UPGRADED STUDY REPORT

PROPOSED INSTALLATION OF 3 × 30 MWe MENENGAI MODULAR POWER PLANTS PROJECTS IN NAKURU COUNTY

University of Eldoret

flame of knowledge and innovation

GDC

Powering the Vision

SEPTEMBER 2013

DECLARATION BY THE ENVIRONMENTAL CONSULTANT

I, **Dr. Gelas Muse** of University of Eldoret, School of Environmental Studies (SES) submit this Updated Environmental and Social Impact Assessment (ESIA) Study Report for the Proposed 3 × 30 MW Menengai Modular Power projects in Nakuru County. The ESIA Study Report has been carried out according to the Environmental Management and Coordination Act (1999) and Environmental (Impact Assessment and Audit) Regulations, 2003. To my knowledge, all information contained in this report is accurate and a truthful representation of all findings as relating to the proposed geothermal power generation and related infrastructural development

Signed at **Eldoret** on this 21st day of September, 2013

Signature: 

Designation: EIA/Audit Lead Expert Reg. No. 0654
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DECLARATION BY THE PROPONENT

I, **Mr Benjamin M. Kubo** on behalf of Geothermal Development Company submit this Updated Environmental and Social Impact Assessment (ESIA) Study Report of the Proposed 3 × 30 MWe Menengai Modular Power projects in Nakuru County. To my knowledge, all information contained in this report is accurate and a truthful representation of all findings as relating to the proposed geothermal power generation and related infrastructural development.

Signed at Nakuru this ------- day of September, 2013

Signature: ----------

Designation: ----------

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ACRONYMS

dB	Decibels
EA	Environmental Audit
EIA	Environmental Impact Assessment
ESIA	Environmental & Social Impact Assessment
EIS	Environmental Impact Study
EMCA	Environmental Management and Coordination Act
EMP	Environmental Management Plan
GPS	Geographical Positioning System
KEBS	Kenya Bureau of Standards
KFS	**Kenya Forest Services**
KPLC	Kenya Power and Lighting Company (now Kenya Power)
KRA	Kenya Revenue Authority
KWS	Kenya Wildlife Service
NEMA	National Environment Management Authority
PPE	Personal Protective Equipment
TOR	Terms of Reference
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

GLOSSARY: WEIGHT, MEASURES AND CURRENCY

Acid Rain: Also called acid precipitation or acid deposition, acid rain is precipitation containing harmful amounts of nitric and sulphuric acids. pH is a measure of acidity or alkalinity and ranges from 0 to 14. A pH measurement of 7 is regarded as neutral.

Air Pollution: Unwanted particles, mist or gases put into the atmosphere as a result of human activities.

Ambient: Natural condition of the environment at any given time.

Anthropogenic: Caused by human action, such as changes in vegetation, an ecosystem, or an entire landscape.

Binary-Cycle Plant: A geothermal electricity generating plant employing a closed-loop heat exchange system in which the heat of the geothermal fluid (the "primary fluid") is transferred to a lower-boiling-point fluid (the "secondary" or "working" fluid), which is thereby vaporized and used to drive a turbine/generator set.

Biomass: Energy resources derived from organic matter. These include wood, agricultural waste and other living-cell material that can be burned to produce heat energy.

Brine: A geothermal solution containing appreciable amounts of sodium chloride or other salts.

Capacity: The amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station, or system is rated by the manufacturer.

Capacity Factor: A percentage that tells how much of a power plant's capacity is used over time. For example, typical plant capacity factors range as high as 80 percent for geothermal and 70 percent for cogeneration.

Carbon Dioxide (CO_2): A colourless, odourless gas that isone of the major constituents of the air.

Combined Cycle: An electric generating technology in which electricity is produced from waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a

conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Consumption (Fuel): The amount of fuel used for gross generation, providing standby service, start-up and/or flame stabilization.

Cooling Tower: A structure in which heat is removed from hot condensate.

Condensate: Water formed by condensation of steam.

Crust: Earth's outer layer of rock; also called the lithosphere.

Demand (Utility): The level at which electricity or natural gas is delivered to users at a given point in time. Electric demand is expressed in kilowatts.

Direct Use: Use of geothermal heat without first converting it to electricity, such as for space heating and cooling, food preparation, industrial processes, etc.

Drift: Drift droplets are any water droplets and dissolved and suspended solids that are entrained in the air and emitted from the cooling tower stack.

Drift Eliminator: Drift eliminators reduce the amount of drift in the exiting air flow. Drift droplets can be reduced to less than 0.1 % by effective use of an eliminator.

Drilling: Boring into the Earth to access geothermal resources, usually with oil and gas drilling equipment that has been modified to meet geothermal requirements.

Dry Steam: Very hot steam that doesn't occur with liquid.

Effluent: Treated wastewater

Efficiency: The ratio of the useful energy delivered by a dynamic system (such as a machine, engine, or motor) to the energy supplied to it over the same period or cycle of operation.

Emissions Standard: The maximum amount of a pollutant legally permitted to be discharged from a single source.

Energy: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy).

Energy Efficiency: Refers to programs that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. **Energy Source:** The primary source that provides the power that is converted to electricity through chemical, mechanical, or other means.

Fault: A fracture or fracture zone in the Earth's crust along which slippage of adjacent Earth material has occurred at some time.

Flash Steam: Steam produced when the pressure on a geothermal liquid is reduced; also called flashing.

Fossil Fuel: Any naturally occurring organic fuel, such as petroleum, coal, and natural gas.

Fossil-Fuel Plant: A plant using coal, petroleum, or gas as its source of energy.

Fumarole: A vent or hole in the Earth's surface, usually in a volcanic region, from which steam, gaseous vapours, or hot gases issue.

Geology: Study of the planet Earth, its composition, structure, natural processes, and history.

Geothermal: Of or relating to the Earth's interior heat.

Geothermal Energy: Natural heat from within the Earth, captured for production of electric power, space heating or industrial steam.

Geothermal Heat Pumps: Devices that take advantage of the relatively constant temperature of the Earth's interior, using it as a source and sink of heat for both heating and cooling.

Geothermal Plant: A plant in which the turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the Earth.

Geothermal Steam: Steam drawn from deep within the Earth.

Generation (Electricity): The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in watt-hours (Wh).

Geyser: A spring that shoots jets of hot water and steam into the air.

Gigawatt (GW): One billion watts.

Gigawatt-hour (GWh): One billion watt-hours.

Greenhouse Effect: The increasing mean global surface temperature of the Earth caused by gases in the atmosphere (including carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbon).

Grid: The layout of an electrical distribution system.

Heat Exchanger: A device for transferring thermal energy from one fluid to another.

Heat Pumps: See Geothermal Heat Pumps

Hot Dry Rock: A geothermal resource created when impermeable, subsurface rock structures, typically granite rock 15,000 feet or more below the Earth's surface, are heated by geothermal energy. The resource is being investigated as a source of energy production.

Hydroelectric Plant: A plant in which the turbine generators are driven by falling water.

Hydrothermal Resource: Underground systems of hot water and/or steam.

Injection: The process of returning spent geothermal fluids to the subsurface, sometimes referred to as reinjection.

Kilowatt (kW): One thousand watts.

Kilowatt-hour (kWh): One thousand watt-hours.

Load (Electric): The amount of electric power delivered or required at any specific point or points on a system. The requirement originates at the energy-consuming equipment of the consumers.

Magma: The molten rock and elements that lie below the Earth's crust.

Mantle: The Earth's inner layer of molten rock, lying beneath the Earth's crust and above the Earth's core of liquid iron and nickel.

Megawatt (MW): One thousand kilowatts (1,000 kW) or one million (1,000,000) watts. One megawatt is enough energy to power 1,000 average homes.

Megawatt-hour (MWh): One million watt-hours.

Micron: A unit of length equal to one-millionth of a meter.

NOx: Oxides of nitrogen that are a chief component of air pollution that can be produced by the burning of fossil fuels; also called nitrogen oxides.

Nuclear Energy: Power obtained by splitting heavy atoms (fission) or joining light atoms (fusion). A nuclear energy plant uses a controlled atomic chain reaction to produce heat. The heat is used to make steam run conventional turbine generators.

Nuclear Power Plant: A facility in which heat produced in a reactor by the fissioning of nuclear fuel is used to drive a steam turbine.

Particulate Matter (PM): Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines

Point Source: A stationary location or fixed facility from which pollutants are discharged.

Power Plant: A facility comprising electricity generators and auxiliary equipment for converting mechanical, chemical, and/or nuclear energy into electric energy.

Pyroclastic: Formed by or involving fragmentation as a result of volcanic or igneous action.

Regulation: The governmental function of controlling or directing economic entities through the process of rulemaking and adjudication.

Reliability: Electric system reliability has two components--adequacy and security.

Renewable Energy: Resources that constantly renew themselves or that are regarded as practically inexhaustible, i.e. solar, wind, geothermal, hydro and wood.

Reservoir: A natural underground container of liquids, such as water or steam (or, in the petroleum context, oil or gas).

Selective Catalytic Reduction: A post combustion control to reduce nitrogen oxide gas emissions.

Solar Energy: Heat and light radiated from the sun.

Stability: The property of a system or element by virtue of which its output will ultimately attain a steady state.

Subsidence: A sinking of an area of the Earth's crust due to fluid withdrawal and pressure decline.

System (Electric): Physically connected generation, transmission, and distribution facilities operated as an integrated unit under one central management, or operating supervision.

Thermal Pollution: a reduction in water quality caused by increasing its temperature, often due to disposal of waste heat from industrial, power generation processes, or urban impervious surfaces (such as parking lots).

Transmission: The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas).

Vapour-Dominated: A geothermal reservoir system in which subsurface pressures are controlled by vapour rather than by liquid; sometimes referred to as a dry-steam reservoir.

Watt: The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.

Watt-hour (Wh): An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

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EXECUTIVE SUMMARY

E1: Introduction: Geothermal Development Company (GDC), a 100% Government of Kenya owned company, is tasked with accelerating development of geothermal resources to support development of at least 10,000 MW by 2030 in line with Vision 2030. The Proponent plans to generate electricity using modular geothermal power generation technology (i.e. early generation with Modular Generation Units) from the Menengai Caldera, Nakuru County. The proponent considers this as a more sustainable, environmentally and socially friendly, which would ensure adherence to the requirements of the Kenyan laws and international laws. It is in this regard that, a contract was signed between the Project Proponent (GDC) and the Consultant, University of Eldoret, 11th September, 2013 wherein the Proponent requested that an Updated Environmental and Social Impact Assessment (ESIA) for the proposed 3 × 30 MW Menengai Modular power plants projects be carried out.

The Executive summary presents the various sections of the report. The introduction of the main report discusses the background information of the study, purpose, focus and expected deliverables, which include information on the present status of the proposed project area. This chapter presents information on methods and procedures used for the ESIA.

E2: Description of the Project: This chapter describes the proposed project in terms of its geographic location and operational activities. The first section describes the geographic setting of the project, followed by the description of the three phases of the project namely: Construction, operation and decommissioning. The construction phase mainly entails construction and installation of the three (3) geothermal modular power plants of 30 MW each, construction of the substations, sump, re-injection well and transmission lines to the various proposed drilling sites. The operation phase consists of power generation and Steam field management. Decommissioning phase involves dismantling of geothermal modular plants, substation and rehabilitation of the sites and utilizing of low discharge wells as re-injection wells. Details of activities, materials and technologies to be used at each phase are described.

E3: The Legal Framework: The legal framework related to the development of energy resources is discussed. Information on legal aspects was obtained mainly from secondary sources. The activities of the proposed project are regulated by several legal instruments and policies, the main ones being the EMCA, which sets the requirements and procedures for

obtaining operating licenses and permits. EMCA is supported by several general and project specific laws, including, Mining Act, Water Act, Factories Act, and the Geothermal Resources Act, Energy Act, among others. Besides the national institutional and legal framework, projects of this magnitude are also regulated by international conventions and treaties, some of which Kenya is signatory and also considering that some organizations such as the World Bank (WB), European Investment Bank (EIB), African Development Bank (AfDB), French Development Bank (AfD), Japan International Cooperation Agency (JICA), Japan Bank for International Cooperation (JBIC) among others are potential financial partners. The relevant environmental and social safeguards for these Financiers have also been highlighted. This chapter highlights the specific sections of both national and international laws and institutional framework which will enable the proponent be compliant with the law and attain the set standards. The Environmental and Social safeguard policies for various donors (see section 3.5.1) in relation to the planned development activities are discussed. The principal international conventions (see section **Error! Reference source not found.**), some of which have been ratified and Kenya is a signatory are analyzed.

E4: Baseline Information of the Proposed Project Area: Baseline information of the project area data is discussed and illustrated with respective figures and tables with regard to physical, biological and socio-economic aspects of the environment. Biophysical, socio-economic and cultural environmental data were collected from primary and secondary sources. Field visits to the project sites were made during the study period. Observations, photography, administration of questionnaires, and one-on-one meeting methods were used.
The project area is classified into two main agro-climatic zones: the low land areas that fall in semi-arid zone IV with an annual rainfall of 800 mm and mean temperatures of 30°C and the dry sub-humid equatorial climatic zone. The area is characterized by two trachytic main rock series - the older ones that is Pliocene, which is characterized by two successive strata and the earlier one that is Pliocene that is characterized by phonolitictrachytes. Overall the soils in the prospect area are volcanic soils of superficial deposits.

The streams in the area are seasonal and discharge into rivers at the floor of the rift valley.
The noise levels range from low of 43.3 dB to relatively high levels of 91.5 dB at discharging wells. The latter is above the recommended ambient and occupational standards (45 and 85 dB) respectively.

The Caldera is covered by vegetation with a cover density ranging from 15% to 65% consisting of Bush lands (23%), Grasslands (21%), Forests (18%), Disturbed land (14%), Woodlands (10%), Rocky outcrops and lava vegetation (9%), Montane forest (3%) and riverine vegetation (2%).

E5 Hydrogen Sulphide Dispersion Modelling: H_2S concentration is monitored by GDC Environment Department around Menengai wells by use of gas detectors since inception of Menengai geothermal drilling project. Data for the last two years was used to model dispersion of H_2S within the project area and environs using AERMOD model. Based on results of the air quality dispersion modelling studies, the proposed 90 MW modular power plants which will discharge H_2S through the cooling towers emission, which will provide greater plume rise and better dispersion. Overall the H_2S emission will have insignificant impact to environment and public in the project area.

E6 Public Participation: The public participation process was carried out to collate feelings and concerns of local community and other stakeholders. The process allowed interaction, consultation and participation of the stakeholders. During this process the consultants interacted with local people, provincial administration, NGOs/CBOs, and other groups such as women, youth, church leaders and councilors (see Appendix 2). Socio-economic concerns such as employment, health, human-wildlife conflict and cultural issues were captured (see Table 6.1) in the public participation chapter.

E7: Impact Identification, Cumulative Impact Assessment and Risk Analysis: Impact assessment was carried out in order to identify where the interactions were likely to occur between the proposed project activities and the receiving environments. A modified Leopold Matrix (LM) integrated with Lohani & Thanh methods were used to identify and estimate the magnitudes and importance of the potential impacts (see Table 7.1). The cumulative impacts were assessed and risk ranking carried out using the risk assessment model adapted from the South African Department of Environmental Affairs' guideline document on EIA regulations of 1998. The model predicts the significance of impacts by considering magnitude, duration, spatial scale and factoring in probability of the impact to occur. The cumulative impacts range from minor to moderate and can be mitigated.

The chapter establishes the potential environmental and socio-economic impacts based on: impact identification; prediction and cumulative risk analysis of potential impacts at all stages of the project cycle. Significant negative impacts are:

- Gas (H_2S and CO_2) emissions,
- Vegetation loss due clearance of project sites
- Dust emissions
- Health related impacts such as HIV/AIDS.

The positive impacts are mainly of socio economic nature namely:

- Improved infrastructure such as road network, water supply, and electricity
- Education and awareness creation amongst the community.
- Employment opportunities to the local community
- Improved business opportunities and improved income

Overall, the impacts are of low significance and the indicative estimated mitigation costs are indicated in the EMP (Table 10.1 & 10.2) and in the proposed action plan (Table 11.1).

E8: Mitigation Measures and Monitoring Programmes: Mitigation of physical, biological and socio-economic impacts of the proposed project are discussed. Cleared vegetation is mitigated by reforestation initiative whereby trees are planted at the cleared sites or compensatory planting of equivalent or more trees in the project area including schools. Water abstraction will be done sustainably as per the water abstraction permit. Noise mufflers to be fitted on the modular power plants where applicable and workers and other permitted persons to use protective gears as described in occupational health and safety subsection 8.2.3 of this report and EMP Tables 10.1-10.3.

E9: Analysis of Project Alternatives: The various project options are considered in this chapter. These include: No Project Alternative option, Alternative Energy Sources other than modular power generation, and alternative power generation technologies.

The following options are available to the proponent:

- Dry steam plant that makes use of a direct flow of geothermal steam (Figure 9.1).
- Flash system is the next most common type of power plant (Figure 9.2).
- Binary geothermal plants (Rankine cycle) – Figure 9.3.

- Flash/binary combined cycle (Figure 9.4), which is a combination of flash and binary technology also referred to as the hybrid power plant technology.

Of the four available options to the developer, one of the fastest growing is the binary cycle, which includes a Rankine cycle engine. It is cost effective and also environmentally friendly. The choice of cooling system is also analyzed, which include water-cooled and air-cooled systems.

The option of Hybrid model (Combined Heat and Power) in the proposed project area is also provided. The water from a geothermal power plant can provide energy for direct use in projects such as greenhouse and fish pond heating, industrial applications, cereal drying, spa and pool heating. Mineral recovery, for example silica and sulphur, may also be recovered.

E10: Environmental and Social Management Plan: An environmental and social management plan (ESMP) has been provided based on the implementation phases of the project, i.e. Construction, operation and decommissioning. Indicative costs, time frame and the responsible institutions are indicated in Tables 10.1-10.3. If the suggested mitigation measures are adhered to as per the plan, the implementation of the proposed project will have minimal negative impacts and the positive ones will be highly enhanced. The ESMP will be carried as per the suggested action plan (Table 11.1).

E11: Environmental and Social Impact Action Plan: The main purpose of the environmental action plan is to identify adverse environmental and social impacts and plan action to be taken in the implementation period. The environmental and social action plan presented outlines the specific steps that will need to be taken at different stages in the geothermal resources development activities and aims to minimize both short term and long-term impacts resulting from various alternative options (see Table 11.1). Indicative costs are provided together with responsible institutions. Real costs can be calculated so that planned actions are undertaken to minimize potential harmful impacts and maximize beneficial impacts for the benefit of the community and the country in general.

E12: Conclusion and Recommendations:

Conclusion

In View of the information collected, the ESIA Team concludes that the proposed project is suitable to the ongoing geothermal power development at Menengai caldera. Based on the updated ESIA study findings, it is concluded that positive impacts outweigh negative ones notwithstanding the fact that most potential negative impacts identified can be easily mitigated. Outlines of these impacts and proposals of mitigation measures for the negative ones are covered in chapters 6 and 7 of this report.

Recommendations

Recommendations are made based on the assessment of cumulative and potential impacts of the proposed project and are summarized as:

Environmental Issues

- The proponent adheres to proposed ESMP and action plan suggested in ESIA,
- The impacts be monitored closely by the Proponent in collaboration with NEMA, Environmental consultant and Environment Department at GDC.
- To rehabilitate unoccupied areas that were affected during implementation of the project

Socio-Economic Issues

- Raise awareness of control of Human Immune Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) and health risks for construction workers and service providers
- Employment of unskilled labour be limited to local community and be distributed equitably to all locations within the project area
- Implementation of CSR plan should allow community participation.

Licensing

- The consultant recommends licensing of the project to allow for speedy implementation of the project as an initial stage towards increasing the geothermal development in Menengai Caldera and increasing electricity production in the country, towards attaining vision 2030.

- Proponent should meet the conditions on which NEMA may set during issuance of license.
- Consultation with stakeholders and local communities is crucial so that projects proceed with little conflict of interest or adverse effects to direct or indirect stakeholders.
- Consultation strategies should efficiently and effectively reach the stakeholders and to give more empowerment to the local communities through the Participatory Rural Appraisal (PRA) process.
- The local community should form a basis of future consultations but subject to revision particularly at the pre-feasibility study.
- Issues pertaining employment should be addressed through company employment and CSR policies.

- Issues pertaining grazing grounds in the caldera should be addressed through collaboration between GDC, Kenya Forest Services (KFS) and affected community.

CHAPTER 1

INTRODUCTION

1.1 Background

Geothermal Development Company Limited (GDC), herein after referred to as the Project Proponent, is one of the key organizations entrusted with energy development in Kenya. It is tasked with accelerating development of geothermal resources to support development of at least 10,000 MW by the year 2030 in line with Vision 2030. The Proponent is 100% Government owned and receives its funding from GoK Treasury and from international partners. The mandate of the Proponent includes surface exploration, drilling, resource management, early generation and promotion of direct utilization of geothermal in Kenya.

Towards meeting its obligation, the Proponent is carrying out geothermal drilling of the Menengai Caldera Geothermal Field in Central Rift, which is among the many geothermal prospect areas in Kenya (Figure 1.1). The project area is situated in Nakuru County and covers an area of about 7,000 km^2. Detailed surface studies estimates the Field potential to be over 1600 MW.

To date GDC has drilled and tested over 20 wells at the Menengai Caldera, each with an estimated production 5-10 Mw. GDC has proposed to install 3 × 30-35 MW Modular power stations so as to generate and upload 100 MW of electricity to the National Grid. Kenya Electricity Transmission Company Limited (KETRACO) will construct transmission lines to evacuate power from the proposed Modular power stations to sub-station through Rongai to connect to Olkaria-Lessos transmission line approximately, 15 km from the proposed modular power stations.

Besides supporting the on-going drilling activities at the Menengai Caldera, the generated electricity will boost the National electricity supply using cheap and environmentally friendly energy. This will go a long way towards supporting the Vision 2030.

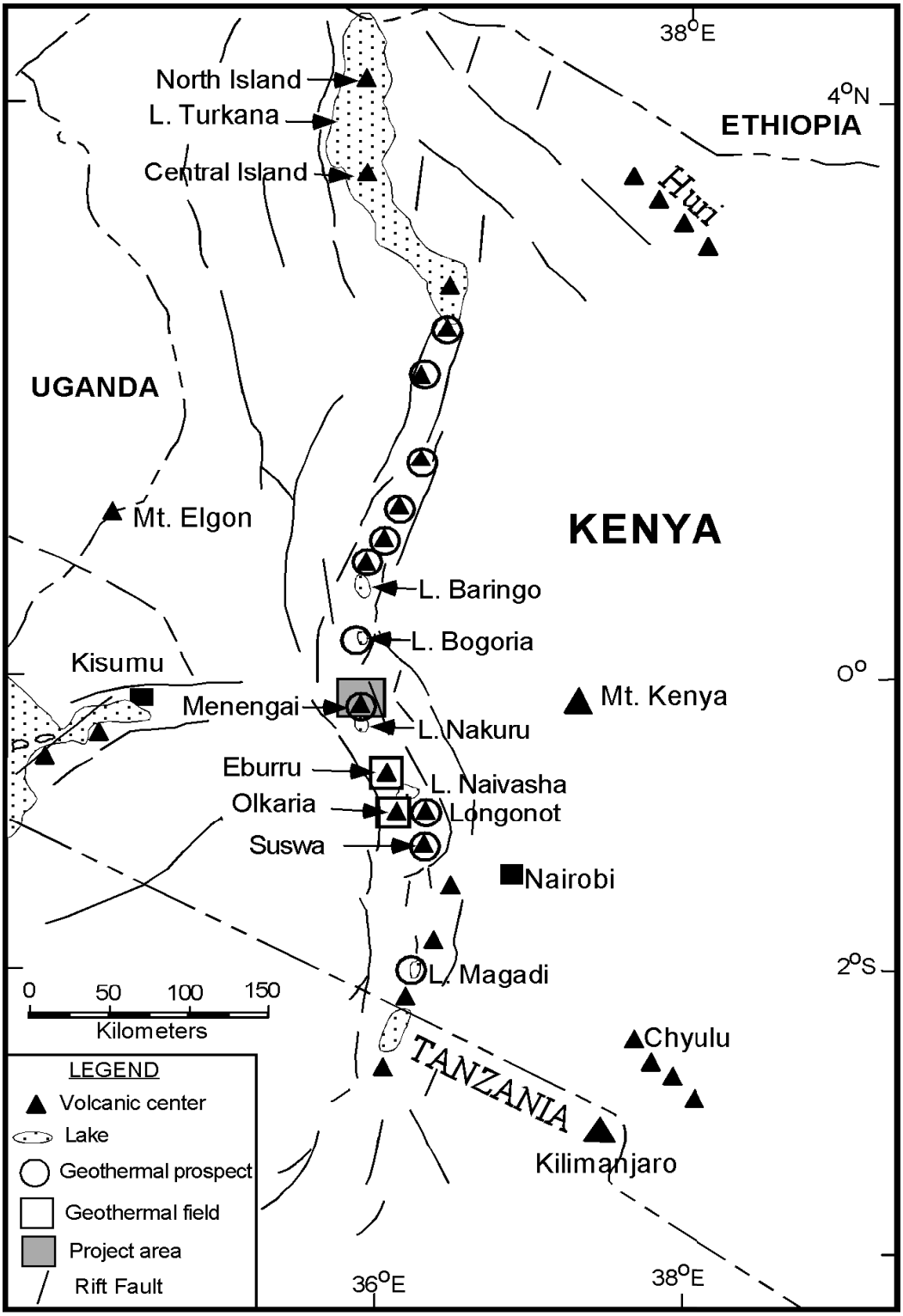

Figure 1.1: Geothermal Potential in Kenya

According to Sections 58 and 138 of the Environmental Management and Coordination Act (EMCA) No. 8 of 1999 and Section 3 of the Environmental Impact Assessment (EIA) and Environmental Audit (EA) Regulations 2003 (Legal No. 101), development as the such proposed require an EIA study report prepared and submitted to the National Environment Management Authority (NEMA) for review and Licensing before the development is undertaken. This is necessary since some developmental activities can cause damage to the environment and hence the greatest challenge today is to maintain sustainable development where all the three pillars of sustainability are adhered to i.e. economic viability, social viability & environmental viability.

A team of EIA Registered experts, herein after referred to as the Consultants, from the University of Eldoret were commissioned by GDC to conduct the environmental impact assessment (an update) or the proposed project.

1.2 Purpose of the Study

The aim of this study is to carry out an Environmental and Social Impact Assessment for 3 × 30 MW Modular Geothermal Power Plants at the Menengai Caldera. By undertaking the initial project activities, the Proponent will absorb the attendant risks associated with geothermal development and therefore open up opportunities for both public and private participation. The study will document the findings in updated reports (EIA/827) that will be submitted to NEMA in compliance with the environmental (Impact Assessment and Audit) regulations, 2003.

1.2.1 Project Objective

The project is intended to achieve the following objectives:

a) Reduce the costs of lengthy steam piping associated with conventional system of geothermal power generation;
b) Enable early access to electricity from Menengai geothermal field to augment the country's power supply;
c) Displace the use of diesel for powering the drilling rigs and hence reduce drilling costs;
d) Generate an early revenue stream that can be used to support the Government's budgetary allocation for geothermal development

Advantages of Modular Geothermal Power Plants

- Easy to transport and install,
- Accommodate wide range of temperatures,
- Accommodate changing loads,
- Accommodate changing resource conditions,
- Operate unmanned and automatically
- Lowest environmental impacts,
- Use shallow or existing wells,
- Used with air or water cooled condensers,
- Power may be used on on-site, and
- Slow speed turbine (1800 rpm)

1.2.2 Justification of Study

In order for the planned utilization of available steam by early electricity generation to proceed, there is need for a sound environmental and social management plan and hence the significance of this study. The environmental and social implications as outlined under this report highlight potential impacts and integration of mitigation measures into the project design.

1.2.3 The ESIA Study Focus

The Kenya Government policy on all new projects, programmes or activities requires that an ESIA is carried out at the planning stages of the proposed undertaking to ensure that significant impacts on the environment are taken into consideration during the design, construction, operation and decommissioning of the facility. The scope of this ESIA covered:

- The baseline environmental conditions of the area,
- Description of the proposed project,
- Provisions of the relevant environmental laws and regulations,
- Identification and discussion of any adverse impacts to the environment anticipated from the proposed project,
- Appropriate mitigation measures,
- Provision of an environmental management plan outline.

1.3 Terms of Reference (TOR)

The consultants on behalf of the proponent conducted the study by incorporating, but not limited to, the following terms of reference:

- To evaluate the suitability of the proposed location for Geothermal development
- To review the national environmental legislative framework and any other relevant regulatory framework related to the project
- To employ site visits, direct observations, public consultations, personal interviews, review of existing documents, checklist and environmental interaction matrix methods
- To evaluate the technologies, procedures and processes to be used and analyses alternatives in relation to the proposed project
- To evaluate the suitability of process to be used in the development and implementation of the project factoring in environmental and social concerns
- To evaluate the products, by-products and wastes likely to be generated by the project
- To evaluate the environmental and social effects of the projects including the social and cultural effects and the direct, indirect cumulative irreversible, short-term, and long-term effects on pre and post project operation
- To develop an environmental and social management plan proposing the measures for eliminating, minimizing or mitigating any adverse impacts on the environment; including the cost, time frame and responsibility for implementation
- To draw up an action plan for the prevention and management of foreseeable accidents and other work related hazards during the running of the project
- To collect and collate views from the local community and other stakeholders whom may be affected by the project in one way or the other
- To draw up a non-technical summary outlining the key finding, conclusions and recommendations of the study
- To submit study report and facilitate acquisition of EIA license from National Environmental Management Authority (NEMA)

1.4 Methodology and Approach

This ESIA Report has been prepared in accordance with the Environmental (Impact Assessment and Audit) Regulations of 2003. It is also guided by other environmental and social

safeguards such as the World Bank's requirements for industrial projects and IFC's EHS Guidelines for Geothermal Projects.

The study methodology comprised the following activities:

Preliminary meetings

- Document review
- Site inspection and discussions with site personnel
- Baseline condition survey
- Public consultation
- Air and Noise Dispersion Modeling
- Impact identification and assessment
- Data analysis and report preparation

The ESIA Report has confined itself to the construction of three (3) 30MW modular power stations and associated infrastructure, including the transmission lines from Menengai to Olkaria-Lessos line through Rongai.

1.4.1 Preliminary Meetings

The Consultants held one meeting with the Proponent representatives in order collect information that was pertinent in understanding the nature of the proposed project. The roles were clarified and the Proponent undertook to provide relevant project document including existing permits, current MOU with KFS and existing scientific data.

This included documentary review on the nature of the proposed activities, project documents, designs policy and legislative framework as well as the environmental setting of the area among others. It also included discussions with managers and design engineers as well as interviews with neighboring communities.

1.4.3 Site Visits

The consultants visited the site together with the representatives of the proponent to see the site where the plants will be located.

1.4.4 Baseline Condition Survey

A detailed survey of the pre-project biological and socio-economic characteristics of the project area and its surrounding was carried out.

1.4.5 Public Consultation

In compliance with the Constitution and the Environment Management Coordination Act (EMCA) a series of consultative meetings were held with the public and other stakeholders to sensitize them on the proposed project as well as seek their views and consent. Key informant interviews, public and stakeholder meetings as well as questionnaire administration were the methods used to engage the public.

1.4.6 Air and Noise Dispersion Modeling

In order to assess the likely air quality and noise impacts it is necessary to predict how air and noise will move within and around the project area at different atmospheric conditions. Appropriate models were used to model air and noise movements (See Chapter 5).

1.4.7 Impact Identification and Assessment

The anticipated impacts were identified and evaluated using standard methods of impact prediction and evaluation, i.e. checklists and matrices. Checklists of project activities were used and impact scores were assigned through consultative approach. The significance of impacts is subjective, but the value judgments required were best arrived at by consensus.

1.4.8 Data Analysis and Reporting

Socio-economic data from administered questionnaires was analysed using SPSS critical programming for social science. Regular consultations and reports were made to the proponent. The final report was presented to the proponent for submission to NEMA as required by law.

1.5 Environmental Determinations

1.5.1 Physical Environment

Physical environment factors assessed included noise levels, temperatures, humidity, pressure, and wind speed. Weather secondary data from GDC's automatic weather station were assessed to determine their environmental significance. Noise levels in the proposed project were assessed using an Integrated Handheld Sound Level meter (Model Extech 407768). Slope was measured using Inclinometer (Model Ross FR3). The geology and drainage of the area was inferred from secondary data obtained from feasibility studies carried out by the project proponent.

1.5.2 Chemical Environment

The chemical environment assess included air quality measurements specifically hydrogen sulphide (H_2S), carbon dioxide (CO_2), Methane (CH_4) and Oxygen measurements. The gases were determined by using a multigas detector (Model Gas Alert Micro 5 IR). Chemistry of brines was also measured and additional data obtained from literature. Radon and ammonia gas levels were inferred from secondary data obtained from scientific monitoring data by proponent.

1.5.3 Biological Environment

Flora

Vegetation sampling was carried out on and around the six determined sites. Visual observation and recording of all spermatophytes encountered. Plant scientific names, family names, growth forms, natural habitat and their status whether indigenous or exotic were also noted and recorded. Selected plants images were also collected and the sites geo-referenced.

Birds/Avifauna

Birds' investigation was based on line transect, which was designed at every site by use of binoculars. Bird species were identified and recorded. Also bird calls or songs or any other songs were incorporated in birds' identification exercise. During observations, only birds' visible within a range radius of 25 m from transects were recorded.

Mammals

The survey used was standard line transect methods that are practiced widely in animal census (Burnharm *et al* 1980). Each site held one transect of 500 m in length and tracks, dung, footprint and other signs associated to certain species of mammals observed within the transect were recorded.

Herpeto fauna

Field search were conducted in the study area where and at time when the reptiles were known to be active or detectable. The search for reptiles was centered on the ground and on trees. Active and barrowing reptiles encountered were recorded. Any other evidence or signs of presence of particular vertebrate were noted.

1.5.4 Health

Information on health was collected by evaluation of health reports and administration of questionnaires that asked specific questions on health issues. Health aspects were also inferred based on the expected emissions vis-a-vis the recommended standards. Medical records from centres in the project area were obtained.

1.5.5 Socio-Economic and Cultural Environment

Information on socio-economic and cultural environment was collected through administration of questionnaires, stakeholder's meetings, barazas (public meetings) and leaders meetings. Meetings were conducted in a mutual atmosphere in which agreements were reached by consensus. Secondary data were obtained by reviewing relevant documents and reports.

CHAPTER 2

DESCRIPTION OF THE PROJECT COMPONENTS

2.1 Introduction

This chapter describes the proposed project in terms of its geographic location, construction and operational activities. The first section describes the geographic setting of the project with a view of identifying the extent of the project's impact. This is followed by the description of the three phases of the project namely construction of the power generation units and steam collection systems; generation of geothermal electricity (operation) and decommissioning. The construction phase mainly entails putting up the 3 × 30 MW Modular Power plant Units and associated works; construction of power transmission line and associated substations; and development of infrastructure including access roads. Decommissioning phase involves rehabilitation of the project site after winding up power generation and relocation to another site. Details of activities, materials and technologies to be used at each phase are described.

2.2 Project Location and Sites

The project is located in the Menengai Geothermal Field on the outskirts of Nakuru Town, about 180 Km west of Nairobi. Approximately the project area is bounded by 36°01′E and 36° 07′ E and 0° 09′ S and 0° 15′ S (Figure 2.1). The proposed modular power plants site boundaries are defined by the coordinates in Table 2.1. Administratively, the geothermal field is as shown in Figure 2.2. Nakuru is the fourth largest town in Kenya with a population of about 300,000 and has well developed social amenities such as educational institutions, medical facilities, hotels, banking and shopping facilities. The main economic activities include agriculture, manufacturing, tourism and construction.

Electricity and telephone service lines serve most of the habitation and the surrounding farm land (Figure 2.3). The project area is within 15 km from the 132 kV double circuit Tororo – Lessos - Juja line and about 30 km to the Lanet 132 kV substation.

