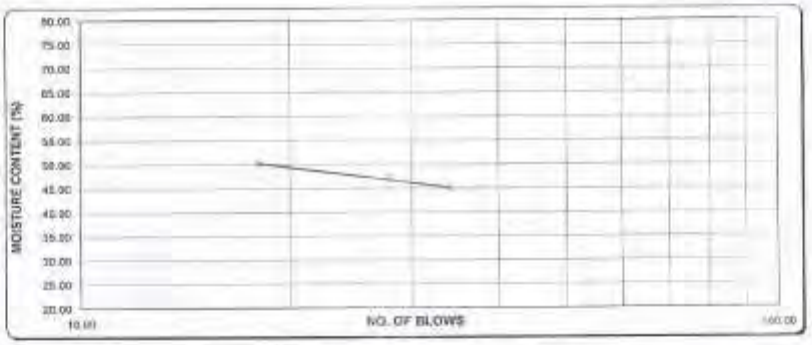
Ayelwubega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering Plc.
P.O. Box 62868 Addis Ababa, Ethiopia Tel. 39 05 82 / 39 10 66 / 39 16 17 / 39 14 99 / 39 1733 Fax. 39 12 30 / 39 16 17 E-mail: saba.engr@telecom.net.et

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	34	28	18		
Wt. wet soil (g.)	15.73	14.09	14.39	2.29	2.68
Wt. dry soil (g.)	17.57	9.57	9.58	1.87	2.20
Moisture content (%)	44.98	47.23	50.21	22.46	21.82
				AV. PL (%)	22.1



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS 2 mm	0.425 mm	0.076 mm	AASHTO SOil Classification
48	22	26	96	83	59.9	A-7-6(11)

REMARKS :

REPORTED BY :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

APPROVED BY :

Ayalnubeza Alegechew
Soil and Const. Mat. Testing
Dept. Manager

L:\TP 2 Black Cotton Soil And 10 % Lime Stone Powder.xls

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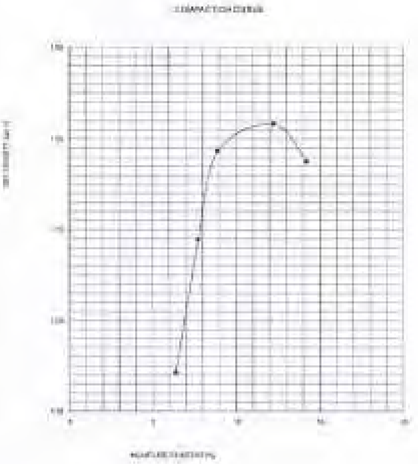
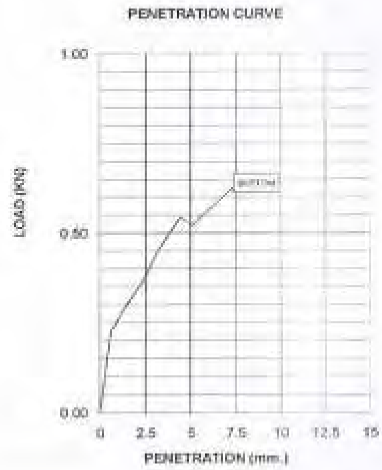
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambela-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 2 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD (gm/cm3)	OMC (%)
1.067	13.25

Standard Load (KN)		Load (KN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.38	0.52	2.9	2.6	1.48

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

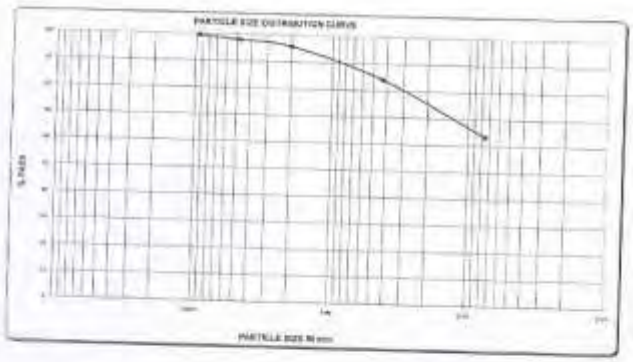
Ayehutsega Awoke[illegible]
Soil and Const. Mat. Testing
Dpm. Manager

