1,050MW Coal Fired Power Plant

Geology and Soils Study

Report Prepared for

Amu Power Company Limited

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10 July 2016

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1 Executive Summary

This Report presents the results of a baseline study of the Soils and Geology of Kwasasi, Lamu area where a coal fired power project is proposed. It is located in Kwasasi sub-location, about 30 kilometres north of the proposed Lamu port. The relatively low altitude of the area makes it ideal for a coal power project due to the good windy conditions, nearness to a seaport harbor, sea water for steam generation and cooling as well as availability of land that prevail there. The project targets to produce about 960 megawatts of electricity power at the project's maturity development.

Kwasasi project area is predominantly covered by fine sandy soils, black cotton soil which is underlain by highly weathered coral limestone, clay, silt and shales. The area has low seismic activity and is therefore geologically stable for long term development of major infrastructures.

This report outlines the baseline soil and geological environment, the sensitivity of this baseline environment in relation to the proposed project and the potential impacts that may emanate due to it. Appropriate measures are recommended in order to ensure that the potential adverse impacts of the proposed project on geology and soil environment are mitigated throughout the project cycle.

The report concludes that the greatest disturbance and risk to the soils and geology is expected during the construction phase of the project as this is when there will be a lot of excavation for the coal power project foundations, access tracks construction and use, trenching for underground cables, and construction of the power house, substation ash yard, administration block, and staff houses. It will also be the time when there will be a lot of vehicles and heavy machinery at the site that may be sources of hydro-carbon substance leaks.

Mitigation measures recommended include construction of access tracks with tarmac, stone and laterite (murram) that are well compacted to carry the weight of expected heavy vehicles. The tracks should also be constructed in such a way as to allow for easy drainage of surface run-off on either side of the track to minimize the potential for water-logging and land slippage around the track. In steeply sloped areas the side drainage trenches of the tracks should have concrete barriers at intervals of around 30 to 50 metres (depending on the slope) to check erosion and deep cutting of the trench. Stockpiles of excavated materials for later re-use will be stored in designated areas at minimum distance of 30m from any nearby watercourses or drains to minimize risk of silt laden surface water runoff entering water courses. A HDPE should be placed at the bottom of the excavated coal ash yard to prevent any leachate from ash waste such as mercury and asernic, altering the chemistry of the soil and geology below the site.

Other mitigation measures include refueling of vehicles/machinery offsite. Where necessary, construction machinery will be re-fueled onsite by means of a mobile fuel bowser by experienced personnel. The volume of traffic is expected to significantly decrease after the construction phase and at full operation of the coal power facility. This will consequently decrease risk of spillage and leakage of oils, fuels and other contaminants as the only vehicles expected will be those bringing the operators and the management of the facility.

It is however, recommended that routine checks are carried out around the facility sites to ensure that any leakage of oil/petroleum from the maintenance vehicles, change in surface and groundwater levels and quality do not go undetected. Appropriate monitoring tool kits will be located within and around the facility to ensure that any water level, temperature, sedimentation, tidal levels and quality changes are immediately detected and mitigated.

2 Introduction

2.1 Description of the study area

Lamu County is generally flat and lies between altitude zero and 50m above sea level, making it prone to flooding during the rainy seasons and periods of high tides. The main topographical features include coastal Island and Dudol plains, sand dunes and the Indian Ocean. The county has four major catchment areas categorized as Dodori coastal zone, Dudol, Lamu bay drainage and Tana River Delta.

The county enjoys two rainy seasons and temperatures ranging between 230 and 320C throughout the year. Due to the physiographic climate and other natural conditions, the county is made of two broad economic zones covering the mainland for agriculture and livestock keeping and Islands for marine activities. The county is made of cosmopolitan population composed of indigenous communities made of Swahili's, Arabs, Korei, Boni and Ormas and migrant communities from the rest of the country.

The LAPSSET project will require water supply, electricity supply among others and will also attract huge migrant population estimated to be over one million (CIDP 2013-2017). This will certainly overstretch the county's social services necessitating development planning for adequate service provision.

A consortium of investors (Amu Power, Gulf, Centum and Kenya Power) has planned to spend Kenya Shs 174 billion on developing a 960 megawatts coal¬ fueled power plant project. The coal powered facility will consist of the coal power plant, cooling systems, electric power transmission and waste management facilities.