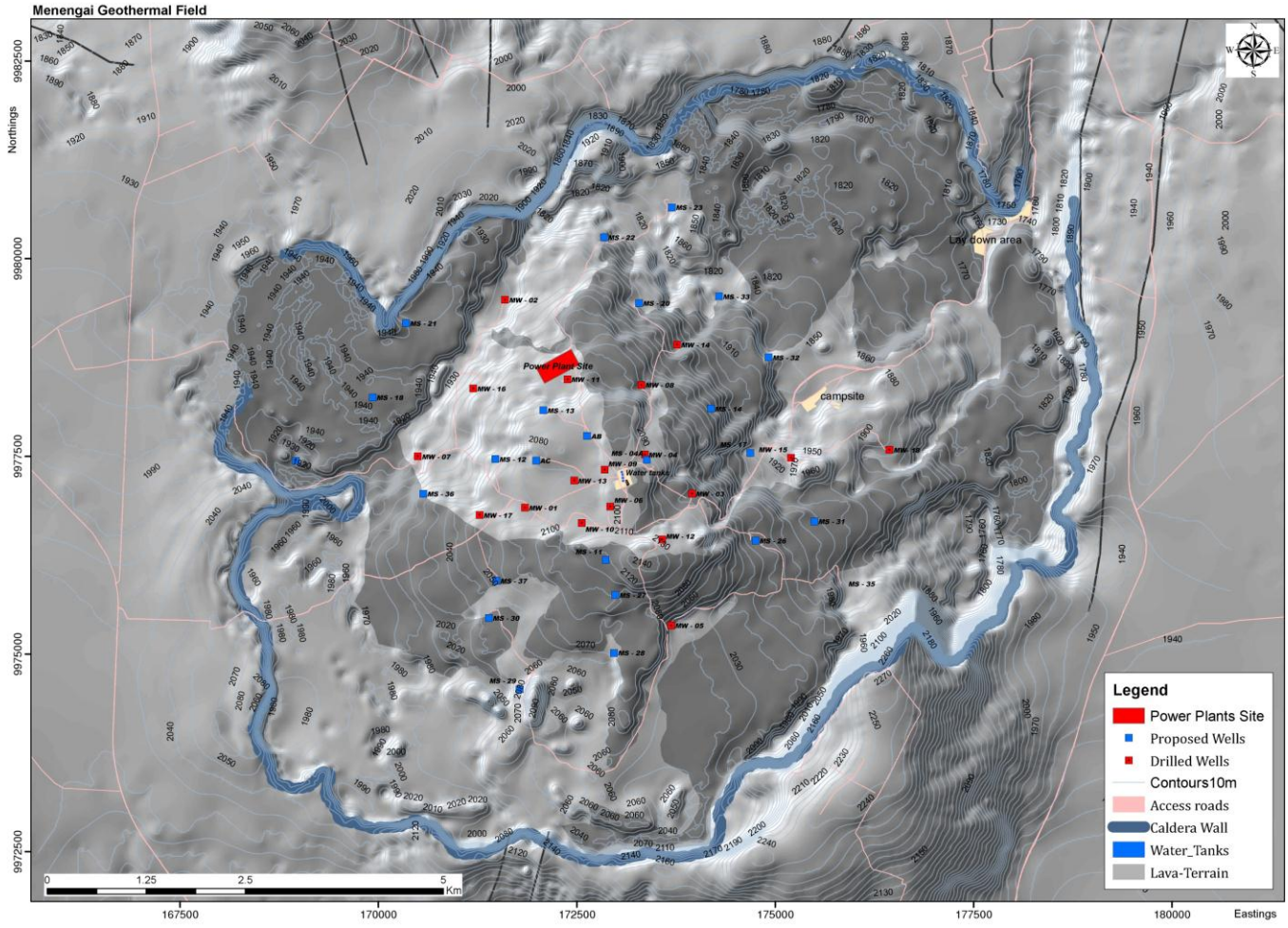

Figure 2.1: Menengai geothermal field showing location of the proposed plants

(Source: GDC GIS Section)

Table 2.1: GIS Coordinate showing Modular Power plants and substation site boundaries

Site Boundary	Eastings (m)	Northings (m)
Modular Power Plants		
A	171988	9978612
B	172427	9978851
C	172531	9978660
D	172094	9978421
Substation Boundaries		
A	172162.5	9978455.9
B	172250.5	9978503.6
C	172298.10	9978416.3
D	172210.8	9978367.9

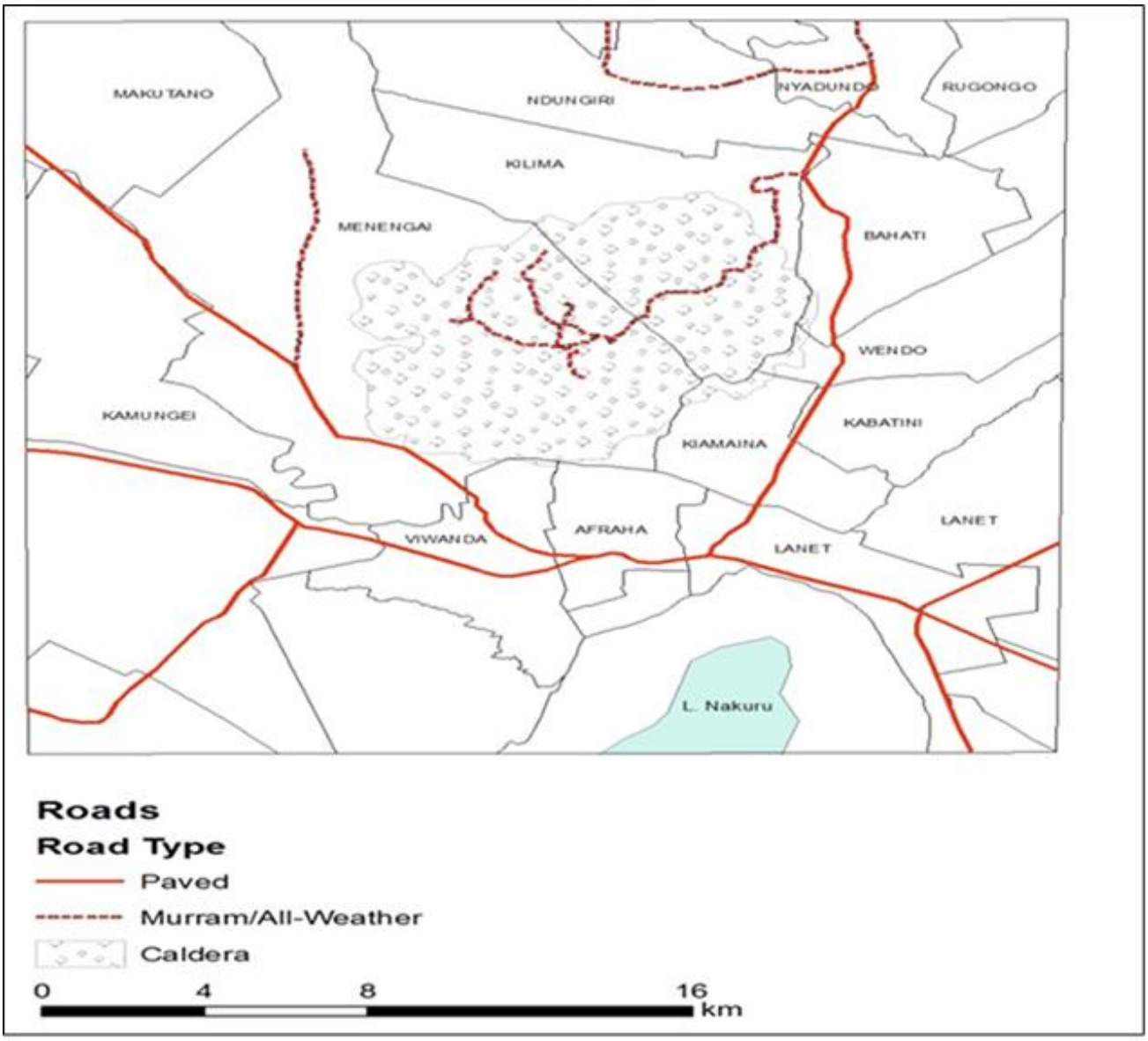

Figure 2.2: Map Showing the Administrative Location of the Project Area

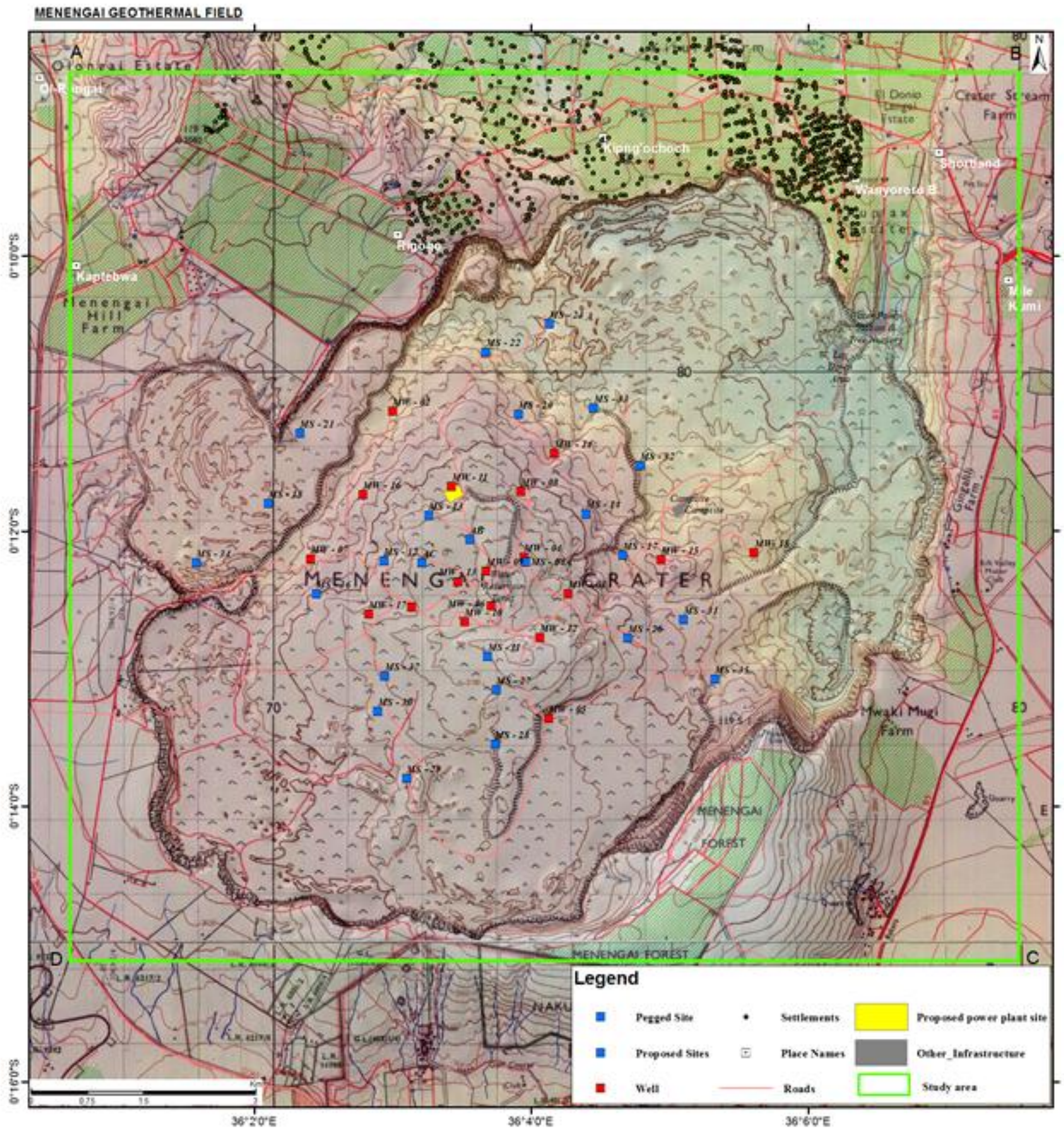

Figure 2.3: Map of the Menengai Volcano showing Farm Distribution and Road Network

The proposed power plants will be located within the Menengai Caldera at the location indicated in Table 2.1 above and Figure 2.1. Geothermal power generation plant will include Construction and installation of the 3 modular power plants as per the indicated plant layout (Figure 2.4), re-injection wells and transmission lines to the proposed drilling well sites.

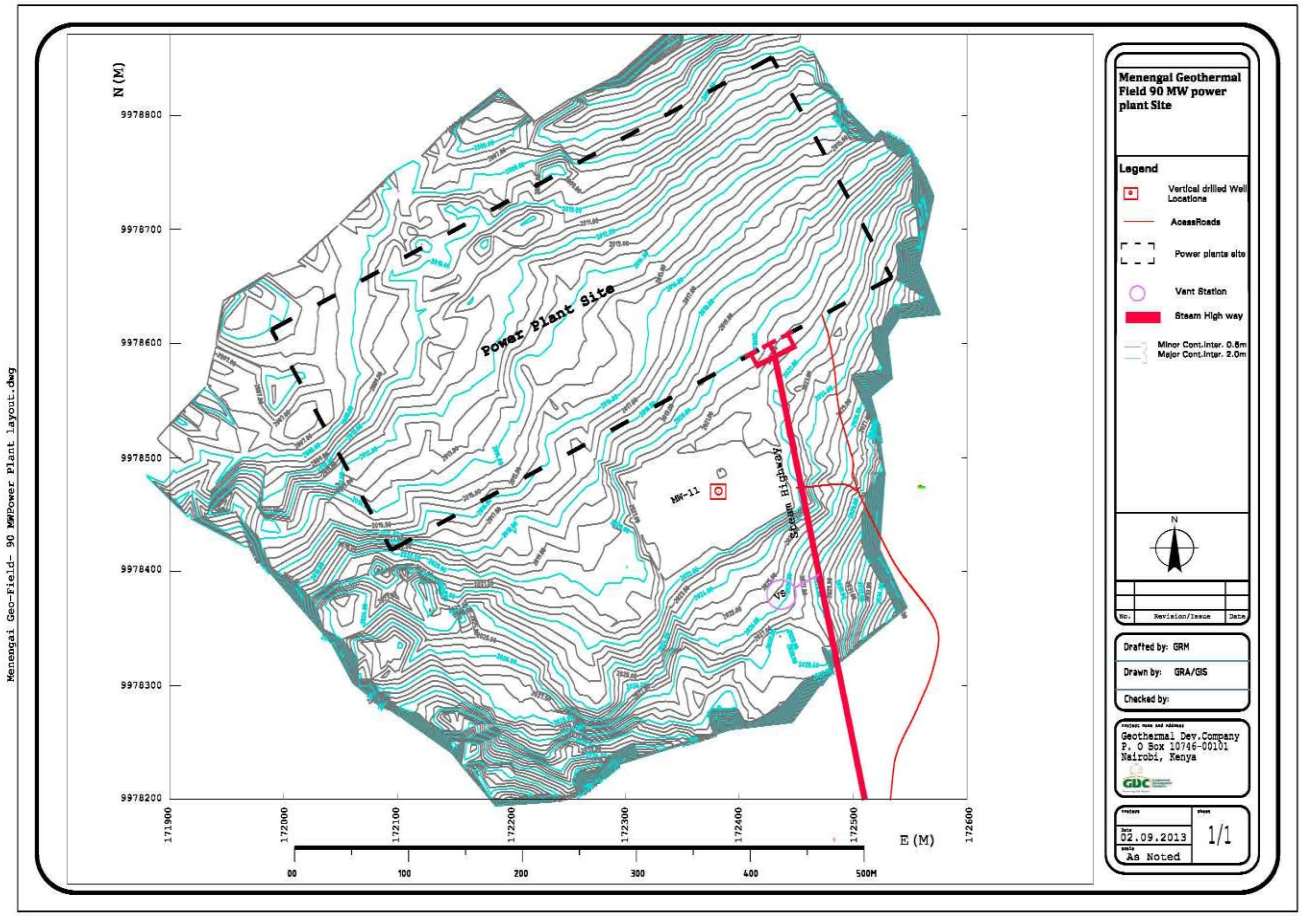

Figure 2.4: Menengai geothermal field 3x30 MW power plant site

2.3 Geothermal electricity Generations

Geothermal electricity is energy generated from heat from underneath the earth's surface. The process of generating geothermal electricity involves collection of steam from production wells through a pipeline system that is channelled to a power house to turn turbines that generate electricity.

About 8,000 kg of steam will be consumed to generate one (1) megawatt (MW) of electricity per hour. So for the 90 MW, approximately 720,000 kg of steam will be utilized per hour. The measured composition by volume of the main steam flowing through each of the existing turbines is:

- Steam – 96.7%
- Non Condensable Gases (NCGs) Contents – 3.3%

2.4 Power plants Construction and infrastructure development

2.4.1 Power Plants

The power plants construction activities will involve demarcation and leveling of the power plant area around construction sites within the Menengai Caldera. Excavation of equipment foundations will be done and soil cuttings removed and where possible used for landscaping and land filling. The power plant equipment will consisting of Turbine, Generators, Heat Exchangers (Figure 2.5).

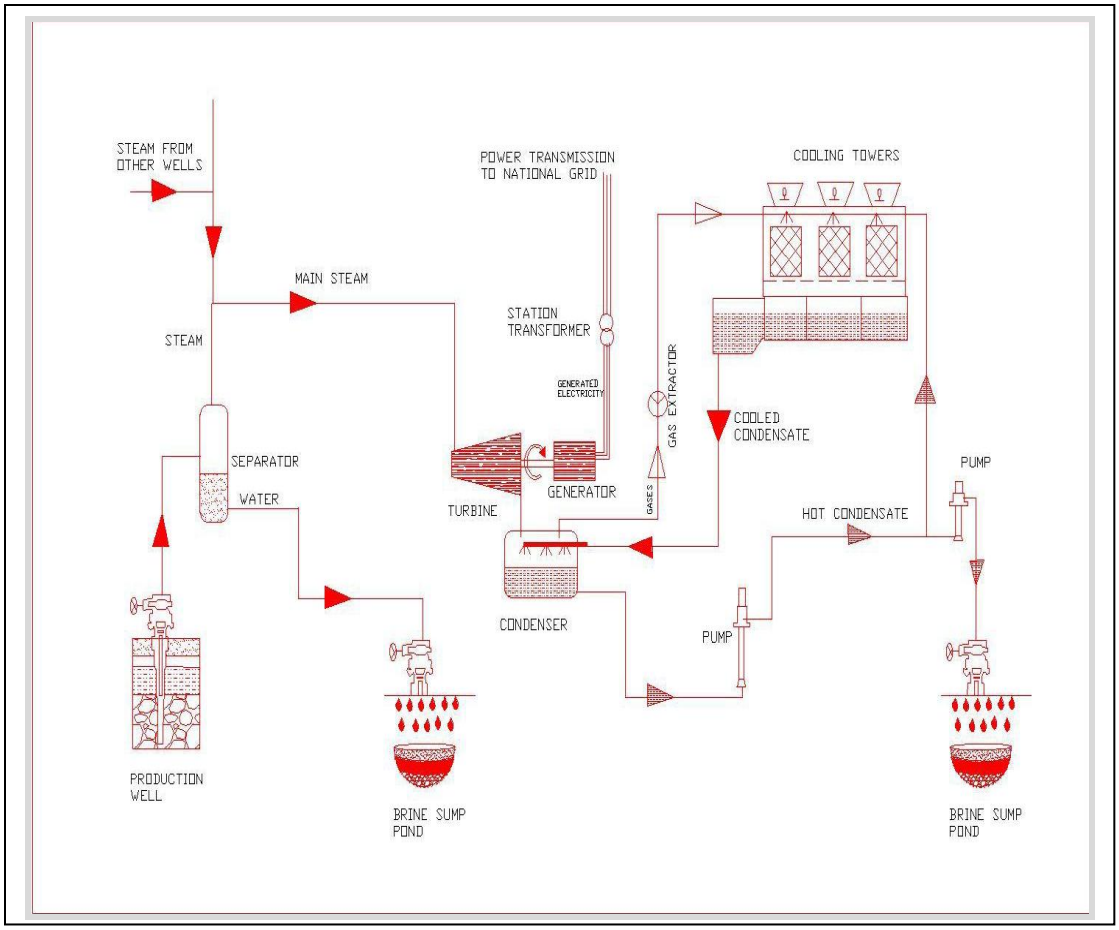

Figure 2.5: A schematic diagram showing the geothermal power plants system at the project site

Concrete foundations will be built in excavated areas for mounting the equipment. The equipment will be mounted on the site foundation and assembled by bolting and welding.

Site preparation activities will be undertaken with due care to ensure minimal land surface disturbance through vegetation clearance. The proposed modular power plant site layout plan is as indicated in Figure 2.6.

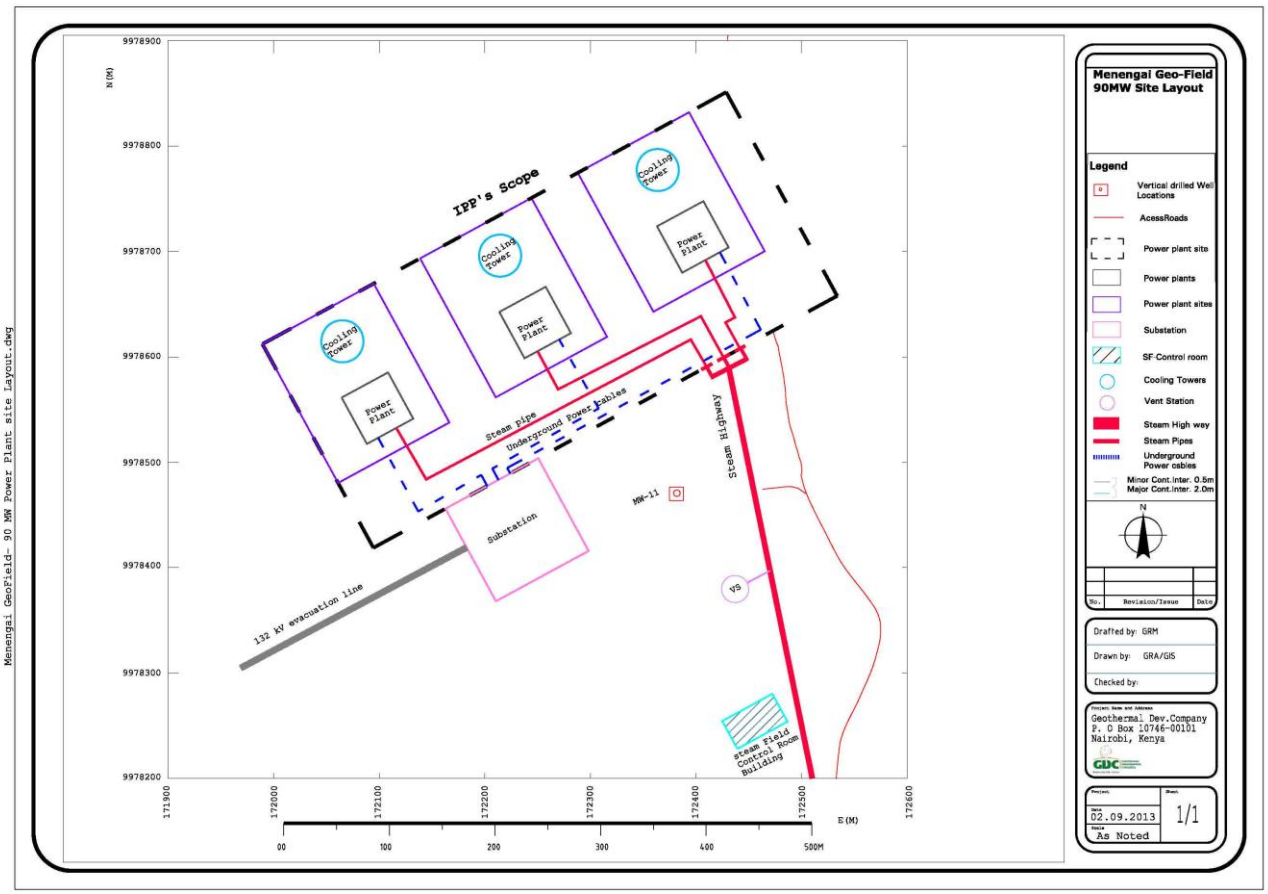

Figure 2.6: 3 x30MW Modular Power Plants Site Layout Plan at Menengai Geothermal field

2.4.2 Steam gathering system

The design and piping layout will incorporate steam pipeline consisting of steam separator/ heat exchanger, Steam separation station, silencer/muffler. The piping layout will determined based on location of production wells and their respective wellhead pressure and the acceptable turbine pressure. The layout and network of steam gathering system in the proposed project will be as shown in Figure 2.5. Pipeline supports will be installed along the pipeline routes comprising of steel poles cemented in ground holes. Steam separator vessels will be installed on the pipeline between the productions wells and the power plant.

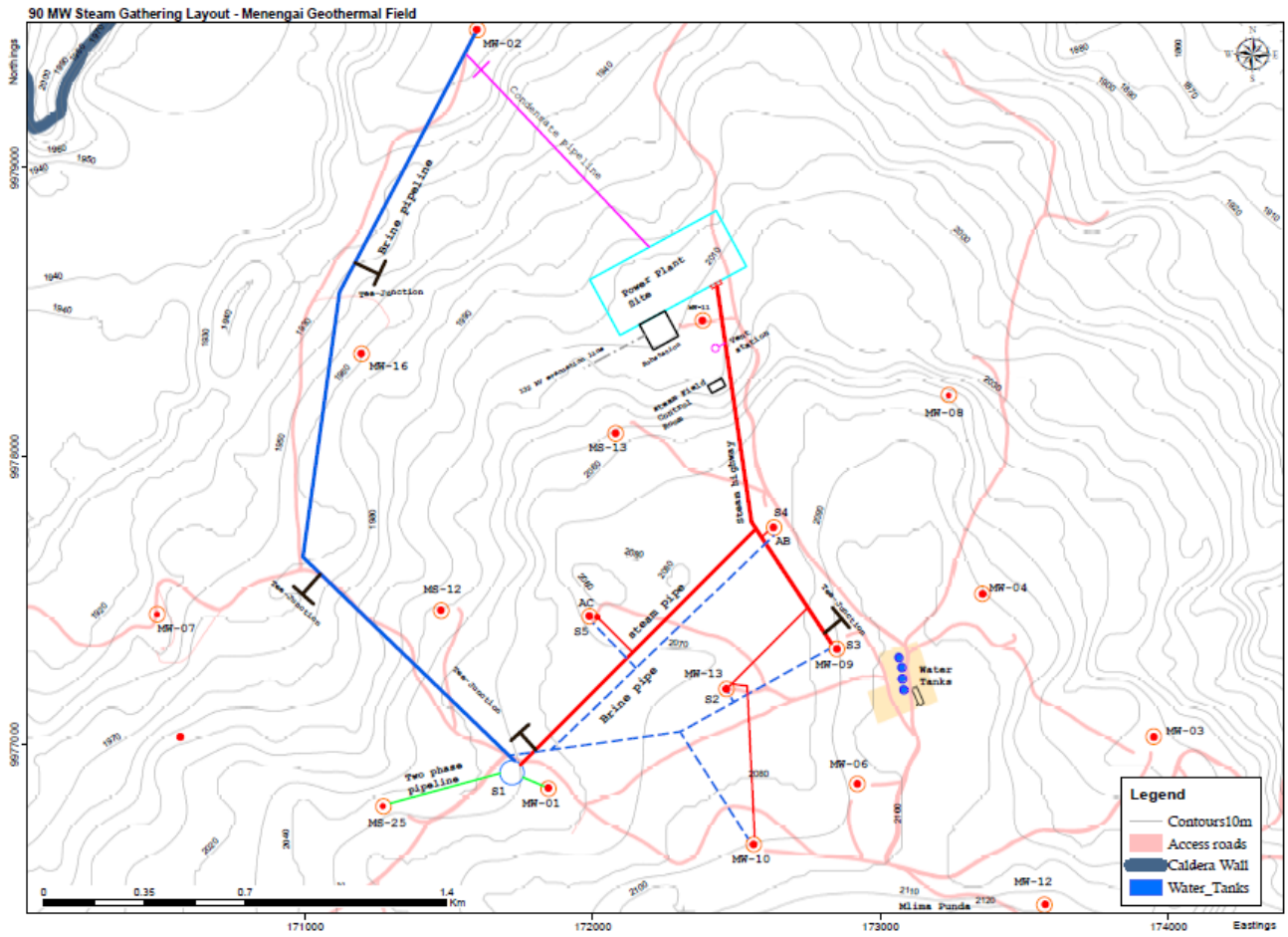

Figure (2.7) The layout and network of steam gathering system in the proposed project area

In addition there will be silencers, lined brine sump pond and other control devices such as valves will be installed to control the geothermal fluid discharge. These equipments will be in use under normal operations for venting of the fluid. A chain-link perimeter fence will be installed at the production well, brine sump pond and the power plant. Activities involved during steam field development will also be undertaken with due care to avoid causing adverse impacts on soil profiles and vegetation. The plant and pipelines will then be painted to a color that camouflages the surrounding environment. (Figure 2.8)

Figure 2.8: The plant and pipelines painted to a color that camouflages with the surrounding environment.

The final steam field layout after construction of the steam gathering system for the proposed 3 x30 MW may appear as shown in Figure 2.9.

Figure 2.9: Illustration of what Menengai steam field may look Like

2.4.3 Re-injection System

Hot used brine from wellhead steam separators and power plant will be channeled to the re-injection well i.e. MW-02 and injected back to the ground by gravity. Similarly the cold brine will be re-injected through re-injection pipeline from the blow-down re-injection pumps at the power plants.(see Figures 2.5 and Figure 2.10)

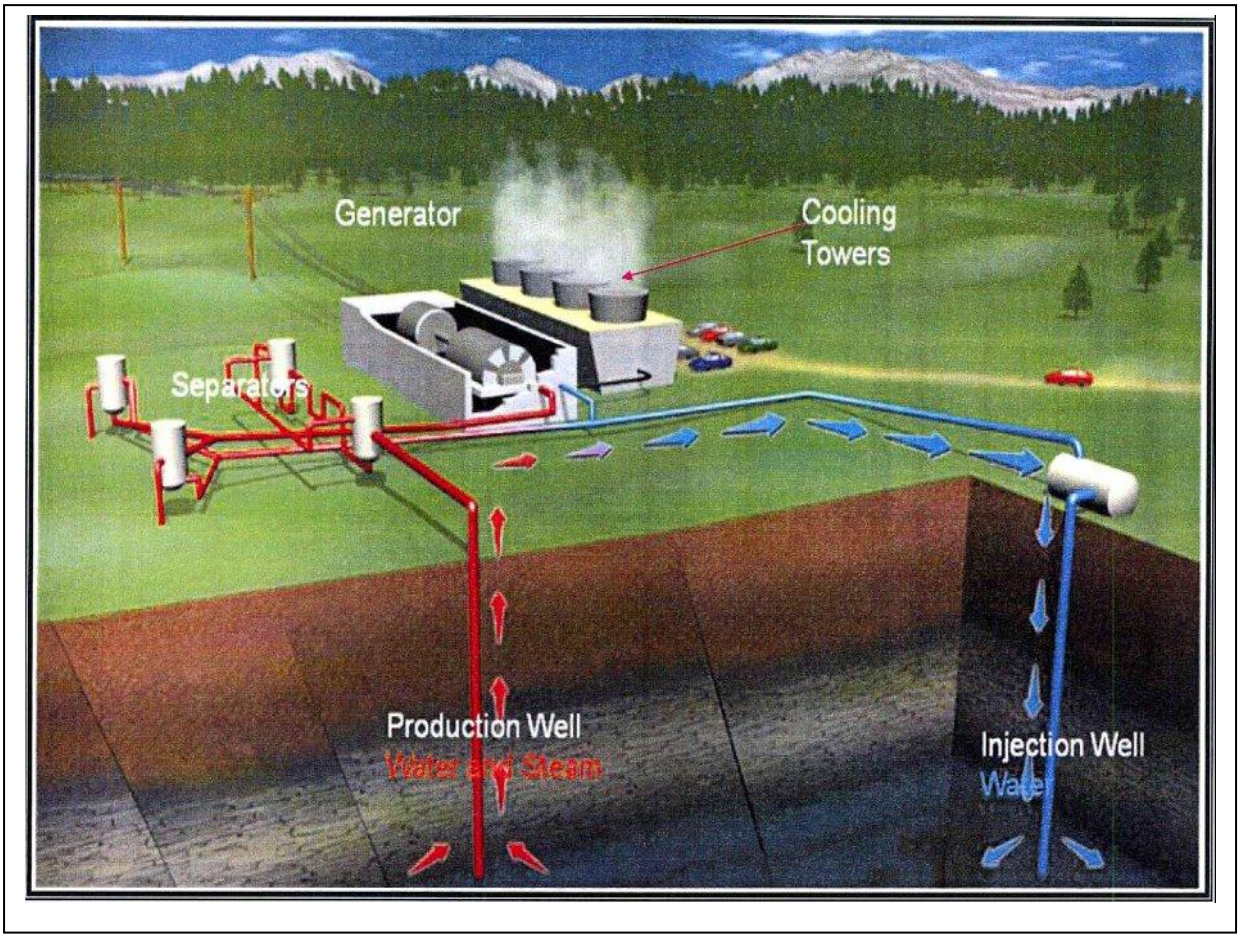

Figure 2.10: Illustration steam transmission from production wells and the steam re-injection pipeline from the blow-down re-injection pumps at the power plants

2.4.4 Water Supply System

GDC has constructed a water storage capacity of 20 million liters supplied from drilled water boreholes and supplemented by supply from the Nakuru Water and Sewerage Company (NAWASCO). The water supplied will be useful for cooling the power plant and the spent geothermal fluids after generation of electricity.

2.4.5 Road Construction

Most of the area is well served by a network of earth and all weather roads. The Nairobi – Kisumu Railway line and Trans-Africa highway passes through the southern part of the area. For purposes of transporting plant and equipment as well as personnel and supplies on daily basis, the project site is connected to the main trunk Nairobi Nakuru road through a reliable all weather road. Road network to various proposed wells is ongoing and is a continuous activity.

2.4.6 Power transmission and Energy Systems

The project area is within 15 km from the 132 kV double circuit Tororo – Lessos - Juja line and about 30 km to the Lanet 132 kV substation. The power generated will be relayed to the constructed switchyard using a 132 kv single circuit transmission line network (see Figure xxx). The switchyard will be interconnected with switchyard by a bay installed with the controls, protection and supervisory facilities – including communication systems.

The transmission lines are of steel lattice towers either suspension or tension towers. The suspension types are made to take vertical loads while the tension towers light and are designed to take both vertical and horizontal loads. Tension towers are suitable for angle points, dead end points and in areas where topography cannot allow the suspension towers (See Figure 2.11).

Figure 2.11: Power Transmission line network from the proposed power plants to the designated

The construction of transmission lines will involve excavation of foundations in marked tower sites. Excavations will be carried out manually using locally sourced unskilled labour. In the event that hard rock is encountered, explosives will be used to break the rocks. The lattice tower anchor base will be made concrete in the ration of 1:3:6. This will be followed by tower erection.

The towers and the accessories are transported to sites by lorries and erected with support of cranes.

The tower straightening is achieved by guy wire tensioning. In order to prevent tower overloading or excessive movement it is important to ensure the correct tension in all guy wires. The contractor shall develop a tensioning process and ensure all guy wire tensions are checked with a calibrated aviation industry standard tension meter. The tension wire equipment will include a tensioner, conductor puller, drum winder, conductor stringing blocks with neoprene lined sheaves, line stringing swivels and hauling bond.

The tower accessories includes the anti-climbing device and climbing steps; danger contact number and helicopter patrol plates; tower earthing; and aircraft and birds warning devices.

2.4.7 Substations

A substation will be put up for the purpose of boosting power before joining the national pylon grid. The substation will be mounted with equipment such transformers, circuit breakers, isolators, and switchgears (Figure 2.12).

2.5 Project Cost

The proposed project was earlier described in EIA Report Reference number NEMA/EIA/5/2/827. This amount include the cost of materials and construction of power plant, purchase of generator, turbines, construction of transmission line/power cables, site offices and related infrastructure. Other costs will human personnel electrical services installations, mechanical service installations, external works, water reticulation and drainage services among others. .

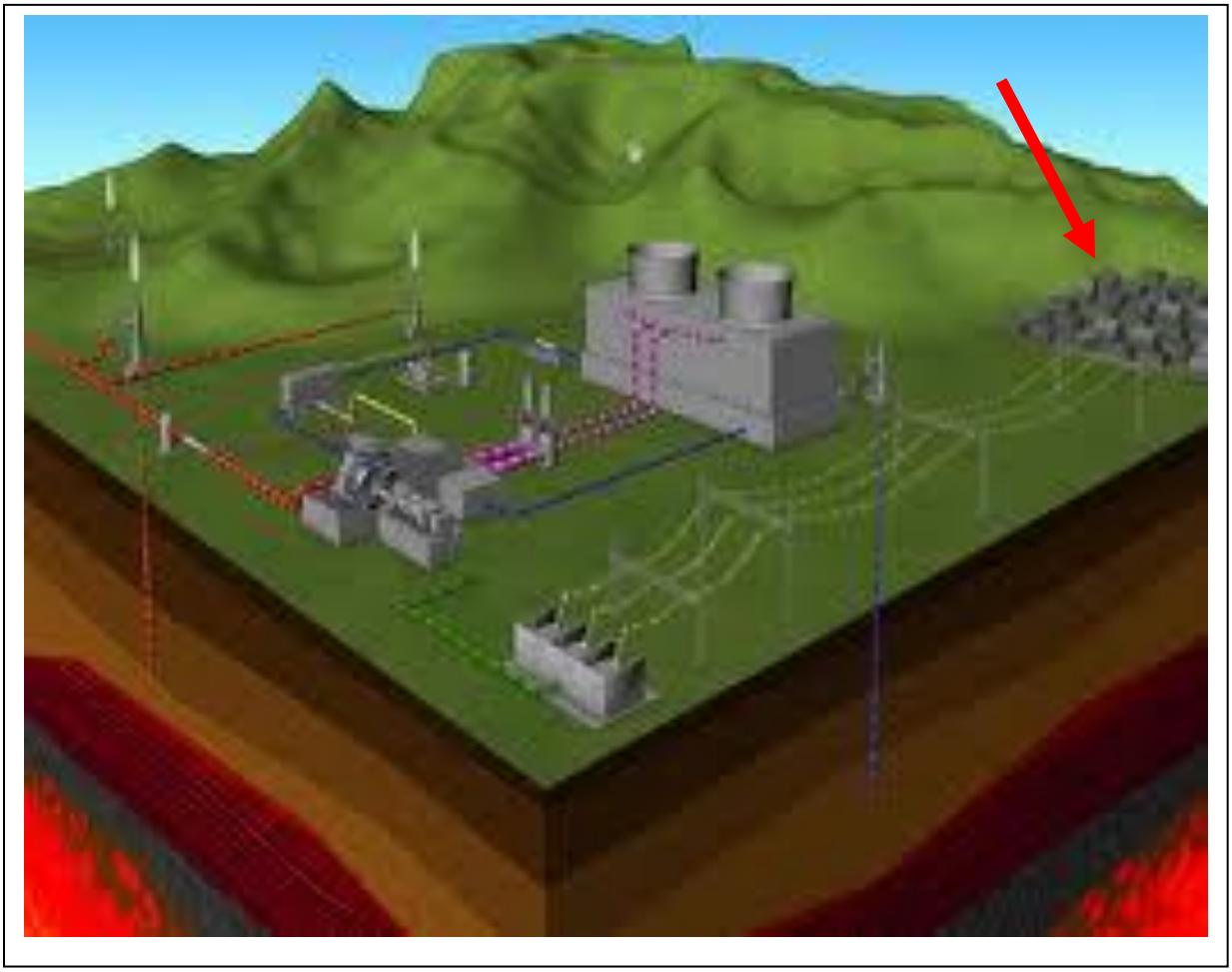

Figure 2.12: Substation (shown with arrow) mounted with equipment such transformers, circuit breakers, isolators, and switchgears

CHAPTER 3

LEGAL FRAMEWORK

3.1 Introduction

The activities of the proposed project are regulated by several legal instruments and policies, the main ones being the EMCA, which sets the requirements and procedures for obtaining operating licenses and permits and the Vision 2030. This chapter highlights the specific national and international legal and institutional framework which will enable the proponent be compliant with law and attain the set standards.