SABA Engineering PRIVATE LIMITED COMPANY

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 3 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84) ON :20/03/13
TEST RESULT REPORTED TO	:	The Client ON : '05/04/13

TEST RESULT

SIEVE SIZE (mm)	% PASSING
75.00	
37.50	
19.00	
9.50	
4.75	100
2.00	98
0.425	96
0.075	93.5



REMARKS:

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehuteaga Awgachew
Soil and Const. Mat. Testing
Dept. Manager

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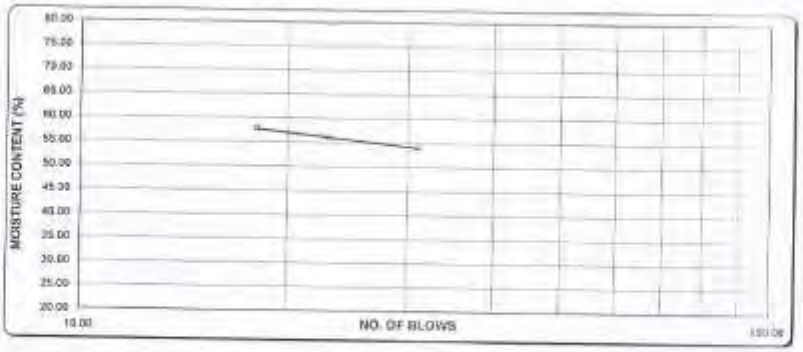
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 3 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	31	23	16		
Wt. wet soil (g.)	13.54	15.90	12.80	2.56	2.66
Wt. dry soil (g.)	17.67	10.19	8.11	2.06	2.38
Moisture content (%)	54.04	56.04	57.83	25.24	24.37
				AV. PL (%)	24.8



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
			2 mm	0.425 mm	0.075 mm	
56	25	31	96	84	63.5	A-7-5(16)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. MATERIAL LABORATORY

Yeshuleqa Awgechew
Soil and Const. Mat. Testing
Dept. Manager

1 TP-3 Black Cotton Soil And 6 % Lime Stone Powder.stp

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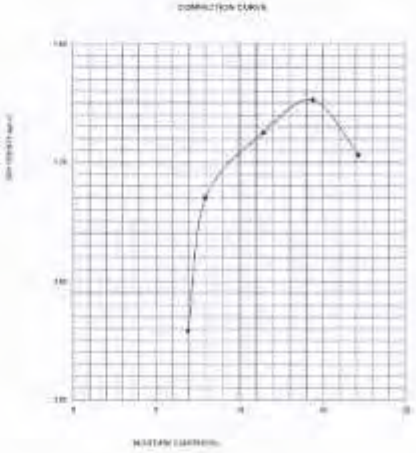
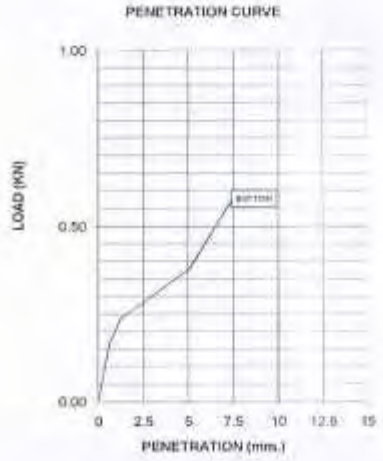
LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 3	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder	
SAMPLED BY	:	The Client	
SPECIFIED BY	:	The Client	ON :26/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :26/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 06/04/13

TEST RESULT





AASHTO T - 180	
MDD gm/cm3	OMC (%)
1.803	14.42

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.28	0.38	2.1	1.9	2.23

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Arehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