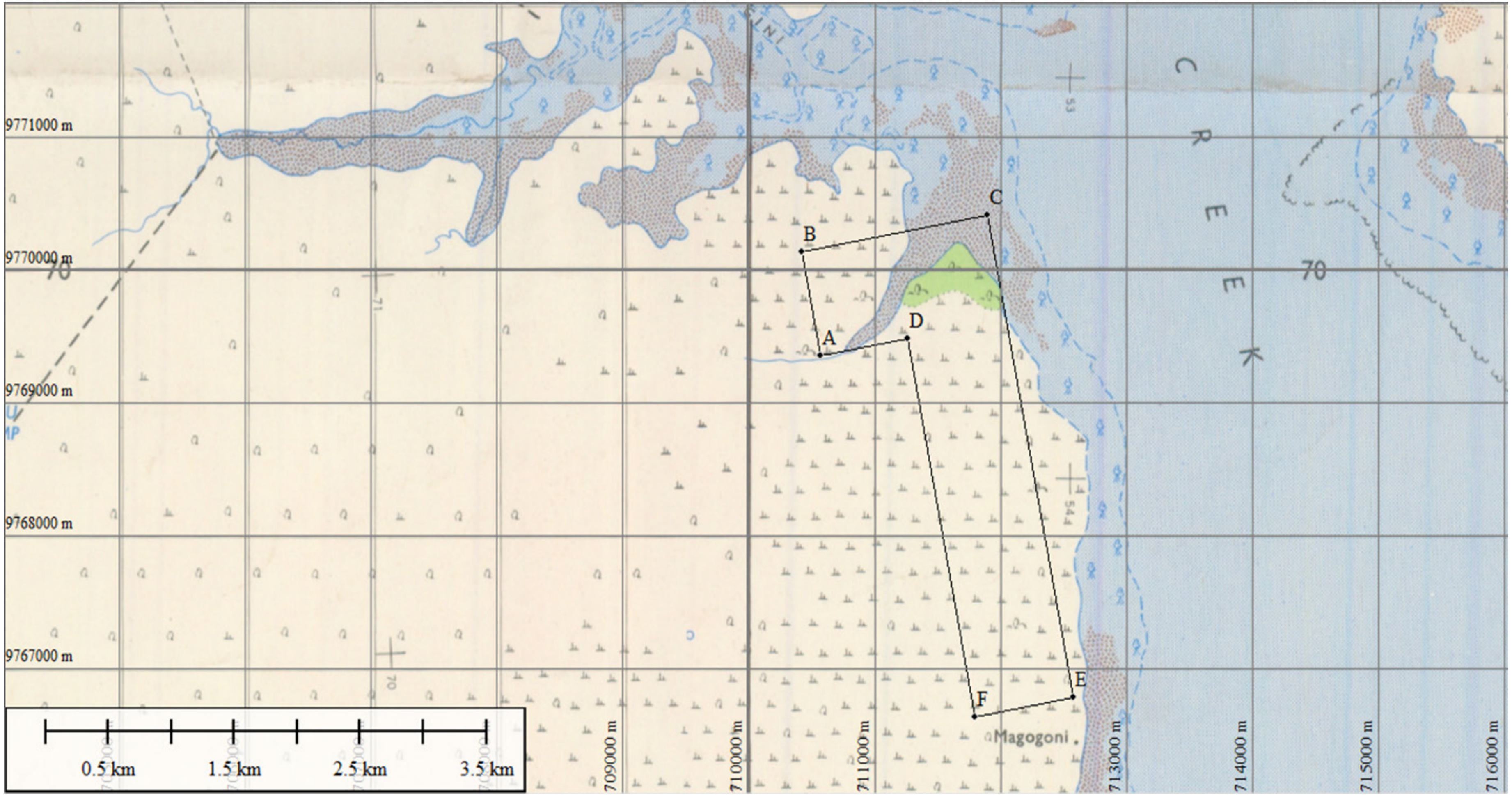
The project site is located at Kwasasi sub-location near and to the north of the Lamu port. The project site is on land that will be leased by the Lamu County for 25 years. This project will not only benefit the residents and LAPSSET project, but also directly benefit the Lamu County and employ of 1000 youths through the sales of electricity to Kenya Power.

Coal is the least expensive, most abundant fossil fuel source for electric generation (IDB, 2009). It is one of the world's fastest growing energy sources and is likely to increase its share in the energy matrix in many countries. Coal-fired power plants produce a series of pollutants and other environmental impacts derived from the combustion of the coal.

Technological developments over the last few decades have led to cleaner coal technologies that are able to increase the efficiency of a coal plant (i.e. increase the amount of energy gained from each tonne of coal) and to significantly decrease its air emissions (specifically sulphur dioxide, particulate matter, and nitrogen oxides) and therefore its environmental impact.

This report therefore gives the sensitivity of the soils and geological baseline environment in relation to the proposed project and the potential impacts that may emanate due to the proposed development. Mitigation measures are recommended in order to ensure that the potential adverse impacts of the proposed coal power plant development on the soils and geological environment are mitigated.

Figure 2-1: Image showing location of proposed coal fired power plant



2.2 Objectives of the study

The objective of this Environmental Impact Assessment (EIA) Study is:

- To identify the types of soils and geological environment that exists in the project area;
- To assess the sensitivity of the soils and geological environment in the subject area with respect to the proposed coal power development;
- To identify existence of geological features such as seismic zones, fault lines or fractured zones, which could affect the project location;
- To identify any potential impacts on the soils and geological environment associated with the proposed development;
- To identify any constraints posed by the existing soils and geological environment to the proposed development; and
- To propose appropriate mitigation measures in order to ensure that the potential impact of the proposed coal power development is slight and neutral.

3 Study methodology

3.1 Desktop study

The study approach involved analysis of various documents available, this included base maps, topographical maps and geological maps of Lamu area. The following data sources were reviewed and used during this assessment.

- "Geological Reconnaissance of the Galole – Lamu area" by Geological Survey of Kenya;
- Topographical Map Sheet 180/2 – Mokowe Sheet by Survey of Kenya;
- Review of existing borehole records within the project area;
- Review of District Development Plans in the Project area;
- Borehole Completion Reports from the Ministry of Water and Irrigation.
- EIA Guidelines – Coal fired power plants – Pakistan 2014.
- Borehole Completion Reports from the Ministry of Water and Irrigation.