3.2 Policy Framework

There are several policy documents that guide the national development agenda. In this section the policy documents that have some direct impact on the proposed project are highlighted.

3.2.1 Kenya Vision 2030

The Kenya Vision 2030 is a long-term development strategy of the country. This vision aims at enabling Kenya attain the status of a middle income county with an annual GDP growth of 10% under its economic pillar. The social pillar endeavors to bring about equitable social development in a clean environment. Adequate and reliable energy supply is the cornerstone of both economic and social development. The proposed project thus supports the Vision 2030.

3.2.2 Updated Least Cost Power Development Plan 2011

Kenya's power industry generation and transmission system planning is undertaken on the basis of a 20 year rolling Least Cost Power Development Plan (LCPDP) annually. Geothermal resources have been chosen for the future generating capacity in Kenya (GoK, 2011). In the Policy paper Geothermal energy is identified as a major energy resource available for future supply and currently considered the most promising indigenous resource for development of power.

3.2.3 Kenya National Climate Change Response Strategy

This policy paper is a comprehensive response to climate change which poses a threat to Kenya's socioeconomic development. The Strategy identifies mitigations efforts to combat climate change in Kenya, chief of which is the Green Energy Development Programme. The development of geothermal in the proposed site is part of the fulfillment of this strategy.

3.2.4 Scaling-Up Renewable Energy Program (SREP) Investment Plan for Kenya

The objective of the Scaling-Up Renewable Energy Program in Low Income Countries (SREP) is to demonstrate, through pilot operations the economic, social and environmental viability of low-carbon development pathway to increasing energy access using renewable energy. The proposed project aims at fulfilling the SREP goal and has actually attracted funding under the SREP program.

3.2.5 The Session Paper No. 4 of 2004 (The Energy Policy Document)

The broad objective of the energy policy in Kenya is to ensure sufficient, quality, cost effective and inexpensive supply of energy through use of indigenous energy resources in order to meet development needs, while protecting and conserving the environment. While implementing the geothermal development at the proposed area, the proponent will endeavor to uphold spirit of this policy

3.3 Institutional Framework

The ESIA is bound to be influenced by the operational interests of the following lead agencies:

3.3.1 National Environmental Management Authority (NEMA)

NEMA was establish to supervise and coordinate all matters relating to the environment and to be the principal instrument of the government in the implementation of all policies relating to the environment. The authority has the discretion to determine license applications among other statutory required licenses needed for approval by the Proponent for it to achieve environmentally friendly operations.

3.3.2 Nakuru County Government

The proposed site falls within the jurisdiction of the Nakuru County. The Local Government's Act Cap 265 and the County Governments Act 2012 vests on the County various powers to control undertakings within its jurisdiction. Section 29 of the Physical Planning Act bestows upon it the discretion to determine development applications and grant all development permissions. Where applicable the proponent will acquire all relevant permits from Nakuru County Government as may be deemed necessary.

3.4 Legislation

Besides the Constitution, there several statutes that deal with a wide range environmental issues. Some of these are sector specific such as the Water Act, while others are cover many sectors, such as the Occupational Safety and Health Act. The statutes that will impact or guide the proposed development are discussed in this section.

3.4.1 Constitution of Kenya 2010

This is the supreme law of the land and it's binding on all activities undertaken within the Republic. The Environmental concerns have been strongly highlighted in the Constitution The right to a clean and healthy environment has been given recognition and safeguard under section 42 of the Constitution. The state is constitutionally obligated to ensure sustainable exploitation and utilization of natural resources and to ensure the equitable sharing of accruing benefits (section 69(1) (a)).

A key pillar of social impact assessment is increasing the benefits of those affected and none of them should be worse off than before due to the proposed project. Hence the Constitution directs that positive social impacts should ensue from the establishment of projects such as the proposed Menengai modular power plants project. Every person is constitutionally obliged to ensure ecologically sustainable development and use of natural resources (section 69(2). The Proponent is thus constitutionally obliged to integrate ecological sustainable concerns in the development of geothermal resources at the proposed site as per section 71 of the constitution.

3.4.2 Environmental Management and Co-ordination Act 1999, Cap 8

This is the chief legislation that governs all environmental management in Kenya. Section 3 of the Act directs courts in their exercise of jurisdiction on environmental cases to take into account the cultural and social principles traditionally applied by any community in Kenya for the management of the environment or natural resources. A social impact assessment has to identify and evaluate those management principles and ensure that they are not detrimentally prejudiced.

The statute under section 78 provides that The Standards and Enforcement Review Committee shall, in consultation with the relevant lead agencies, recommend to NEMA emission standards for various sources. The most significant geothermal gas is hydrogen sulphide (H_2S) with a range of 0.03 – 6.4g/kWh from power plants. The gas creates an offensive pungent rotten – egg-like smell (Odour, 2010). This falls below the World Health Organization threshold of 1-10ppm. Section 80 of the Act requires all owners or operators trade undertakings or establishments that are emitting any substance or energy which is causing or is likely to cause air pollution to apply for an emission license.

Section 101 of the Act provides that The Standards and Enforcement Review Committee shall, in consultation with the relevant lead agencies, recommend to the Authority minimum standards for emissions of noise and vibration pollution into the environment as are necessary to preserve and maintain public health and the environment. Noise is generated during well testing, construction and operational phase of geothermal power generation. Vibrations will be mostly emitted during the drilling of the wells. Care will be taken to mitigate the noise (see section) using the available technology.

3.4.3 The Environmental Impact (Assessment and Auditing) Regulations, 2003

These 2003 regulations were promulgated to shade light and give concrete substance, detail and procedures required to do EIA under sections 58 to 69 of the Act. Regulation 4 provides that No proponent shall implement a project that is likely to have a negative environmental impact and for which an environmental impact assessment is required under the act or these Regulations. Geothermal energy projects require environmental and social impact assessment. The detailed requirements of an EIA are laid down in regulation 7.

Regulation 16 provides that an EIA has to take into account environmental, social, cultural, economic, and legal considerations. Hence the present ESIA is within the wholesome armpit of this regulation for it evaluates the social and environmental repercussions of geothermal energy generation in the proposed area.

3.4.4 The Environmental Management and Co-ordination (Water Quality) Regulations, 2006

Regulation 4 stipulates that everyone has a duty to refrain from any act which directly or indirectly causes, or may cause immediate or subsequent water pollution. Regulation 6 prohibits any abstraction of ground water near lakes, rivers, streams, springs and wells that is likely to have any adverse impact on the quantity and quality of the water. The Proponent takes caution by acquiring necessary permits for abstracting water borehole water in the project area. The Proponent will take steps to discharge their wastes such as brine in an environmentally sound manner as prescribed in the EMP.

3.4.5 The Environmental Management and Co-ordination (Waste Management) Regulations, 2006

Regulation 4 casts a duty on the waste generator to ensure proper waste collection, segregation and disposal in accordance with the regulations. Regulation 5 implores the waste generator to adopt clean production methods so as to conserve energy and reduce emissions or waste that is arising from his activities. The waste generator has a duty to segregate hazardous and non hazardous waste under regulation 6. Regulation 14 creates a general obligation of pollution mitigations in all industrial undertaking by installing anti-pollution equipment for the treatment of waste emanating therein. The Proponent will mitigate the effects of brine, hydrogen sulphide and other wastes that will be generated during the drilling and appraisal of the wells. The proponent has a waste manage licence (Appendix 3.1) and will therefore wastes from the geothermal plants within the permit prescribed conditions.

3.4.6 The Environmental Management and Coordination (Noise and Excessive Vibration Pollution Control) Regulations 2009

Regulation 3 prohibits the making or causing to be made of any loud, unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, repose, health or safety of others and the environment. Regulation 4 prohibits the making or causing to be made of excessive vibrations which annoy, disturb, injure or endanger the comfort, repose, health or safety of others. It is necessary to monitor noise levels continuously.

3.4.7 Geothermal Resources Act - Act No. 12 of 1982

The Act's objective is to control the exploitation and use of geothermal resources and vest the resources in the Government. The Act defines geothermal resources to include any product derived from and produced within the earth by natural heat and includes steam, water and water vapour and a mixture of any of them. All un-extracted geothermal resources under or in any land vest in the Government of Kenya subject to any rights which may be vested in any person under written law. Section 7 of the Act empowers the minister to grant geothermal resources license which may carry terms and conditions as he deems fit. Section 14 gives guidance on obtaining licence to construct and operate power generating infrastructure.

3.4.8 The Geothermal Resources Regulations Act, 1990

Regulation 6 prohibits the use of a geothermal resource license to give rights over or enter upon a burial ground, church, public roads, national park or reserve. Regulation 9 directs that licensee shall give the Minister thirty days notice of any proposed geophysical survey and drilling. Regulation 10 directs for the supervision of a competent representative of the licensee during the drilling of all bore holes who shall also maintain a driller's log for each bore hole. Regulation 13 provides that all geothermal operation must be conducted in a workman-like manner and must prevent the unnecessary waste of or damage to geothermal resources, protect the quality of surface waters, air, and other natural resources including wildlife, protect the quality of cultural resources among other provisions. Any information given by the licensee to the Minister will be treated as confidential as per regulation 14.

3.4.9 Energy Act Cap. 2096

This Act consolidates regulations relating to energy in Kenya. Section 103 of the Act specifically makes provisions on renewable forms of energy including geothermal energy. The Minister is

obligated to promote the use of renewable energy in Kenya (Section 103 (1)). The Minister is charged with formulating a national strategy for coordinating research in renewable energy. The Act expressly identifies geothermal energy as a form of renewable energy whose production should be fostered in the Country. The Energy Regulatory Commission must take into account the impact of the undertaking on the social, cultural or recreational life of the community when determining license generation applications under section 30 of the Act. Under this Act, the Ministry of Energy and Petroleum released The Energy (Electricity Licensing) Regulations, 2010 which describe the manner and form for applying for generation and transmission licences

3.4.10 Local Authority Act Cap. 265

This Act establishes all local governments in Kenya including the Nakuru County Councils. They have been accorded the discretion under section 29 of the physical planning Act to permit development plans within their jurisdiction.

3.4.11 The County Governments Act No. 17 of 2012

This statute vests the power of spatial and environmental planning on the county. Section 114 specifically outline the procedures for planning nationally significant project such as the proposed project. The Proponent is required to involve the public and seek approval from the county assembly.

3.4.12 Physical Planning Act, Cap. 286

The Act *inter-alia*, governs the preparation and implementation of physical development plans in Kenya. Section 29 of the Act gives power to local authorities to determine development applications and grant all development permissions. The Nakuru County Council has to determine all physical development plans and the proponent will operate in full consultation with the respective council.

3.4.13 Water Act, 2002

Section 3 vests all water resources in the state through several state agencies including the Water Resources Management Authority (WRMA). WRMA receives and determines applications for permits for water use under section 8 of the Act. Section 25 provides that a permit shall be required for the use of water from a water resource. Section 45 governs the abstraction of ground water in accordance with the forth schedule. Water will be required for cooling spent steam and

abstraction of this water will be done in accordance with the provisions in the act as prescribed in the water abstraction permit (Appendix 1).

3.4.14 The Way Leaves Act, Cap 292

The Act in section 3 gives the government power carry any sewer, drain, pipeline or power line into, through, over or under any lands whatsoever, but may not in so doing interfere with any existing building. The affected land owner is entitled to a one month's notice from the government of any undertaking it deems to undertake upon his land under section 4 of the Act. The proprietor is entitled to compensation for any damage done to his or her trees or crops from government as per section 6 of the statute. The Proponent, being a state owned company, has a duty to work within the provision of this act.

3.4.15 Lands Act 2012

The Kenyan Constitution under the bill of rights provides protection of property rights under Article 40. It further provides for the acquisition of private property by government for public purposes or for public interest. Conditions and guidelines for acquiring are described in Part VIII of the Act. However the land on which the proposed project will be undertaken is owned by a state agency, Kenya Forest Services (KFS). The Proponent has an agreement with KFS allowing GDC to explore, exploit and generate electricity from geothermal resources (Appendix 2).

3.4.16 Occupational Safety and Health Act, 2007

This Act promotes and guarantees the protection and wellbeing of workers in the workplace. The high temperatures of the steam, emission of hydrogen sulphide, excessive noise and vibrations generated in geothermal development process pose occupational hazards to the workers therein. Section 6(1) of the Act provides that every occupier shall ensure the safety, health and welfare at work of all persons working in his workplace.

The Proponent has a corporate Environment Policy statement (Appendix 3) which will guide it project's implementation and operation. They will ensure that they provide protective (heat resistant) clothing and safety equipment to all workers and person authorized to be in the project site. Workers should be trained on how to safely go about the duties.

3.4.17 Public Health Act, Cap 242

Section 116 of the Act imposes a duty to all local authorities to maintain sanitary conditions within their district and prevent nuisances therein. Nuisance is defined under Act as any accumulation or deposit of refuse, offal, manure or other matter whatsoever which is offensive or which is injurious or dangerous to health. The Proponent will at all stages of the power generation adhere to environmentally sound waste disposal procedures of the geothermal waste materials so as prevent nuisance that is prohibited by this Act.

3.4.18 The Use of Poisonous Substances Act, Cap 247

Section 3 of the Act casts a duty of all employers of protecting their employees against the risk of poisoning by poisonous substances. In the event that Proponent uses poisonous substances in their exploration or in the generation of the energy in all this activities the occupational health and safety will be considered paramount and be safeguarded appropriately.

3.4.19 The Wildlife Conservation and Management Act, Cap 376

This act has a purpose to consolidate and amend the law relating to the protection, conservation and management of wildlife in Kenya. The project is not located in a wildlife conservancy. However, in the whole lifecycle of the project actions the Proponent will ensure as much as possible not to jeopardize the wellbeing of wildlife, (if any) which are one of Kenya's greatest heritage. Failure of which will attract the consequences enumerated in section 56 of the Act which include a fine not exceeding forty thousand shillings.

3.5 International Law and Regulatory Considerations

There are several international treaties and conventions regarding the protection of the environment and public of which Kenya is a signatory. The Constitution of Kenya 2010 provides under section 2(6) provides that all treaties and conventions ratified by Kenya will form part of the law in Kenya. This provision guarantees the recognition and enforcement of international law in the Kenya legal system and domestic courts. Section 124 of EMCA provides that where Kenya is a party to any treaty or convention concerning the environment NEMA shall make legislative proposal for its implementation.

3.5.1 Convention on Biological Diversity

Article 1 of the convention states its objectives as the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Section 50 of EMCA provides that NEMA shall, in consultation with the relevant lead agencies, prescribe measures necessary to ensure the conservation of biological diversity in Kenya. The EMP and action plan prescribed in this report will ensure conservation of biodiversity in the project area.

3.5.2 Convention on the Protection of the Ozone Layer

In March 1985 the intergovernmental negotiations for an international agreement to phase out ozone depleting substances, meeting in Vienna, Austria adopted the Vienna Convention for the Protection of Ozone Layer. This convention encourages intergovernmental cooperation in research, observation of the ozone layerand monitoringof CFC production and exchange of information.

3.5.3 The Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in September 1987.

This protocol provided for the revision of the phasing schedules on the basis of scientific and technological assessments. 3.5.3 The 1992 United Nations Framework Convention on Climate Change (UNFCC). The UNFCC was adopted on 9thMay 1992 and became into force on 21st March 1994. Its main purpose was to establish methods for minimizing global warming in particular the emission of greenhouse gases. Kenya ratified this convention in August 1994. NEMA is the focal point for the convention.

3.5.4 The Kyoto Protocol to the United Nations Framework Convetion on Climate Change

The Kyoto Protocol, which came into force in February 2005, requires signatories to the UNFCC to reduce their greenhouses gases emissions to below 5% of their 1990 levels. NEMA is the focal point of this protocol in Kenya.

3.6 International Guidelines

Geothermal Development Company is fully owned by the Government of Kenya. However, the company receives some funding as well as technical assistance through bilateral agreements

from international partners and governments. Such partners include the World Bank (WB), African Development Bank (AfDB), Japan Bank for International Cooperation (JBIC), among others. This section outlines lending/support guidelines of the major development partners.

3.6.1 World Bank Safeguard Policies

a) Environmental Assessment (Operational Policy 4.01)

The policy addressed an ideal environmental impact assessment that meets the World Bank standards. The World Bank policy paper champions for preventive measure rather than mitigatory or compensatory steps. The operational policy outlines five prerequisite steps that must be undertook in any environmental impact assessment. Emphasis is put on an evaluation of all pertained legal and institutional framework including ratified international treaties and convention; secondly, on stakeholder consultation by public participation to increase the acceptability of the projects by all those affected. The present environmental and social assessment is consistent within this policy (see Table 10.1 to Table 10.2).

b) Natural Habitats (Operational Policy OP 4.04)

This policy recognizes that the conservation of natural habitats is essential to safeguard their unique biodiversity so as to maintain the environmental services and products they provide to human society for long-term sustainable development. The Bank therefore supports the protection, management and restoration of natural habitats in its project financing, as well as policy dialogue and economic and sector work. The Bank supports, and expects borrowers to adopt and apply the "precautionary principle" approach to natural resource management to ensure opportunities for environmentally sustainable development. Natural habitats comprise of many types of terrestrial, freshwater, coastal and marine ecosystems where most of the original plant and animal species are still present. They also include areas lightly modified by human activities, but retaining their ecological functions and most native species. The Menengai Caldera, the proposed geothermal stations site, is such a habitat.

c) Public Disclosure (Operational Policy OP 17.50)

The World Bank adopts this measure as the best way to improve project planning and implementation**.** This procedure cast a duty on governmental agencies to monitor and manage the environmental and social impacts of development projects, particularly those impacting on natural resources and local communities. Community resources may be widely defined to

include geothermal energy though all natural resources are owned by the state local community peg ownership to them because they are found within their ancestral land. Based on this, the policy requires that the public be given sufficient information on the projects to enable them partake in informed effective decision making. Monitoring and addressing grievances of the local community is suggested in the EMP of this report.

3.6.2 African Development Bank (AfDB) Requirements

In January 2004, the AfDB board approved the new Bank Group Policy on the Environment. This policy incorporates and redefines the former policy on environmentally sustainable developments in Africa. The new policy acknowledges that to sustain economic growth in Africa, there is an urgent need to preserve and enhance the ecological capital that enriches this growth. Two guidelines relevant to the policy on the environment were completed and disseminated in 2004, these are the Strategic Environmental Impact Assessment (SEIA) Guidelines and Integrated Environmental and Social Impact Assessment (IESIA) Guidelines. Of importance is the Integrated Environmental and Social Impact Assessment (IESIA) Guidelines

3.6.3 Japan Bank for International Cooperation (JBIC) Guidelines

The Japan International Cooperation Agency (JICA), which is responsible for the implementation of technical cooperation and the preliminary study of grant and projects in Japan's bilateral grants, prepared environmental guidelines for infrastructure projects in 1990. These guidelines were revised and the new guidelines for environmental and social considerations were completed in March 2004. These guidelines cover development studies, preliminary studies of grant and projects and technical cooperation projects. The objectives of these guidelines are to encourage the recipient governments to take appropriate considerations of the environmental and social factors as well as ensure that JICA's support for and examination of environmental considerations are conducted according to the guidelines.

a) Japans Official Development Assistance Charter, June 30 1992

This charter was established to obtain broader support for Japan's Official Development Assistance (ODA). The basic philosophy of this charter is that the international community, from a humanitarian viewpoint, cannot ignore the fact that many people in developing countries, which constitute a majority among countries in the world, suffer from famine and

poverty. Japan's ODA is provided in accordance with the principles of the United Nations Charter, as well as an additional four principles.

Further outlined in the Charter are the priorities, measures for the effective implementation of ODA, and measures to promote understanding and support at home and abroad. African countries are considered priority regions in the Charter, as well as infrastructure improvement, hence the application of this Charter to the current project.

(b) Japan Bank for International Cooperation (JBIC) Guidelines for Confirmation of Environmental and Social Considerations, 2002

JBIC establishes and makes public the above guidelines with the objective of contributing to efforts by the international community, particularly developing regions, towards sustainable development, through consideration of the environmental and social aspects in all projects subject to lending or other financial operations. Environmental and social considerations refer not only to the natural environment, but also to social issues such as involuntary resettlement and respect for the human rights of indigenous people.

Procedures for confirmation of environmental and social considerations include:

- Screening: each project is classified in terms of its potential environmental impact, taking into account such factors as the sector and scale of the project; the substance, degree and uncertainty of its potential environmental impact; and the environmental and social context of the proposed project site and surrounding areas:

- Categorization: Three categories A, B, and C exist. A proposed project is classified as Category A if it is likely to have significant adverse impact on the environment; Category B if its potential adverse environmental impact is less adverse than that of Category A projects; and Category C if it is likely to have minimal or no adverse environmental impact. This project is classified as Category B, under Section (1), Paragraph 2, Article 23 of The Japan Bank for International Cooperation Law.

- Environmental review for each category: This includes evaluation of measures necessary to prevent, minimize, mitigate or compensate for potential negative impact, and measures to promote positive impact if any such measures are available

(Category A). The scope of environmental reviews for Category B projects may vary from project to project, but is narrower than that for Category A projects. Environmental reviews for projects in Category C do not proceed beyond screening.

- Monitoring: JBIC in principle confirms through the borrower over a certain period of time, the results of monitoring the items which have a significant environmental impact by the project proponents.

According to JBIC categorisation, this project falls under category A because there are likely to be significant impacts to the project environment within and around Menengai Crater.

3.6.4 IFC Performance Standards

These are set out to help in carrying out the policies outlined in the Operational Policy on Environmental Assessment (OP 4.01) and related documents. More specifically, detailed environmental, health and safety guidelines exist for electric power generation and for Geothermal Power Plants.

CHAPTER 4

BASELINE INFORMATION OF THE STUDY AREA

4.1 Physical Environment

Along the Kenyan segment of the Eastern African rift valley there are volcanic centres one of which is the Menengai volcano. They are sandwiched between the eastern and western shoulders of the rift valley. The floor of the caldera forms a fairly undulating surface characterized by trachytic and glassy flows, and volcanic soils. At the edge of the caldera is a ring, fault structure that defines the caldera area covering about 77 km^2. At the sloppy sides of the volcano are gorge and gully features resulting from surface runoff during rain seasons.

4.1.1 Climate

The project area is classified into two main agro-climatic zones. The lowland areas of Mogotio and Kisanana in the north are located in semi-arid zone IV with an annual rainfall of 800 mm and mean temperatures of 30°C. Njoro, Bahati and parts of Kampiya Moto divisions with an altitude of between 1800 m and 2400 m above sea level and average rainfall of between 760 mm and 1270 mm per year fall within a dry sub-humid equatorial climatic zone. Around Nakuru area, mean annual rainfall is approximately 900 mm. The rainfall regimes are bimodal with the long rains occurring in March to July and the short rains in September to November. Temperatures vary with topography and range from 9.4 to 29.3 ºC.

4.1.2 Geology and Soils

Menengai Caldera is characterized by two trachytic main rock series by age. The older one is that of Pliocene which is characterized by two successive strata. The earlier one is of Pliocene and is characterized by phonolitictrachytes. These appear to have formed during volcanic processes before the formation of the caldera as depicted by their outcrops on the walls of the caldera's ring-structure. Overlying the phonolitictrachytes is the successive stratum that comprises welded vitreous tuffs and ignimbrites. These extendbriefly outwards from the ring-structure, except markedly longer extensions towards south east and north-west, with bias towards northwest direction (Figure 4.1). This implies a major direction of flow during the volcanic episode.

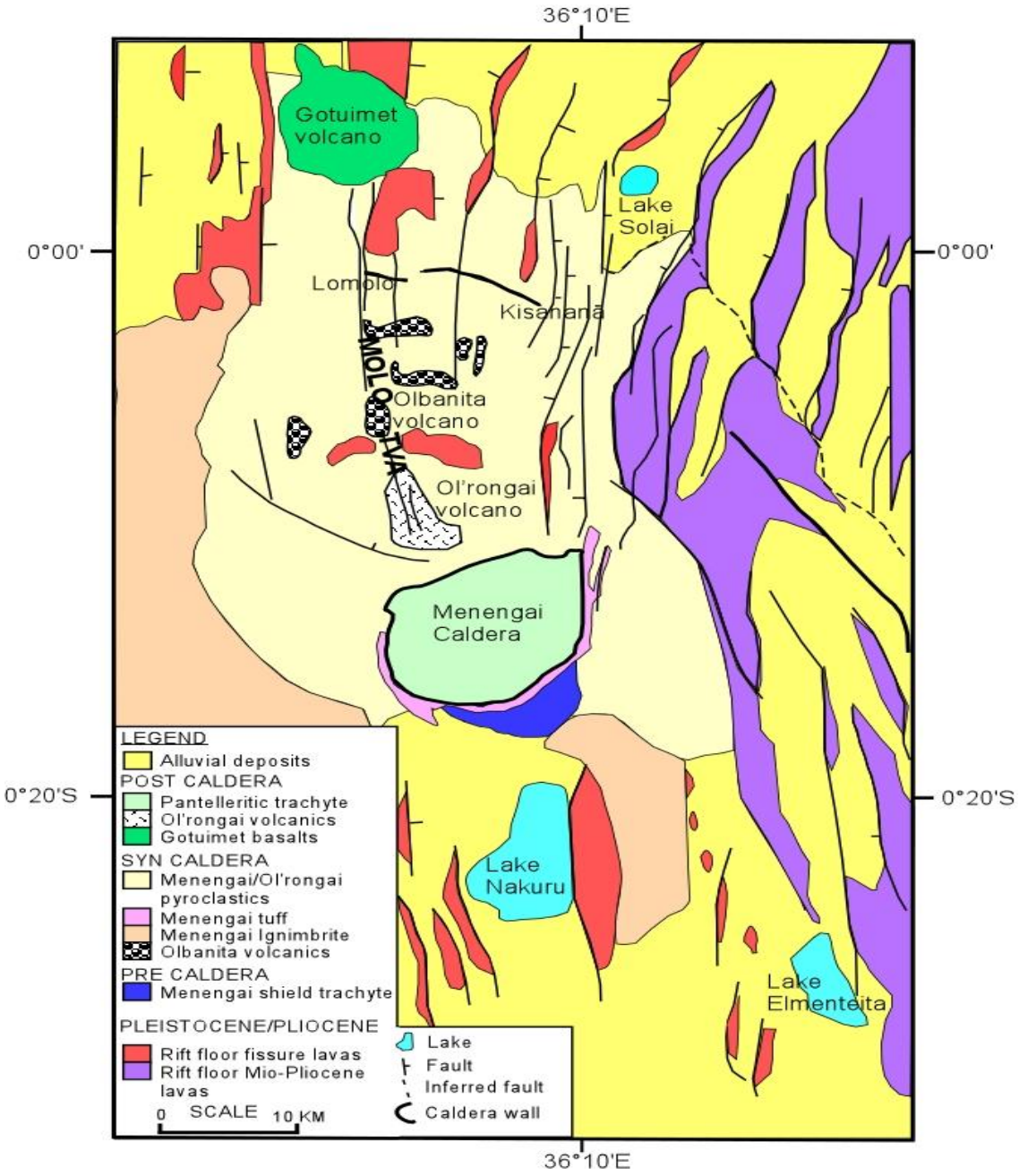

Figure 4.1: Geological Map of the Menengai Crater

The younger rock series is recent (Quaternary) and is characterized by trachyte flows. Glassy flows are common among the recent series. This series cover almost all the caldera floor (Figure 4.1 and its occurrence depicts products of volcanic processes that accompanied or followed after the caldera-collapse.

Like in many other sections Eastern African Rift System, Menengai Caldera occurs within a normal-fault-system. Generally, the occurrence appears as an interruption of intense faulting and fracturing that runs north-south Kenya's rift valley. However at and around the caldera, the ring-structure of the fault created by formation of the caldera is conspicuous. Other associated faults are also observed in and around the caldera. Other noticeable structures are lava flow structures that are depicted by the rocks structures. These include ropy, bandy, blocky and glassy structures of rocks observed inside the caldera during this study. The lithological and structural geology play a part in the physiography of the project area.

The soils in the prospect area are volcanic soils of varying thickness. These occur together with superficial deposits (Figure4.1). Due to the physiography of the caldera, patches of alluvial deposits are found in some basinal features within the caldera, and the lower areas from the base of the volcano outwards.

4.1.3 Hydrology

The Menengai area lies on the rift floor that gently slopes northwards. On the east, the Bahati and Marmanet scarps bound the eastern inner rift trough and are relatively higher and wetter grounds. To the west the rift floor slopes gently into a series of ridges connecting the Mau-Londiani-Kilombe hills. The surface drainage system is therefore largely internal from the east and the western scarps (Figure 4.2). On the rift floor, the drainage is mainly from Menengai Caldera northwards with the exception of the drainage from the southern rim or slopes of Menengai Caldera into Lake Nakuru. The permanent rivers in the area are Molo and Rongai in the NW area. The perennial rivers are the Crater and Olbanita streams in the eastern parts. The N-S, NE-SW, and NW-SW trending fault/fracture systems provide underground channels resulting to stream water disappearing underground at some places interrupting the Olbanita stream at several places. Other surface water bodies include Lakes Nakuru and Solai, and the Olbanita swamp (see Figure 4.2).

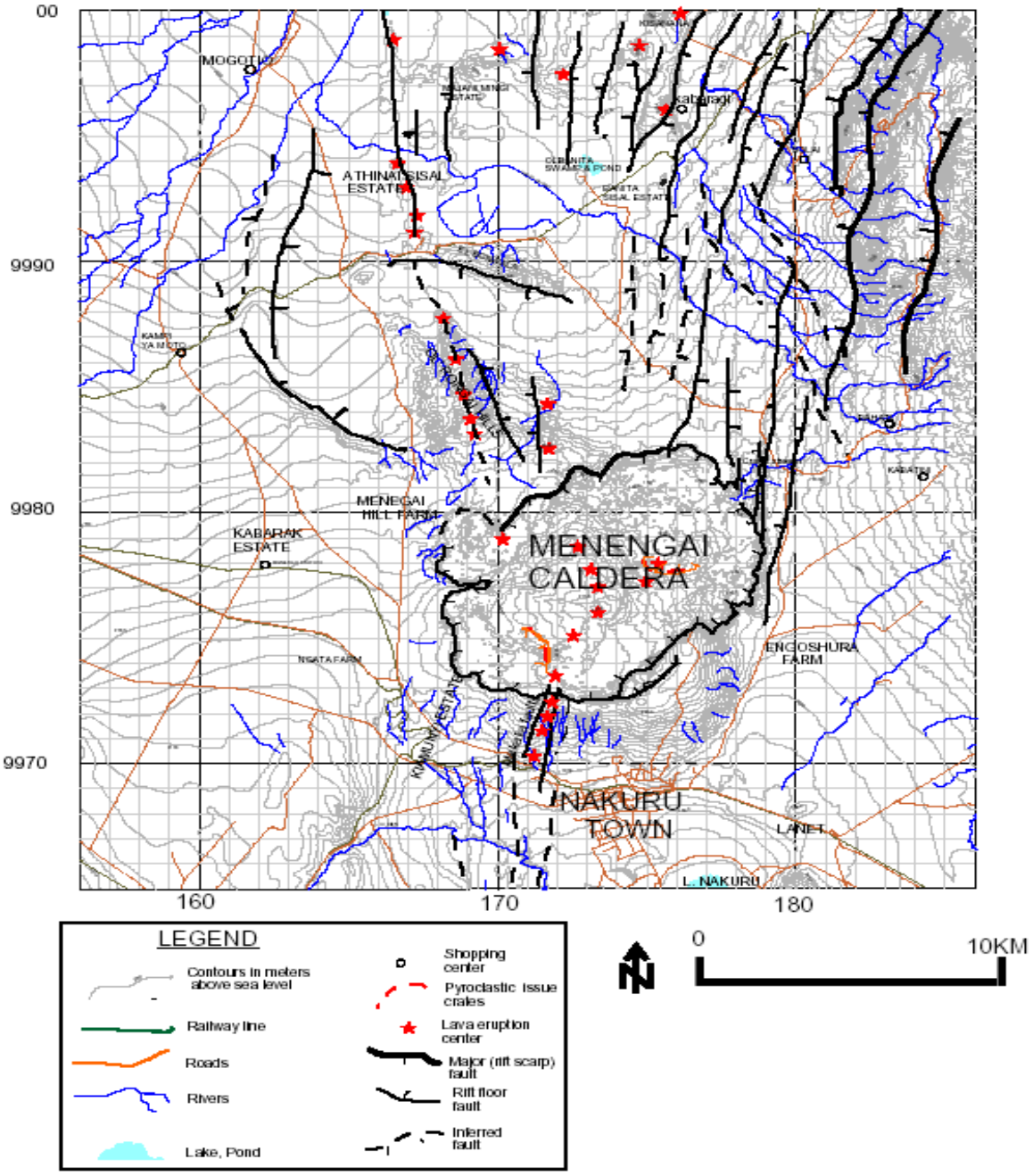

Figure 4.2: Map of Menengai Volcano Showing Surface Drainage Pattern and Lava Eruption Centres among Other Features

Source: GDC

Lake Nakuru represents the intersection of a piezometric surface and a topographic surface (see Figure 4.3). The ground water around Lake Nakuru and northwest of the lake is controlled by a sedimentary formation comprising of lake sediments and reworked pyroclastics. The boreholes

immediately to the north and northwest of the lake show lake water contamination indicating interconnection (Geotermica Italiana Srl, 1987). The same sedimentary formations are found in the boreholes located in the east of Menengai caldera implying connectivity with the N-S running Solai tectonic axis. There is one location inside the caldera on the eastern rim where a cold spring occurs at the foot of the caldera, further confirming that the southern part of the Solai tectonic axis is an important control for groundwater movement.

The Olbanita swamp is located in an area dominated by dry and thermally anomalous boreholes. The productive ones are characterized by very shallow, low-yield aquifers that get depleted fast since the deeper formations are impervious. These are perched water bodies adjacent to the swamp. The swamp owes its existence to impervious bedrocks that have been affected by hydrothermal alteration. The formations underlying the swamp are the ignimbrite beds that show marked hydrothermal alteration.

Majority of the boreholes in the prospect area were drilled to between 100-200 m depths. The relative yields may be matched with petro-physical property of the feeder formations expounded below.

1. *Very high yield boreholes (>20 m^3/h)*: Hosted in fractured, fresh lavas and talus. These are boreholes located on the eastern scarps and Bahati areas and are normally fed by channels along rift scarps faults.
2. *Moderate high yield boreholes (9-15 m^3/h)*: Aquifers include lacustrine beds, reworked volcanicalstics and fractured lavas in the rift floor. These are mainly found in boreholes around Lake Nakuru, Nakuru town, to the east and north east of Menengai caldera along the Solai TVA and around Kisanana.
3. *Poor yield Boreholes (<6 m^3/h)*: Aquifers are inter-bedding contacts between tuff and ignimbrite beds. These types of boreholes are found to the east of Menengai caldera, Kampi ya Moto and Rongai areas.
4. *Dry and thermally anomalous boreholes*: These include the completely dry boreholes and those that encountered perched water bodies and therefore dried up after the aquifer was depleted and those that produced low-pressure steam, hot water and CO_2. These are

distributed along the Molo TVA that extends from the Menengai caldera northward through the Ol'rongai volcano, Lomolo, Goitumet volcano (See Figure 4.3).

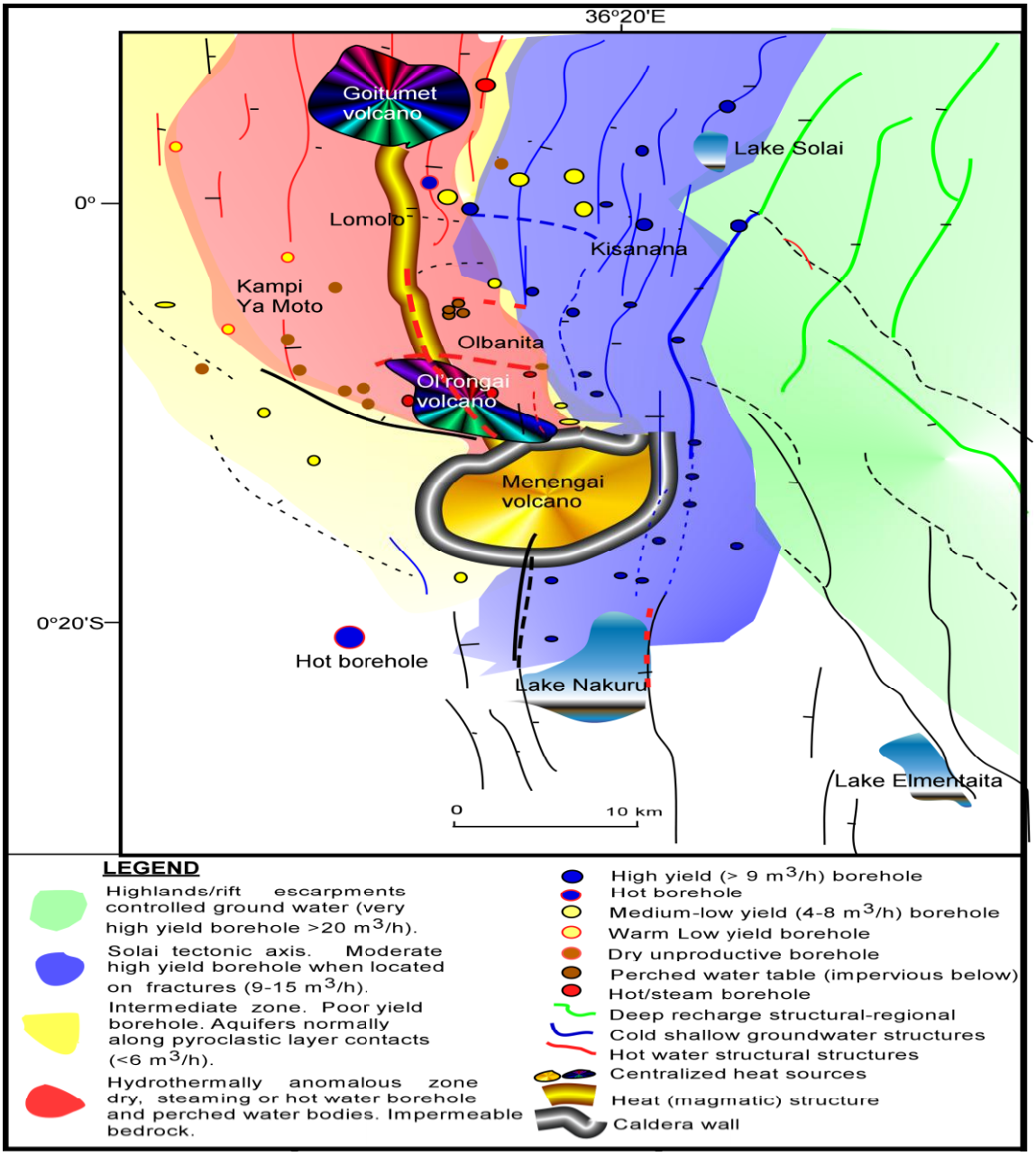

Figure 4.3: The hydrogeological regimes of Menengai area based on interpretations from natural springs, borehole data and the possible effects of occurrence of geothermal phenomena

The geology and soils of Menengai volcano partly control the surface run off pattern. Radiating away from the caldera are gullies and stream valleys along which run off water flows. The streams are seasonal and discharge into rivers at the floor of the rift valley. From the walls of the fault surrounding the caldera, streams drain into the caldera, some of which flow most times of the year. Some of the streams flow over structures within the caldera (Plate 4.1).