C TP-3 Black Cotton Soil and 6 % Lime Stone Powder

SABA Engineering PRIVATE LIMITED COMPANY

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 3	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSED
75.00	
37.50	
19.00	
9.50	
4.75	100
2.00	98
0.425	91
0.075	83.4

REMARKS:

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayalsulsega Awgachew
Soil and Const. Mat. Testing
Dept. Manager

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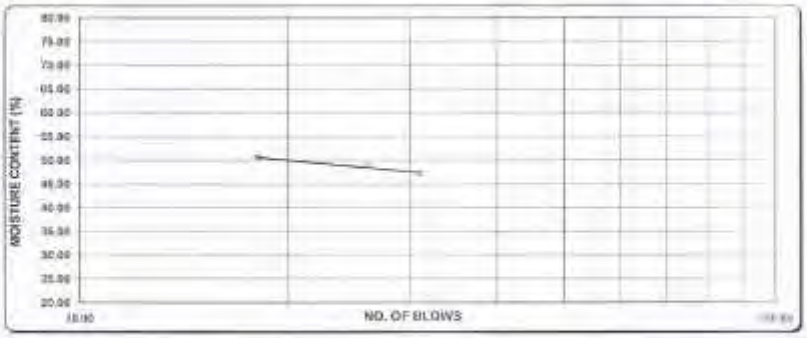
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 3 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	31	28	18		
Wt. wet soil (g.)	14.80	16.58	15.09	3.33	3.62
Wt. dry soil (g.)	17.57	11.21	10.02	2.72	2.90
Moisture content (%)	47.28	48.80	50.69	22.43	22.30
				AV. PL (%)	22.4



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS 2 mm	0.425 mm	0.075 mm	AASHTO Soil Classification
49	22	27	96	84	63.4	A-7-6(14)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Asmuddegn Awgechew
Soil and Const. Mat. Testing
Dept. Manager

L TP 3 Black Cotton Soil And 8 % Lime Stone Powder.xls

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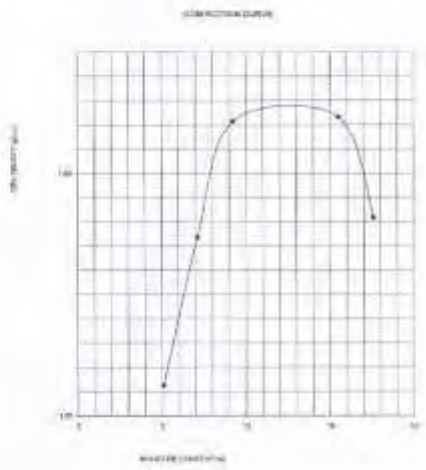
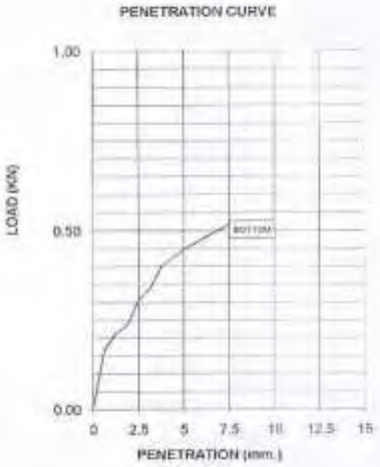
LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella Abwero-Rice Project	
PROJECT	:	Gambela Abwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 3	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8% Lime Stone Powder	
SAMPLED BY	:	The Client	
SPECIEFIED BY	:	The Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 193	
MDD (pcf/cm³)	OMC (%)
1.629	13.00

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.31	0.48	2.3	2.2	2.92

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

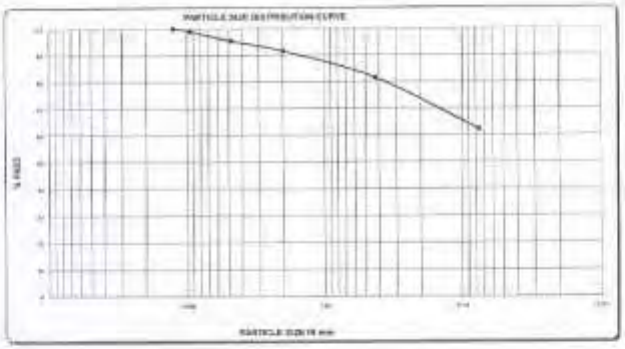
Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 3 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON : 20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON : 20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