The geological formations underlying the site were identified from the available geological series map and borehole log data obtained from Borehole Completion Reports. Based on the analysis of the soils and geology, the potential risk of their contamination with consequent adverse impact on the surface and ground water were assessed.

3.2 Field Survey Methodology

3.2.1 Reconnaissance survey

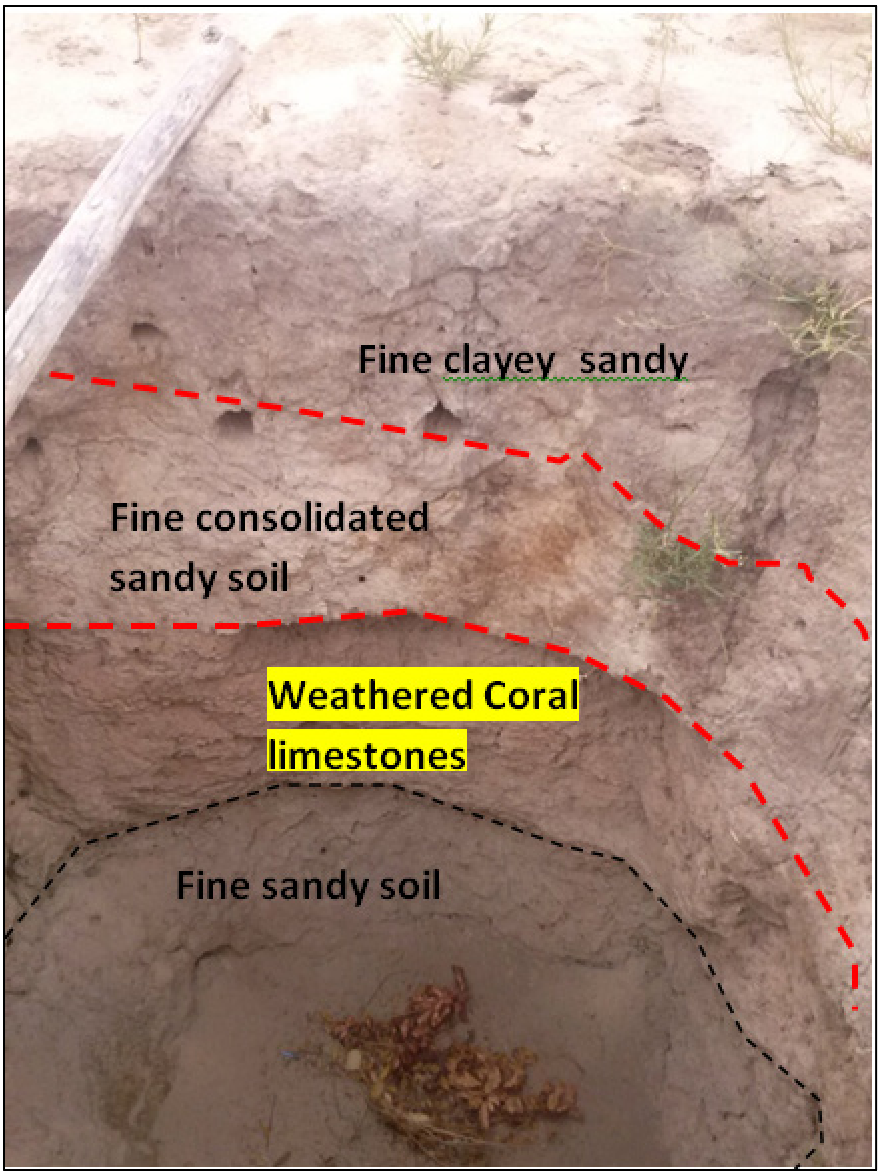
A site reconnaissance to record observations and features of significance was done on 3rd of February 2015. Pertinent site information was gathered to determine how and where the proposed development can affect the local soils and geological environment. The following information was therefore gathered:

- The general topography and drainage pattern of the project area.
- The Soil types and exposed geology
- Potential nearby receptors of contamination, such as rivers, streams, wells, service ducts, and residential areas
- Observation of significant features such as shallow water wells, faults, etc.

3.2.2 Digging of Trial pits

The excavation of trial pits in the project area was carried out simultaneously with the geophysical survey to find out the nature, permeability, vulnerability to pollution and type of the top-soil and determine the depth to the underlying formation. The trial pit sites were done in such a way that they would be used for correlation with VES data. There was also a bias on where there were shallow water wells in use or have been abandoned due to declining fresh water levels.

Figure 3-1: Image showing dry well and soil horizons power plant site.



4 Baseline conditions

4.1 Soils

4.1.1 Introduction

A baseline study was carried out in the project area to determine the susceptibility of the soils to pollution or contamination as well as erosion, landslides and siltation/ponding. It is noted that the likely sources of contamination in the area will be limited as coming from any storage of solvents and other petroleum products, and leakage of fuel and oils from heavy machinery and other vehicles that will be used during construction of the coal power facility and other related power distribution/transmission infrastructure. The concern over soil contamination stems primarily from health risks, from direct contact with the contaminated soil, vapors from the contaminants, and from secondary contamination of aquifer systems underlying the soil. Soil erosion, siltation and ponding due to tidal surging may take place depending on the nature of the soil.

4.1.2 Type of Soils

The project area is overlain by relatively shallow mainly black cotton soils which in some areas grade into more grayish colored loamy soils. The soils of the Kwasasi sub-location in Lamu area are classified as below. (Speck, 1978, Sombroek et al, 1982).