Plate 4.1: A Stream adjacent the water pump station inside the Caldera (Note the white coloration at the center caused by a fumarole)

The presence of boreholes in and outside the caldera is depictive of the hydrogeology of the project area. GDC has successfully drilled bore holes inside the caldera, while numerous other bore holes have been drilled in the wider Menengai area (Figure 4.4).

Geothermal wells with over 2km depth have been drilled in the caldera mainly in the central parts. This is indicative of occurrence of aquifers at different levels and with different water qualities. The structural geology and possible presence of porous volcanic rocks could be the main features that allow for ground water at the different levels and therefore different chemical composition depicted by the white colour geothermal spring at the bottom of the stream (See Plate 4.1 above).

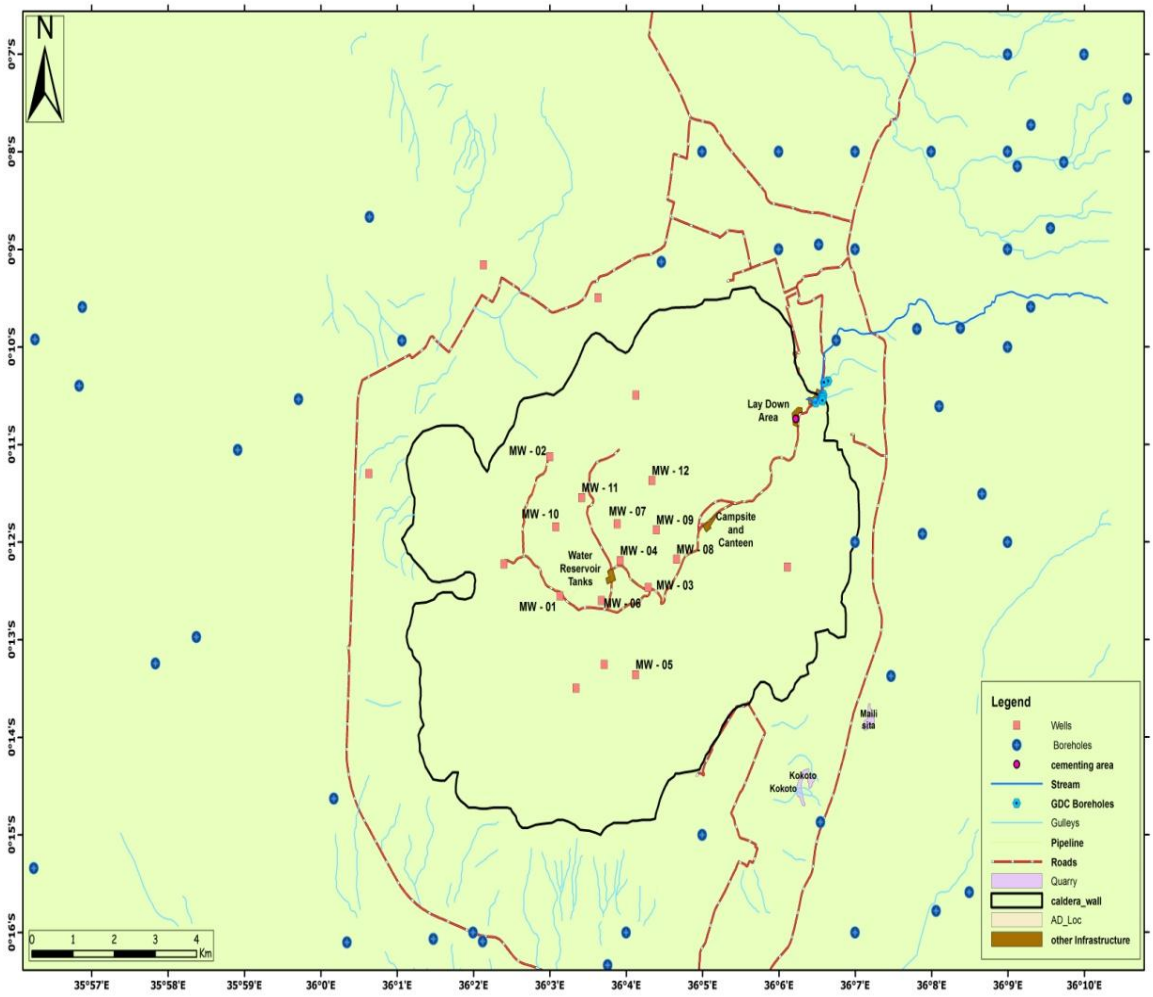

Figure 4.4: Map Showing Surface and Ground Hydrology of Menengai Volcano
Source: GDC

4.1.4 Noise

Noise level monitoring and assessment in Menengai is carried out at least three times per week to establish both background and operational noise levels. This monitoring is carried out in compliance to the provisions of Environmental management and co-ordination (Noise and excessive vibration pollution) (control) regulations 2009 regarding noise limits at the work place and also the Occupational Safety and Health and Act 2007. The noise level in the proposed project area was assessed using an Integrated Handheld Sound Level meter (Model Extech 407768). The results are summarized in Table 4.1 below. The noise level at the discharging well measured 91.5 dB, which is above the recommended ambient and occupational standards (45 and 85 dB) respectively. As one gets away from the well the noise decreases to a low of 43.5 dB at the pumping station (Pump not running at the time of study).

Menengai contain many potential sources of noise, such as generators supplying power to the rig, discharging wells, electric motors, air compressors, mobile machinery, mud pumps, drilling operation, all of which operate around the clock. The environmental noise impact of geothermal drilling operations results from a combination of noise from all these sources propagated to some point beyond the boundary of Menengai to the surrounding areas.

Drilling operation noise levels are higher closer to the drilling rig and under weather conditions that allow drilling noise to dominate the overall noise levels, such as light winds from the drilling sites towards the neighbour, low cloud, temperature inversions etc. Background noise is significantly low at night.

Since GDC started the geothermal exploration and development in Menengai, the Environment department has pursued a noise management program which has succeeded in preventing excessive noise pollution particularly around discharging wells and drilling sites. Noise reduction strategies include fixing silencers in the drilling generators; awareness sensitization among the employees and enforcing the use of ear mufflers.

Table: 4.1 Average noise levels of various locations in Menengai taken over a period of 8 months in 2012-2013

ZONES		STATIONS	SOUND LEVEL LIMITS DB(A)
		Coordinates	Day (Average)
A	Pump house	9980536.71N 177969.17E	58.6
B	Laydown	9980346.51N 177647.11E	61,6
C	Campsite	9978263.77N 175548.60E	67.7
D	MW-03	9976408.8N 174140.9E	72.1
E	Tank site	9976588.0N 173220.0E	58.0
G	MW-01	9976852.51N 173498.67E	64.1
H	MW-04	996900.05N 173565.68E	42.2
I	Mlima Punda	9975742.66N 173498.67E	64.9
J	Mw-06	99766243.5N 173119.6E	50.1
K	MW-07	9977586.30N 1705504.21E	44.4
	MW-08	9977809.9N 173458.92E	53.3
L	MW-09	9977299.73N 172879.32E	77.3
M	MW-10	9975815.38N 173729.9E	70.8
N	MW-11	9976592.79N 172433.511E	59.9
O	MW -12	9978707.31N 1723745.12E	60.4
P	MW- 13	9977192N 772464E	68.7
Q	MW - 14	9979004N 173744E	87.6
R	MW - 15	9977463N 175201E	76.7

Environmental noise monitoring undertakes three types of noise monitoring to support its noise management program:

- *Source Monitoring* – regular noise surveys and spot measurements are made within and around the Menengai using portable noise monitoring equipment to check on any changes in noise levels generated by equipment or operating practices. This includes surveys before and after noise attenuation projects.
- *Receptor monitoring* – measurements of noise levels including the monitoring contribution are made using portable hand held noise meters. These measurements can be prompted by neighbour concerns or be part of periodic surveys.
- *Continuous monitoring* -- environment has established three continuous noise monitors which help to define the refinery noise contribution within the surrounding community. Two of these monitors are within 1 km of operating areas to the north (Near Osembo primary school Access Road) and south (towards Menengai view point), and the third is 3-4km eastern towards the edge of caldera (Rigogo, Ol rongai,) These are generally closer to the Menengai caldera than most receptors so that noise can be readily distinguished from other sources.

In the month of July, 2012 to the Month of February 2013, the highest average noise levels recorded were at MW-14, MW-09, MW-03 and MW-12 respectively were 87.6, 77.3, 76.7, 70.8 dB (A). This was because most of these wells were either under drilling operations or discharging. Monitoring equipment limitations mean that it is very difficult to measure the noise contribution from a specific source as you get further away. Noise contributions under varying weather conditions can be predicted using computer modeling techniques. Reliable predictions are achieved using source and continuous monitoring data as described above and in comparing the predicted levels with measurements made near the receptors.

4.2 Chemical Environment

4.2.1 Air Quality

Air quality in the proposed project site was determined by measuring concentrations of carbon dioxide, hydrogen sulphide, methane and oxygen. Modelling of H_2S gas emissions is discussed as a separate chapter (See Chapter 5) in this ESIA report due to the weight apportion to the

potential air quality impacts that may arise from emission discharge from the proposed power plants. Installation of automated monitors to indicate any abnormal levels of H_2S in the atmosphere around the power plants is pertinent.

4.2.2 Water and Effluent Quality

Results of the assessment of quality of drilling water returns, geothermal brine and hot springare presented in Table 4.3 below. The brine is alkaline. Chloride concentration is high (444.4 ppm) which is typical of chloride geothermal water. Silica was also higher than the NEMA recommended limits. Except chlorides and conductivity, which varied significantly (subject to experimental errors), compared to the GDC monitoring data, the rest of the data obtained during the ESIA study, fairly agreed with the GDC data.

The toxic heavy metals such as lead, cadmium, zinc and copper were below detection limits. With proper disposal, the dangers of accumulation of heavy metals in the environment is minimal and even non-existent considering that the brine is alkaline and therefore uptake by plants especially lead and cadmium from geothermal water is inhibited (Simiyu, 2004). The drilling water returns and brine effluent will be discharged in lined ponds and later reinjected, to safeguard the ground water.

Table 4.2: Quality of the Stream Water, Hot Spring and MW-01 Geothermal Brine

Station Parameter	Geothermal feature (Plate 4.1)	Stream at Pump Station Menengai	MW-01 Brine	NEMA Effluent Standards
pH	7.63	7.31	9.24	6.5-8.5
Chlorides(ppm)	7.18	0.69	444.8	
Total dissolved solids (ppm)	690.00	354.00	190.90	1.0
Conductivity (µS/cm)	544.00	95.30	313.00	10
Fluorides (ppm)	1.20	0.72	2.76	10
Turbidity (NTU)	15.17	291.00	0.14	0.5
Silica(ppm)	ND	ND	17.90	1.0
Aluminium(ppm)	0.81	10.57	0.05	1.0
Iron(ppm)	0.12	6.34	0.37	250
Potassium(ppm)	8.24	5.74	392.00	1.5
Manganese(ppm)	0.02	0.22	NIL	0.01
Lead(ppm)	ND	ND	0.10	2.0
Zinc(ppm)	0.02	0.12	ND	0.01
Cadmium(ppm)	ND	ND	ND	0.01
Copper	ND	1.13	ND	
Boron	ND	ND	ND	

Table 4.3: Effluent Quality of Drilling Water Returns and MW1 Geothermal Brine

Parameter	**MW1 Drilling Water Returns**	**MW1 Brine**	**NEMA Effluent Standards**
pH	7.58	9.72	6.5-8.5
Conductivity (mS/cm)	1.13	15430	
Sulphur (S)	117.3		1.0
Iron (Fe)	0.66	ND	10
Manganese (Mn)	2.89	ND	10
Zinc (Zn)	0.03	0.2	0.5
Copper (Cu)	<0.01	ND	1.0
Boron (B)	0.43	ND	1.0
Chloride (Cl)	10.99	1.0	250
Florides (F)	10.95	193.71	1.5
Cadmium (Cd)	<0.01		0.01
Chromium (Cr)	<0.01	0.007	2.0
Lead (Pb)	0.02	ND	0.01
Selenium (Se)	<0.01		0.01

Source: GDC Monitoring Report

Wanyororo Spring water and raw water from Nakuru Water Sanitation Services Company (NAWASSCO) before treatment have elevated fluoride concentrations (Table 4.4).However, after treatment the fluoride levels reduced to below recommended safe limit (1.5 ppm). Thus water treatment is necessary in this area if fluoride associated effects have to be minimized**.**

Table 4.4: Drinking Water Quality of Water Sources in Menengai Project Area

Parameters	**NAWASSCO Treat Water**	**NAWASSCO Raw Water**	**Wanyororo Spring Water**	**Standards KEBS**	**Standards W.H.O**
pH	8.91	8.87	1.4	6.5-8.5	8.5
Conductivity µS/cm	13.86	1030		2500	<1500
Chloride	1.0	50	4.93	250	<250
Fluoride	0.07	13.31	2.01	1.5	1.5
Sulphide	0.001	0.001	1.68	0.1	<84
Copper	ND	0.02	<0.01	1.0	<2.0
Zinc	0.72	0.23	<0.01	5.0	<3.0
Chromium	0.004	0.008	<0.01	0.05	<0.05
Boron	ND	ND	ND	<0.01	<0.3
Cadmium	ND	ND	ND	<0.01	<0.1
Lead	ND	ND	ND	0.01	<0.01
Nickel	ND	ND	ND	0.01	<0.02
Selenium	ND	ND	ND	<0.01	<0.02
Mercury	ND	ND	ND	<0.01	<0.01
Arsenic	ND	ND	ND	<0.01	<0.02

4.3 Biological Environment

A detailed biological survey covering flora and fauna in both the disturbed and undisturbed areas of the caldera was carried out. The idea behind this survey was mainly to determine biological baseline before implementation of the proposed project.

4.3.1 Flora

A survey conducted during the EIA study shows that the crater has a total of 217 plant species (Appendix 4). Most of these species belong to herbs (132), while the rest were shrubs (45) and trees (40). The *Rhus natalensis, Dodonea sp.* and *Tarchonanthus comphoratus* were among the most dominant species in the caldera.

The caldera contains some plant species that are believed to be rare and unique to this area such as *Artemisia afra* (Plate 4.2), *Protea gaguedi, Tetradenia riparia, Diplolophium afficanum, Agauria salicifolia* and *Osyris lanceolata.*

Plate 4.2: *Artemisia afra* - one of the rare and unique to the Menengai Caldera

Remnants of endangered tree species such as the sandlewood (*Osyris lanceolataone*) were sighted in the Caldera (Plate 4.3).

Plate 4.3 Sandlewood (*Osyris lanceolataone*) of the endangered trees species

4.3.2 Fauna

There are few wild animal species in the project area as reported by FOMEC (2011). This is because large parts of the area are farmlands with no open grazing and dispersal areas. Animal species such as Baboons (Plate 4.4), Leopards Wild pigs and Snakes are common within Menengai Caldera. Cases of Human - Wildlife conflicts mainly due to invasions of farms by the Baboons and Monkeys have been reported. Antelopes, Dikdik, Gazelles, Monkeys (Vervets, Columbus), Ant bears, Baboons, Leopards, Snakes (Puff udder), Birds (Quills, Guinea fowls, Cave sparrows, bats, weaver birds) and Wild pigs also exist in the project area.

Plate 4.4: A baboon sported in one of the sites near the forest in Menengai Caldera

The caldera was found to be a home of 9 species of mammals (Appendix 5). Hyraxes, rabbits and baboons were recorded. Evidence of some cats including jackals and leopards was also confirmed from faecal remains and paw-prints (Plate 4.5).

Plate 4.5: Leopard foot prints at Well 1

4.3.3 Herpetofauna

Three reptile families (Agamidae, Boidae and Elapidae) were encountered in the project area (Appendix 5). Four species from these families were recorded; namely: Red-headed Rock Agama, the Elmentaita Rock Agama, African Rock Python and Forest cobra.

4.3.4 Birds

A total of 40 birds species were recorded at the Menengai crater (Appendix 6). Among them are rare species such as African black eagle (Plate 4.6). Common bird species spotted in the caldera include malachite sunbird, doves, swifts, swallows and woodpeckers.

Plate 4.6: The African black eagle in Menengai caldera

4.4 Socio Economic and Cultural Environment

4.4.1 Demographic Characteristics

Based on the 2009 population census, the population of Nakuru County was 1,603,325with an average growth rate of 3.4 % per annum. Apparently the growth rate is above the then national average of 2.4%. Nakuru has an almost equal number of males and females, for example in 2009 there were 804582 males and Females 798743. The district has a youthful population (see Table 4.5). The dependency ratio is 100:91.

The district has a population density of 214 people per sq Km². Bahati, which is one of the new districts adjacent to the project area is one of the most highly densely populated rural area.

4.4.2 Socio-Economic Characteristics

As per the information in Table 4.6, most of the respondents, constituting 58 percent were farmers, while businessmen and women constituted 15 percent. Teachers, the self-employed and casuals constituted 12 and seven percent respectively. Interestingly civil servants and civil society employees were equal and constituted 4 percent of the respondents. Most of the respondents are farmers, constituting 58 percent of all the respondents.

Majority (45%) of the population in the proposed project area, fall within the absolute poverty level. Agriculture is the main source of income with 48% of the population depending on it for their livelihoods (Table 4.6). Wage employment contribute 19% while urban self employed ar 23% of the entire population in the project area.

Table 4.5: Distribution of respondents by occupation

Occupation	Respondents	Percentage
Farmers	68	58
Businessmen or Women	17	15
Teachers	14	12
Civil Servants	5	4
Civil Society employees	5	4
Self employed and casual	8	7
Total	117	100

Table 4.6: Socio-economic indicators of the proposed project area

Socio-Economic Indicators	
Total number of Households	327,797 (2002)
Average Households size	4
Number of female headed households	79,241
Number of disabled	40,500
Children needing special protection	1,329
Absolute Poverty (Rural & Urban)	45% (313,275)
Income from Agriculture	48%
Income from Rural Self employment	8%
Wage employment	19%
Urban self-employment	23%
Number of unemployed	194,195 (15%)

Education

Nakuru district has a total of 1,219 Pre-Primary schools, 558 Primary Schools, and 140 Secondary schools. The dropout rates for both male and female in primary school is 38%, while in secondary schools it increases to 49.1% and 54.8% respectively. The pupil teacher ratio is 1:35 in primary schools and 1: 16 in secondary schools. Enrolment of boys in Pre-Primary, Primary, and Secondary Schools is higher than that of girls

The population of primary school going children was projected to increase from 288,278 in 2002 to 352,465 in year 2008. This represents an increase of 64,187 0r 22.3%. This will necessitate investments in educational facilities and services. For the secondary going children population is projected to increase from 125,274 in 2002 to 153,167 an increase of about 22.3%.

Health

The larger Nakuru District has 15 hospitals and 279 other health facilities that are spread all over the district. The doctor to patient ratio is 1:31,251 and average distance to the nearest health facility is 8 kilometers.

The most prevalent diseases in the district are Malaria, Upper Respiratory- Tract Infections, Malaria and Skin Diseases. Thus programmers of Primary Health Care (PHC); and STI/STD including HIV/AIDS should be put in place.

HIV/AIDs prevalence in the district has showed increasing trend, reaching the peak in 1998, before it started showing signs of decline. The declining trend in HIV/AIDs prevalence could be attributed to the fact that Nakuru has been one of the HIV/AIDs pilot campaign districts. The Government through the campaign encourages patients to be transferred to their nearby health facilities and also to go for home-based treatment. This factors combined, could have accounted for the decline but the prevalence rate of 18% recorded in 2000is still high especially if translated in terms of figures given the fact that the population of the district is about 1.2 million people.

The impact of the scourge has been felt at all levels of the district's economic and social circles. Already Nakuru Town has more than 15 children homes and majority of the children are HIV/AIDs orphans. This is one of the major challenge facing the major urban centers of Nakuru District, while at village level orphans are been taken care of by the old, while some of the young people are forced to take care of the their siblings. This has increased the dependency ratio and impacted much more negatively on the labor force. Table 4.7 below, summaries some of the health indicators in Nakuru District.

Table 4.7: Health Indicators

Crude Birth Rate (CBR)	**18/1000**
Crude Death Rate (CDR)	7/1000
Life Expectancy	57 years both sexes
Under 5 Mortality Rate	67.8/1000
Infant Mortality Rate (IMR)	50.3/1000
Total Fertility Rate	5.3 per 1000
HIV Prevalence Rate	13% (2001)
Doctor/Patient Ratio	
Total Bed Space	

Source: Strategic Plan 2007 -2012

Transport and Communication

Nakuru County is adequately served with loose surface and tarmac roads, railway lines, and telecommunications systems. This has been enhanced by the recent government enhanced investment in road improvement and mobile coverage. The tarmac road network is estimated to extent over 300 kilometres in addition to extensive mobile coverage.

Food Security

As far as food security is concerned, Nakuru County is fairly food secure. However recent population influx owing to the 2007-2008 post-election violence and subsequent displaced persons in the urban centres seems to have strained the existing food resources. Climate change has also worsened the situation. The peasant farmers have suffered most owing to their disempowered positions especially financially.

4.4.7 Sports and Recreation

Being centrally located in the heart of the Rift Valley, Nakuru is a centre of sports and recreation, hosting various primary and secondary schools' district and provincial games. It occasionally hosts national and regional games. This is effected in the various stadiums in the town.

Culture

Nakuru county being cosmopolitan, is a float with the culture (defined as shared understanding) of the various communities inhabiting the county, including the Kikuyu, Kalenjin, Maasai, Abaluyha, Abagusii among others.

Socio-Cultural Issues

The Nakuru county as discussed above is not only cosmopolitan; hosting the various communities but also has various hospitals; both public and private, housing and educational institutions. Indeed it hosts one of the oldest provincial hospitals, that is the Rift Valley provincial general hospital& War Memorial Hospital. It occasionally hosts provincial music festivals including rich traditional presentations across the province. Thus the province is socio-culturally rich.

CHAPTER 5
HYDROGEN SULPHIDE (H_2S) EMISSION DISPERSION MODELLING

Summary

The Modular geothermal power stations assessed in this study operate by collecting steam from the Menengai geothermal field. The steam is used to turn the turbines which generate electric energy. The used steam will be discharged as liquid water and vapour. The water vapour is harmless in the atmosphere, but associated with steam are non-condensable gases such as carbon dioxide (CO_2), hydrogen (H_2), and hydrogen sulphide (H_2S). H_2 and CO_2 do not pose a threat to ambient air quality but are greenhouse gases but H_2S can be toxic at sufficiently high concentrations.

There are no ambient air quality standards for hydrogen sulphide under EMCA (1999) thus the study adopted WHO and WB guidelines and standard. According to the WHO guidelines, 24 hour average concentrations should not be permitted to exceed 0.10ppm (0.15mg/m3), beyond the immediate modular power plant boundary. H_2S concentration is monitored by GDC Environment Department around Menengai wells by use of gas detectors since inception of Menengai geothermal drilling project.

The objective of the air quality monitoring program is to monitor both occupational health exposure rather than just environmental conditions, as the data provide some guidance on the maximum levels that are likely to arise in the environment close to the modular power stations. The monitoring are related to observation of over a few minutes all made during the day.

The wells monitored include MW-01, MW-03, MW-04, MW-09, MW-10 among others. Most of the wells have recorded low concentration, at the well sites would be expected, the odour threshold is frequently exceeded, but none of the observation exceed the United States the threshold limit values (TLVs) for H_2S which is set at 10 ppm (15mg/m^3) for an 8 hour exposure.

The proposed development will have no impact on local climate. Modular geothermal power stations emit insignificant amounts of H_2 and CO_2 which are greenhouse gases. There are no air quality guidelines/standards for H_2S, however WHO standards have been used in this study and shows that the operations are within the acceptable limits.

From the results of the air quality dispersion modelling studies, it is notable that the proposed 90 MW modular power plants which will discharge H_2S through the cooling towers emission provides greater plume rise and better dispersion. Thus the H_2S impact will be minimal. The air quality modelling has been done based on the anticipated Modular power plants. The results indicate there is going to be effects of H_2S (odour nuisance to due exposure to 0.76-3.21 mg/m^3 (0.00047-0.002ppm H2S) to the following receptor sites under 1hour, 8 hour and 24 hour prediction scenarios. For 1 hour H_2S prediction, the odour will be received at all sites except Kiamunyi. Under 8 hour H_2S prediction scenario, the H_2S odour will be felt at Drillers camp, Laydown area, Kipngochoch, Wanyororo B, MailiSita and Mosonik cattle boma. It is only Rigogo that will receive H_2S odour under the 24 hour H_2S prediction scenario. The detection of H2S odour depends on the short term concentration of a few seconds exceeding the odour threshold.

The detection of odour would not normally be sufficient grounds to prevent a geothermal development or to require mitigation to be undertaken. The predicted H_2S concentration at far away areas/receptor sites will also be low compared to the California 60 minutes (1 hour) standards where areas away from the power plant should not exceed 0.03ppm (0.042 mg/m^3).The predicted H_2S concentration levels at the power plant and various potential receptor sites where workers reside for 8 working hours much lower compared to the recommended concentration of 10 ppm exposure

5.0 Introduction

When a pollution source emits a chemical into the atmosphere at an initial concentration, the chemical does not remain at that initial concentration. Atmospheric processes act to disperse the emissions downwind into lesser concentrations. Therefore, the atmospheric dispersion model can be defined as a computation tool that uses mathematical equations to describe the dispersion process. If the initial concentration of the chemical is known, then one can use a dispersion model to predict the downwind concentration of pollutant emitted by various pollution sources (Westbrook, 1999).

5.1 Raw materials and process chemicals

The main raw material is geothermal steam. About 8,000 kg of steam will be consumed to generate one (1) megawatt (MW) of electricity per hour. So for the 90 MW, approximately 720,000 kg of steam will be utilized per hour. The measured composition by volume of the main steam flowing through each of the existing turbines is:

- Steam – 96.7%
- Non Condensable Gases (NCGs) Contents – 3.3%

Table 1 below shows the actual composition of the non-condensable (% by Volume) gases in the main steam in Menengai geothermal wells.

Table 5.1 Composition of non-condensable Gases (% by Volume) in Menengai Wells

Non Condensable Gases	Actual Composition
Carbon dioxide (CO_2)	94.0%
Hydrogen Sulphide (H_2S)	3.0%
Hydrogen (H_2)	3.0%
Methane (CH_4)	Not measured

Water from Boreholes will be used as a coolant in the cooling towers. This is a closed system, where there is a balance between condensed steam and emissions released through the cooling towers. Soda ash (sodium carbonate) will be used to dose the condensate produced by the plants in order to maintain a pH value of 7-9, to eliminate algal and bacterial growth. Water for the cooling towers will also be dosed with sodium hypochlorite (abiocide) to prevent algae and other bacteria clogging up the cooling tower fins. Some water from the cooling tower will also be cold reinjected, and will also be neutralized with soda ash.

Other chemicals currently used on site and will also be used include diesel oil for the standby generator, silica gel to dry air going into the transformers, greases and lubricants for maintenance

of the plant and equipment, paints, detergents and solvents. Mercury is stored the Instrumentation Laboratory for calibrating plant control instruments.

5.2 Project Area

The Project is located in the Menengai Geothermal Field on the outskirts of Nakuru Town within Nakuru County, about 180 Km west of Nairobi. Nakuru is the fourth largest town in Kenya with a population of about 500,000 and has well developed social amenities such as educational institutions, medical facilities, hotels, banking and shopping facilities. The main economic activities include agriculture, manufacturing, tourism and construction.

Most of the area is well served by a network of earth and all weather roads. The Nairobi – Kisumu Railway line and Trans-Africa highway passes through the southern part of the area. Electricity and telephone service lines serve most of the habitation and the surrounding farm land. The project area is within 15 km from the 132 kV double circuitTororo – Lessos - Juja line and about 30 km to the Lanet 132 kV substation.

Detailed surface studies carried out in 2004 and updated in 2010 comprising of geology, geophysics, surface heat measurement, baseline environmental and social economic assessment estimates the field potential to be about 1,600 MW.

GDC currently has four drilling rigs operating in the Project with three more rigs expected to be delivered by December 2013. Through the ongoing drilling effort, GDC has availed 60MW at the Wellhead. A Feasibility Study for 400MW Phase I is currently ongoing and is expected to be completed by April 2014. However the consultants undertaking the Feasibility study have indicated that the appraised area will support at least 100MW.

Civil infrastructure facilities consisting of access roads and water reticulation system have been developed. A 33KV line has also been extended into the Project area.

The projects area has no geothermal power stations in operation. Menengai Caldera land is also gazetted as a Forest under Menengai Forest. The caldera has a variety wild

animal and avifauna populations. Many tourists especially from schools and other educational institutions visit the caldera to see the geothermal developments in the area. The air quality dispersion modelling during this study is as shown in Figure 5.1. The modelling domain considered was 20km radius from the proposed 3x30 MW modular power plants.

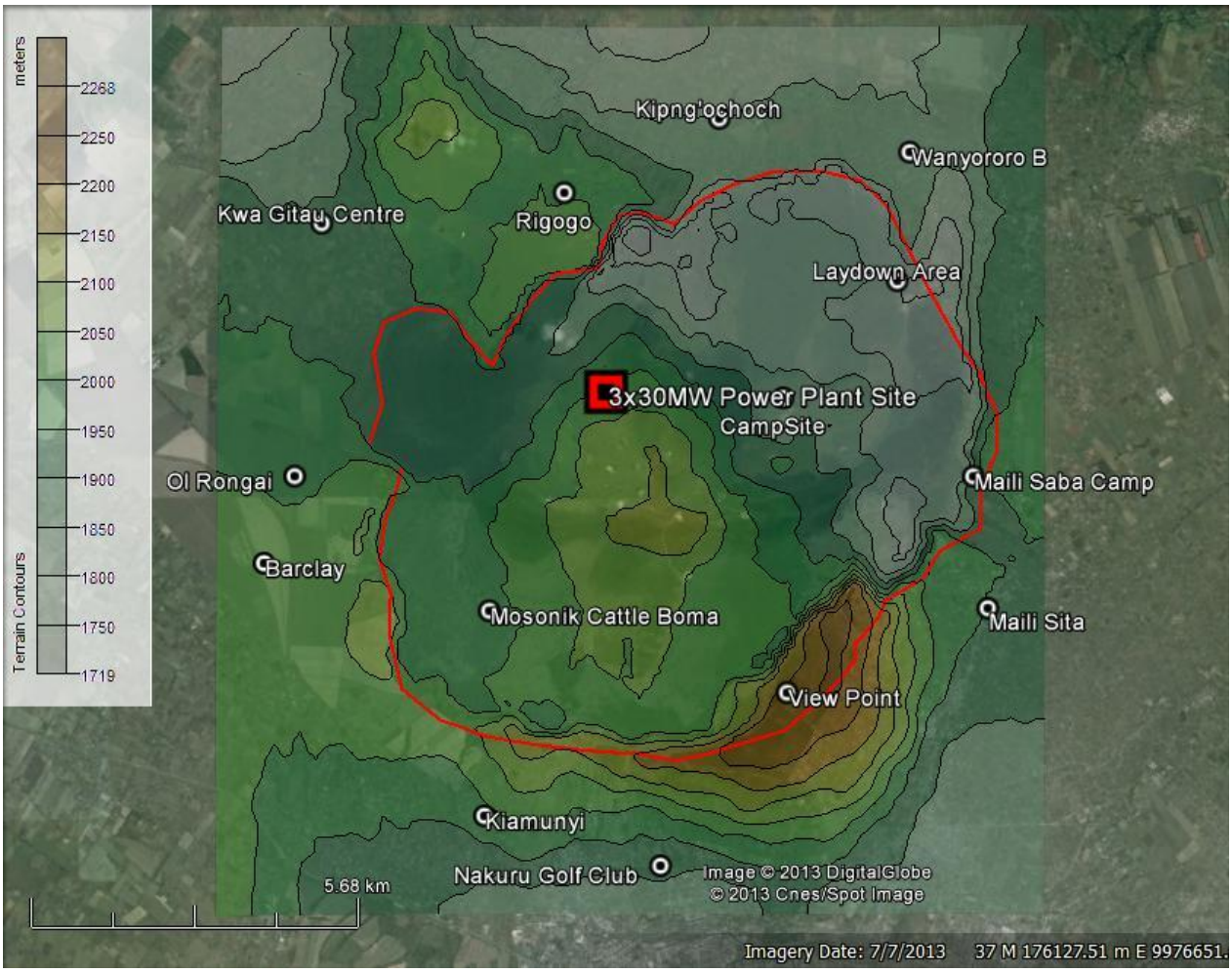

Figure 5.1: Map of the Project area showing proposed 3x30 MW Menengai Modular geothermal power stations site, extent of dispersion modelling domain and receptor sites

5.3 Modelling Methodology

5.3.1 Atmospheric Dispersion and Deposition Model

The potential air quality impacts that may arise through H_2S emission from three proposed modular geothermal power plants in Menengai area, have been quantified at different time scales of 1 hr, 8 hr and 24 hr using Lakes Environmental ISC-AERMOD View Version 8.2.0 of April 2013, which is a steady state, next generation, dispersion model (Lakes Environmental Software 2010). The C is a development from the Industrial Source Complex (ISC3) dispersion model and incorporates improved dispersion algorithms and pre-processors to integrate the impact of meteorology and topography within the modelling output.

The simulations were carried out under the model configurations of rural dispersion coefficients and flat &elevated terrain while considering downwash effects. The model was run by combing the three plants. This model only considers air dispersion up to 50 km from an emission source (Cimorelliet al. 2003). The sources of the meteorological, topographical, emission data are described in the subsequent sections.

5.3.2 Model Description

In February 1991, the U.S. Environmental Protection Agency (EPA) in conjunction with the American Meteorological Society (AMS) formed the AMS and EPA Regulatory Model (AERMOD) Improvement Committee (AERMIC), with the purpose of incorporating scientific advances from the 1970s and 1980s into a state-of-the-art dispersion model for regulatory applications. AERMIC's early efforts are described by Weil (1992). To improve planetary boundary layer (PBL) parameterizations, other concerns such as plume interaction with terrain, surface releases, building downwash, and urban dispersion were addressed. These efforts resulted in AERMOD. AERMOD has been developed as a replacement of EPA's Industrial Source Complex Short-Term model (ISCST3) (U.S. Environmental Protection Agency 1995). The early formulations of AERMOD are summarized in Perry et al. (1994) and Cimorelli et al. (1996). An extensive discussion of the current models' formulations appears in Cimorelli et al. (2003).

AERMOD, a steady-state dispersion model, includes the effects on dispersion from vertical variations in the planetary boundary layer (PBL). In the stable boundary layer (SBL) the concentration distribution is Gaussian, both vertically and horizontally, as is the horizontal distribution in the convection boundary layer (CBL). However, the CBL's vertical concentration distribution is described with a bi-Gaussian probability distribution function (PDF), as demonstrated by Willis and Deardorff (1981). Buoyant plume mass that penetrates the elevated stable layer is tracked by AERMOD and allowed to re-enter the mixed layer at some distance downwind.

For flow in complex terrain, AERMOD incorporates the concept of a dividing streamline (Snyder et al. 1985), and the plume is modelled as a combination of terrain-following and terrain-impacting states. The model considers the influence of building wakes and it enhances vertical turbulence to account for the "convective like" boundary layer found in night time urban areas.

5.4 Model Inputs

5.4.1 Emission Source Parameters

Parameters for stack diameter, gas exit velocity, volumetric flow rate, temperature, were determined for the proposed project site. The pollutant emission rates used within the model are described in subsquent sections.

5.4.2 Building Downwash

The existing project site has no building structures hence they were not incorporated as building inputs within the model. The integrated Building Profile Input Programme (BPIP) module within AERMOD usually assess the potential impact of building downwash upon predicted dispersion characteristics. Building downwash occurs when turbulence, induced by nearby structures, causes pollutants emitted from an elevated source to be displaced and dispersed rapidly towards the ground, resulting in elevated ground level concentrations.

5.4.3 Meteorological Data

Surface and upper air meteorological data used in this modeling were obtained from GDC's MlimaPunda Automatic Weather station (Easting 173363, Northing 9976379, Elevation 2153

m.a.s.l) and Upper Air Estimator Tool in Model respectively. This included the missing cloud cover and ceiling height data for MlimaPunda weather station. MlimaPundaAutomatic weather station is located approximately 2.65 km Northwest of the Proposed 3 x 30 MW Menengai Modular Power Plant site in the Menengai geothermal field. Two years of meteorological data observed between November 2011 and December 2012 was used within the assessment. The general wind patterns are summarized in Figure 5.2. The general wind direction is from South to North during most part of the year.