SIEVE SIZE MM	% PASSED
75.00	
37.50	
19.00	
9.500	
4.750	
2.000	100
0.850	96
0.425	90
0.250	82
0.075	62.5



REMARKS:

REPORTED BY :

APPROVED BY :

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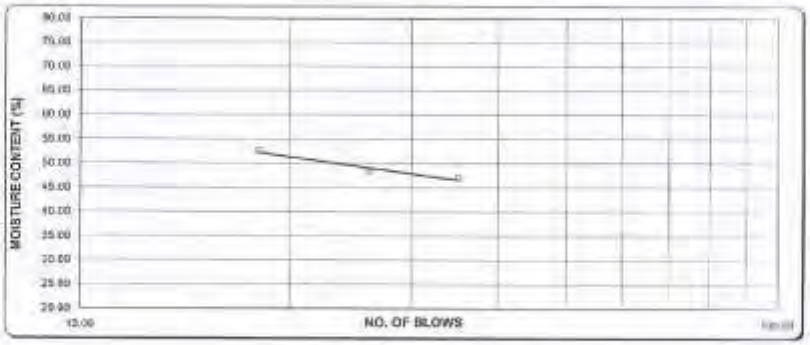
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 3 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	26	18		
Wt. wet soil (g.)	13.63	14.67	12.45	4.09	5.04
Wt. dry soil (g.)	17.57	9.88	8.15	3.31	4.08
Moisture content (%)	47.03	48.48	52.76	23.56	23.53
				AV. PL (%)	23.5



Liquid Limit	Plastic Limit	Plasticity Index	WET SEIVE ANALYSIS, % PASS			AASHTO Soil Classification
LL(%)	PL(%)	PI	2 mm	0.425 mm	0.075 mm	
48	24	24	92	82	82.2	A-7-6(12)

REMARKS :

REPORTED BY :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

APPROVED BY :

Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

I. TP 3 Black Cotton soil And 10 % Lime Stone Powder

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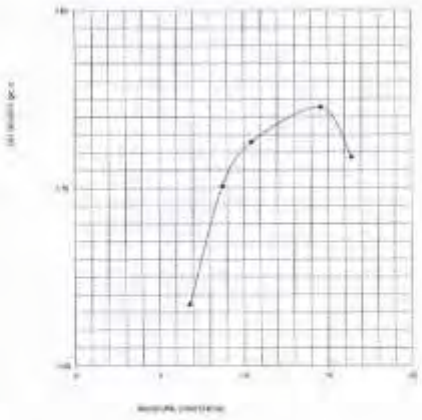
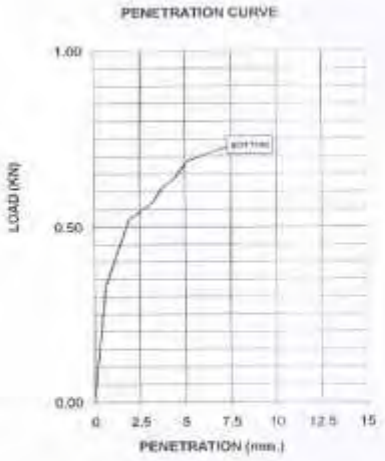
LAB. NO.	:	872/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 2	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 15% Lime Stone Powder	
SAMPLED BY	:	The Client	
SPECIFIED BY	:	The Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD (gm/cm3)	OMC (%)
1.755	14.59

Standard Load (KN)		Load (kN) /Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.54	0.68	4.1	3.4	1.44

Remark :

Reported by :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Approved by :