The quaternary soils are usually grey sands clays outcropping in and of the Tertiary marine sediments, which yield off white or buff sandy soils by reworking. Black cotton soils are present along drainage channels and are also found overlaying the tertiary and quaternary sediments along the drainage channels.

Figure 4-1: Dry well 2m deep brown-grey fine sandy soils and weathered coral limestone

Figure 4-2: Grey fine sandy Soil

4.1.2.1 Ferralsols

Ferralsols occur on gently undulating to undulating topography. They are very old, highly weathered and leached soils, and therefore with a poor fertility, which is restricted to the top soil, as the subsoil has a low cation exchange capacity. Phosphorous (P) and Nitrogen (N) are always deficient. Ferralsols are rich in Aluminium (Al) and Iron (Fe). The nutrient reserves are easily disturbed by agricultural practices. Important management practices include the use of fertilizers (e.g. rock phosphate) and the maintenance of soil organic matter by using green manures, farmyard manures and mulching. Ferralsols have also good physical properties including an excellent capacity to hold moisture. Ferralsols are used to grow several annual and perennial crops, being particularly suited to tree crops such as oil palm and cashewnut.

4.1.2.2 Planosols and Vertisols

Planosols and Vertisols occur on very gently undulating to flat topography, mostly in depressions and water logged areas. They are found in semi-arid and sub-humid environments. Due to the high clay content in the subsoil (higher than in the topsoil), is this layer in the B-horizon impermeable resulting in a very slow vertical and horizontal poor drainage and also in an extremely poor workability of the soils. These soils are dark coloured and strongly cracking.

4.1.3 Results of Digging Trial pits

The surface soil samples were excavated up to a depth of 1.5m and soil texture and colours observed. The results of the soil survey are given below and it gives the baseline soil conditions within the project area.

The reddish-brown to gray fine loose sandy or clayey sandy soils that vary from 5 to over 10m are overlain by fine loose and/or compact sandy soils that are relatively deep and vary in depth between 0.3 and 1.5 metres thickness in most places. The soils are mainly a product of the weathering and deposition of sand dunes, coral limestones, hence giving them the light colour and high quartz content. Loamy and dark clayey soils are also quite widespread in the area.

The soils and geological data from desk study indicate that the area in which the Lamu Coal Power Plant facility is to be built has the following characteristics:

- The first 4m of the ground contain fine loose at the top and compact sandy soil of low fertility but is useful for agricultural practice and farming activities.
- The lithology up to 10m is generally permeable and therefore in the event of construction of coal power facilities, care should be taken to put strong foundations, hard standing and proper underground supporting systems.
- Highly weathered coral limestones are encountered after 3-8 metres below which saline water is encountered.
- The upper sub-surface geology is vulnerable to the infiltration in the event of the spillage of contaminants and that in the event of leakage and of seepage; the surface and groundwater is likely to be contaminated.

Figure 4-3: Abandoned well sandy clays

Figure 4-4: Fine loose red sands

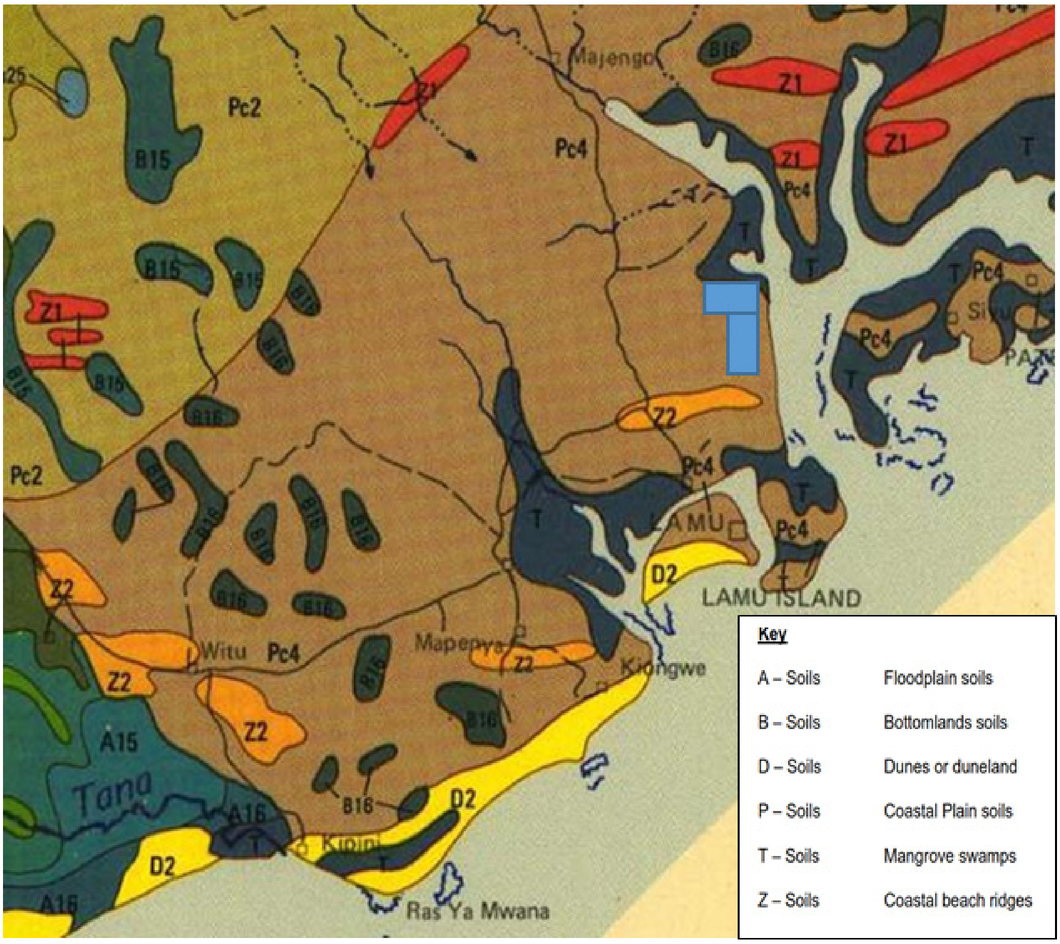
The relatively high sand content of the soil samples obtained at the site (averages about 50 percent) means that the permeability is quite high thus making them vulnerable to pollution in case of any petroleum leak or spill at the proposed site during construction or in its operational stage. The data of each trial pit is summarized in Table 4-1 below:

Table 4-1: Summary of shallow well/Trial Pit Data

VES No. of Pit Site	UTM Location 37m		Altitude (m.a.s.l.)	Thickness (m)		
	Easting	Southing		Top Dry Sandy	Clayey sands	Weathered Coral Limestone
1	711042	9769513	11.1	0-0.1	0.1-2.0	2-2.3
2	711470	9769419	15.2	0-0.2	0.2-0.6	3.0-5.0
3	710527.86	9770060.9	7.0	0-0.4	0.4-1.5	
4	712085.8	9769186	8.0	0-3	3.0-4.0	4.0-5.5
5	712460.8	9767200.9	8.0	0-0.3	0.3-3.0	3.0-6.0

The relatively shallow soil profile implies that any contaminant percolating in the soil will reach the underlying formation rather quickly and start spreading directed by the confining clayey profile. Contamination of the deeper subsurface geological formations and aquifers may also take place through fractures through the coral limestones which would allow vertical penetration of contaminants.

Figure 4-5: Soil map extract from the Ministry of Agriculture, 1982



4.2 Geology

4.2.1 Introduction

The whole of the study area is covered by superficial soils of Quaternary to Recent so that natural exposures are extremely rare and the underlying geology has to be deciphered from the type of soil present and/or the hand dug wells. All the rocks are sedimentary in origin and can be divided into three main groups:-

- Quaternary soils
- Quaternary marine sediments
- Tertiary sediments

The oldest Tertiary sediments are the limestones and outcrops at Walu of which their fossil content dates them as Miocene. The limestones-proper are largely covered by secondary limestone. The Walu limestones form a ridge above the end-tertiary peneplain at this point (Baker and Saggerson 1963 map) while the other tertiary sediments rest on the peneplain so are upper Pliocene. The end- tertiary peneplain has been shown to be of mid-pliocene age near Mombasa (Caswell

1953). North-west of the Walu limestones, grey and black sandy clays cover the surface of the area and holes drilled in the area reveal that similar deposits extend to a depth of 300 metres. As the Pliocene sea reached 100 mteres (Caswell1956) the lower part of these fluviatile sediments must have been deposited before the sea reached this height so that the Pliocene marine sands and clays are banked against them. The inland part of the marine sediments was probably laid down under deltaic conditions with interdigitations of marine and fluviatile deposits.

South-east of the Walu limestones, marine sands and clays occur in a belt varying between 1 and 2 kilometres wide, sub-parallel to the present coast-line and 0.6 to 1 kilometre inland from it. Their surface is covered by sandy soils which are fluviatile in character and cannot have moved far from their original location because of the low relief and sluggish drainage.

4.2.2 Geology of the Kwasasi Project Area

The study area is covered by superficial soils and marine sediments. The oldest rocks are Tertiary limestones and are largely covered by Quaternary limestones. Marine sands and clays occur in a belt varying from 16 to 24 km wide, sub-parallel to the present coast-line. Their surface is covered by sandy soils which are fluviatile in character. The Quaternary marine sediments contain raised coral reefs and wind-blown dunes sands which are often red in colour. These outcrop between the Tertiary sediments and the present coast. The Pleistocene sands and clays, like those of the Tertiary, were probably deposited under deltaic conditions in this region.

The Quaternary soils are usually grey sands and clays outcropping over the Tertiary marine sediments. Black cotton soils are present along drainage channels and are also found overlying the Tertiary and Quaternary sediments along the drainage channels. Red soils in the area may be merely better drained variants of the common grey sandy soils but they may also represent tertiary dunes or valley deposits. The alluvium of the Tana River Valley is of Quaternary age.

Figure 4-6: A generalized geological map of Lamu area

Key

Quaternary sediments – alluvium, clays, sands, sandstones

Tertiary sediments – carbonates & mudstones

5 Potential impacts on geology and soils

5.1 Introduction

The potential impacts on the soils and geological environment as a result of implementation of the proposed coal fired power plant facility project, are categorized and then grouped under the various project phases. Mitigation measures are also suggested as under:

- Disturbance of soils and subsurface geological formations during the following activities:
    - ✓ Creation of temporary construction compounds and crane platform areas;
    - ✓ Construction of foundations for the coal power facility and ash yard;
    - ✓ Construction of a substation and associated facilities;
    - ✓ Upgrade of existing access tracks and construction of new access tracks.
    - ✓ Excavation of ash yard, power plant, substation foundation, cooling water pipes.
- Improper disposal of excavated material that could potentially be eroded to water bodies;
- Leakage of oil and fuels from storage areas and from site vehicles and machinery.