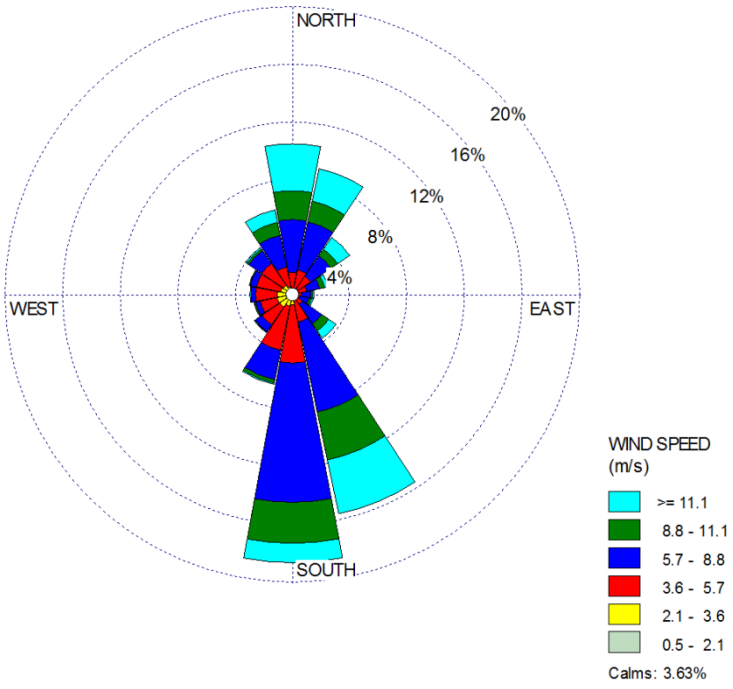

Figure 5.2 Seasonal wind pattern in the area (data from Automatic Weather station at MlimaPunda)

The AERMET processor within AERMOD was used to process the data to be site specific. US EPA guidance on processing met data for use within AERMOD states that land use up to 1km upwind from a site should be considered when determining surface roughness characteristics, whilst for Bowen ratio and albedo, land use types within a 10km by 10km area centred over the site should be considered. Land use within the 20km by 20km area covering the Menengai geothermal field is dominated by Forest, Shrubland, Grassland and Cultivated land.

As such, met data was processed to be site specific using the "Forest, Shrubland, Grassland and Cultivated land" option within AERMET. AERMET requires as input, surface characteristics, cloud cover, a morning upper-air temperature sounding, and near-surface measurement of wind speed, wind direction, and temperature. With this, the model computes the hourly boundary layer parameters, such as the friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height, and surface heat flux. Table 5.2 contains the assumed parameters for surface roughness, albedo and Bowen ratio.

Table 5.2. Parameters for Surface Roughness, Albedo and Bowen Ratio

Parameter	Shrubland	Forest	Grassland	Cultivated Land
Surface Roughness	0.2625	1.3	0.04025	0.0725
Albedo	0.3275	0.1775	0.29	0.28
Bowen Ratio	4.75	0.825	0.925	0.75

5.4.4 Terrain Data

Topographical features can have a significant impact on pollutant dispersion, therefore digital terrain data was included within the model. This results in improved accuracy of model results. The modelling used the non-default dispersion option with no stack tip downwash assuming an elevated terrain. The Universal Transverse Mercator (UTM) projection for zone 37 south of the equator was employed using the world geodetic system of 1984 (WGS-84). The prediction H_2S concentrations was simulated using averaging time options of 1-hour, 8-hour, 24-hour and Annual periods. A uniform Cartesian grid spacing of 955 m by 835 m was considered over a length of 20 km by 20 km extending from E167260 m to E179984 m and N9972108 m to N9984011 m. The integrated AERMOD terrain processor, AERMAP, was run to calculate terrain heights for all structures, sources and receptors within the modelling domain. AERMOD simulates a plume, in elevated terrain, as a weighted sum of concentrations from two limiting states: a horizontal plume (terrain impacting) and a terrain-following plume. Each plume state is weighted using the concepts of the critical dividing streamline and a receptor-specific terrain height scale (Cimorelli et al. 2003).

5.4.5 Dispersion modeling

AERMOD VIEW was set up to make use of the AERMET VIEW meteorological data described above and to make predictions of H_2S concentrations for 1-hour, 8-hour, 24-hour and 1-year average periods. A uniform Cartesian grid spacing of 900 m by 800 m was considered over a length of 20 km by 20 km extending from E167260 m to E179984 m and N9972108 m to N9984011 m. The emissions assumed for the model simulations were taken from Steam Quality data. The emissions and other parameters required for modeling are shown in Table 5.3 for the proposed power stations. The precise locations and designs of the proposed modular power stations have not been finalized at this time but the locations are known with sufficient accuracy to allow the dispersion modeling assessment. Changes in locations of a few meters or less would be of minor consequence in the context of this study.

5.5 Air Quality Guidelines for Hydrogen Sulphide

The setting of air quality standards is based on considerations of health effects. Concentrations must be set that protect against adverse impacts on human well-being. For odorous compounds it may be necessary to set limits lower than those at which no effect on human health is experienced. In addition, the effect of pollutants on flora, fauna and materials is a matter for consideration. For hydrogen sulphide all of these factors were taken into account suitable guidelines that protect against all adverse impacts adopted.

Table 5.3: Assumed emission parameters used in modeling proposed power stations

Location	Menengai Modular I Plant		Menengai Modular II Plant		Menengai Modular III Plant)	
Height of emission point Above grade (m)	19		19		19	
Height of grade above sea Level (m)	2020		2020		2020	
Exit velocity (m/s)	8.6		8.6		8.6	
Exit temperature (K)	375		303			
Diameter of discharge point at tip (m)	9.64		9.64		9.64	
Mass emission rate of hydrogen Sulphide for each of 12 emission points for Menengai Modular Plants (g/s)	3.3		3.3		3.3	
Existing sources Coordinates of discharge points	Easting 172053 172062 172070 172078	Northing 9978606 9978612 9978617 9978623	Easting 172202 172211 172218 172226	Northing 9978687 9978693 9978699 9978704	Easting 172351 172359 172368 172376	Northing 9978769 9978774 9978779 9978785

5.5.1 Threshold Limit Values

There is a distinction between air quality standards for the ambient air and those for the workplace/occupational exposure. The workplace/occupational exposure is referred to as

threshold limit values (TLV). TLVs are those doses that cause no apparent harm to workers exposed for eight hours a day, five days a week. In the United States the TLV for hydrogen sulphide is set at 10ppm (15 mg/m^3).

5.5.2 Ambient Air Quality

Several countries have adopted both long and short-term hydrogen sulphide standards for ambient air quality criteria (see Table 4), prepared from data published by the Subcommittee on Hydrogen Sulfide (1979) and from information published by WHO (1987). The US EPA has not yet formulated a standard for hydrogen sulphide although several states in the United States such as California, New Mexico and Texas have developed independent regional standards.

The short-term concentrations are generally higher than those for long-term exposure and it is useful to note that short-term exposure to a given concentration of pollutant will in general have less effect than a long-term exposure to the same concentration. Therefore the air quality standards for long-term exposure are usually lower than those for short-term exposure. The most stringent air quality goal presented in Table 4 is based on considerations of odour and is applied by the Victorian Environmental Protection Authority (VEPA) (Australia).

VEPA sets a goal of 0.0001 ppm (0.14mg/m^3) for the maximum 3-minute average ground-level concentration of hydrogen sulphide. This value is approximately 20 per cent of the odour threshold of 0.00047ppm (0.76 mg/m^3), which is the lowest odour threshold reported in the literature. The value is referred to in Victoria, as the design groung-level concentration and it is used by VEPA as the objective, which must not be exceeded when determining stack heights. The reason of selecting air quality criteria that is apparently less than the odour threshold and well below the concentration at which any health effects have been reported, is that the concentration is expressed as a 3-minute average. The human nose responds to odour exposure of the order of seconds. During any 3-minute period, concentrations at groung-level close to a stack emitting a pollutant may fluctuate by as much as ten times the average value, so that if the 3-minute average air quality goal is set at the odour threshold, this value will be exceeded some of the time. For this reason a level of one-fifth to one-tenth of the odour threshold is usually set as the maximum 3-minute average concentration to protect against such impacts.

In practical terms this would result in little or no detectable odour of hydrogen sulphide at groung-level. This is clearly not a necessary goal for all areas, in particular areas such as Menengai where natural hydrogen sulphide emissions occur.

The implications of applying the VEPA air quality criteria to the proposed project are that human health would be protected. In addition, in view of the similarity of the response of other animal species to hydrogen Sulphide, no adverse impacts are likely to be experienced by the local fauna. Similarly it is unlikely that at these levels there would be any significant deterioration of materials, particularly metals, in the vicinity of the plant.

However, in practical terms this is unrealistic goal as the stack concentration of hydrogen Sulphide in a 90MW power station will be of the order of 3.3 g/m^3. To achieve the VEPA ground-level concentrations a dilution of over 23 million would be needed hence not attainable. The World Bank (1998) sets a standard of $5mg/m^3$ (3.3 ppm) at the boundary to protect against odour impacts and this is included for completeness.

The approach adopted here is to select criteria that human health, local crops and fauna, but will not protect all areas against an odour impact. The WHO (1997) provides useful guidance in this respect (for non-occupational exposure), where:

- $15mg/m^3$ (9.9 ppm) is recommended for lowest-adverse health effect of hydrogen sulphide
- A guideline value of 0.10 ppm ($0.15mg/m^3$) with an averaging time of 24-hours"
- To avoid odour annoyance among the exposed population, hydrogen sulphide concentrations should not be allowed to exceed 0.0046 ppm ($7mg/ m^3$) , with a 30 minute averaging period

This will form the basis of the impact assessment presented in chapters in this report.

Table 5.4 Ambient air quality standards for hydrogen sulphide

Country/State	Concentration mg/m^3	ppm	Averaging time
California USA	0.042	0.03	60 minutes
New Mexico USA	0.0042	0.003	30 minutes
Texas USA (industrial area)	0.168	0.11	30 minutes
Victoria Australia	0.00014	0.0001	3 minutes
Alberta Canada	0.017 0.014 0.004	0.011 0.009 0.003	30 minutes 60 minutes 24 hours

Source: United States Environmental Protection Agency

5.5.3 Air Quality Guidelines for the study

There are no ambient air qualities for quality criteria for hydrogen sulphide currently in force in Kenya under the Environmental Management and Coordination Act, 1999. The Act however provides that where no national standards exist, then International standard have to be applied. For this study it is suggested that the WHO 24-hour guideline should be used to assess impacts beyond the immediate power station boundary. That is 24-hour average concentrations should not be permitted to be above 0.10 ppm (0.15 mg/m^3), beyond the immediate power station boundary. Provided the level is complied with, the health will be safe-guarded. .

Areas located far away from the project should be assessed on the 60-minute Californian Standard of 0.03 ppm (0.042 mg/m^3) and residential areas should be considered affected if 30-minute concentrations are above 0.004 ppm (7 mg/m^3).The protection of workers within the power station is beyond the scope of an Environmental Assessment, but it is suggested that the United States TLVs for work-place exposure, namely10 ppm (15 mg/m^3) 8-hour average, be used for this purpose.

5.6 Hydrogen sulphide and Air quality

The modular geothermal power stations assessed in this report will operate by use of steam from the geothermal wells. The steam is used to drive turbines which generate the electrical energy. The used steam is discharged as liquid water and vapour. The water vapour is harmless in the atmosphere, but associated with the steam are non-condensable gases including carbon dioxide (CO_2), methane (CH_4) and hydrogen sulphide (H_2S). The CO_2 and CH_4 do not pose a threat to ambient air quality, although they are, along with water vapour, greenhouse gases, but H_2S can be toxic at sufficiently high concentrations. In addition H_2S will accelerate the corrosion of metals. GDC is currently taking 3days in a week monitoring of H_2S concentrations in the air around discharging wells and the results have been used for modeling of the possible effects of air quality to the environment posed by the proposed modular plants.

5.6.1 Properties of hydrogen sulphide

Hydrogen sulphide is colourless, flammable, denser than air and liquefies at -60^0C. It is soluble in both polar and non-polar solvents and is rapidly oxidized in air and in solution. It is corrosive to many metals and may discolour paint by its reaction with the metals present in the pigments. Because of its density when it is concentrated, it will have negative buoyancy and sink to the lowest point. In geothermal projects it is usually associated with high concentrations of carbon dioxide, which is also denser than air. Thus a slow leak of the non-condensable fraction of cooled geothermal gas emitted into a sheltered environment, can allow a build-up of dangerous concentrations of hydrogen sulphide in low-lying or sheltered and enclosed areas. Such areas are unlikely to be naturally occurring topographical features such as gullies or valleys, but could be the concreted cellars that are part of the well-heads, or sumps within the power station.The controlled discharge of non-condensable gases from the power station may contain initially up to approximately 4.9 per cent hydrogen sulphide and 96 per cent carbon dioxide (EwbankPreece Limited, 1989).

5.6.2 Effects of Hydrogen Sulphide on Humans

Geothermal energy production always increases H_2S release to the atmosphere (Kristmannsdottir et al. 2000). This has sometimes raised the opposition of the nearby living population to geotheral development, for example, at Puna, Hawaii (Anderson 1991) and Milos, Greece (D'Alessandro et al. 2009).

But atmospheric concentrations of H_2S in volcanic/ geothermal areas, although uncomfortable, are generally below toxic levels. Although the World Health Organization states that data are still insufficient to definitely exclude any adverse effect (WHO 2003), many studies at Rotorua (New Zealand), where a large population is exposed to low-levels (10-500 ppb) of H_2S, revealed that chronic sub-toxic exposition has only limited effects on human health (Bates et al. 1998). Physiologic effects of human exposure to H_2S are reported in Table 5.

Table 5.5: Hydrogen sulfide: established dose-effect relationships (WHO 1981, WHO 2000)

H_2S Concentration		
mg/m^3	**ppm**	**Effects on Humans**
1400–2800	1000–2000	Immediate collapse with paralysis of respiration
750–1400	530–1000	Strong central nervous system stimulation, hyperpnoea followed by respiratory arrest
450–750	320–530	Pulmonary oedema with risk of death
210–350	150–250	Loss of olfactory sense
70–140	50–100	Serious eye damage
15–30	10–20	Threshold for eye irritation
	0.0047	Rotten egg odour detected by 50% of humans

5.6.3 Effects Hydrogen Sulphide on Materials

Hydrogen Sulphide is corrosive to metals including copper, silver and even gold. It also reacts with lead-based paints to produce discolouration. Apart from aesthetic considerations, this corrosion of materials can cause problems in electronic equipment when connecting wires are affected.

5.7 Existing air quality

Air quality monitoring has been going on in Menengai project area. The concentrations of the gases monitored were O_2, CO_2, CO, Cl, SO_2, and CH_4. It was noted that they were all within acceptable OSHA levels in all working areas monitored.

The concentrations of hydrogen sulphide were monitored and it was found that they were high at the weir box in the discharging wells while in the rest of the working areas the concentration levels were zero ppm. The average nose height concentration of H_2S in all stations is presented in Table 5.6. However, the concentrations recorded were within OSHA Short Term Exposure level. These locations record low concentrations. At most of these monitored wells, the odourthreshold (0.0046 ppm-0.002 ppm or 0.76-3.21mg/ m^3) is frequently exceeded, but none of the observation exceed the United States the TLV for hydrogen sulphide which is set at 10 ppm (15 mg/m^3) for an eight hour exposure. Note concentrations averaged over eight hours would be expected to be much lower than the short-term average values reported above.

Table 5.6: Monitoring of H_2S concentration for selected Menengai wells

2013	Well	H_2S Concentration (ppm)
January	MW-1	0.8
January	MW-4	1.2
January	MW-3	0.6
January	MW-9	6.5
February	MW-1	1.4
February	MW-4	1.8
February	MW-3	0.4
February	MW-9	4.5
March	MW-1	1.6
March	MW-4	2.2
March	MW-3	1.6
APRIL	MW-3	1.2
APRIL	MW-9	1.4
APRIL	MW-12	4.8
MAY	MW-12	5.7
MAY	MW-3	1.8
JUNE	MW-1	2.3
JUNE	MW-3	1.4
JUNE	MW-4	2.6
JUNE	MW-9	1.7

5.8 Air Dispersion Modelling results and assessments of effects

To assess the effects of the proposed developments the operating scenario of the modular power plants has been modelled. Each case represents the operating modular power stations to show how air quality will be affected. The model has been used to predict the maximum 1 hour, 8 hour, 24 hour and 1 year concentrations. The modelledcase is Menengai Modular power plants (Plant 1, Plant 2 and Plant 3).

The results presented in the figures below as follows

- Predicted 1 –hour average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3, Figure 5.3).

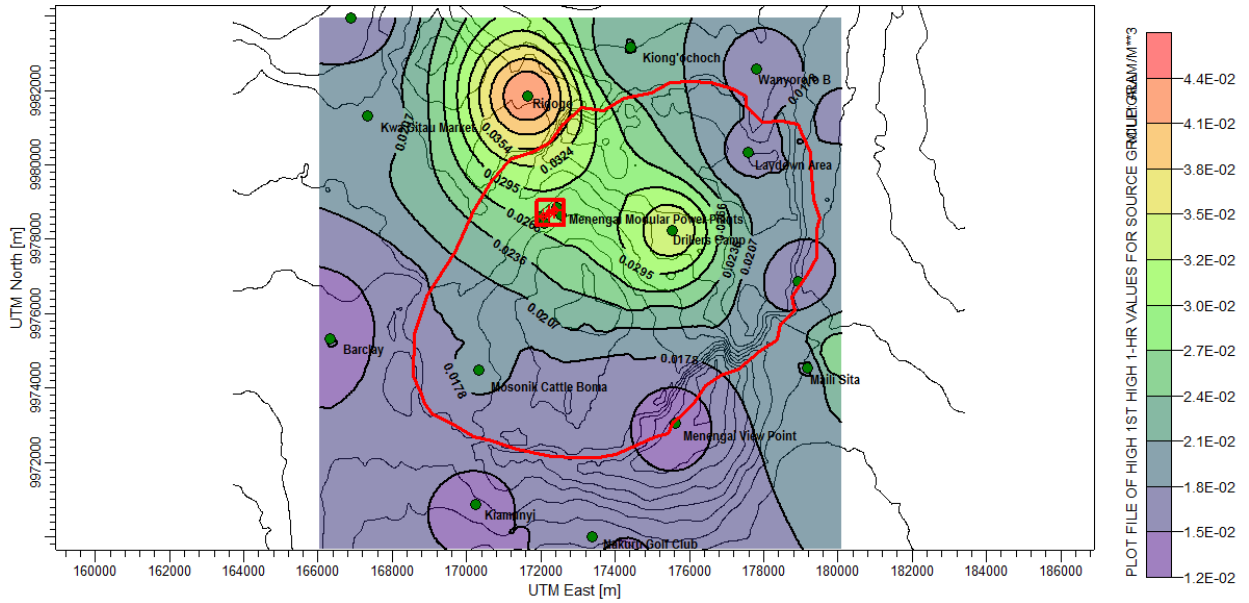

Figure 5.3:Predicted 1 –hour average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3)

- Predicted 8– hour average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3, Figure 5.4).

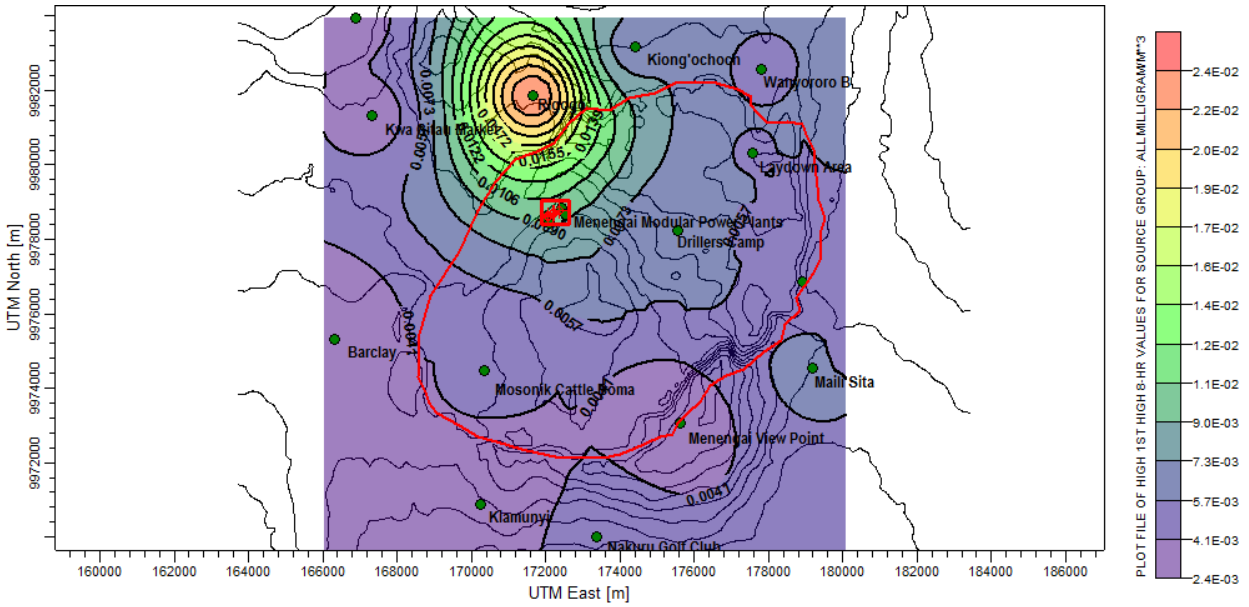

Figure 5.4: Predicted 8 –hour average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3)

- Predicted 24 – hour average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3, Figure 5.5).

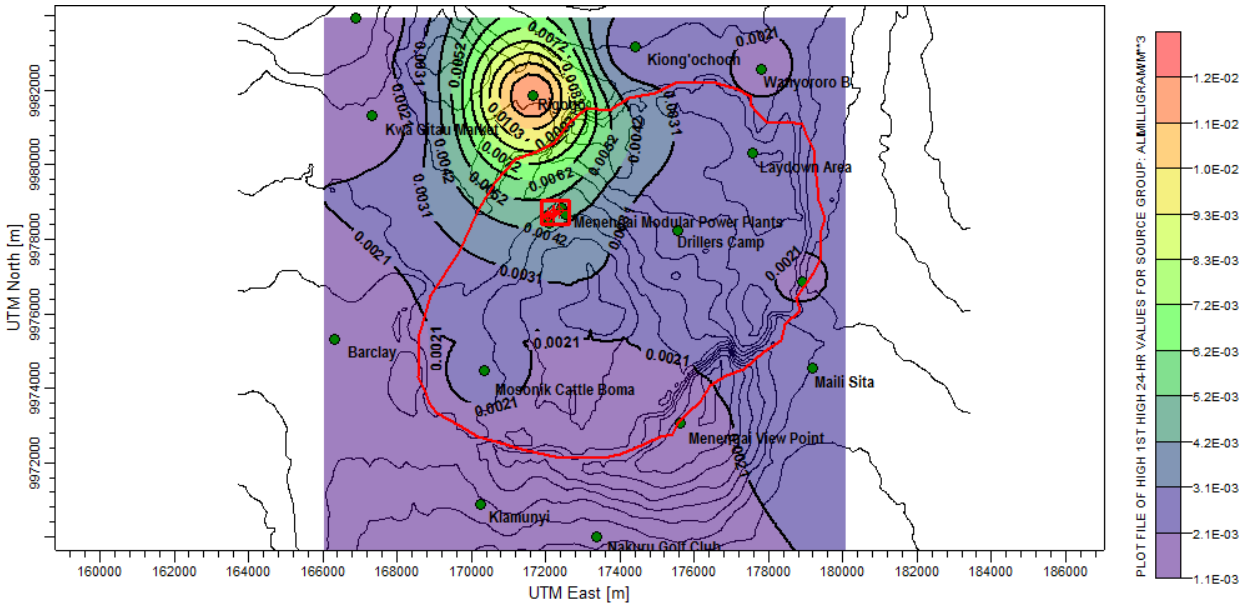

Figure 5.5:Predicted 24 –hour average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3)

- Predicted 1-year average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3, Figure 5.6).

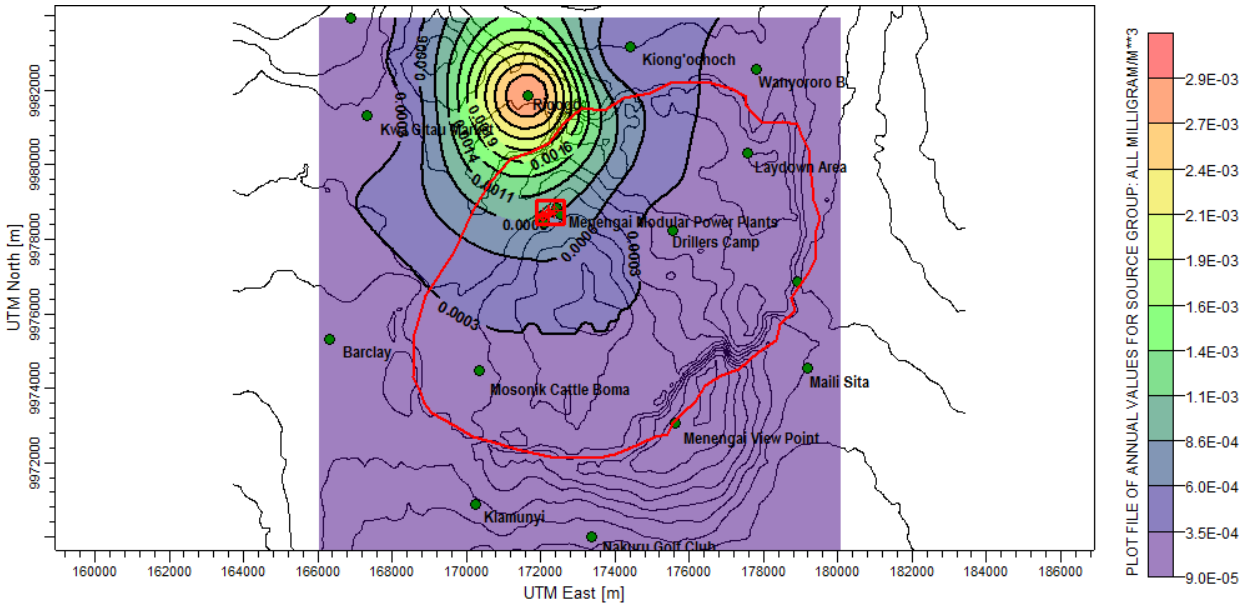

Figure 5.6:Predicted 1 –year average H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3)

From the above modeled scenarios, the potential air quality impacts due to hydrogen sulphide have been assessed based on the three guidelines namely

- WHO Air Quality Guidelines where 24hour Concentration should not exceed 0.10ppm (0.15mg/m^3) beyond the Power plant boundary.
- WHO guidelines odour annoyance concentrations should not be allowed to exceed 4.6 ppm (7mg/ m^3) , with a 30 minute averaging period
- California 60 minutes (1 hour) standards where areas away from the power plant should not exceed 0.03ppm (0.042 mg/m^3).
- United States Threshold Limit Values (TLVs) of 10ppm (15mg/m^3) for 8 hour for protection of workers (occupational exposure).

An evaluation of the potential impacts revealed that the H_2S concentration beyond the modular power plants boundary will range from 0.0028 ppm (0.0042 mg/m^3) to 0.0035ppm (0.0052 mg/m^3). This predicted concentration is 28-35 times lower than the 24hour 0.10ppm (0.15mg/m^3) WHO Air Quality Guidelines Concentration levels that should not exceed beyond the Power plant boundaries (Figure 5.5).

The predicted 1 hour H_2S at all receptor sites did not exceeded WHO odour annoyance guidelines which recommends that concentrations should not be allowed to exceed 4.6 ppm (7mg/ m^3) , with a 30 minute averaging period (Table 5.7). The detection of H_2S odour depends on short-term concentrations of a few second exceeding the odour threshold. The detection of odour would not normally be sufficient grounds to prevent a development or to require mitigation to be undertaken. The predicted H_2S concentration at far away areas/receptor sites will also be low compared to the California 60 minutes (1 hour) standards where areas away from the power plant should not exceed 0.03ppm (0.042 mg/m^3).

Evaluation of workforce (occupational exposure) exposure limit was based United States Threshold Limit Values (TLVs) of 10ppm (15mg/m^3) for 8 hour for protection of workers (occupational exposure). The predicted H_2S concentration levels at the power plant and various potential receptor sites where workers reside for 8 working hours much lower compared to the recommended concentration of 10 ppm exposure (Table 5.8).

Table 5.7: Predicted 1 hour maximum H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3) at potential receptor sites

Receptor Sites	Eastings (m)	Northings (m)	Max. Conc. (mg/m^3)	Max. Conc(ppm)	Elevation (m.a.s.l)
Drillers Camp	175542	9978242	0.035	0.0234	1857.53
Laydown Area	177579	9980325	0.016	0.0109	1770.95
Rigogo	171652	9981856	0.044	0.0294	1989.35
Kipng'ochoch	174408	9983158	0.021	0.0137	1848.71
Wanyroro B	177793	9982576	0.016	0.0108	1863.42
Menengai View Point	175618	9973065	0.013	0.0086	2213.73
MailiSita	179181	9974531	0.017	0.0114	1950.6
Maili Saba Camp	178920	9976856	0.015	0.0102	1919.07
OlRongai Market	166874	9983951	0.015	0.0099	1821.83
KwaGitau Market	167332	9981319	0.020	0.0130	1917.57
Barclay	166332	9975324	0.015	0.0102	2023.41
Kiamunyi	170241	9970875	0.014	0.0096	1986.53
Nakuru Golf Club	173371	9970001	0.016	0.0103	1921.64
Mosonik Cattle Boma	170334	9974487	0.018	0.0121	1998.09
WHO odour annoyance guidelines			7mg/ m^3	4.6 ppm	
California 60 minutes (1 hour) standards for Far away areas			0.042 mg/m^3	0.03ppm	
Warren Springs Laboratory 1980 Odour Annoyance			0.76-3.21	0.00047-0.002	

Table 5.8: Predicted 8 hour maximum H_2S concentrations due to emissions from Menengai Modular power plants (Plant 1, Plant 2 and Plant 3) at potential receptor sites

Receptor Sites	Eastings (m)	Northings (m)	Max. Conc. (mg/m^3)	Max. Conc(ppm)	Elevation (m.a.s.l)
Power Plant area	172226	9978704	0.0106	0.0071	
Drillers Camp	175542	9978242	0.0062	0.00413	1857.53
Laydown Area	177579	9980325	0.0055	0.00368	1770.95
Mosonik Cattle Boma	170334	9974487	0.0046	0.00309	1998.09
United States Threshold Limit Values (TLVs) for 8 hour exposures			15.00	10	

5.9 Conclusions:

It is notable that the proposed modular power plants will discharge the H_2S through the cooling tower emission thus providing much greater plume rise and much better dispersion of the emissions. Compliance with the WHO 24-hour assessment criterion does not ensure that odours will not be detected. There are no major impacts foreseeable which can't be mitigated as this has been done in other geothermal power plants worldwide. The following management and mitigation measures are proposed:

- Daily Monitoring of H_2S will be carried out;
- Training workers on the dangers of exposures to H_2S.

CHAPTER 6

PUBLIC PARTICIPATION

6.1 Introduction

Public participation is important in the environmental and social assessment process. It promotes feeling of ownership, cooperation, and accountability, and builds rapport. The process allows interaction, consultation and participation of the stakeholders. The overall goal of public consultation is to disseminate project information and to incorporate the views of the local community and other stakeholders in the identification of potential impacts, design of the mitigation measures and the management plan. The specific aims of the consultation process are to:

- Sensitize the community on the proposed project;
- Seek public views on the proposed project;
- Obtain public endorsement of the proposed project;
- Improve project design and, thereby, minimize conflicts and delays in implementation;
- Increase long term project sustainability and ownership; and
- Increase the participation, effectiveness and sustainability of mitigation.

During this process the consultants held meetings and interacted with local people, provincial administration, NGOs/CBOs, and other groups represented such as women, youth, church leaders and health workers (see Appendices 7.1 – 7.5). This enabled consultants to collect information about the communities' leadership, characteristics, expectations and whether they approved of the implementation of the project.

6.2 Public Participation Process and Outcomes

The public participation process began with stakeholder identification, followed by stakeholder engagement using various methods and ended with data analysis and interpretation.

6.2.1 Stakeholder Identification

The proposed project affects a wide variety of stakeholders ranging from the Proponent to the general public, both within and away from the project area. The main stakeholders identified for engagement are presented in Table 6.1.

6.2.2 Stakeholder Engagement

The public participation exercise involved administration of questionnaires, stakeholder meetings at - in location and Kabarak (GDC plot) in Rongai division. During this exercise the local people were informed of the proposed project and they freely expressed their interests and concerns, which were collected and documented. The knowledge and experience of the local people is pertinent in impact identification. High priority is given to the concerns of the local people in the project implementation process.

Outcomes and Expectations

Outcomes

The background information of the public involved in the study is summarized in Tables 6.1–6.10 below. There was 1/3 women representation in the study compared to men (66% male and 34% female respondents), which is legally representative. This is expected because culturally, men are the household spokespersons.

Table 6.1 Composition of public and stakeholders consulted

Stakeholder	Description	Mode of Engagement
Proponent	GDC staff	a) Group Discussions; b) One-on-one interviews with specific departmental heads.
Local community	Residents of settlements bordering the project's immediate zone of influence that is the area directly outside the power stations and Menengai Crater	Information sessions followed by question and answer sessions through a public baraza/ meeting. The venues of the meetings had to be easily accessible to the people and included market centres or area chief's compounds.
	Key informants among the project affected persons. These included: a) Village Elders and Chairmen;	Meetings; One-on-one interviews.
Administrative Representatives of people in the greater project area, that is Nakuru County	Nakuru county District Commissioners, DistrictOfficers, Chiefs and Assistant Chiefs	Information sessions followed by focus group discussions
Key government agencies These are agencies involved in management of relevant sectors of the bio-physicalandsocio-economic environment	a) Ministry representatives at the County level for: Environment, Mining, Wildlife, Water resources management,Health, Education, Lands b) National Environment Management Authority	a) Information sessions followed by focus group discussions; b) One on one interview to collect specific information.
Non-governmental organisations (NGOs):	Registered organisations dealing with conservation in the project area. These included: a) Lake Nakuru, Menengai Dundori and Bahati (LANAMEDUBA) Ecosystem	One on one interviews to collect specific information

Respondent Background information

Age

The distribution of respondents by age groups shows that the attendance was representative of the main active groups (Table 6.2).

Table 6.2: Distribution of Respondents by Age

Age Group	Frequency	Percentage
11-20	3	3
21-30	27	25
31-40	21	20
41-50	13	12
51-60	23	21
61-70	15	14
71-80	5	5
Total	107	100

Marital Status

Tables 6.2 and 6.3, suggest that marriage begins from age group 21-30 years. This suggests that any benefits to the local communities will go to families rather than individuals.

Table 6.3: Distribution of Respondents by Marital Status

Marital Status	Frequency	Percentage
Married	103	84
Single	19	15
Divorced	1	1
Total	123	100

Family Size in Terms of Number of Children

Given that most respondents were married adults (21 years and above), Table 6.4 suggests that there is no preferred family size within the project area.

Table 6.4: Distribution of Respondents by Their Number of Children

Number of Children	Frequency	Percentage
1-2	22	18
3-4	33	27
5-6	28	23
7-8	22	18
9 and above	16	13
Total	121	99

Education Levels

Based on Table 6.5, the level of education and hence literacy is relatively high. However that majority are secondary school level and minority are in college level may depict high rate of unskilled job seekers.

Table 6.5: Distribution of Respondents on Highest Education Level Attained

Education Level	Frequency	Percentage
No education	1	1
Primary	34	27
Secondary	77	62
College/Certificate	10	8
University (Bachelors)	3	2
Total	125	100

Occupation

Table 6.6: Distribution of Respondents by their Occupation

Occupation	Frequency	Percentage
Farmers	68	58
Businessmen or Women	17	15
Teachers	14	12
Civil Servants	5	4
Civil Society employees	5	4
Self-employed and casual	8	7
Total	117	100

Majority (58 %) of the respondents are farmers (Table 6.6), which explains the source of livelihood for the community. About 70% of the farmers own up to 2 acres of land (Table 6.7), meaning that farming practised in the area may be largely subsistence. Thus care should be taken so that the installation of the modular power plant should not cause any adverse effects to the farms and crops.

Land Tenure and Farming

Table 6.7: Distribution of Respondents by Land Size

Land Size (Acres)	Frequency	Percentage
0.25	12	27
0.5	5	11
1	5	11
2	10	22
over 3	13	29
Total	45	100

Tables 6.8 and 6.9 show the distribution of types of farming activities, indicating chicken and maize as the main livestock and crop farming activities respectively.

Table 6.8: Distribution of Respondents by Type of Livestock Kept

Type	Frequency	Percentage
Cow/ Cattle	134	17
Goats	50	6
Sheep	169	22
Chicken	426	54
Rabbit	7	1
Total	786	100

Table 6.9: Distribution of Respondents by the Crops They Grow

Crop	Frequency	Percentage
Maize	58	43
Beans	42	31
Millet	2	1
Potatoes	6	4
Pasture (Napier)	9	7
Oranges	3	2
Vegetables	10	7
Tomatoes	2	1
Others: 1 each Onions, Coffee, Sorghum, Bananas	4	3
Total	136	99

Farming is supplemented by other economic activities which include illegal charcoal burning, quarrying, tourism, site hunting, wood logging, and grass harvesting.

Water Sources

The main sources of water to the residents are harvested rain water (44%) and piped water (38%). About 11% of the respondents rely on borehole and dam water (Table 5.10). The project activities should thus take precaution against pollution of both surface and ground water.