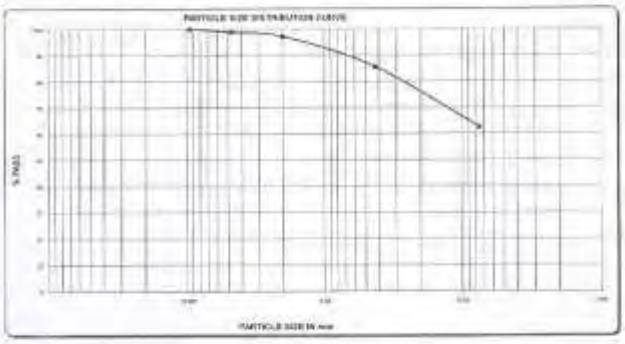
Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

ሳባ ኢንጂነሪንግ
SABA Engineering

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

SIEVE SIZE (mm)	% PASSED
75.00	
37.50	
19.00	
9.50	
4.75	100
2.00	98
0.425	87
0.075	56
0.075	52.6



REMARKS:

REPORTED BY :

APPROVED BY:

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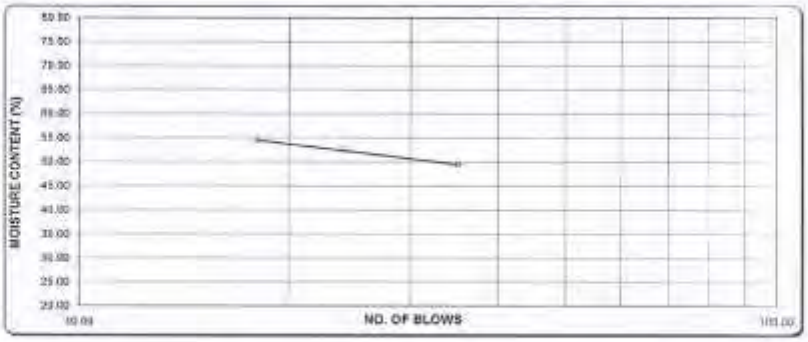
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	24	18		
Wt. wet soil (g.)	14.81	17.48	14.00	2.59	3.02
Wt. d/y soil (g.)	17.57	11.45	9.06	2.09	2.44
Moisture content (%)	49.54	52.66	54.53	23.92	23.77
				AV. PL (%)	23.8



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
			2 mm	0.425 mm	0.075 mm	
53	24	29	97	86	62.6	A-7-6(14)

REMARKS :

REPORTED BY :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

APPROVED BY :

Ayehutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

I. TP 4 Black Cotton Soil Blend 6 % Lime Stone Powder

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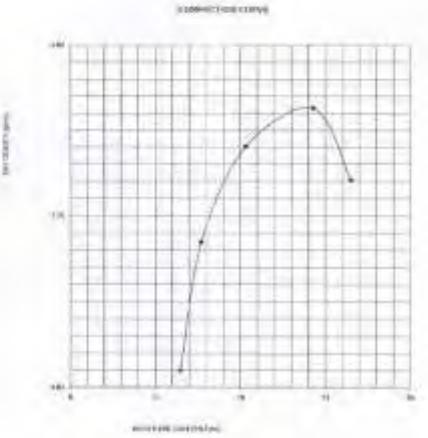
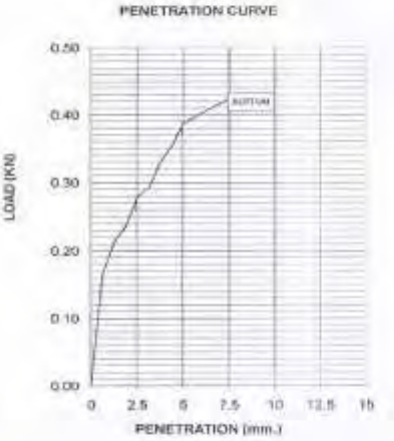
LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella Alwero-Rice Project	
PROJECT	:	Gambella Alwero-Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 4	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6 % Lime Stone Powder	
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD (gm/cm3)	OMC (%)
1.793	14.29

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell (%)
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	
13.24	20	0.28	0.39	2.1	1.3	3.78