5.2 Potential Impacts at Construction phase

The construction phase of the proposed coal fired power facility project involves the following key activities that may have potential adverse impacts on the local soils and geology, if not appropriately managed:

- Excavation and stockpiling of material at the location of proposed power plant and access tracks;
- Disposal of excess excavated material;
- Pollution of nearby surface water from wash out of the excavated materials;
- Contamination of soils, surface water and groundwater from leakage of oils and fuel;
- Excavation of laterite material (murram) for grading of access tracks. Effects that can occur during construction or operations include:
    - ✓ Cut and fill activities leading to soil erosion
    - ✓ Removal of vegetation and landscaping leading to soil erosion and ponding.

- ✓ Use of heavy equipment resulting in soil compaction
- ✓ Impacts to fractured topography (surface collapse)
- ✓ Impervious surface increase resulting in increased runoff and soil erosion
- ✓ Vehicle movements on unpaved surfaces resulting in increased soil erosion and compaction
- ✓ Fires resulting in reduced vegetation and increased soil erosion

There is the potential for the loss of soil and other excavated material through erosion caused by run off during rainy weather or from wind during the dry period during the construction phase of the proposed development. This is considered a negative and minor impact in the absence of suitable mitigation measures. The nature of the construction activities will involve the stripping and stockpiling of soil and other excavated material until it is reinstated, when required.

The continuous use of heavy machinery and other vehicles on unsealed areas of ground has the potential to adversely impact the soil structure, which is considered a direct impact. This is considered a negative and moderate impact in the absence of suitable mitigation measures. The coal power plant and associated structures will be located in rangeland areas and therefore the use of machinery will be limited to assigned access tracks and areas agreed with Amu Power. The time taken for the use of heavy machinery on each part of the site will be limited. During construction of the coal power facility, there is a potential risk of accidental pollution incidences, which are considered direct impacts, from the following sources:

- Spillage or leakage of oils and fuels stored on site;
- Spillage or leakage of oils and fuels from construction machinery or site vehicles;
- Spillage of oil or fuel from refueling machinery on site;
- Spillage or leakage from onsite toilet facilities; and
- The use of concrete and cement for the foundations of the coal power facility.

Laterite material (murram) to be used for grading the access tracks will be obtained from outside the project area. Thick layers of laterite are available in the area of limestone rock formations found to the west. To excavate this resource the proponent needs to make an agreement with the land owner, get a letter of no objection from the Mines and Geology Department in the Ministry of Environment and Mineral Resources, and get another letter of no objection from the National Environmental Management Authority (NEMA).

The above potential impacts are considered negative and minor with mitigation. During the initial site preparation and construction stage, there will be several types of machinery on the site, which is likely to include diesel powered trucks, excavators, bulldozers, cranes and graders.

The potential impacts to the underlying soil from the construction of the proposed development could arise from accidental spillage of fuels, oils, paints and solvents, which could adversely affect soil and bedrock quality if allowed to infiltrate into the ground during storage and dispensing operations. The underlying soil and geology quality could also be affected, indirectly, if surface contamination migrates downwards.

To mitigate this, the site Engineer will undertake grass planting as the construction progresses to avoid the soil being washed or carried by wind as well as ensure that borrow pits are reclaimed by backfilling with appropriate construction waste materials. Places of least vegetation cover will be identified for the camp site and only construction points will be completely cleared to ensure minimum vegetation disturbance. Proper roof catchments and gutters will be put in place to control the possible increased runoff. Temporary storage tanks will be supplied to trap this water for irrigating planted vegetation.

5.3 Potential Impacts at Operational Phase

Excavation could lead to the risk of land slide due to bed rock disturbance and possible over saturation of of the overburden soil. Scattered trenches and mounds of top soil and tailings from screening could be a common feature. Therefore the stripped topsoil and tailing from the screening process will be used to progressively backfill the dugout trenches immediately behind the abandoned site. This combination of mining and backfilling leaves only minimal sized pit opening at any given time. Care will be taken not to interfere with the course of the seasonal streams and ponds, by leaving clearance of at least 30m from the operations points. This is in keeping with the Legal Notice 120 – water Quality Regulations 2006.

The built-up area and bare ground such as roads tracts will lead to increased volume and velocity of storm water run-off across some points of the area covered by the project. This will make loose soils and debris be carried and deposited at places where they could create siltation. Since the area is arid and semi-arid, the amount of continuous runoff will be minimal and therefore of little impact however, the site Engineer will construct surface rainwater trap pits and cut-off drains to check occasional runoff. Roof catchments' gutters connected to tanks will harvest excess rainwater and be used for irrigating planted vegetation and for outdoor cleaning of vehicles, toilet, thereby reducing the demand on water supply. The operation of the proposed coal fired power facility project is not expected to have a notable impact on the underlying soil or geological environment during normal operating conditions.

Routinely, vehicles carrying management, operators and maintenance staff will visit the site. Potential impacts on the soils and geological environment during the operational phase are expected to include minor, localized contamination in the event of leakage of oil/fuel from the maintenance vehicles and coal ash waste. This is considered a direct, negative, short term and very slight impact. The construction of access tracks using a stone base and the presence of a surface water drain alongside the access track will help prevent burrowing and gulling of the ground surface.