Table 6.10: Distribution of Sources of Water for Livestock and Domestic Uses

Source	Frequency	Percent
Piped	32	38
River	5	6
Tank/rain/harvest	37	44
Borehole	4	5
Dam	5	6
Bought	1	1
Total	84	100

6.2.3 Expectations

With regard to awareness of the process of geothermal power generation project implementation and operation processes, all the 131 respondents said they expected benefits and problems related to the geothermal power project's implementation. Key issues by the public and leaders in the project area are summarized in Table 6.11 below. These issues were classified as concerns, representing identified negative impacts and expectations, which represented the perceived positive project impacts.

Table 6.11: Major Impacts Expected by the Public

POSITIVE IMPACTS	NEGATIVE IMPACTS
Job Creation	Air and water pollution
Access Roads	Relocation of people
Power/Electricity supply	Human illnesses
Water Supply	Reduced crop production
Raised property/land value	Vegetation clearance
Tourist Attraction	Noise pollution
Enhanced agriculture	Acid rain
Boost Business	Reduced rainfall
Building of health Centre	Bad odor
Reduced Power bill	Fear of Volcanic eruption
Afforestation	Employment of outsiders
Building of schools	Prostitution increases
Boost Security	Human-wildlife conflicts

6.2.4 Project Improvement and Acceptance by Public

The main strategies proposed by the public were improved water and pollution control (27%), disaster preparedness and infectious disease surveillance (25% each) and sanitation programmes (23%). With regard to project acceptance, ninety eight (98%) per cent of respondents recommended implementation of the geothermal power project.

CHAPTER 7

IMPACT IDENTIFICATION, CUMULATIVE IMPACT AND RISK ANALYSIS

7.1 Impact Identification

From the description of the project activities and technologies, it is clear that the proposed project will likely modify the environment. Impact assessment is carried out in order to identify where the interactions are likely to occur between the proposed project activities and the receiving environments. A modified Leopold Matrix (LM) was used to identify and estimate the magnitudes and importance of the potential impacts. The matrix was marked with a diagonal line in the interaction box. The interactions were then described in terms of magnitude (M) in the upper section and importance (I) in the lower section. The magnitude of interaction is described by assigning values ranging from 1 (for small magnitude) to 10 for large magnitude (Table 7.1). The Lohani and Thanh (1980) relative weights were assigned to each activity of the project. Relative priority of the development activity is determined based on a scale of 1 to 10. The total value of a particular activity is the sum of vertical values by that activity and it is multiplied by the priority value (Table 7.2). It is on the basis of this interaction matrix that the potential impacts outlined in section 7.2 below were identified.

Table 7.1: Leopold Impact Identification Matrix Showing Magnitude and Importance Values

		Phases of the Project											
		Construction					Operation				Decommissioning		
Environmental Aspects	Project Activity / Resource	Transportation of Power Plant parts and construction materials	Power house	Brine sump and store	Transmission lines	Power substation	Steam abstraction	Electricity generation	Waste handling	Fluid Management	Dismantling of generator	Well capping	Wellpad rehabilitation
Physical	Water resources		1/9	2/5		2/6	4/7		3/8	4/7	1/7		
	Geology/ soil			3/4	2/5	2/4	4/5		4/5	5/6			
	Vibrations	1/6					5/8	4/8		6/7	3/6		
Biological	Flora				5/8				4/8				5/9
	Wild animals	1/6			2/7	2/6		3/5	2/6		2/8		6/8
Socio-economic	Employment/ economy	2/6	4/4	2/3	3/5	4/3	2/4	8/8	2/4	1/3	1/4	1/3	2/3
	Health	2/6	5/7	3/6	2/6	4/7	2/4	1/7	5/6	6/5	2/6	1/4	4/5
	Infrastructure	1/6	4/8		2/8	2/9		8/8			4/8		
	Local Culture	2/4			2/3	2/2		5/4					2/4

Table 7.2: Modified Leopold Matrix Showing Incorporating Lohani and Thanh Priority Values

		Phases of the Project													
		Construction					Operation				Decommissioning				
Relative Priority	Project Activity / Resource	Transportation of Power plant parts and construction materials	Power house	Brine sump and store	Transmission lines	Power substation	Steam abstraction	Electricity generation	Waste handling	Fluid Management	Dismantling of generator	Well capping	Wellpad rehabilitation	Leopold Methods	Lahani & Thanh
6	Water resources		1/9	2/5		2/6	4/7		3/8	4/7	1/7			17/49	624
1	Geology/ soil			3/4	2/5	2/4	4/5		4/5	5/6				20/29	100
4	Noise/Vibrations	1/6					5/8	4/8		6/7	3/6			19/35	552
5	Flora				5/8				4/8				5/9	14/25	585
7	Wild animals	1/6			2/7	2/6		3/5	2/6		2/8		6/8	18/46	861
9	Employment/ economy	2/6	4/4	2/3	3/5	4/3	2/4	8/8	2/4	1/3	1/4	1/3	2/3	32/50	846
10	Health	2/6	5/7	3/6	2/6	4/7	2/4	1/7	5/6	6/5	2/6	1/4	4/5	37/69	2160
3	Infrastructure	1/6	4/8		2/8	2/9		8/8			4/8			21/47	480
2	Local Culture	2/4			2/3	2/2		5/4					2/4	13/17	92
3	Religion/ historical sites				4/7	3/9								7/16	165
Lohani& Thanh		50	92	46	141	112	104	202	126	133	99	7	127		

7.1.2 Project Activities and Environmental Parameters of Importance as Depicted from Analysis

Based on the analysis in Table 7.2 above, the activity that is of relatively high priority is waste handling both gaseous and brine and geothermal modular generation unit construction. The later may be due to clearing of vegetation at the construction site. Health, wild animals and employment issues also depict somewhat pronounced Lohani values. The health impacts are due to emission of gases (H2S and GHGs) and noise. Health, wild animal and employment are major environmental and socioeconomic parameters of concern.

7.2 Cumulative Impact and Risk Analysis

For the purpose of the ESIA, the cumulative impacts were assessed by considering effects of various planned activities of the project. The Leopold, and Lohani and Thanh methods (Table 6.1 and Table 6.2) assisted to identifying major activities and in defining areas where attention is mostly needed. That information together with information available from the baseline data and professional judgment of the assessment team, constituted the basis for cumulative impact and risk analysis. The ranking scale is given in Table 6.3. Example of Consequence and Probability Ranking was used to quantify the significance of the impacts. The risk assessment model is adapted from the 'South African Department of Environmental Affairs' guideline document on EIA Regulations, April 1998. The consequence of impacts is derived by considering the following criteria:

- Severity/magnitude (how severe the impact will be);
- Duration of the impact (how long the impact may be prevalent for); and
- Spatial extent (the physical area that would be affected by the impact).

The overall probability of the impacts is regarded as the likelihood of impact occurrence based on professional judgment and guided by weighted indicators in Leopold/Lohani and Thanh methods.

The overall risk from the impact is determined by multiplying the consequence by the probability of occurrence (as illustrated below). The probability value criterion is based on subjective judgement of the professional team.

Significance of Impact = Consequence (magnitude + duration + spatial scale) x Probability

Table 7.3: Example of Consequence and Probability Ranking

Residual Magnitude / Severity	Duration	Spatial Scale	Probability
10 – Very high / Don't Know	5 – Permanent	5 – International	5 – Definite / Don't know
8 – High	4 – Long-term (impact ceases after operational life)	4 – National	4 – Highly probable
6 – Moderate	3 – Medium-term (5-15 years)	3 – Regional	3 – Medium Probability
4 – Low	2 – Short-term (0-5 years)	2 – Local	2 – Low probability
2 – Minor	1 – Immediate	1- Site only	1 – Improbable
0 – None			0 – None

Significance of Impact = Consequence (2 + 4 + 2) x 4 = 32

A case in the provided example can be noise from power plant and also from the cooling towers. The impacts are considered long-term but localized.

The maximum value that can be obtained is 100 SP. Environmental and social effects are rated High, Moderate, Low or No Impact accordingly, based on the following criteria:

- SP>75 indicates **high** environmental and social significance
- SP 50 to 75 indicates **moderate to high** environmental and social significance
- SP 30 to 50 Indicates **moderate** environmental and social significance
- SP<30 Indicates **low** environmental and social significance
- SP = 0 Indicated **no** environmental or social impact

The cumulative impacts, possible mitigation and ranking for the various activities are summarised in Table 7.4 below.

Table 7.4: Cumulative Impact Assessment, Possible Mitigation and Risk Ranking for the Various Activities

Parameter	Likely Impact	Mitigation	Residual Impact	Risk Ranking
Wildlife Habitat	Habitat integrity degradation due to noise scare Degradation of habitat with surface disposal of geothermal water Built structures altering natural environment	Development structures to be camouflaged to suit the surroundings. Muffle the sound during power generation to reduce noise. Geothermal waste-water to be re-injected	If measures are taken impacts can be mitigated	48 [(4+4+4) x 4 =48] Indicates moderate environmental and social significance
GHG and H_2S gas	Contributes to global warming (Climate change Contributes to acid rain. Respiratory diseases	Choice of technology that minimizes fluid interaction with the atmosphere	Impacts mitigated during power generation	30 [(2+4+5) x 4= 30] Indicates moderate environmental significance
Vegetation Clearance	Clearing of vegetation to give way for transmission lines and construction of sub-station	Reforestation of cleared sites	Regenerated when trees are planted	32 [(4+2+2) x 4 = 32] Indicates moderate environmental significance
Aesthetic and Scenic	Construction of structures results in cut and fill slopes and alteration of natural sceneries	Camouflaging buildings, and Landscaping to avoid interfering with scenic sites	Restored following the prescribed measures and adds tourist attraction	16 [(4+2+2) x 2= 16] Indicates low environmental significance
Socio-economic and cultural	Settlement of foreign workers; Increased disease such as HIV/AIDS Acculturation	Provide health facilities Education awareness	Highly achievable with correct mitigation measures considering that the area is metropolitan	16 [(2+4+2) x 2=16] Indicates low environmental significance

Parameter	Likely Impact	Mitigation	Residual Impact	Risk Ranking
Waste generation	Wastes oils, metal scraps generated from power house	Skim off oils from wastewater effluent, used oils repository sites and scrap metal storage and re-use	Manageable with adherence to mitigation measures	16 [(2+4+2) x 2=16] Indicates low environmental significance
Water resources	Interference with hydrology of the project area Contamination of underground and surface water bodies	Monitor changes in the area ecosystem Pump acceptable daily rates from the bore holes and balance the rest with surface water Acquire permit from WARMA Discharge drilling effluents in lined ponds	Impacts minimized with adherence to permitted abstraction rates and adherence to mitigation measures.	30 [(4+4+3) x3=33] Indicates moderate environmental significance

7.2.1 Cumulative Impacts Depicted from the Analysis

The cumulative impacts for the proposed geothermal Modular power generation unit in the project area will be low to moderate (Table 7.1) and can be mitigated. No adverse cumulative impacts are expected from implementation of the project in the area if the generation technology will minimize release of H_2S into the atmosphere. Besides, with geothermal water re-injection, no adverse effect is expected from geothermal brine.

7.3 Potential Environmental and Socio-Economic Impacts

Given that no development can take place without impacting on the environment, this chapter outlines potential impacts that are expected to occur to the bio-physical and socio-economic environments as depicted in the impact identification matrix.

7.3.1 Negative physical impacts

a) Dust and Exhaust Emissions

Aerosol contribution to the atmosphere will occur during excavation for construction of brine sump, roads and buildings, and during use of fuel-run equipments including vehicles, generators, and compressors. Oxides of nitrogen, carbon monoxide and oxides of sulphur emitted from internal combustion engines will be released during all phases of the project.

During construction, dust will result from disturbances of the surface soils and vehicle travel on unpaved roads. Dust carried by wind blowing across exposed surfaces may have deleterious effect.

Noise and Vibrations

Noise and vibrations will occur during transportation and installation of equipment, and the power generation process. Table 7.5 below shows noise levels from these operations, which may rise up to 120 decibels (dB). For comparison, noise levels in quiet suburban residences are of the order of 50 dB, noise levels in noisy urban environments are typically 80–90 dB, and the threshold of pain is 120 dB at 2,000–4,000 Hz. The Menengai wells are in a more or less secluded area, where the natural level of noise is low, ranging from 37.7 to 67.2 dB. As a result of drilling, a slight change in noise is detectable. These levels will increase during power generation. Site workers can be protected by wearing ear mufflers. With best practices, noise levels can be kept to below 65 dB, and construction noise should be practically indistinguishable from other background noises at distances of one kilometre.

Table 7.5: Geothermal Exploration and Construction Noise Levels by Operation

Operation	Noise Level (dB)
Discharging wells after drilling (to remove drilling debris)	Up to 120
Well testing	70–110
Diesel engines (to operate compressors and provide electricity)	45–55
Heavy machinery (e.g., for earth moving during construction)	Up to 90

Liquid Waste

i) Storm Water

Compaction of surface on well-sites, in roads and campsite construction will create impervious surfaces (slab environment). There is a likelihood of increased storm water runoff from these sites, which result in gully erosion with time. In addition to creating unattractive terrain, this may cause flood incidences along streams downhill during high rainfall times.

ii) Oil Spills

The machines at site and project vehicles require oils during maintenance. The oils will be transported and may be stored at project site. Any major accidental oil spill would impact negatively on the environment as a whole. Cumulatively, small releases of oil would also impact negatively on the environment. Such impacts include creation of new sceneries due to destruction of biological diversity and pollution of water and soil. But these dangers are contained by maintaining the machinery in specific areas designed for this purpose.

iii) Geothermal Waste Water

Geothermal waste water occurs at the well sites as steam condensate and also from the power plants. Depending on the cooling system, geothermal waste water is discharged at the cooling towers. The geothermal wastewater contains pollutants including heat, ammonia, CO_2, H2S, CH4, silica and toxic heavy metals such as lead, cadmium, arsenic and mercury.

Soil Erosion

The proposed project involves activities that will require clearance of areas for project infrastructure such as buildings, brine sump, power station, and electricity transmission lines and therefore excavation to construct roads and level the site, vegetation clearance, and ground vibration are expected. Such activities may loosen the soil hence making it vulnerable to erosion due to wind and surface water run-off. The fact that there is minimum cover of low-slope terrain makes it obvious that without soil erosion prevention measures in place, erosion will take place. This may impact on vegetation and quality of surface water in the environment. The creation of impervious surfaces during site preparation for infrastructure development could also cause increased erosion rates.

Water Quality Degradation

Project related excavation can lead to surface and ground water quality degradation. Excavation activities can disturb contaminated soil or ground water in the path of the project which could result in transfer of the contamination to surface waters. The excavated area, if linear could act as a conduit to extend groundwater contamination to new areas. Spills of hazardous materials in excavated areas during construction could introduce contaminants to ground water.

Development activities such as industrial operations and administration offices development as well as the spill over effect of development such as increased demand for drinking water and increased auto use can impact water quality by contributing sediment, nutrients, and other pollutants to limit water supplies, increasing the temperature of the water, and increasing the rate and volume of runoff.

Air quality and dust Impacts

The proposed site is close to discharging wells and there could possibility of the existing wells impacting the construction site with H_2S smell in the atmosphere. During the construction phase, atmospheric pollution sources include airborne dust from earthworks, and gases from construction equipment and vehicles. Air emissions from construction machinery, including dust, reduces visibility, soils private property and is aesthetically displeasing – it may also affect palatability of grazing. Dust generated by construction related activities must be minimized. There is need for vehicles speed limits within the project operation sites. The workers and permitted persons in the project site should be provided with relevant personal protective equipment (PPE).

Impacts on climate change

The proposed development will have no impact on the local climate; however geothermal power stations emit methane and carbon dioxide which are both greenhouse gases. The Modular power plants will have no significant effect on the climate of the area. An equivalent amount of electrical energy delivered by a coal-fired power station, would result in the emission of approximately much higher tonnes of carbon dioxide. Nevertheless, the quantities of these gases emitted will be substantially less than from a fuel-burning power station of a similar capacity.

Ground Subsidence

In geothermal development, geothermal fluids withdrawal rate may surpass the natural rate of replenishment. Ultimately pressure drop in the reservoir as a result of fluid withdrawal could occur leading subsidence.

In general, subsidence is greater in liquid-dominated fields because of the geological characteristics typically associated with each type of field. Ground subsidence can affect the stability of pipelines, drains, and well casings. It can also cause the formation of ponds and cracks in the ground and, if the site is close to a populated area, it can lead to instability of buildings. Fluid re-injection at proper rates and pressures reduces subsidence potential significantly.

Solid Waste Generation

During construction solid wastes will be generated. These include cement bags, plastics and timber remains among others. Dumping within the site will interfere with the aesthetic status of the area. This has a direct effect to the surrounding community. Disposal of the same solid wastes off-site could also be a social inconvenience if done in the wrong places. The off-site effects could be aesthetic, pest breeding, pollution of physical environment, invasion of scavengers and informal recycling communities.

Extraction and Use of Building Materials

Building materials such as hard core, ballast, cement, rough stone and sand required for construction in the proposed project will be obtained from quarries, hardware shops and sand deposit sites such as river beds. Since substantial quantities of these materials will be required for construction of the buildings, the availability and sustainability of such resources at the extraction sites will be negatively affected as they are not renewable in the short term.

In addition, the sites from which the materials will be extracted may be significantly affected in several ways including landscape changes, displacement of animals and vegetation, poor visual quality and opening of depressions on the surface leading to several human and animal health hazards.

Energy Consumption

The project will consume fossil fuels (mainly diesel) to run transport vehicles and construction machinery. Fossil energy is non-renewable and its excessive use may have serious environmental implications on its availability, price and sustainability.

7.3.2 Negative biological impacts

a) Vegetation

The vegetation will be cleared during construction of substation, office buildings, transmission lines, and roads. However, this impact is short-term and not significant because the spatial extent will be minimised by ensuring that vegetation disturbance is confined to construct sites. Further, the project sites can be re-vegetated with the same species after construction.

b) Fauna

The project area is a protected forest housing wildlife such as monkeys, leopards, several bird species and reptiles (Appendix 4.2 - 4.4). The most significant effect of geothermal power plant operation on the environment is noise, power transmission cables and air pollution. These may disturb the habitat, interfere with breeding and displace the animals and thus increase animal-human conflict.

If animals graze at the contaminated sites, the chemical might accumulate in the animal body and cause side effects such as mineral imbalances leading to anemia. However, geothermal effluents from the proposed project will be re-injected and sites will be fenced off. Ultimately animals' access to contaminated sites will be minimal and therefore potential impacts are unlikely to occur.

7.4 Health Impacts

Negative health impacts that are associated with geothermal power generation include respiratory diseases, nausea and headaches due to inhalation of gases such as H_2S and ear defects due to noise. Although the level of H_2S level from geothermal plants is low and within acceptable occupational limits and thus of low health risks, the odour can be a nuisance. Loss of life and impairment can occur as a result of accidents from excess exposure to H_2S during repair of confined section of power plants and even the steam systems such as the silencers. Other sources of accidents may occur during machine operations, electrocution and transport. Installation of automated H_2S detectors within working spaces is necessary to mitigate potential impacts.

7.5 Positive Socio-Economic Impacts

a) Improved infrastructure

- The project will provide a number of socio-economic benefits such as improvement of roads, which will increase the area's accessibility;
- Power and telephone network arising from the project will provide reliable and consistent energy supply and communication respectively;
- The power plant will add 90 MW of the national grid. This will go a long way to stabilize electricity supply in the country and reduce power outages during high demands

b) Business opportunities

- Construction and operation of the power plants in the proposed project area will result into influx of construction workers who will have a positive impact on the local economy in terms of improved business.
- Construction materials such as building stones and marrum may be sourced from the local communities hence enhancing their income
- The proponent will sell power generated to Kenya Power and thus earn revenue thereby contribute to national income

c) Employment

- Project activities will provide employment opportunities to the local especially in case of unskilled labour.

d) Institutional improvement

- The proponent has a clear and operational social corporate responsibility (SCR) policy which will benefit institutions such as schools and health facilities in the project area.

e) Tourism enhancement

- Geothermal power plants within the Menengai Caldera will enhance the scenery and therefore increase local tourism.
- Educational tours will definitely increase because the power plants provide unique training facilities in the area

f) Cleaner production and reduction of greenhouse gases

- Geothermal energy is considered as green energy resource and as such generation of electricity from geothermal energy is an integrated cleaner production technology.
- The proposed project replaces use of fuel energy to generate electricity.
- The environmental benefits of the proposed project are realised in terms of reduction of greenhouse gas emissions hence contributing significantly to reduction of global climate change

g) Impact on land use

- The proposed project will be located in Menengai Caldera, which is a gazetted government forest reserve.
- As such there will be no displacement of settled communities. Further, geothermal exploration drilling is already on-going in the Caldera where power plants will be located.
- The proposed project fits in the ongoing activities and therefore change of user will not be needed for the proposed project.

- However, the way leave for power transmission lines will pass through individual farms. The width of land affected will normally depend on the magnitude of the transmission line voltage and for the case of 220 kV, the way leave width may range up to 40 m.
- Way leave ensures safety of the people leaving close to the transmission lines
- The proponent will ensure that people whose land is affected by way leave are compensated appropriately.

h) Impact on health

- The influx of workers may increase pressure on local resources such as water and sanitation, which may lead outbreak of water borne disease namely dysentery, typhoid and diarrhoea.
- Similarly, the influx of workers may also come with negative impacts such as promiscuity and sexually transmitted diseases and danger of increased upsurge in HIV and AIDS infections.
- There is need for education awareness and improvement of medical facilities in the project area.

CHAPTER 8: MITIGATION MEASURES

For most projects to be implemented mechanisms for mitigating against impacts are necessary. Impacts can be mitigated by changing design, down-scaling, and change of project site or compensating affected people. In this chapter methods of mitigating against identified impacts are presented.

8.1 Mitigation of Potential Physical Impacts

8.1.1 Soil Erosion

The cleared sites need to be re-vegetated to improve soil cover and minimize soil erosion in addition to improving the aesthetics of the project area.

a) Air Quality

It is suggested that a standard set of feasible dust control measures be implemented at all phases of the project implementation. These include the following measures:

- Water all active construction areas as and when necessary to lay dust.
- Cover all trucks hauling soil, sand and other loose materials or require all trucks to maintain at least two feet of freeboard.
- Pave or apply (non-toxic) soil stabilizers on all unpaved access roads, parking areas and staging areas at construction sites.
- Sweep daily (with physical sweepers) all paved access roads, parking areas and staging areas at construction sites.
- Plant fast-growing trees around the project area to act as a wind breaks to reduce the uplift of particulate matter that lead to respiratory diseases.
- Plant suitable lawn or ornamental grasses in all open grounds within the project area

b) Noise and Vibration Pollution

Significance of noise impacts depends on whether the project will increase noise levels above the existing ambient levels by introducing new sources of noise. The proponents shall put in place several measures that will mitigate noise pollution arising during the project implementation

process. A variety of noise muffling techniques and equipment are available for geothermal facilities. The following noise-suppression techniques should be employed:

- Install portable barriers to shield noisy equipment where necessary.
- Turbine-generator buildings, should be well-insulated acoustically, and equipped with noise absorptive interior walls.
- Use quiet equipment (i.e. equipment designed with noise control elements).
- Limit trucks and other small equipment to a minimum idling time and observe a common-sense approach to vehicle use, and encourage workers to shut off vehicle engines whenever possible.
- Workers on-site will need to wear appropriate hearing protection as a necessary safety precaution to keep the environmental noise level below the 85 decibels (dB) occupational first action limit.
- In case of non-occupational, the noise level should be kept within 45 dB ambient limit.

c) Generation of Exhaust Emission

During the construction the following mitigation measures are proposed:

- Daily monitoring of air quality standards is proposed;
- Workers shall be trained on management of air pollution from vehicles and machinery.
- All construction machinery shall be maintained and serviced in accordance with the manufacturers specifications;
- Workers shall be trained on dust minimization techniques;
- The removal of vegetation shall be avoided until such time as clearance is required and exposed surfaces shall be re-vegetated or stabilized as soon as practically possible;
- Dust generating activities shall not be carried (excavation, handling and transport of soils) during times of strong winds.
- Vehicles delivering soil materials shall be covered to reduce spills and windblown dust;
- Vehicles speeds shall be limited to minimize the generation of dust on site and on diversion and access roads.

d) Water Quality Degradation

Several measures shall be put in place to mitigate the impacts that are likely to lead to water quality degradation. The proponent will:

- Prepare for emergency response program to ensure quick and safe cleanup of accidental spills.
- Oil absorbent material, traps and storage drums will be used to contain and control any minor releases of engine and other equipment oil.
- Identify areas where refueling and vehicle maintenance activities and storage of hazardous materials, if any, will be permitted.
- If excavation of hazardous materials is required, they will be handled in accordance with applicable regulations (see Chapter 3)

e) Increased Runoff

Surface runoff and roof water shall be harvested and stored in underground reservoir for reuse. A storm water management plan that minimizes impervious area infiltration by use of recharge areas and use of detention and/or retention with graduated outlet control structures will be designed. In the project vicinity, create slab only where necessary and plant lawn grass in areas with no slab and of no use in project operations. Proponent will put measures that will include terracing and levelling the project site to reduce run-off velocity and increase infiltration of rain water into the soil. In addition, construction vehicles will be restricted to designated areas to avoid soil compaction within the project site, while any compacted areas will be ripped to reduce run-off. Drainage channels along runoff paths outside project compound minimize possibility of gully erosion by creating check dams to reduce runoff erosive energy.

f) Reduction of Energy Consumption

The proponent shall ensure responsible electricity use at the construction site through sensitization of staff to conserve electricity by switching off electrical equipment or appliances when they are not being used. In addition, proper planning of transportation of materials will ensure that fossil fuels (diesel, petrol) are not consumed in excessive amounts. Complementary to these measures, the proponent shall monitor energy use during construction and set targets for reduction of energy use.

g) Minimization of Water Use

The proponent shall ensure that water is used efficiently at the site by sensitizing construction staff to avoid irresponsible water wastage and to use water efficiently. The proponent will install water-conserving automatic taps and toilets. Moreover, any water leaks through damaged pipes and faulty taps should be fixed promptly by qualified staff. Recycles of water in the cooling towers is highly encouraged to avoid over abstraction of water.

8.2 Health Impacts

Possible exposure of workers to diseases from building materials at construction site shall be mitigated by occupational health and safety standards enforcement (see ESMP Table 10.1, 10.2 and 10.3). Waterborne diseases such cholera, typhoid shall be minimized by provision of potable drinking water and proper sanitation and waste management. Proper refuse collection and handling service will be provided by the proponent so that this is not a hazard. HIV/AIDs will be reduced by awareness and sensitization programs with the Proponent's CSR policy.

8.2.1 Chemical Pollution

Re-injection of spent geothermal fluid is recommended. If disposed off on the surface, it should be in lined ponds, to prevent infiltration and percolation into the ground water. The concentration of dissolved solids and gases in geothermal water and steam are greater than in shallow ground water. Therefore, it is necessary to monitor the effect of geothermal fluid on surface water and shallow groundwater after the installation of a power plant

8.2.2 Solid and Liquid Wastes

Domestic liquid waste from the campsite and well drilling sites should be treated on site in septic tanks since there are no sewer lines in the project area. Additional recommendations for minimization of solid waste especially during construction of the project include:

- Use of durable, long- lasting materials that will not need to be replaced as often, thereby reducing the amount of construction waste generated over time
- Provision of facilities for proper handling and storage of construction materials to reduce the amount of waste caused by damage or exposure to the elements
- Purchase of perishable construction materials such as paints incrementally to ensure reduced spoilage of unused materials

- Use of building materials that have minimal packaging to avoid the generation of excessive packaging waste
- Separate and categorize solid wastes into different forms and reuse, recycle, incinerate or dispose of in carefully designated site(s) based on category.
- Oil absorbent material, traps and storage drums will be used to contain and control any minor releases of engine and other equipment oil.

8.2.3 Occupational Health and Safety

Occupational health and safety issues during construction, operation and decommissioning of the modular power generation unit should be prevented as outlined in the EMP (Tables 10.1 -10.3). The specific health and safety issues in geothermal power projects include the potential for exposure to:

- Geothermal gases
- Confined spaces
- Heat
- Noise

a) Geothermal Gases

Occupational exposure to geothermal gases, mainly hydrogen sulfide gas, may occur during non-routine release of geothermal fluids (for example, pipeline failures) and maintenance work in confined spaces such as pipelines, turbines, cellars, and condensers. The significance of the hydrogen sulfide hazard may vary depending on the location and geological formation particular to the facility.

Where there is a potential for exposure to hazardous levels of hydrogen sulfide, geothermal power facilities should consider the following management measures alongside the environmental management policy (Appendix 8):

- Installation of hydrogen sulfide monitoring and warning systems.
- Development of a contingency plan for hydrogen sulfide release events, including all necessary aspects from evacuation to resumption of normal operations;

- Provision of facility emergency response teams, and workers in locations with high risk of exposure, with personal hydrogen sulfide monitors, self-contained breathing apparatus and emergency oxygen supplies, and training in their safe and effective use;
- Provision of adequate ventilation of occupied buildings to avoid accumulation of hydrogen sulfide gas;
- Development and implementation of a confined space entry program for areas designated as 'Confined Spaces' such as turbine, condenser, and cooling water towers;
- Providing workers with a fact sheet or other readily available information about the chemical composition of liquid and gaseous phases with an explanation of potential implications for human health and safety.

b) Heat

Occupational exposure to heat occurs during construction activities, and during operation and maintenance of pipes, wells, and related hot equipment. Non-routine exposures include potential blowout accidents during drilling as well as malfunctions of the steam containments and transport installations.

Recommended prevention and control measures to address heat exposure include:

- Reducing the time required for work in elevated temperature environments and ensuring access to drinking water;
- Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc.;
- Use of personal protective equipment (PPE) as appropriate, including insulated gloves and shoes.

c) Noise

Apart from noise from well drilling, noise sources in geothermal power generation facilities are associated with steam flashing and venting. Other sources include equipment related to pumping facilities, turbines, and temporary pipe flushing activities.

Noise abatement technology includes the use of rock mufflers, sound insulation, and barriers during drilling, in addition to silencers on equipment in the steam processing facility. Occupational noise and vibration should be managed by the use of appropriate PPE.

d) Community Health and Safety

Community health and safety issues during the operation of geothermal power generation unit include:

- Exposure to hydrogen sulfide gas
- Infrastructure safety
- Water pollution
- Noise pollution

e) Hydrogen Sulfide

There are no ambient air quality criteria for hydrogen sulphide currently in force in Kenya. As an interim measure it is suggested that the WHO 24-hour guideline should be used to assess impacts beyond the immediate power station boundary. The approach adopted here is to select criteria that protect human health, local crops and fauna, but will not protect all areas against an odour impact. The WHO (1987) provides useful guidance in this respect (for non-occupational exposure), where it states the following:

- 15mg/m^3 (9.9 ppm) is recommended for lowest-adverse health effect of hydrogen sulphide
- A guideline value of 0.10 ppm (0.15mg/m^3) with an averaging time of 24-hours
- To avoid odour annoyance among the exposed population, hydrogen sulphide concentrations should not be allowed to exceed 0.0046 ppm (7mg/ m^3) , with a 30 minute averaging period
- Installation of a hydrogen sulfide gas monitoring network in the project area and continuous operation of the hydrogen sulfide gas monitoring systems to facilitate early detection and warning;
- Emergency planning involving community input to allow for effective response to monitoring system warnings.

f) Infrastructure Safety

Communities may be exposed to physical hazards associated with the wells and related pipeline networks. Hazards may result from contact with hot components, equipment failure, or the presence of active and abandoned well infrastructure which may generate confined space or falling hazards.

Recommended management techniques to mitigate these impacts include:

- Placement of access deterrents, such as fences and warning signs, to prevent access and warn of existing hazards;
- Minimizing the length of necessary pipeline system is the case in the proposed modular power generation unit;
- Consideration of the feasibility of subsurface pipelines or heat shields to prevent public contact with hot geothermal pipelines;
- Managing closure of infrastructure such as pipelines and access roads, including: cleaning, disassembly, and removal of equipment;

g) Water Pollution

Water pollution can result from acid rainfall due to release of gasses from the power generation plant into the atmosphere, poor sanitation at camp and well sites, accidental or deliberate release of waste waters from power generation systems into surrounding water catchment (read runoff) and aquatic environments, and oil leakages from machines.

h) Noise Pollution

Noise pollution will occur during all phases of the project and sources include vehicle movements, during construction, from fuelled electricity generators, vehicle movements, and drilling. This will affect mainly workers.

These can be managed through:-

- Use of PPE by all workers;
- Controlled vehicular movements and hooting;
- Ensuring all machinery are well serviced and tuned up.

8.3 Biological Impacts

Rehabilitation of cleared vegetation needs to be carried out. The constructional and project operational sites especially effluent dumping sites should be fenced off to avoid access by animals. This will also ensure that any disturbance to flora and fauna is restricted to the actual project area and avoid spill over effects on the neighbouring areas.

In the same vein, there will be strict control of construction vehicles to ensure that they operate only within the area to be disturbed by access routes and other works**.**

Another important measure aimed at reducing disturbance of vegetation in the project area will be preservation of individual trees within the site. In addition, the proponent should re-vegetate disturbed areas through implementation of a well designed landscaping programme. It is recommended that part of the topsoil excavated from the construction site be re-spread in areas to be landscaped to enhance plant health.

Wildlife should be kept off the construction and operation sites by fencing. The structures should be camouflaged to integrate with the natural environment to reduce visual intrusion. Besides, noise and vibrations should minimized (see sub-section 8.1.3) to avoid scaring the animal from their habitats. This latter measure can help reduce human-wildlife conflict.

8.4 Social and Cultural Impacts

The proponent should have a programme for educating the workers and the public by providing information about HIV/AIDS transmission and preventative measures.

Construction will take place away from sites of national significance such as archaeological, historical, fossil or heritage sites. Thus, it will not intrude the protected areas.

8.5 Decommissioning Phase Impacts

8.5.1 Efficient Solid Waste Management

Solid waste resulting from demolition or dismantling works will be managed as described in Section 8.2.2.

8.5.2 Reduction of Dust Concentration

High levels of dust concentration resulting from demolition or dismantling works will be minimized as described in Section 8.1.3 and 8.1.5

8.5.3 Minimization of Noise and Vibration

Significant impacts on the acoustic environment will be mitigated as described in Section 8.1.5.

CHAPTER 9

ANALYSIS OF PROJECT ALTERNATIVES

9.1 No Project Alternative

The No Project Alternative option in respect to the proposed project implies that the status quo is maintained. This option is the most suitable alternative from an extreme environmental perspective as it ensures non-interference with the existing conditions. Under the No Project Alternative, the proponent's proposal would not need to seek any approval from NEMA. The proposed geothermal development project would not take place. This option will, however, involve several losses both to the proponent, the community and the Country as a whole.

The 'No Project Option' is the least preferred from the socio-economic and partly environmental perspective due to the following factors:

- The Kenyan Government requires energy resources to spur Vision 2030 and 'No Project Option' will impact that negatively.
- Reduced business opportunities due to lack of infrastructure in the proposed project area
- Reduced interaction both at local, national and international levels by the community, hence education and general awareness is a major loser
- No employment opportunities will be created for the local community in project area and for Kenyans in general who would have worked in the proposed project area.
- Increased urban poverty and crime in Kenya.
- Discouragement for investors.
- Development of infrastructural facilities (roads, electrical etc.) will not be undertaken.
- Lack of development, research and innovation in the Country.
- Loss of money by government because money has been spent on exploration and well drilling phases.

In addition, the anticipated environmental impacts resulting from pre-construction and construction phases of the proposed project are insignificant. From the analysis above, it becomes apparent that the 'No Project' alternative is not the best alternative to the local people, other Kenyans, and the government of Kenya.

9.2 The Proposed Development Alternative

9.2.1 Assessments of Alternative Energy Sources

The proposed project area is within 15 km from the 132 kV double circuit Tororo – Lessos - Juja line and about 30 km to the Lanet KPLC 132 kV substation. GDC uses part of power from KP and could continue buying all the power from Kenya Power (KP) for exploration drilling without installing 3 × 30 MW Modular Power Plants. However this would not assist GDC to fulfil its mandate of accelerated power production to drive the Kenya Governments Vision 2030.

8.2.2 Construction of the proposed 3 × 30 MW Modular Power Plants

The Proponent plans to construct 3 × 30 MW Modular Power Plants using modular generation unit technology. In geothermal power development, the size of a power plant is determined primarily by resource characteristics, cost, which normally decreases when larger quantities of materials, including steel, concrete, oil, and fuel, are purchased at one time. The other factors that favour large geothermal plants include high transmission costs; regardless of plant size (this includes land use and rights-of-way fees). Development of smaller modular geothermal generation unit at Menengai as proposed by the proponent is preferable because:

- It will allow the proponent to understand the potential of the resource through continued use before expanding the production;
- Smaller plants require less time to process operation permit (in some countries such as USA);
- The production tax credit (PTC) induces developers to construct smaller plants that can qualify for the short timeframe of the PTC;
- Reduces the costs associated with steam piping;
- It will enoble faster access to electricity to meet the Country's current power deficit and also to accelerate investment in the country;

- It will displace the use of diesel for powering GDC's drilling rigs, thereby reduce drilling costs

On the basis of the above mentioned factors, the larger power plant is a feasible option considering magnitude of drilled and tested wells at proposed project site..

9.2.3 Geothermal Power Plants technology options

Geothermal plants rely upon one or a combination of three types of conversion technologies – binary, dry steam and flash steam – to utilize the thermal energy from the hot subsurface fluids and produce electricity. After the thermal energy has been used to turn the turbine, spent steam is condensed back to a liquid and injected into the ground where it is reused in the geothermal system, prolonging the lifetime of reservoir and geothermal plant. Electricity is then transported by transmission lines into the national grid.

The following four options are available to the proponent:

- **Dry steam plant** that makes use of a direct flow of geothermal steam (Figure 9.1).