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C CENTRAL LABORATORY

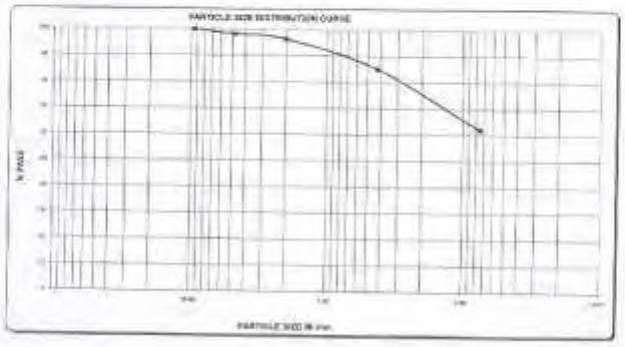
Ayehubelga Awgechaw
Soil and Const. Mat. Testing
Dept. Manager

SABA Engineering

LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

SIEVE SIZE (MM)	% PASSING
75.00	
53.00	
50.00	
25.00	
19.00	
12.50	
9.50	100
4.75	93
2.00	86
0.425	55
0.075	42.1



REMARKS:

REPORTED BY :

APPROVED BY:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehubsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

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LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 8% Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	28	18		
Wt. wet soil (g.)	15.67	16.93	17.68	2.87	3.09
Wt. dry soil (g.)	17.57	10.45	11.44	2.32	2.49
Moisture content (%)	50.38	52.44	54.50	23.71	24.10
				AV. PL (%)	23.8

Liquid Limit	Plastic Limit	Plasticity Index	WET SEIVE ANALYSIS, % PASS			AASHTO SOil Classification
LL(%)	PL(%)	PI	2 mm	0.425 mm	0.075 mm	
52	24	28	96	88	62.1	A-7-6(13)

REMARKS :

REPORTED BY :

Lab. Engineer

APPROVED BY :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehulsega Awgechew
Bld and Const. Mat. Testing
Dept. Manager

L:\TP 4 Black Cotton Soil And 8 % Lime Stone Powder.xls

SABA Engineering plc.

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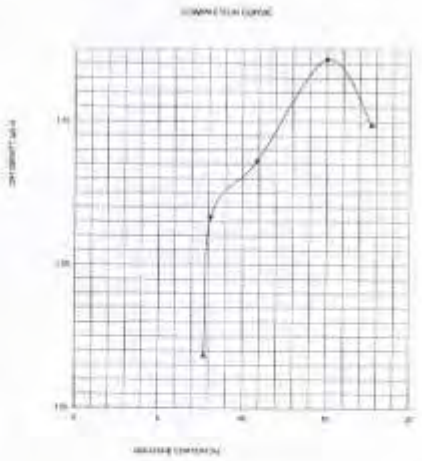
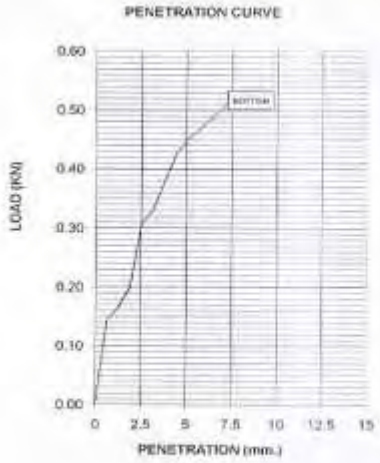
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 6 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON : 20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON : 20/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT





AASHTO T 193	
MDD gram/cm³	OMC (%)
1.793	15.02

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.31	0.45	2.3	2.2	2.71

Remark :

Reported by :

Approved by :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Eyelutsega Awgachew
Civil and Const. Mat. Testing
Dept. Manager