Disposed excavated soils and tailing mounds will cause both visual and movement obstruction. This will be mitigated by restricting public movement through the operation area. However, emergency responses will be provided for by clear operating procedures. Most of the excavated materials will be used for backfilling and some will be applied in landscaping.

The digging up of borrow sites and excavation for shallow and deep foundation sites to enable accommodation of the proposed components of the plant facilities and residential areas, will bring up to the surface a mixture of rock fragments, that include gravels, silt, clays and sand. Once weathered and decomposed due to exposure to vagaries of environment, they are bound to alter the soil geochemistry of the project sites. Besides, prolonged human activity, the intensive transport system around the project may lead to break up of soil texture that may lead to change in area's physical chemistry. The site Engineer will make use of the beneficial chemical dynamics by investing on plant species that can get outmost benefit from the available minerals though efficient absorption. Assistance from KEFRI, other soil and botanical experts can provide advice, while backfilling will help in restoration of the overburden and tailings, where the latter will go in first.

5.4 Potential Impacts at Decommissioning Phase

Demolition will leave disused unsightly scenery with unaesthetic derelict land.

Proper site restoration or reconstruction measures will be carried out in the event of complete phase-out of the project. Landscaping and plant enrichment will be done at phase-out. Environmental, health and legal requirements will be followed

6 Impact assessment

The proposed coal fired power facility Project will involve excavation of the subsurface soils and geological formation during construction of the access tracks, underground cable trenches, turbine foundations and other minor structures. The excavated material may be washed to surface water channels and wetland areas if mitigation measures are not put in place. The soil structure may also be destroyed by heavy vehicles and machinery if the access tracks and working areas are not well constructed to take the weight of these vehicles and machinery.

During the construction phase there will be many heavy vehicles and machinery that could be potential sources of oil or petroleum leaks. Accidental spill could also be a source of hydro-carbons contamination of the soil and subsurface geology.

Table 6-1: Impact significance for soil erosion-construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Short	Low	Probable
	2	2	4	3
	Result: (-24) Low negative			
Mitigation measures	**Comments/Mitigation:** • The site Engineer will ensure that silt control measures are implemented such as silt fences and silt traps to check occasional runoff. • The site Engineer will ensure that stockpiles of excavated materials stored appropriately in designated areas and at a minimum distance of 30m from any nearby watercourses or drains. Measures should also be taken to avoid direct rainfall on stockpile materials or exposed areas of ground that may result in slippage and washout of sediments into nearby drainage channels. • The site Engineer will ensure that long term stockpiles will be sealed at a suitable gradient and grass planted as part of rehabilitation plan. • The site Engineer will ensure that the stripped topsoil and tailings from the screening process will be used to progressively backfill the dugout trenches immediately behind the abandoned quarry site.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Short	Minor	Improbable
	2	2	2	2
	Result: (-12) Low negative			

Table 6-2: Impact significance for ground contamination from coal ash, oil, fuel and chemical leaks-construction and operational phases

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Long-term	Moderate	Probable
	2	4	6	3
	Result: (-36) Medium negative			
Mitigation measures	**Comments/Mitigation:** • The site Engineer will ensure that regular monitoring of soils is done to detect for any geochemistry changes on soil and/or alteration of soil geochemistry. • The site Engineer will ensure that storage of chemicals will be in bunded areas of sufficient capacity. • The site Engineer will ensure that refueling of vehicles/machinery will be done offsite. Where necessary, construction machinery will be re-fuelled onsite by means of a mobile fuel bowser done by trained personnel. This will be done in designated, bunded areas of hard-standing that are situated a minimum of 30m from surface water bodies. A spill tray and an emergency response spill kit will be brought onto the site with the mobile fuel bowser during refueling operations. • The site Engineer will ensure that logistical procedures eases movement of coal, coal ash, oil fuel and other on-site materials. Materials will be packed properly in specialized carriers to reduce chances of falls on the road, thus affecting the soil and geology. • The site Engineer will ensure that the coal ash yard is well lined with an impermeable HDPE membrane to prevent landfill leachate does not contaminate the soils and geology of the project site.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Long-term	Minor	Improbable
	2	4	2	2
	Result: (-16) Low negative			

Table 6-3: Impact significance of soil structure destruction by heavy vehicles-construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Regional	Short	Moderate	Probable
	3	2	6	3
	Result: (-33) Medium negative			
Mitigation measures	**Comments/Mitigation:** • The site Engineer will ensure that vehicles and other heavy equipment use approved tracks as access routes. • The site Engineer will ensure that well paved tracks (stone and laterite/murram) are used as access tracks to protect underlying soil. This should be well compacted in order to carry the weight of the expected heavy vehicles. The tracks should be constructed in such a way as to allow for easy drainage of surface run-off on either side of the track. In sloped areas the drainage channels on the sides of the tracks should have concrete barriers at intervals of 30 to 50 metres (depending on the slope) to check erosion and cutting into the drainage channel.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Regional	Short	Low	Improbable
	3	2	4	2
	Result: (-18) Low negative			

7 Mitigation measures and management plan

7.1 Construction phase mitigation measures

It is proposed that the access tracks be constructed of stone and laterite (murram) which should be well compacted in order to carry the weight of the expected heavy vehicles. This should consequently minimize the potential for soil erosion through surface runoff and also minimize the destruction of the soil structure, which could occur by the continuous use of these heavy vehicles on unsealed tracks. The tracks should be constructed in such a way as to allow for easy drainage of surface run-off on either side of the track. This will minimize the potential for water-logging and land slippage around the track. In sloped areas the drainage channels on the sides of the tracks should have concrete barriers at intervals of 30 to 50 metres (depending on the slope) to check erosion and deepening of the drainage channel.