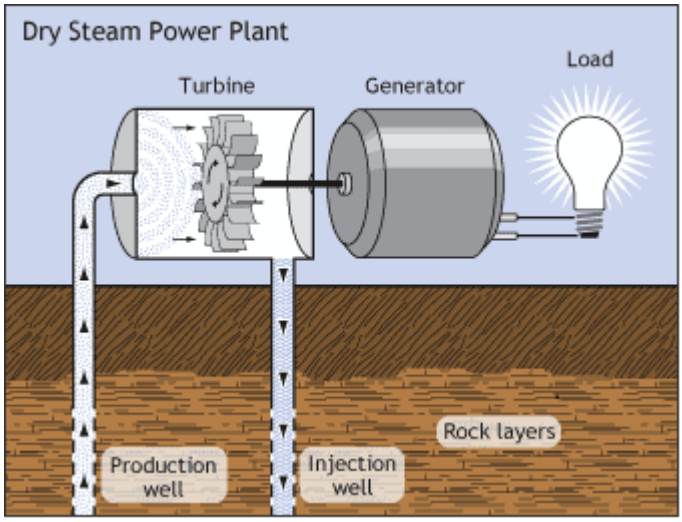

Figure 9.1: Schematic Diagram of Dry Steam Plant

- However the nature of the geothermal resource at the Menengai Caldera is water mixed with steam and thus dry steam plant is not appropriate. The next most common type of power plant is the flash (Figure 8.2) below.

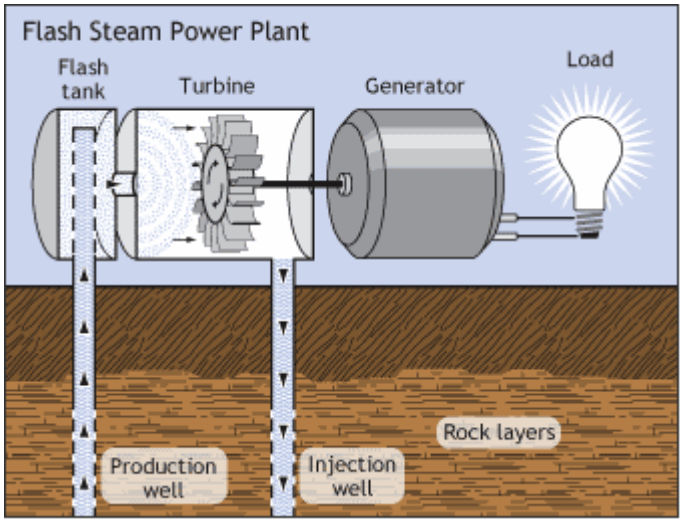

Figure 9.2: Schematic Diagram of Flash Power Plant

Flash power plants typically require resource temperatures in the range of 177^{o}C to 260^{o}C. A number of technology options can be used with a flash system. Double flashing, the most popular of these, is more expensive than a single flash, and could concentrate chemical components if they exist in the geothermal water. Despite the potential drawbacks, most geothermal developers agree that double flash is more effective than single flash because a larger portion of the resource is used.

Binary geothermal plants (Figure 9.3) are an option that is available on market. It functions as closed loop system that makes use of resource temperatures as low as (74^{o}C) and as high as 177^{o}C. Approximately 15 percent of all geothermal power plants utilize binary conversion technology. A Rankine cycle, which converts heat into work**,** is the commercial binary cycle. In the binary process, the geothermal fluid, which can be either hot water, steam, or a mixture of the two, heats another liquid such as isopentane or isobutane (the "working fluid"), that boils at a lower temperature than water. Geothermal fluids never make contact with the atmosphere before they are pumped back into the underground geothermal reservoir. Because the geothermal water never flashes in air-cooled binary plants, 100 percent can be injected back into the system through a closed loop. This serves the dual purpose of reducing already low emissions to near zero, and also maintaining reservoir pressure, thereby extending project lifetime

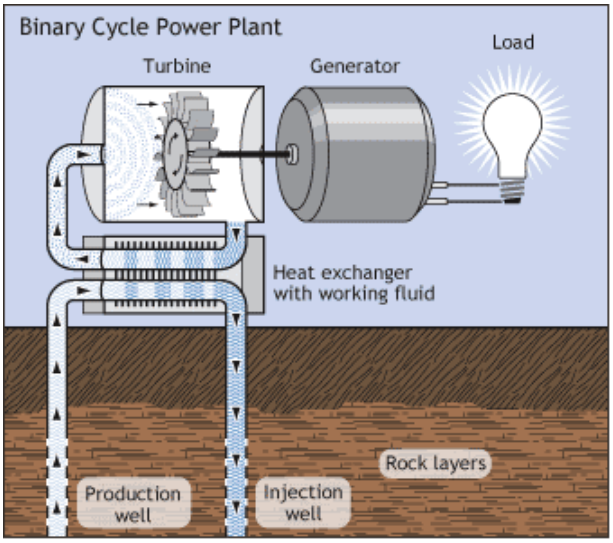

Figure 9.3: Schematic Diagram of Binary Cycle Power Plant

Since the steam pressure in the vaporizer/heat exchanger remains above atmospheric pressure, the noncondensable gases (NCG) can be reinjected together with cooled-geothermal fluid or simply vented without the need for a power consuming vacuum pump. A combination of flash and binary technology, known as the flash/binary combined cycle (Figure 9.4), and also referred to as the Hybrid power plant technology has been used effectively to take advantage of both flash and binary technologies. In this type of plant, the flashed steam is first converted to electricity with a steam turbine, and the low-pressure steam exiting the backpressure turbine is condensed in a binary system. This allows for the effective use of air cooling towers with flash applications and takes advantage of the binary process. The flash/binary system has a higher efficiency where the well-fields produce high pressure steam.

For a high enthalpy water-dominated resource, the most effective power plant configuration may be integration of a combined cycle for the steam and a standard binary unit for the separated brine into one unified plant. In this case, each unit operates with common controls, fluid collection, and reinjection systems. The developer must closely monitor the injection water temperature in combined cycle systems, as declines could occur that lead to scaling. As with any geothermal conversion technology, proper management is critical. Of the four available to developers, one of the fastest growing is the binary cycle, which includes a Rankine cycle engine.

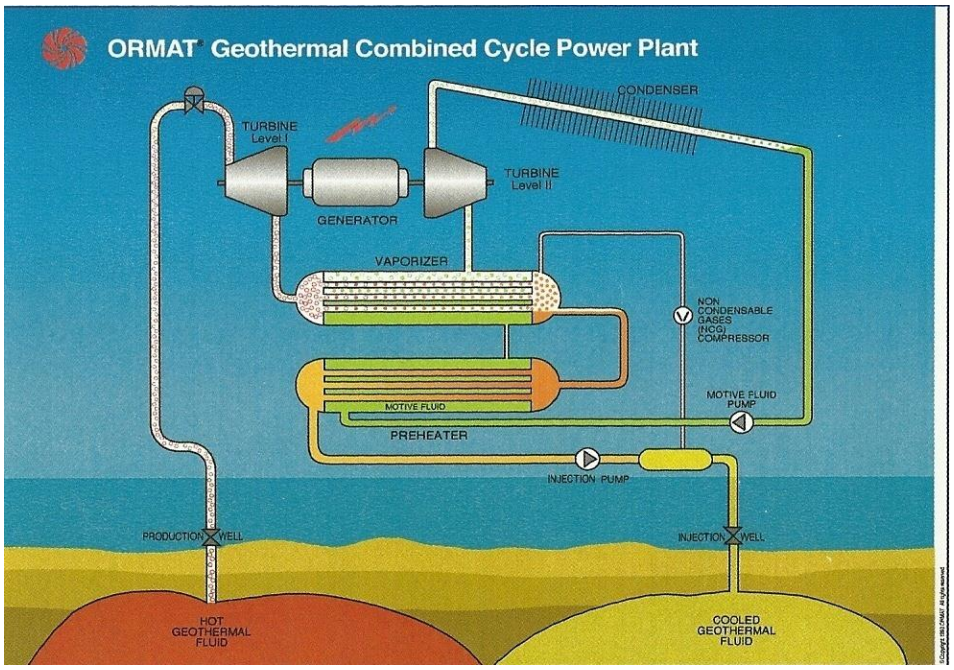

Figure 9.4: Schematic Diagram of Flash/Binary Combined Cycle

9.2.4 Hybrid Model (Combined Heat and Power)

At certain resource locations and under favorable circumstances, geothermal resources can be used both to produce electricity and also for direct use purposes. Such arrangement takes the hybrid model. The hybrid model (CHP) increases net efficiency, improves power plant economics, and creates jobs. The hybrid model essentially takes the "waste" heat produced by geothermal electric plants and uses it for other useful purposes. Cascading water from a geothermal power plant provides energy for direct use projects such as greenhouse and fish pond heating, industrial applications, cereal drying, spa and pool heating.

Some geothermal fluids contain significant concentrations of dissolved minerals, which can be recovered. Mineral recovery offers several benefits, which include improvement of the function of the power plant (reducing scaling, allowing greater power production by lowering the injection temperature), or increased profits (through the sale of mineral by-products). Minerals found at geothermal power plants include zinc, silica, lithium, manganese, boron, lead, silver, antimony and strontium depending on the prevailing geochemistry.

In case of the Menengai geothermal field, silica is high and could be a potential candidate for recovery. Silica has high commercial demand as it is useful additive in products such as paint, paper, tires, and toothpaste.

9.2.5 Conversion Technology Selection Criteria

Resource characteristics—temperature, pressure, volumes of fluid produced, and chemical properties of the geothermal reservoir—are the primary determinants of the size and type of power conversion equipment. Assuming sufficient volumes of fluid are produced, temperature determines the most efficient conversion design. The enthalpy of MW-01 is 1250 KJ/kg and given that pressure (9.42 bars) and steam flow (40 T/hr) are high, the conversion technology will be dependent majorly on temperature. Since the Menengai field temperature is high (Over 250^{o}C) binary plants can be utilized.

High temperature resources are most economical when steam or flash systems are employed, as these are simpler and therefore less costly. Flash systems are less expensive than binary systems especially under high temperatures. Steam plant equipment costs rise as temperature decreases (as a result of efficiency losses). Despite a more complex design, binary power systems are generally less expensive than steam systems for temperature close to 177^{o}C. The cost of binary systems rises as temperature drops. Binary systems may be preferred in highly sensitive environmental areas, since they operate as closed-loop, virtually emissions-free systems.

9.2.6 Cooling Systems

A cooling system, which condenses the working fluid, is essential for the operation of any modern geothermal power plant. A cooling tower provides a greater temperature and pressure differential across the turbine to increase efficiency.

a) Water Cooled

Most geothermal plants use water-cooled systems – typically in cooling towers. As these are more efficient, they generally require less land than air-cooled systems. Water-cooled systems are less expensive to build and operate if water is readily available and inexpensive to obtain. These systems lose most of the water to the atmosphere by evaporation in the form of water vapor, while the remainder is injected back into the system.

Emissions from a wet cooling tower (i.e. water vapor plus dissolved solids and H_2S) depend upon the quality of the geothermal liquid injected back through the system. Water cooling is mostly used in higher-temperature non- binary facilities due to the use of the geothermal fluid for cooling. Otherwise it is less preferred for binary geothermal power plants.

b) Air Cooled

Because the efficiency of power generation is affected by the difference between the temperature of the fluid exiting the turbine and the temperature of the cooling medium, air-cooled systems are influenced by seasonal changes in air temperature. These systems can be extremely efficient in temperate climates during winter months, but are less efficient in hotter seasons or in the tropics where the contrast between the air and water temperature is insignificant.

It is estimated that efficiency in air cooled systems decreases by 15 percent in warmer climates. This means that an air-cooled plant is least efficient in the tropics where temperatures are mostly warm throughout the year. However, the system is beneficial in areas where extremely low emissions are desired, where water resources are limited, or where the view of the landscape is particularly sensitive to the effects of vapor plumes (as vapor plumes are only emitted into the air by water cooling towers).

CHAPTER 10

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

10.1 Introduction

Environmental and Social Management Plan (ESMP) for development projects provides a logical framework within which identified negative environmental impacts can be mitigated and monitored. In addition the EMP assigns responsibilities of actions to various actors and provides a timeframe within which mitigation measures and monitoring can be done. EMP is a vital output of an ESIA as it provides a checklist for project monitoring and evaluation. The EMP outlined in Tables 10.1-10.3 considers mitigation measures for impacts during construction, Operation and decommissioning respectively. The EMP addresses the identified potential negative impacts and mitigation measures of the proposed project during Construction, Operation and decommissioning phases, based on identified environmental impacts and mitigation measures (See Chapters 7 & 8).

10.2 Construction Phase ESMP

The necessary objectives, activities, mitigation measures, and allocation of costs and responsibilities pertaining to prevention, minimization and monitoring of significant negative impacts and maximization of positive impacts associated with the construction phase of proposed Project are outlined in Table 10.1 below. In this phase, most of the environmental responsibilities are borne by the contractor. The proponent is however required to ensure that these responsibilities are covered in the terms of reference for the contractor. One of the proponent's main responsibilities will be to ensure adherence to environmental requirements by the contractor.

Table 10.1: Construction Phase Environmental and Social Management Plan for the Proposed Project

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Minimize solid waste generation and ensure efficient solid waste management during construction				
Increased solid waste generation	Use of an integrated solid waste management system i.e. through a hierarchy of options: 1. Source reduction 2. Recycling 3.Composting and reuse 4. Combustion 5. Sanitary land filling	Proponent & Contractor	Throughout construction period	1,000
	Through accurate estimation of the sizes and quantities of materials required, order materials in the sizes and quantities they will be needed rather than cutting them to size, or having large quantities of residual materials	Proponent & Contractor	Continuous	0
	Ensure that construction materials left over at the end of construction will be used in other projects rather than being disposed off.	Proponent & Contractor	One-off	0
	Ensure that damaged or wasted construction materials including cabinets, doors, plumbing and lighting fixtures, marbles and glass will be recovered for refurbishing and use in other projects	Proponent & Contractor	One-off	8,000
	Donate recyclable/reusable or residual materials to local community groups, institutions and individual local residents or homeowners.	Proponent & Contractor	One-off	0
	Use of durable, long-lasting materials that will not need to be replaced as often, thereby reducing the amount of construction waste generated over time	Proponent & Contractor	Throughout construction period	To be based on type of use selected
	Provide facilities for proper handling and storage of construction materials to reduce the amount of waste caused by damage or exposure to the elements	Proponent & Contractor	One-off	6,000
	Purchase of perishable construction materials such as paints should be done incrementally to ensure reduced spoilage of unused materials	Proponent& Contractor	Throughout construction period	0
	Use building materials that have minimal or no packaging to avoid the generation of excessive packaging waste	Proponent& Contractor	Throughout construction period	0

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Increased solid waste generation	Use construction materials containing recycled content when possible and in accordance with accepted standards.	Proponent & Contractor	Throughout construction period	0
	Reuse packaging materials such as cartons, cement bags, empty metal and plastic containers to reduce waste at the site	Proponent & Contractor	Throughout construction period	0
	Dispose waste more responsibly by dumping at designated dumping sites or landfills only.	Proponent & Contractor	Throughout construction period	20,000
	Waste collection bins to be provided at designated points on site	Proponent& Contractor	Throughout construction period	85,000
	Private waste disposal company to be contracted to transport and dispose the solid waste from site	Proponent & Contractor	Throughout construction period	
	Running an educational campaigns amongst employees, e.g. through use of posters, to encourage reuse or recycling of the solid waste	Proponent & Contractor	Throughout construction period	
Reduce dust emissions				
Dust emission during construction of site infrastructure and transportation of machinery such as modular power generation equipment and their accessories	Ensure strict enforcement of on-site speed limit regulations	Proponent & Contractor	Throughout construction period	20,000
	Avoid excavation works in extremely dry weathers	Proponent & Contractor	Throughout construction period	
	Sprinkle water on graded access routes when necessary to reduce dust generation by construction vehicles	Proponent& Contractor	Throughout construction period	
	Personal Protective equipment to be worn	Proponent	Throughout construction period	
Minimization of exhaust emissions				
Exhaust emission	Vehicle idling time shall be minimized	Proponent & Contractor	Throughout construction period	0
	Sensitise truck drivers to avoid unnecessary racing of vehicle engines at loading/offloading points and parking areas, and to switch off or keep vehicle engines at these points	Proponent & Contractor	Throughout construction period	0

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Minimization of noise and vibration				
Noise and vibration during construction and generation	Sensitise construction vehicle drivers and machinery operators to switch off engines of vehicles or machinery not being used.	Proponent & Contractor	Throughout construction period	0
	Sensitize construction drivers to avoid running of vehicle engines or hooting especially when passing through sensitive areas such as churches, residential areas and hospitals	Proponent & Contractor	Throughout construction period	0
	Ensure that construction machinery are kept in good condition to reduce noise generation	Proponent & Contractor	Throughout construction period	3,000
	Ensure that all generators and heavy-duty equipment are insulated or placed in enclosures to minimize ambient noise levels	Proponent & Contractor	Throughout construction period	15,000
	Workers on-site will need to wear appropriate hearing protection as a necessary safety precaution	Proponent & Contractor	Throughout construction period	5,000
	The noisy construction works will entirely be planned to be during daytime when most of the neighbours will be at work	Proponent &Contractor	Throughout construction period	0
	Comply with the provisions of Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009 regarding noise limits at the workplace	Proponent & Contractor	Throughout construction period	0
Minimization of energy consumption				
Increased energy consumption	Ensure electrical equipment, appliances and lights are switched off when not being used	Proponent & Contractor	Throughout construction period	0
	Install energy saving fluorescent tubes at all lighting points instead of bulbs which consume higher electric energy	Proponent & Contractor	Throughout construction period	5,000
	Ensure planning of transportation of materials to ensure that fossil fuels (diesel, petrol) are not consumed in excessive amounts	Proponent & Contractor	Throughout construction period	9,000
	Monitor energy use during construction and set targets for reduction of energy use.	Proponent & Contractor	Throughout construction period	940

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Minimize water consumption and ensure more efficient and safe water use				
High water demand	Install water conserving taps that turn-off automatically when water is not being used	Proponent & Contractor	One-off	-
	Promote recycling and reuse of water as much as possible	Proponent & Contractor	Throughout construction period	5,500
	Install a discharge meter at water outlets to determine and monitor total water usage	Proponent & Contractor	One-off	300
	Promptly detect and repair of water pipe and tank leaks	Proponent & Contractor	Throughout construction period	5,500
	Sensitise staff to conserve water by avoiding unnecessary water use	Proponent & Contractor	Throughout construction period	2,500
	Provide for breathers along the pipeline to minimize pipe busts	Proponent & Contractor	Throughout construction period	2,500
Minimize release of liquid effluent				
Generation of wastewater	Provide means for handling sewage generated by construction workers	Proponent & Contractor	One-off	5,000
	Monitor spent geothermal fluids quality regularly to ensure that the stipulated discharge rules and standards are not violated	Proponent	Throughout construction period	2,000
	re-inject all geothermal fluids underground	Proponent	Throughout construction period	4,000
Minimize occupational health and safety risks				
Posting of abstract of Act, rules and notices	There shall be displayed at prominent places within the site the prescribed abstract of the OSHA and the relevant notices as stipulated in section 121 of the OSHA, 2007.	Proponent & Contractor	One-off	2,500
Incidents, accidents and dangerous occurrences.	Ensure that provisions for reporting incidents, accidents and dangerous occurrences during construction using prescribed forms obtainable from the local Occupational Health and Safety Office (OHSO) are in place.	Proponent & Contractor	Throughout construction phase	4,000
	Enforcing adherence to safety procedures and preparing contingency plan for accident response in addition safety education and training shall be emphasized.	The Contractor, Proponent	Throughout construction phase	24,400

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Insurance	Ensure that the premises are insured as per statutory requirements (third party and workman's compensation)	Proponent	Annually	-
Safety, health and environment (SHE) policy	Develop, document and display prominently an appropriate SHE policy for construction works	Proponent & Contractor	One-off	2,500
Health and safety committee	Provisions MUST be put in place for the formation of a Health and Safety Committee, in which the employer and the workers are represented	Proponent & Contractor	One-off	5,500
Sanitary conveniences	Suitable, efficient, clean, and adequate sanitary conveniences should be provided for workers	Proponent & Contractor	One-off	5,000
Medical examination	Arrangements MUST be in place for the medical examination of all employees before, during and after termination of employment	Proponent & Contractor	Throughout construction phase	500
Machinery/equipment safety	Ensure that machinery, equipment, personal protective equipment, appliances and hand tools used in construction and power generation do comply with the prescribed safety and health standards and be appropriately installed, maintained and safeguarded	Proponent & Contractor	One-off	5,000
	Ensure that equipment and work tasks are adapted to fit workers and their ability including protection against mental strain	Proponent & Contractor	Throughout construction phase	3,000
	All machines and other moving parts of equipment MUST be enclosed or guarded to protect all workers from injury	Proponent	One-off	2,000
	Train and supervise workers regarding construction and power generation machinery and other procedures/operations	Proponent	Throughout construction phase	5,000
	Equipment such as fire extinguishers MUST be examined by a government authorized person. The equipment may only be used if a certificate of examination has been issued	Proponent	Throughout construction phase	500
	Reports of such examinations MUST be presented in prescribed forms, signed by the assessor and attached to the general register	Proponent	Throughout construction phase	30 per examination

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Storage of materials	Ensure that materials are stored or stacked in such manner as to ensure their stability and prevent any fall or collapse	Proponent	Throughout construction phase	8,000
	Ensure that items are not stored/stacked against weak walls and partitions	Proponent	Throughout construction phase	_
Emergency preparedness and evacuation procedures	Design suitable documented emergency preparedness and evacuation procedures to be used during any emergency	Proponent & Contractor	One-off	500
	Such procedures MUST be tested at regular intervals	Proponent & Contractor	Every 3 months	500
	Ensure that adequate provisions are in place to immediately stop any operations where there in an imminent and serious danger to health and safety and to evacuate workers	Proponent & Contractor	One-off	18,000
	Ensure that the most current emergency telephone numbers posters are prominently and strategically displayed within the construction site	Proponent & Contractor	One-off	300
	Provide measures to deal with emergencies and accidents including adequate first aid arrangements	Proponent & Contractor	Throughout construction phase	2,500
First Aid	Well stocked first aid box which is easily available and accessible should be provided within the premises	Proponent & Contractor	One-off	5,800
	Provision MUST be made for persons to be trained in first aid, with a certificate issued by a recognized body.	Proponent & Contractor	One-off	10,000
Ensure the general safety and security of the site and surrounding areas				
Increased Pressure on Infrastructure	Coordinate with other planning goals and objectives for the region	Proponent& Contactor	Throughout construction phase	100,000
	Upgrade existing infrastructure and services, if and where feasible.	Proponent& Contactor	Throughout construction phase	

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	**Cost (Kshs. 000)**
High socio-economic interest of the communities	Have a clear employment policy for the locals and implement it fairly to all neighbouring communities	Proponent & GOK	Throughout construction phase	
	Allow access of the community to their grazing grounds and have regular consultations on matters pertains the grazing grounds and geothermal exploration interface	Proponent & GOK	Throughout construction phase	0
Insecurity	Ensure the general safety and security at all times by providing day and night security guards and adequate lighting within and around the construction site.	Proponent & Kenya Police	Throughout construction phase	100,000
	Body-search the workers on entry, to avoid getting weapons on site, and leaving site to ensure nothing is stolen.	Proponent	Throughout construction phase	
	Ensure only authorized personnel get to the site	Proponent	Throughout construction phase	
Environmental monitoring of the project				
Environmental concern during the construction phase	Due to the magnitude of the project the proponent will monitor construction phase and ensure that the conditions of approval are adhered to.	Proponent, Contractor , NEMA and Environment Consultant	Throughout construction phase	20,000

10.3 Operation Phase

The operation phase will involve production of power using the modular generators units to be installed. Table 10.2 below proposes an environment management plan in cases where the wells pass suitability test and construction and installation phases are accomplished. Noteworthy, some of the related environmental concerns are similar to those related to earlier phases.

Table 10.2: Operation Phase Environmental and Social Management Plan for the Proposed Project

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (KShs. 000)
Balance pressure of strata above geothermal aquifer				
Increased possibility of subsidence due to higher rate of steam extraction compared to rate of natural replenishment of fluids	Reinject into the geothermal system spent geothermal liquids; Carry out regular geophysical monitoring to detect any changes related to subsidence in the project area and immediate environs	Proponent	At least twice per year	40,000/yr (assuming no hiring required for equipment)
Minimize solid waste generation and ensure efficient solid waste management during construction				
Increased solid waste generation	Use of an integrated solid waste management system i.e. through a hierarchy of options: 1. Source reduction 2. Recycling 3.Composting and reuse 4. Combustion 5. Sanitary land filling	Proponent	Continuous	20,000
	Donate recyclable/reusable or residual materials to local community groups, institutions and individual local residents or homeowners.	Proponent	One-off	0
	Dispose waste more responsibly by dumping at designated dumping sites or landfills only.	Proponent	Continuous	20,000
	Waste collection bins to be provided at designated points on site	Proponent	Continuous	85,000
	Private waste disposal company could be contracted to transport and dispose the solid waste from site	Proponent	Continuous	
	Running an educational campaigns amongst employees, e.g. through use of posters, to encourage reuse or recycling of the solid waste	Proponent	Continuous	
Reduce dust emissions				
Dust emission during operation phase	Ensure strict enforcement of on-site speed limit regulations	Proponent	Continuous	200,000/yr
	Avoid excavation works in extremely dry weathers	Proponent	Continuous	
	Sprinkle water on graded access routes when necessary to reduce dust generation by construction vehicles	Proponent	Continuous	
	Plant unused areas of site-compound with lawn or ornamental vegetation	Proponent	Continuous maintenance	
	Personal Protective equipment to be worn	Proponent	Continuous	

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Minimization of exhaust emissions				
Exhaust emission	Vehicle idling time shall be minimized	Proponent	Continuous	0
	Equipment shall be properly tuned and maintained	Proponent	Continuous	100,000/yr
	Sensitise all resident and visiting drivers to avoid unnecessary racing of vehicle engines when in project site and its immediate environs.	Proponent	Continuous	0
Minimization of noise and vibration				
Noise and vibration during operation	Sensitise all vehicle drivers and machinery operators to switch off engines of vehicles or machinery not being used.	Proponent	Continuous	0
	Sensitize all drivers to avoid gunning of vehicle engines or hooting especially when passing through sensitive areas such as churches, residential areas and hospitals	Proponent	Continuous	0
	Ensure that construction machinery are kept in good condition to reduce noise generation	Proponent	Continuous	23,000
	Ensure that all generators and heavy-duty equipment are insulated or placed in enclosures to minimize ambient noise levels	Proponent	Continuous	15,000
	Workers on-site will need to wear appropriate hearing protection as a necessary safety precaution Unpermitted persons and animals should be kept off the drilling and construction site by fencing off the site. Within the project area, keep noise level below the 85 decibels	Proponent	Continuous	50,000
	Comply with the provisions of Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009 regarding noise limits at the workplace	Proponent	Continuous	0

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Minimization of energy consumption				
Increased energy consumption	Ensure electrical equipment, appliances and lights are switched off when not being used	Proponent	Continuous	0
	Install energy saving fluorescent tubes at all lighting points instead of bulbs which consume higher electric energy	Proponent	Continuous	5,800
	Ensure planning of transportation of materials to ensure that fossil fuels (diesel, petrol) are not consumed in excessive amounts	Proponent	Continuous	9,000
	Monitor energy use during operation and set targets for reduction of energy use.	Proponent	Continuous	940
Minimize water consumption and ensure more efficient and safe water use				
High water demand	Install water conserving taps that turn-off automatically when water is not being used	Proponent	One-off	-
	Promote recycling and reuse of water as much as possible	Proponent	Continuous	5,500
	Install a discharge meter at water outlets to determine and monitor total water usage	Proponent	One-off	300
	Promptly detect and repair of water pipe and tank leaks	Proponent	Continuous	5,500
	Sensitise staff to conserve water by avoiding unnecessary water use	Proponent	Continuous	2,500
	Provide for breathers along the pipeline to minimize pipe busts	Proponent	Continuous	2,500
Minimize release of liquid effluent				
Generation of wastewater	Provide means for handling sewage generated by site workers	Proponent	One-off	25,000
	Re-inject spent geothermal fluids back into the geothermal system.	Proponent	Continuous	10,000
	Potential for contamination of groundwater by re-injected fluids should be minimized by installation of leak-proof well casings in the injection wells	Proponent &Contractor	One-off	5,000
	Consider use of binary power generation technology that reuses rejected geothermal fluids	Proponent	Continuous	-
	Monitor geothermal effluent quality regularly to ensure that the stipulated discharge rules and standards are not violated	Proponent	Continuous	2,000

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Minimize occupational health and safety risks				
Posting of abstract of Act, rules and notices	There shall be displayed at prominent places within the site the prescribed abstract of the OSHA and the relevant notices as stipulated in section 121 of the OSHA, 2007.	Proponent	One-off	2,500
Incidents, accidents and dangerous occurrences.	Ensure that provisions for reporting incidents, accidents and dangerous occurrences during operation phase using prescribed forms obtainable from the local Occupational Health and Safety Office (OHSO) are in place.	Proponent	Continuous	24,000
	Enforcing adherence to safety procedures and preparing contingency plan for accident response in addition safety education and training shall be emphasized.	Proponent	Continuous	24,400
Insurance	Ensure that the premises are insured as per statutory requirements (third party and workman's compensation)	Proponent	Annually	-
Safety, health and environment (SHE) policy	Develop, document and display prominently an appropriate SHE policy for operation works	Proponent	One-off	2,500
Health and safety committee	Provisions MUST be put in place for the formation of a Health and Safety Committee, in which the employer and the workers are represented	Proponent	One-off	5,500
Sanitary conveniences	Suitable, efficient, clean, and adequate sanitary conveniences should be provided for workers	Proponent	One-off	5,000
Medical examination	Arrangements MUST be in place for the medical examination of all employees before, during and after termination of employment	Proponent	Continuous	500
Machinery/equipment safety	Ensure that machinery, equipment, personal protective equipment, appliances and hand tools used in construction and power generation do comply with the prescribed safety and health standards and be appropriately installed maintained and safeguarded	Proponent	One-off	5,000
	Ensure that equipment and work tasks are adapted to fit workers and their ability including protection against mental strain	Proponent	Continuous	3,000

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Machinery/equipment safety	All machines and other moving parts of equipment MUST be enclosed or guarded to protect all workers from injury	Proponent	One-off	2,000
	Train and supervise workers regarding construction and power generation machinery and other procedures/operations	Proponent	Continuous	5,000
	Equipment such as fire extinguishers MUST be examined by a government authorized person. The equipment may only be used if a certificate of examination has been issued	Proponent	Continuous	500
	Reports of such examinations MUST be presented in prescribed forms, signed by the assessor and attached to the general register	Proponent	Continuous	30
Storage of materials	Ensure that materials are stored or stacked in such manner as to ensure their stability and prevent any fall or collapse	Proponent	Continuous	8,000
	Ensure that items are not stored/stacked against weak walls and partitions	Proponent	Continuous	_
Emergency preparedness and evacuation procedures	Design suitable documented emergency preparedness and evacuation procedures to be used during any emergency	Proponent	One-off	500
	Such procedures MUST be tested at regular intervals	Proponent	Every 3 months	500
	Ensure that adequate provisions are in place to immediately stop any operations where there in an imminent and serious danger to health and safety and to evacuate workers	Proponent	One-off	18,000
	Ensure that the most current emergency telephone numbers posters are prominently and strategically displayed within the construction site	Proponent	One-off	300
	Provide measures to deal with emergencies and accidents including adequate first aid arrangements	Proponent	Continuous	2,500
First Aid	Well stocked first aid box which is easily available and accessible should be provided within the premises	Proponent	One-off	5,800
	Provision MUST be made for persons to be trained in first aid, with a certificate issued by a recognized body.	Proponent	One-off	10,000

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs. 000)
Ensure the general safety and security of the site and surrounding areas				
Increased Pressure on Infrastructure	Coordinate with other planning goals and objectives for the region	Proponent	Continuous	10,000
	Upgrade existing infrastructure and services, if and where feasible.	Proponent	Continuous	
High socio-economic interest of the communities	Have a clear employment policy for the locals and implement it fairly to all neighbouring communities	Proponent & GOK	Continuous	
	Allow access of the community to their grazing grounds and have regular consultations on matters pertains the grazing grounds and geothermal exploration interface	Proponent, & community representatives	Continuous	0
Insecurity	Ensure the general safety and security at all times by providing day and night security guards and adequate lighting within and around the construction site.	Proponent	Continuous	15,000
	Body-search the workers on entry, to avoid getting weapons on site, and leaving site to ensure nothing is stolen.	Proponent	Continuous	
	Ensure only authorized personnel get to the site	Proponent	Continuous	
Environmental monitoring of the project				
Environmental concern during the construction phase	Due to the magnitude of the project the proponent will monitor construction phase and ensure that the conditions of approval are adhered to.	Proponent, NEMA	Continuous	20,000

10.4 Decommissioning Phase

In addition to the mitigation measures provided in Tables 10.1 and 10.2, it is necessary to outline some basic mitigation measures that will be required to be undertaken once all operational activities of the proposed project have ceased. The objectives, mitigation measures, allocation of responsibilities, time frames and costs pertaining to prevention, minimization and monitoring of all potential impacts associated with the decommissioning and closure phase of the proposed project are outlined in Table 10.3.

Table 10.3: Environmental Management Plan for the Decommissioning Phase

Expected Negative Impacts	Recommended Mitigation Measures	Responsible Party	Time Frame	Cost (Kshs)
1. Demolition waste management				
Demolition waste	Use of an integrated solid waste management system i.e. through a hierarchy of options: 1. Source reduction 2. Recycling 3.Composting and reuse 4. Combustion 5. Sanitary land filling.	Proponent & Contractor	Once-off	30,000
	All buildings, machinery, equipment, structures and partitions that will not be used for other purposes MUST be removed and recycled/reused as far as possible	Proponent & Contractor	Once-off	20,000
	All foundations MUST be removed and recycled, reused or disposed of at a licensed disposal site	Proponent & Contractor	Once-off	25,000
	Where recycling/reuse of the machinery, equipment, implements, structures, partitions and other demolition waste is not possible, the materials should be taken to a licensed waste disposal site	Proponent & Contractor	Once-off	0
	Donate reusable demolition waste to charitable organizations, individuals and institutions	Proponent & Contractor	Once-off	0
Dismantling of modular power generation equipment and accessories	The wells external parts should removed up to the ground level and disposed off as any other scrap metals for recycling.	Proponent	Once-off	10,000
	The well pad should be loosened and levelled with top soils	Proponent, & Contractor	Once-off	5,000
2. Rehabilitation of project site				
Site degradation	Implement an appropriate landscaping and re-vegetation programme to restore the site to its original status. Consider use of indigenous plant species in re-vegetation	Proponent, & Contractor	Once-off	12,000
	Trees should be planted at suitable locations so as to interrupt slight lines (screen planting), between the adjacent area and the development.	Proponent & Contractor	Once-off	0

CHAPTER 11

ENVIRONMENTAL AND SOCIAL IMPACT ACTION PLAN

The purpose of the environmental action plan is to identify adverse environmental impacts and plan action to be taken in the implementation period. The implementation period for the proposed geothermal development is subject to government approval of the suitability of the project vis-à-vis the environmental and social impact considerations. Otherwise, it would be immediate since already feasibility study has been conducted. The environment action plan presented outlines the specific steps that will need to be taken at different stages in the geothermal resources development activities and aims to minimize both short term and long-term impacts resulting from various alternative options. Environmental and social impact action plan for sustainable development of geothermal resource in proposed project area is presented in Table 11.1 below.

Table 11.1: Summary of the Environmental and Social Impact Action Plan for 3 × 30 MW Menengai Modular Power Plants Projects

Project Activity	Potential Environmental Impacts	Potential Social Impacts	Proposed Mitigation Measure(s) (Incl. Legislation and regulations)	Institutional Responsibilities (Incl. Enforcement and , coordination)	Cost Estimates (Ksh ,000)	Comments (e.g. secondary impacts)
Construction and implementation Phases	Noise & vibrations, Dust emissions, H2S and CO2 gas emissions	Loss of grazing land, Health effects, HIV/Aids,	Monitor air quality, acquire water abstraction permit from WRMA, Install mufflers to reduce noise from drilling and well testing, Education awareness, provision of Infrastructure and employment opportunities	the Proponent, NEMA and WRMA, KFS	300,000	Moderate and highly manageable with mitigation measures
Operation Phase	Land subsidence; Noise, air, soil and water pollution; occupational health and safety	Health effects, HIV/Aids; insecurity		Proponent, GOK agencies such as NEMA, WRMA and District development offices	Variable hence should be estimated each year and factored in proponent's annual financial plan	Important as they are long-term impacts.
Decommissioning	Demolition materials, dust, Noise, scrap metals	Loss of aesthetics and scenic value, Lose of employment	Integrated waste management, landscaping and restoration of project site, donation of re-usable materials to the local community, monitoring residual impacts	the Proponent, MoE, and NEMA	100,000	Minor

CHAPTER 12

CONCLUSION AND RECOMMENDATION

12.1 Conclusion

In View of the information collected, the ESIA Team concludes that the proposed project is feasible as planned. However, like in any other project, the project is bound to have both social and environmental impacts, negative and positive. Based on the ESIA study findings, it is concluded that positive impacts outweigh negative ones notwithstanding the fact that most potential negative impacts identified can be mitigated. Outlines of these impacts and proposals of mitigation measures for the negative ones are covered in Chapters 7 and 8 of this report. It is further inferred that the developed EMPs will enable the proponent to manage or mitigate any negative environmental and social impacts.

12.2 Recommendations

Recommendations are made based on the assessment of cumulative and potential impacts of the proposed project and are summarized as:

12.2.1 Environmental Issues

- The proponent adheres to proposed EMP and action plan suggested in ESIA,
- The impacts be monitored closely by the Proponent in collaboration with NEMA and environment consultant.
- To rehabilitate unoccupied areas that are affected during implementation of the project
- H_2S gas dispersion in the study area be monitored in areas of concentrations depicted by in the modelling outcomes for effective planning and manage of likely effects especially during temperature inversions

12.2.2 Socio-Economic Issues

- Raise awareness of control of Human Immune Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) and health risks for construction workers and service providers
- Employment of unskilled labour be limited to local community and be distributed equitably to all locations within the project area
- Implementation of CSR plan should involve community participation.