@ TP 4 (Black Cotton Soil mixed with 6 % Lime Stone Powder)sa

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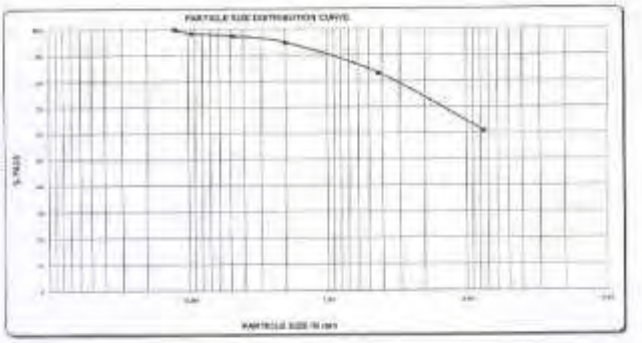
SABA Engineering

LAB. NO	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Wet sieve Analysis(AASHTO T27-84)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

SIEVE SIZE (mm)	% PASSED
75.00	
63.00	
50.00	
37.50	
25.00	
19.00	
12.50	100
9.50	98
4.75	97
2.00	95
0.425	91
0.075	80.8



REMARKS:

REPORTED BY :

APPROVED By:

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehubegea Awgechew
Soil and Const. Mat. Testing
Dept. Manager

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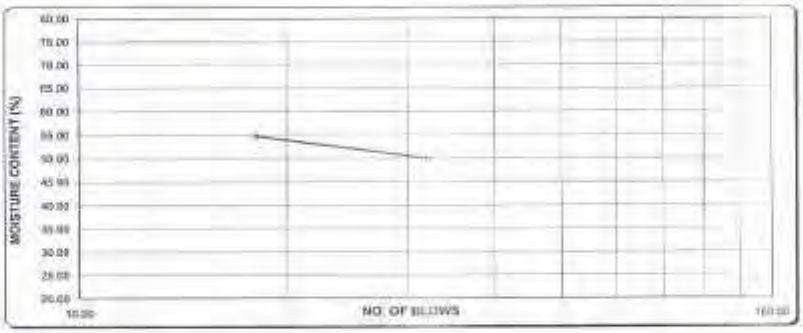
LAB. NO.	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE SOURCE/STATION/CODE	:	TP 4 Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder
SAMPLED BY	:	THe Client
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
SPECIEFIED BY	:	THe Client ON :20/03/13
TEST FOR	:	Atterberg Limit(AASHTO T89 - 90)
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULT

	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	32	27	18		
Wt. wet soil (g)	16.57	16.16	14.54	2.92	3.44
Wt. dry soil (g)	17.57	16.65	9.40	2.38	2.76
Moisture content (%)	49.82	51.92	54.68	22.69	23.74
				AV. PL (%)	23.2



Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS			AASHTO Soil Classification
			2 mm	0.425 mm	0.075 mm	
52	23	29	95	83	60.9	A-7-6(14)

REMARKS :

REPORTED BY :

Lab. Engineer

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

APPROVED BY :

Tesfahutsega Awgechew
Soil and Const. Mat. Testing
Dept. Manager

1. TP 4 Black Cotton Soil And 10 % Lime Stone Powder(B)

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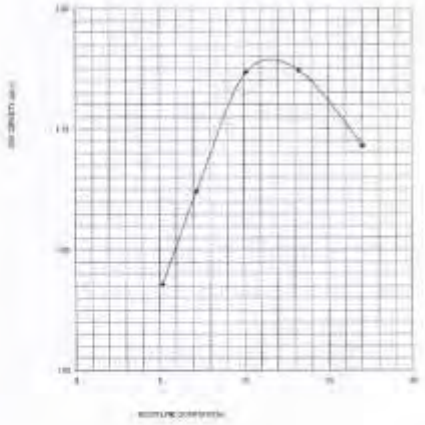
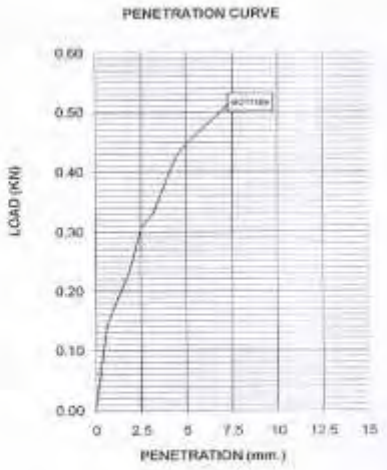
LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero Rice-project	
SAMPLE SOURCE/STATION/CODE	:	TP 4	Depth, m :
SAMPLE OF	:	Black Cotton Soil Blended With 10 % Lime Stone Powder	
SAMPLED BY	:	The Client	
SPECIFIED BY	:	The Client	ON :25/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	The Client	ON :28/03/13
TEST FOR	:	California Bearing Ratio AASHTO T193	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULT





AASHTO T - 180	
MDD gm/cm3	OMC (%)
1.997	11.80

Standard Load (KN)		Load (kN) Bottom		CBR(%) Bottom		Swell
2.54mm	5.08mm	2.54mm	5.08mm	2.54 (mm)	5.08 (mm)	(%)
13.24	20	0.31	0.46	2.3	2.3	2.63

Remark :

Reported by :

Lab. Engineer

Approved by :

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehutsega Awgechew
Soil and Const. Mat. Testing
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E-mail: saba.eng@telecom.net.et

LAB. NO.	:	672/13	
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project	
PROJECT	:	Gambela Alwero-Rice-project	
SAMPLE OF	:	Black Cotton Soil	Depth :
SAMPLED BY	:	THe Client	
SPECIEFIED BY	:	THe Client	ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client	ON :20/03/13
TEST FOR	:	Linear Shrinkage Limit	
TEST RESULT REPORTED TO	:	The Client	ON : 05/04/13

TEST RESULTS

Sr. No.	source	Sample of	Original Length of specimen (140mm)-Lo	Length of dry specimen(mm)-Ld	Linear Shrinkage %(Lo-Ld/Lo)x100
1	TP 1	Black Soil	140	122	12.86
2	TP 2	Black Soil	140	121	13.57
3	TP 3	Black Soil	140	115.5	17.50
4	TP 4	Black Soil	140	116	17.14

Remark :

Reported By

Approved By

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayehutsega Awgachew
Soil and Concl. Mat. Testing
Dept. Manager

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E-mail: [illegible]

LAB. NO	:	672/13
CLIENT	:	Saudi Star Agricultural Development (Gambella-Alwero-Rice Project
PROJECT	:	Gambela Alwero-Rice-project
SAMPLE OF	:	Black Cotton Soil Bended With Lime Stone Powder
SAMPLED BY	:	THe Client
SPECIEFIED BY	:	THe Client ON :20/03/13
SAMPLE AND TEST ORDER SUBMITTED BY	:	THe Client ON :20/03/13
TEST FOR	:	Linear Shrinkage Limit
TEST RESULT REPORTED TO	:	The Client ON : 05/04/13

TEST RESULTS

Sr. No	TP-No	Sample of	Original Length of specimen (140mm)-Lo	Length of dry specimen(mm)-Ld	Linear Shrinkage %(Lo-Ld/Lo)x100
1	1	Black Soil,Blended with 6% Lime	140	115	17.86
2		Black Soil,Blended with 8% Lime	140	116	17.14
3		Black Soil,Blended with 10% Lime	140	117	16.43
4	2	Black Soil,Blended with 6% Lime	140	117	16.43
5		Black Soil,Blended with 8% Lime	140	118	15.71
6		Black Soil,Blended with 10% Lime	140	119	15.00
7	3	Black Soil,Blended with 6% Lime	140	114	18.57
8		Black Soil,Blended with 8% Lime	140	115	17.86
9		Black Soil,Blended with 10% Lime	140	118	15.71
10	4	Black Soil Blended with 6 % Lime	140	113	19.29
11		Black Soil Blended with 8 % Lime	140	114.5	18.21
12		Black Soil Blended with 10 % Lime	140	117.6	16.00

Remark :

Reported By

Approved By

SABA ENGINEERING P.L.C. CENTRAL LABORATORY

Ayahutsega Awgachew
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Dept. Manager