Stockpiles of excavated materials should be stored appropriately in a designated area of the site at a minimum distance of 10m from any nearby watercourses or drains. Measures should also be taken to avoid rainfall on stockpile materials or exposed areas of ground resulting in slippage and washout of sediments into nearby drainage channels. As most of the excavated material is expected to be reused, the generation of significant quantities of surplus spoil is not expected. Excess excavation material should be removed from the site and appropriately deposited in a designated area where it will have minimal chances of being eroded into drainage channels. This would best be in a depressed area that does not have an outlet into the local drainage system.

The control of the generation of silt laden surface water runoff will be by means of the use of mitigation measures such as bunds, settlement ponds, silt fences or by covering the stockpiles with plastic sheeting. Any runoff from stockpiles will be passed through a silt trap or buffer zone prior to any discharge to local watercourses. Stockpiles will be sealed at a suitable gradient and grass planted, if stored long term.

The refueling of vehicles/machinery will be expected to be done offsite. Where necessary, construction machinery will be re-fueled onsite by means of a mobile fuel bowser (comprising a double skinned tank) accompanied by trained personnel. Refueling operations will only take place at a designated, bunded area of hard-standing that is situated a minimum of 10m from surface water bodies. A spill tray and an emergency response spill kit will be brought onto the site with the mobile fuel bowser during refueling operations. Site personnel operating machinery or vehicles on the site will be trained in the use of emergency spill kits. The spill tray will be placed beneath the fill point of the vehicle and the emergency response spill kit will be used in the event of an accidental spill.

In order to minimize any adverse impact on the underlying subsurface strata from material spillages, all oils, solvents and paints used during construction will be stored within specially constructed bunded areas or suitable bunded lockable storage containers. Filling and draw- off points will be located entirely within the bunded area(s). Drainage from the bunded area(s) shall be diverted for collection and safe disposal.

It is recommended that areas affected during construction phase of the coal fired power project that will be outside the perimeter of each proposed facility be rehabilitated by planting appropriate vegetation cover. This will reduce potential of soil erosion. The overall area that will eventually be covered by the coal power facility and substation will be relatively small compared to the total project area and therefore the effect on the local population's livelihood is negligible.

Strict supervision of contractors will be adhered to so as to ensure that all plant and equipment utilized onsite, are in good working condition. Any equipment not meeting the required standard will not be permitted for use within the site. This will minimize the risk of soils, subsoil and bedrock becoming contaminated through site activity.

7.2 Operational phase mitigation measures

The volume of traffic is expected to significantly decrease after the construction phase full operation of the coal power facility commences. The only vehicles expected will be those bringing the operators and maintenance crew and therefore there will be a decreased risk of spillage and leakage of oils, fuels and other contaminants from these vehicles.

However, it is recommended that routine checks are carried out around the coal power facility sites to ensure that any leakage of oil/petroleum from the maintenance vehicles and coal ash do not go undetected. A spill kit will be located within the depot to ensure that any minor leaks of oil and from coal ash are cleaned up immediately on detection.

7.3 Management plan

The purpose of an EMP is to ensure that social and environmental impacts, risks and liabilities identified during the EIA process are effectively managed during the construction and operation phase of the project. The EMP specifies the mitigation and management measures to which the proposer is committed, and shows how the organizational capacity and resources to implement these measures will be mobilized. The EMP also shows how mitigation and management measures will be scheduled.

The EMP will highlight the sequence of environmental audit by a qualified person to ensure implementation and compliance of all the mitigation measures recommended in the final EIA report.

7.4 Gaps in knowledge and uncertainties encountered

The geological set-up of the project area was not studied as no previous literature on the same was available since the area was inhabited by wildlife and covered by thick vegetation.

It could not clearly be determined either from visual observation or from the geophysics conducted in the area whether the sink-holes and drying-up of the wells as well as increasing salinity with lowering of the water table in the few remaining shallow wells phenomena is also found in the subsurface. This has direct implication on the location of the facility and types of foundations to be constructed. This however may be resolved by carrying out Geotechnical surveys for each location marked for a facility construction and water level monitoring from drilled boreholes/wells.

8 Conclusions from the geology and soils study

From the foregoing study of the Kwasasi area it may be concluded that the main risk to the soil and geological environment are during the construction phase when there will be a lot of excavations for road track, coal power facility foundation, staff quarters, administration block as well as the operational phase when raw coal and coal ash stock piling commences. However if the proposed mitigation measures are implemented the residual effect on soil and geology will be slight.

Monitoring required during the construction and operational phases will comprise monitoring of nearby surface and ground water quality and tidal levels in order to ensure that the proposed works do not adversely impact on its quality via soil erosion, buoyancy and soil consolidation. The site Engineer will conduct routine monitoring by visual means to ensure that the site works (vehicles, equipment and fuel/chemical storage areas) do not adversely impact on the soils and geological environment.

9 References

- Sombroek, et al 1982; Exploratory Soils Map of Kenya, 1982;
- Lamu County Integrated Development Plan (2013-2017);
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