12.2.3 Licensing

- The consultant recommends licensing of the project to allow for speedy implementation of the project to contribute to electricity production in the country, towards attaining Vision 2030.
- Proponent should meet the conditions, which NEMA may set during issuance of license

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LIST OF APPENDICES

The Chief Executive Officer,
Water Resources Management Authority,
P.O.Box 45250-00100.
Nairobi.

Form: WRMA 010
Catchment: Rift Valley
WRMA ID: WRMA\20\00480
File: WRMA/20/NSA/2FB/10339/G

Water Resources Management Authority

WATER PERMIT

(Rule 38)

By virtue of the authority vested in us by the Water Act 2002, we, the Water Resources Management Authority, do hereby grant unto (name) GEOTHERMAL DEVELOPMENT CO. LTD.BH1 , hereinafter called the permit holder, or his/her/their executors, Administrators and ~~assigns permission to use water in a~~ccordance with them details contained herein, subject to the provisions of the Water Act 2002, and the Rules thereunder, and the conditions following hereafter and endorsed hereon and attached hereto: -

Permit No. P	WRMA/20/NSA/2FB/10339/G	Permit Expiry Date	06-June-2017

Type Of Water use	Surface water				Ground Water		Effluent discharge	Swamp Drainage
	Diversion	Abstraction	In-stream Works	Storage	Shallow Well	BoreHole		
Tick Box						X		

PARTICULARS OF PERMIT HOLDER	DETAILS		
1. Full name of applicant(s) (In Block letters)	GEOTHERMAL DEVELOPMENT CO. LTD.BH1		
2. Category of Applicant - Individual, Group [Association, Society], Company, Institution	Company		
4. ID Number of Applicant (Individual) or Certificate of Incorporation or Registration for Groups or Companies	C 165538		
5. PIN Number (where available)	P051301505F		
Physical Address where water is to be used			
6. L/R Number(s)	BLK 3/688	7. Box Number	17700
8. Village(s)/Ward(s)	WANYORORO B	9. Town	NAKURU
10. Sub-location(s)	Ndungiri	11. Post Code	20100
12. Location(s)	Bahati	13. Telephone Contact (Landline)	0723827359
14. Division(s)	Bahati	15. Telephone Contact (Mobile)	0733901180
16. District(s)	Nakuru North	17. Email Contact	gmetangula@gdc.co.ke

WATER RESOURCE DETAILS

17. Name of Body of Water or Aquifer where water is to be diverted, abstracted or stored	Olbanita/Subukia
18. Is the point of abstraction or storage in a Protected Area or a Groundwater Conservation Area? (yes/no)	NO
19. Sub-catchment Number	2FB
20. Class of Water Resource	
21. Name of Body of Water or Aquifer where effluent is to be discharged	
22. Sub-catchment Number (Effluent)	
23. Class of Water Resource (Effluent)	
24. Category of Application (Class of Permit)	D

Appendix 2: Draft MOU between GDC and KFS

KENYA
Forest Service

GDC Geothermal Development Company
Powering the Vision

MEMORANDUM OF UNDERSTANDING (MOU)

BETWEEN

KENYA FOREST SERVICE

AND

GEOTHERMAL DEVELOPMENT COMPANY LIMITED

ON

GEOTHERMAL RESOURCES DEVELOPMENT AT MENENGAI CRATER FOREST RESERVE

1

THIS Memorandum of Understanding (MOU) is made this 15th day of July Two Thousand and Eleven between **KENYA FOREST SERVICE**, a body corporate established under the Forests Act No 7 of 2005, of the Laws of the Republic of Kenya, whose address is Kiambu Road, Post Office Box Number 30513-00100, Nairobi in the Republic of Kenya (hereinafter called "the Service") of the one part and **GEOTHERMAL DEVELOPMENT COMPANY LIMITED** a registered entity duly established under the laws of the Republic of Kenya and whose address is Post Office Box Number 100746 -00101, Nairobi (hereinafter called "the Company") of the other part.

WHEREAS

A. The Service is a State corporation established under the Forests Act, 2005 as a body corporate with the overall mandate of ensuring establishment, development and sustainable management, including conservation and rational utilisation of forest resources for the socio-economic development of the country.

B. The Company is 100 % owned by the Government of Kenya and is mandated to promote rapid development of geothermal resources in Kenya through surface exploration and drilling for steam and managing the geothermal reservoir's (where the steam has been harnessed) so as to ensure constant supply of steam for power generation.

C. The Service and the Company agree to co-operate in the development of geothermal Resources, management and conservation of Forest resources.

PURPOSE

This MOU is entered into by the parties to ensure proper co-existence and safeguard the interests of the two parties and therefore it shall operate so long as the need for the parties to work in the same environment and areas exists.

NOW THIS MOU WITNESSETH that it is hereby agreed and declared by and between the parties hereto as follows:-

In this MOU, unless the context otherwise requires:-

'Agent' means a person appointed by the Company or the Service to act on its behalf.

'Company Premises' means all or any part of or portion of Forest that the Service shall by way of sub-lease or otherwise grant to the Company for its use.

'Contractor' means a person contracted by the Company to carry out work or to provide supplies under a specific contract.

'Flora' means all the plants including trees within the Company premises and in the surrounding forest area.

'Fauna' means all animals inhabiting the Company premises and the surrounding forest area.

"Term" means the term of this Memorandum of Understanding.

'Visitor' means one who visits the Company premises, on the Company's invitation or to carry out official business with the Company.

'Forest' means any land declared to be a forest land under the Forest Act, 2005.

ARTICLE 1: ENVIRONMENTAL CONSERVATION

The Service shall regularly create awareness to the staff of the Company on the forest rules and regulations particularly with regard to conservation, proper disposal of waste, and handling of forest visitors by the Company's staff.

1.1 Forest conservation

The impacts on flora will be assessed during development and production of geothermal resources and appropriate mitigation measures undertaken against removal of vegetation in areas to be cleared for roads, buildings and other structures.

AS WITNESSED by the hands of the duly authorized representatives of the parties the day and year first above written

SIGNED by **David .K. Mbugua**
For and on behalf of **KENYA FOREST SERVICES**)
In the presence of: -)
)
)
In the presence of)
)
Sam Owino)
Corporation Secretary)
)
MANAGING DIRECTOR)
GEOTHERMAL DEVELOPMENT CO. LTD.)
P. O. Box 100746 - 00101)
NAIROBI, KENYA.)
SIGNED by **Dr. Silas Simiyu**)
For and on behalf of **GEOTHERMAL DEVELOPMENT)**
COMPANY LIMITED)
)
In the presence of)
COMPANY SECRETARY)
GEOTHERMAL DEVELOPMENT CO. LTD.)
P. O. Box 100746 - 00101)
NAIROBI, KENYA.)
Praxidis Saisi)
Company Secretary)

APPENDIX 3: GDC Environmental Policy Statement

GDC Geothermal Development Company
Powering the Vision

GDC Environmental Policy Statement

Geothermal Development Company (GDC) will establish and implement sound environmental management programs that will ensure its activities are environmentally friendly and sustainable.

GDC shall;

- Manage environmental impacts arising from its operations and activities.
- Pursue opportunities that have the potential to realize additional environmental benefits out of the Company's projects.
- Comply with the relevant environmental legislation and any other requirements to which the company subscribes.
- Avail its environmental policy to the public

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DR.SILAS M. SIMIYU, MBS
MANAGING DIRECTOR & C.E.O

Appendix 4: Vegetation of Menengai

BOT NAME	FAMILY	HABIT	STATUS	HABITAT TYPE	WELL PADS				
					4 & 8	6	1	7	3
Abutilon longicuspe A. Rich.	MALVACEAE	SH	N	T	0	0	0	0	1
Abutilon mauritianum (Jacq) Sweet	MALVACEAE	SH	N	T	0	0	0	0	1
Acacia kirkii Oliv.	MIMOSACEAE	TR	N	T	0	0	0	1	1
Acacia seyal Del.	MIMOSACEAE	TR	N	T	1	1	1	1	1
Acacia xanthophloea Benth.	MIMOSACEAE	TR	N	RR	0	0	0	0	1
Achyranthes aspera LL.	AMARANTHACEAE	EH	N	T	0	0	0	1	1
Agauria salicifolia (Comm. & Lam.) Hook.f. ex Oliv	ERICACEAE	TR	N	T	0	1	1	1	1
Ageratum conyzoides L.	ASTERACEAE	EH	N	T	1	1	0	1	1
Aloe deserti Waud.	ALOACEAE	RSH	N	T	1	1	0	0	0
Amaranthus hybridus L.	AMARANTHACEAE	EH	N	T	0	1	0	0	1
Amaranthus spinosa L.	AMARANTHACEAE	EH	N	T	0	0	1	0	1
Andropogon	POACEAE	G	N	T	1	0	0	0	0
Anthospermum ammannioides S. Moore	RUBIACEAE	SH	N	T	1	1	1	1	1
Antopetitia abyssinica A. Rich	PAPPILIONACEAE	TH	N	T	0	0	0	0	1
Aristida kenyensis Henr.	POACEAE	G	N	T	0	0	0	0	1
Artemisia afra Willd	ASTERACEAE	SH	N	T	0	1	0	1	0
Aspilia mossambiscensis (Oliv) Willd.	ASTERACEAE	SH	N	S/A	1	0	0	0	1
Australina flaccida (A.Rich) Wedd	URTICACEAE	TH	N	T	0	0	0	0	1
Bidens buchneri (Klatt) Sherff	ASTERACEAE	SH	N	T	0	0	0	1	0
Bidens pilosa L.	ASTERACEAE	EH	N	T	1	0	1	0	1
Bothriochloa insculpta (A. Rich) A. Camis	POACEAE	G	N	T	0	1	0	1	0
Bromus unioloides (Willd.) Rasp	POACEAE	G	N	T	0	0	0	1	0
Buddleia polystachya Fres	LOGANIACEAE	SH/TR	N	T	0	0	0	1	0
Chamaecrista hildebrandtii (Vatke) Lock.	CAESALPINIACEAE	DSH	N	T	0	1	0	1	0
Chamaecrista usambarensis	CAESALPINIACEAE	DSH	N	T	0	0	0	0	1
Chenopodium album L.	CHENOPODIACEAE	EH	N	T	0	0	0	0	1
Chenopodium ambrosioides L.	CHENOPODIACEAE	EH	N	T	1	1	1	1	1
Chenopodium carinatum R. Br.	CHENOPODIACEAE	PH	N	T	1	1	1	1	0
Chloris gayana Kunth	POACEAE	G	N	T	0	0	0	1	0
Chloris pycnothrix Trin	POACEAE	G	N	T	1	1	1	1	1
Cirsium vulgare (savi) Ten	ASTERACEAE	EH/SH	N	T	0	0	1	0	0
Clematis simensis Fres	RANUNCULACEAE	CL	N	T	0	0	0	0	1
Clerodendrum myricoides(Hochst) Vatke	LAMIACEAE	SH	N	T	0	0	0	1	0
Clutia abyssinica Jaub & Spash	EUPHORBIACEAE	SH	N	T	1	0	0	1	1
Clutia lanceolata Hochst	EUPHORBIACEAE	SH	N	T	1	0	0	0	0
Combretum molle G. Don	COMBRETACEAE	TR	N	T	0	0	0	0	1
Commelina africana L.	COMMELINACEAE	SCH	N	T	1	0	1	1	1

BOT NAME	FAMILY	HABIT	STATUS	HABITAT TYPE	WELL PADS				
					4 & 8	6	1	7	3
Commelina beghalensis L.	COMMELINACEAE	SCH	N	T	0	0	0	0	1
Conyza floribunda H.B.K.	ASTERACEAE	EH	N	T	1	1	1	1	1
Conyza hochstetteri Sch. Bip ex A. Rich	ASTERACEAE	EH	N	T	1	0	0	1	0
Conyza newii Oli & Hiern	ASTERACEAE	SH	N	T	1	1	0	1	1
Conyza schimperi A. Rich	POLYGALACEAE	EH	N	T	0	1	1	1	0
Conyza stricta Willd.	ASTERACEAE	EH	N	T	0	0	0	1	0
Conyza subscaposa O. Hoffm	ASTERACEAE	EH	N	T	0	1	0	0	0
Crassocephalum montuosum (S. Moore) Milne-Redh	ASTERACEAE	EH	N	T	1	0	0	0	0
Crassocephalum picridifolium (Dic.) S. Moore	ASTERACEAE	EH	N	T	0	0	0	1	0
Crassocephalum rubens (Jacq) S. Moore	ASTERACEAE	EH	N	T	0	1	1	1	0
Crassula alba Forsk	CRASSULACEAE	PH	N	T	0	0	1	0	0
Crotalaria agatiflora Schweinf.	PAPPILIONACEAE	SH	N	T	0	0	0	1	0
Crotalaria brevidens Benth	PAPPILIONACEAE	SH	N	T	1	1	1	0	0
Crotalaria incana L.	PAPPILIONACEAE	DSH	N	T	0	1	0	1	0
Crotalaria laburnifolia L.	PAPPILIONACEAE	SH	N	T	1	0	0	1	1
Crotalaria polysperma Kotschy	PAPPILIONACEAE	DSH	N	T	0	0	0	1	0
Cucumis figarei Naud.	CUCURBITACEAE	CL/CR	N	T	0	1	1	0	0
Cussonia holstii A. Rich	ARALIACEAE	TR	N	T	0	0	0	1	1
Cymbopogon nardus (L.) Rendle	POACEAE	G	N	T	1	1	0	1	1
Cynodon nlemfluensis Vanderyst	POACEAE	G	N	T	0	1	1	0	1
Cyperus rigidifolius Steud	CYPERACEAE	SD	N	A	0	0	0	1	0
Cyphostemma adenocaule (A. Rich) Willd & Drum	VITACEAE	CL	N	T	0	0	0	0	1
Cyphostemma junceum (Webb.) Descoign	VITACEAE	CR	N	T	0	0	0	0	1
Cyphostemma maranguense (Gilg.) Descoign	VITACEAE	EH	N	T	0	1	1	0	0
Dactyloctenium aegyptium (L.) Willd	POACEAE	G	N	T	0	0	1	0	0
Datura stramonium L.	SOLANACEAE	EH	N	T	1	1	0	0	1
Delonix elata (L.) Gamble	CAESALPINIACEAE	TR	N	T	0	0	0	1	0
Dichrocephala integrifolia O. Kuntze	ASTERACEAE	EH	N	T	0	0	0	0	1
Digitaria abyssinica (A. Rich) Stapf	POACEAE	G	N	T	0	0	0	0	1
Digitaria diagonalis (Nees) Stapf	POACEAE	G	N	T	1	1	0	1	0
Digitaria macroblephala (Hack.) Stapf	POACEAE	G	N	T	1	0	0	0	0
Digitaria scalarum (Schweif.) Chiov	POACEAE	G	N	T	0	1	0	0	0
Digitaria velutina (Forssk.) P. Beauv	POACEAE	G	N	T	1	1	0	1	1
Dioscorea quartiniana A. Rich	DIOSCOREACEAE	CL	N	T	0	0	0	0	1
Diplolophium afficanum Turcz	APIACEAE	RTH	N	T	0	1	0	1	1
Dissotis brazzae Cogn.	MELASTOMATACEAE	DSH	N	T	0	0	0	0	1
Dissotis senegambensis (Giull & Perr) Triana	MELASTOMATACEAE	SH	N	S/A	0	1	0	1	0

BOT NAME	FAMILY	HABIT	STATUS	HABITAT TYPE	WELL PADS				
					4 & 8	6	1	7	3
Dodonea angustifolius L.f.	SAPINDACEAE	SH/TR	N	T	1	1	1	1	1
Dombeya torrida (J.F. Gmel) P. Bamps	STERCULIACEAE	SH/TR	N	T	0	0	0	0	1
Dracaena steudneri Engl.	DRACAENACEAE	TR	N	T	0	0	0	0	1
Dropteris filix-mas (L.) Schott	DRYOPTERIDACEAE	RH	N	T	0	1	0	0	0
Eleucine indica (L.) Gaertn	POACEAE	G	N	T	1	1	0	1	0
Eleucine multiflora A. Rich	POACEAE	G	N	T	0	0	1	0	0
Emilia coccinea (Sims.) Sweet	ASTERACEAE	EH	N	T	1	0	0	0	0
Emillia javanica (Burm f.) Merr	ASTERACEAE	EH	N	T	0	0	0	1	0
Eragrostis chalcantha Trin	POACEAE	G	N	T	1	0	1	1	1
Eragrostis ciliaris (L.) R. Br.	POACEAE	G	N	T	0	1	0	0	0
Eragrostis tenuifolia A. Rich	POACEAE	G	N	T	0	1	0	0	1
Erica arborea L.	ERICACEAE	SH	N	T	1	1	0	1	1
Eriosaema shirense Bak. f.	PAPPILIONACEAE	SH	N	T	0	0	0	1	0
Erythrina abyssinica DC.	PAPPILIONACEAE	TR	N	T	0	0	0	1	0
Euclea divinorum Hiern	EBERNACEAE	SH/TR	N	T	0	0	0	0	1
Euphorbia candelabrum Kotschy	EUPHORBIACEAE	TR	N	T	0	0	0	0	1
Euphorbia prostrata Ait.	EUPHORBIACEAE	RTH	N	T	0	1	0	0	0
Exotheca abyssinica (A. Rich) Anders	POACEAE	G	N	T	0	0	0	1	0
Ficus natalensis Hochst.	MORACEAE	TR	N	T	0	0	0	0	1
Ficus sycomorus L.	MORACEAE	TR	N	RR	1	0	0	0	0
Ficus thoningii Bl.	MORACEAE	TR	N	T	0	0	0	0	1
Fuerstia africana T.C.E Fr.	LAMIACEAE	DSH	N	T	0	0	0	0	1
Gadiolus newii Bak.	IRIDACEAE	RH	N	T	0	1	1	0	0
Galinsoga parviflora L.	ASTERACEAE	EH	N	T	1	1	1	1	1
Galium scioanum Chiov.	RUBIACEAE	CR	N	T	0	0	0	0	1
Geranium ellamellatum Kokwaro	GERANIACEAE	PH	N	T	1	0	0	0	1
Geranium ocellatum Cambess	GERANIACEAE	RTH	N	T	0	0	0	1	1
Girardinia diversifolia (Link.) Friis	URTICACEAE	EH	N	T	0	0	0	0	1
Gnaphalium luteo-album L.	ASTERACEAE	EH	N	T	1	1	1	0	0
Gomphorcarpus fruticosus (L.) Ait f.	VITACEAE	SH	N	T	0	1	0	1	0
Grevillea robusta A. Cunn ex R. Br	PROTEACEAE	TR	E	T	1	0	0	1	1
Grewia similis K. Schum	TILIACEAE	TR	N	T	0	0	0	0	1
Gutenbergia cordifolia Benth ex Oliv	ASTERACEAE	SH	N	T	1	0	0	0	1
Harpachne schimperi A. Rich	POACEAE	G	N	T	0	0	1	0	0
Hebenstretia angolensis Rolfe	SCROPHULARIACEAE	EH	N	T	1	0	0	0	1
Helichrysum forskahlii (J.F. Gmel) Hilliard & Burt	ASTERACEAE	EH	N	T	1	1	0	0	0
Helichrysum globosum Sch. Bip	ASTERACEAE	EH	N	T	0	0	0	0	1
Helichrysum nandense S. Moore	ASTERACEAE	SH	N	T	0	1	0	0	0
Helichrysum odoratissimum (L.) Less	ASTERACEAE	RTH	N	T	0	0	1	0	0

BOT NAME	FAMILY	HABIT	STATUS	HABITAT TYPE	WELL PADS				
					4 & 8	6	1	7	3
Helinus myrstacinus (Ait.) Steud	RHAMNACEAE	CL/L	N	T	0	0	0	0	1
Heteromorpha trifoliata (Wendl.) Eckyl & Zeyh	APIACEAE	TR	N	T	1	0	0	1	1
Hibiscus canabinus L.	MALVACEAE	SH	N	T	1	1	0	1	0
Hibiscus diversifolius Jacq.	MALVACEAE	SH	N	T	0	1	0	1	1
Hirpicium diffusum (O.Hoffm) Roess	ASTERACEAE	PH	N	T	0	0	0	0	1
Hymenodictyon floribundum Hochst & steudel	RUBIACEAE	TR	N	T	1	0	0	0	1
Hyparrhenia filipendula (Hochst) Stapf.	POACEAE	G	N	T	0	0	0	0	1
Hyparrhenia hirta (L.) Stapf	POACEAE	G	N	T	0	0	1	0	0
Hyparrhenia rufa (Nees) Stapf.	POACEAE	G	N	T	1	1	1	1	1
Impatiens tinctoria A. Rich	MENISPERMACEAE	SH/EH	N	T	1	0	0	0	0
Indigofera homblei Bak f. & Martin	PAPPILIONACEAE	DSH	N	T	0	1	0	0	0
Indigofera volkensii Taub.	PAPPILIONACEAE	DSH	N	T	0	0	0	0	1
Ipomoea wightii (Wall.) Choisy	CONVOLVULACEAE	CL	N	T	0	0	0	0	1
Juniperus procera Endl.	CUPRESSACEAE	TR	N	T	1	0	0	0	1
Lagenaria abyssinica Hook. f.	CUCURBITACEAE	CL	N	T	0	0	0	1	0
Laggera brevipes Oliv & Hiern	ASTERACEAE	SH	N	T	1	0	0	1	1
Laggera elatior R.E. Fries	ASTERACEAE	EH/SH	N	T	0	0	0	1	0
Launea cornuta (Oli & Hiern) C. Jeffrey	ASTERACEAE	EH	N	T	0	1	0	0	0
Leonotis ocymifolia (Burm f.) Iwarsson	LAMIACEAE	SH	N	T	1	1	0	0	0
Leucus callostachys Oliv.	LAMIACEAE	SH	N	T	0	0	0	1	0
Leucus martiniscensis (Jacq) Ait. f.	LAMIACEAE	EH	N	T	0	0	0	1	0
Lippia javanica (Burm. f.) Spreng	VERBENACEAE	SH	N	T	0	0	0	1	0
Lippia kituiensis Vatke	VERBENACEAE	SH	N	T	0	0	0	0	1
Lobelia fervens Thunb.	CAMPANULACEAE	EH	N	T	0	1	0	0	0
Loudentia kagerensis (K. Schum) Hutch.	POACEAE	G	N	T	0	1	0	0	1
Lycopersicum esculentum L.	SOLANACEAE	EH	E/C	T	0	0	0	1	0
Malva verticillata L.	MALVACEAE	SH	N	T	1	0	0	0	0
Maytenus senegalensis (Lam.) Exell	CELASTRACEAE	TR/SH	N	T	0	0	0	0	1
Momordica foetida Schummach	CUCURBITACEAE	CL	N	T	0	0	0	0	1
Monsonia angustifolia A. Rich	GERANIACEAE	PH	N	T	1	1	0	0	0
Myrsine africana L.	MYRSINACEAE	SH	N	T	1	1	1	0	1
Nicotiana glauca R. Grah	SOLANACEAE	SH/TR	N	T	0	1	1	0	0
Oldenlandia lancifolia (Schum.) DC.	RUBIACEAE	CR	N	T	1	1	1	1	1
Oldenlandia monanthes(Hochst ex A.Rich) Hiern	RUBIACEAE	CR	N	T	1	1	0	0	0
Olea africana (Mill.) P. Green	OLEACEAE	TR	N	T	1	1	0	0	0
Osteospermum vaillantii (Decne0 T. Norl	ASTERACEAE	EH	N	T	1	1	1	0	1
Osyris lanceolata Hochst & Steudel	SANTALACEAE	TR	N	T	1	1	1	0	1

BOT NAME	FAMILY	HABIT	STATUS	HABITAT TYPE	WELL PADS				
					4 & 8	6	1	7	3
Oxygonum sinuatum (Meissn.) Dammer	POLYGONACEAE	PH	N	T	1	0	0	0	0
Ozoroa insignis Del.	ANACARDIACEAE	TR	N	T	0	0	0	0	1
Panicum maximum Jacq	POACEAE	G	N	T	0	0	0	0	1
Pappea capensis Eckyl & Zeyh	SAPINDACEAE	TR/SH	N	T	0	1	1	0	1
Paspalum scrobiculatum L.	POACEAE	G	N	T	0	0	0	1	0
Pellaea calomelanos (Sw) Link	ADIANTACEAE	PT	N	T	1	0	0	0	0
Pennisetum cladestinum Chiov.	POACEAE	G	N	T	0	1	1	0	0
Pentas longiflora W.R.B. Oliv.	RUBIACEAE	SH	N	T	0	1	0	0	0
Physalis peruviana L.	SOLANACEAE	EH	N	T	0	0	0	0	1
Phytolacca dodecandra L'Herit	PHYTOLACACEAE	L/SH	N	T	0	0	0	0	1
Phytolacca octandra L' Herit	PHYTOLACACEAE	L/SH	N	T	0	1	0	1	1
Pittosporum viridifolia Sims	PITTOSPORACEAE	TR	N	T	0	0	0	1	0
Plectranthus caninus Roth.	POACEAE	SH	N	T	1	0	0	0	0
Podocarpus gracilior Pilger	PODOCARPACEAE	TR	N	T	0	0	0	0	1
Polygala petitiana A. Rich	POLYGALACEAE	CR	N	T	1	0	0	1	1
Polygala sphenoptera Fres	POLYGALACEAE	DSH/CR	N	T	0	1	0	0	0
Polyscius fulva (Hiern.) Harms	ARALIACEAE	TR	N	T	0	0	0	0	1
Protea gaguedi J. F. Gmel	PROTEACEAE	TR	N	T	0	0	0	1	1
Prunus africana (Hook. f.) Kalkm	ROSACEAE	TR	N	T	0	0	0	0	1
Rhus chiridensis Baker f.	ANACARDIACEAE	TR	N	T	1	1	1	0	1
Rhus natalensis Krauss	ANACARDIACEAE	TR	N	T	0	1	0	1	1
Rhus ruspolii Engl.	ANACARDIACEAE	TR	N	T	1	1	1	1	1
Rhynchérytrum roseum (Willd) C.E. Hubbard	POACEAE	G	N	T	1	1	0	1	1
Rhynchérytrum scabridum (K. Schum) Chiov.	POACEAE	G	N	T	0	1	1	0	0
Rhynchosia minima (L.) DC.	PAPPILIONACEAE	CL/CR	N	T	0	0	0	1	0
Richardia braziliensis Gomez	RUBIACEAE	PH	N	T	0	0	0	1	0
Ricinus communis L.	EUPHORBIACEAE	SH	N	T	0	1	0	1	0
Rubia cordifolia L.	RUBIACEAE	CL	N	T	0	1	1	1	0
Rumex usambarensis (Engl.) Damm	POLYGONACEAE	SH	N	T	0	1	1	1	0
Satureia biflora (D. Don) Benth	LAMIACEAE	DSH	N	T	1	1	1	1	1
Satyrium cotiifolium Rolfe	ORCHIDACEAE	RH	N	T	0	1	0	0	0
Schkhuria pinnata (Lam.) O. Kuntze	ASTERACEAE	EH	N	T	1	1	1	1	0
Senecio ruwenzoriensis S. Moore	ASTERACEAE	EH	N	T	1	0	1	1	0
Senecio syringifolia O. Hoffm	ASTERACEAE	L/SH	N	T	0	0	0	0	1
Senna didymobortrya (Fresen.) Irwin & Barneby	CAESALPINIACEAE	SH	N	T	0	0	0	0	1
Setaria pallide-fusca (Schumach) Stapf & Hubbard	POACEAE	G	N	T	0	0	0	0	1
Setaria plicatilis (Hochst.) Engl.	POACEAE	G	N	T	0	0	0	0	1
Setaria sphacellata (Schummach.) Moss	POACEAE	G	N	T	0	0	0	1	0

BOT NAME	FAMILY	HABIT	STATUS	HABITAT TYPE	WELL PADS				
					4 & 8	6	1	7	3
Sida ovata Forsk.	MALVACEAE	DSH	N	T	0	0	0	0	1
Silene burcheli DC.	CAMPANULACEAE	EH	N	T	0	0	0	1	0
Sisymbrium officinale (L.) Scop	BRASSICACEAE	EH	N	T	1	0	1	1	0
Smithia elliotii Bak. f.	PAPPILIONACEAE	CL/CR	N	T	0	0	0	1	0
Solanum incanum L.	SOLANACEAE	SH	N	T	1	0	0	0	0
Solanum nigrum L.	SOLANACEAE	EH	N	T	0	1	1	0	0
Solanum sessilistellatum Bitter	SOLANACEAE	SH	N	T	0	0	0	1	0
Solanum villosum Miller	SOLANACEAE	EH	N	T	0	1	0	0	0
Sonchus asper (L.) Hill	ASTERACEAE	EH	N	T	1	1	1	1	0
Sparmania ricinocarpa (Eckyl & Zeyh) Kuntze	TILIACEAE	SH	N	T	0	0	0	0	1
Sporobolus pyramidalis P. Beauv	POACEAE	G	N	T	0	1	0	0	0
Steganotaenia araliacea Hochst.	APIACEAE	TR	N	T	0	0	0	0	1
Syzygium guineensis (Willd.) DC.	MYRTACEAE	TR	N	T	0	0	0	0	1
Tagetes minuta L.	ASTERACEAE	EH	N	T	1	1	1	1	0
Tarchonanthus comphoratus L:	ASTERACEAE	SH	N	T	1	1	1	1	1
Tephrosia holstii Taub	PAPPILIONACEAE	DSH	N	T	1	0	0	1	0
Tetradenia riparia (Hochst.) Codd.	LAMIACEAE	SH	N	RR	1	1	1	0	0
Themenda triandra Forssk.	POACEAE	G	N	T	0	0	0	0	1
Tinnea aethiopica Hook. f.	LAMIACEAE	SH	N	T	0	0	0	1	1
Torilis arvensis (Huds.) Link	APIACEAE	EH	N	S/A	0	1	0	0	0
Trema orientalis (L.) Blume	ULMACEAE	TR	N	T	1	1	0	0	1
Triticum aestivum L.	POACEAE	G	E/C	T	0	0	0	1	0
Triumfetta rhoboidea Jacq	TILIACEAE	SH	N	T	0	0	0	1	0
Urtica masaica Mildbr.	URTICACEAE	RH	N	T	0	0	0	0	1
Vangueria infausta Burch.	RUBIACEAE	SH/TR	N	T	0	0	0	0	1
Verbena bonariensis L.	VERBENACEAE	EH/SH	N	T	0	0	0	0	1
Vernonia lasiopus O. Hoffm	ASTERACEAE	SH	N	T	0	0	0	1	1
Vigna parkeri Baker	PAPPILIONACEAE	CL	N	T	1	0	0	0	0
Withania somnifera (L.) Dunal	SOLANACEAE	SH	N	T	1	1	1	1	1
Zea mays L.	POACEAE	G	E/C	T	0	0	0	1	0

Appendix 5: Mammals and Reptiles of Menengai

FAMILY	COMMON NAME	SCIENTIFIC NAME	HABITAT						
			1	2	3	4 & 8	6	7	WYRB
Mammals									
Cercopithecidae	Olive Baboon	Papio anubis		✓					✓
Procaviidae	Rock hydra	Procavia capensis (Pallas)	✓		✓	✓	✓	✓	✓
Cephalophinae/	Kirks dik dik	Maoqua Kirkii		✓	✓	✓			
Neotraginae	Striped ground squirel	Xerus erythropus		✓					
Sciuridae	African Rabbit	Poelogus marjorita	✓						
Leporidae	Mole-rate	Tachyorycetes spalacinus			✓		✓		
Rhizomyidae	Leopard	Panthera pardus			✓			✓	✓
Felidae	African wild cat	Felis libyca	✓		✓				
Felidae	Striped hyaena	Hyaena Hyaena	✓	✓					
Hyaenidae									
Reptiles									
Agamidae	Red-headed Rock Agama	Agama agama					✓		✓
Agamidae	Elmentaita Rock Agama	Agama calldospina						✓	
Boidae	African Rock Python	Python sebae	✓				✓		
Elapidae	Forest cobra	Naja manoleuca			✓				

Appendix 6: Birds of Menengai

FAMILY	COMMON NAME	SCIENTIFIC NAME	HABITAT						
			1	2	3	4& 8	6	7	WYR B
Accipitridae	Black kite	Milvus migrans	✓			✓			
Columbidae	Namaqua Dove	Oena capensis		✓			✓		
Columbidae	Laughing Dove	Streptopelia senegalensis		✓			✓		✓
Columbidae	Red-eyed Dove	Streptopelia senitorqusta		✓			✓	✓	✓
Turdidae	Schalows wheatear	Oenanthe lugubris	✓			✓		✓	
Turdidae	Moutain chat	Pinathochroa sordida	✓	✓	✓	✓	✓		✓
Turdidae	Cliff chat	Thamnolea cinnamomeireatris							✓
Nectariiniidae	Beutiful sunbird	Nectarinia erythrocerca							
Nectariniidae	Malachite sunbird	Nectarinia famosa		✓	✓				✓
Ploceidae	Yellow Bishop	Euplectes capenis	✓	✓	✓	✓	✓	✓	✓
Ploceidae	Red – collared	Euplectes ardens		✓	✓				
Laniidae	widowbird	Lanius collaris	✓	✓					✓
Estrildidae	Common shrike	Lonchura cucullata	✓		✓				✓
Ploceidae	Bronze Mannikin	Eupletes jacksoni							
Turdidae	Jacksons widowbird	Cossypha caffra				✓	✓		✓
Pycnotidae	Robin chat	Pycnotus barbatus	✓	✓		✓	✓		✓
Apodidae	Common bulbul	Apus niansae			✓				✓
Apodidae	Nyanza swift	Apus aequatorialis	✓	✓			✓		✓
Apodidae	Mottled Swift	Apus affinis			✓			✓	
Hirundinidae	Little Swift	Hirunudo fuligula							✓
Hirundinidae	African rock martin	Hirundo angolensis	✓	✓					✓
Coliidae	Angola swallow	Colius striatus	✓	✓					
Picidae	Speckled mousebird	Campethera n*u*bica	✓					✓	
Sturnidae	Nubian woodpeaker	Spreo superbus			✓				✓
	Super starling								

APPENDIX 7.1: MINUTES OF THE PUBLIC AND STAKEHOLDERS FORUM HELD AT LAND MAWE

PUBLIC CONSULTATIVE FORUM FOR THE PROPOSED CONSTRUCTION OF 90 MW MENENGAI MODULAR POWER PLANTS HELD AT LAND MAWE, MUTUKANIO LOCATION, BAHATI DIVISION, NAKURU COUNTY, ON 18TH SEPTEMBER 2013 STARTING FROM 11.00 AM

AGENDA

1. Prayers
2. Introduction
3. Chairman's remarks
4. Brief from the GDC representative
5. Brief from the consultant
6. Views from the public
7. Remarks from the District commissioner
8. Way forward
9. AOB

Attendance: List attached

MIN/1/13: Prayers

The chairman, the District Officer Bahati Division, called the meeting to order at 11.00 AM. He then requested Moses Kinko who said a word of prayer.

Min/2/13: Introduction

The chairman informed participants that the meeting was convened to enable them participate in the Environmental impact Assessment of the proposed GDC 3 × 30 MW Menengai Modular power plants. He welcomed members to the meeting and asked them to make self introduction stating their names and their respective roles in the community. The list of members is attached.

Min/3/13 Chairman's remarks

The chairman in his opening remarks thanked all members for attending the meeting. He also thanked GDC for identifying the area for implementation of the various projects and for updating the community on the upcoming projects. In addition, he thanked GDC for the various Social Corporate Responsibility projects initiated not only in the Division but in the District at large. He informed the members present of the importance of their participation in projects that are being initiated in the area and encouraged them to freely express their concerns, limiting themselves to the proposed project.

Min/5/13: Brief from GDC representative

The GDC representative Mr. Gabriel Wetangula welcomed members present to the public consultative forum and introduced other GDC representative present. He informed participants that GDC has been drilling and testing geothermal wells within the Mengai Caldera since the year 2010. The initial target was to start generating electricity by the year 2017. However, the government has issued a new directive requiring that 90 MW of electricity be generated from Menengai field by December 2014 in order to support efforts of achieving Vision 2030. He noted that the works will be in three phases which will work simultaneously viz the power generation plants each producing 30MWe, construction of steam highway and electricity transmission line.

Power plants will be constructed by three separate companies that will tenders opened recently, while GDC supported by the Government will develop steam collection pipelines. The Kenya Electricity Transmission Company (KETRACO) will construct power transmission lines, which is within their mandate. Mr Wetangula emphasized the role of Environmental and Social Impact Assessment in sustainable geothermal development and hence the need for public and stakeholders to be involved in decision making. He therefore encouraged members to freely express their positive and negative concerns for the proposed project.

Min/4/13 Brief from the Consultant

Dr. Gelas Muse on behalf of the Consultants informed the meeting that the need to conduct EIA is as per EMCA 1999 (revised 2008), section 58, that requires all proposed projects that may have significant impacts on the environments must carry out EIA in order to safeguard the environment from adverse impacts. Public participation in the EIA process is a legal right and therefore their presence and active participation is valuable. The consultant encouraged members to freely express their concerns regarding environmental, social and health issues associated with the proposed project.

Min/6/13: Views from the public

The Chairman opened the floor for the community to present their concerns. All contributors were asked to identify themselves and to ensure they were brief to give room for many people to contribute. The concerns raised as well as the response are given below:

Concern 1

Mr Robert Mungai a pastor was concerned about monkeys which are very destructive to crops especially in the areas around the crater noting that the monkeys have shifted to the farms because their habitat have been disturbed by GDC as the drilling machines cause a lot of vibration. He proposed that an electric fence be constructed. In his support, Anne Wandia also noted that snakes have also increased in the area.

Response

The consultant in his response noted that monkeys live on trees and therefore an electric fence may be a challenging solution. He advised that people should stop destroying the natural eco-system which provides habitat for the monkeys and other animals such as snakes since once disturbed they opt to the nearby farms for their livelihood. The EMP will provide that GDC rehabilitates disturbed sites by planting indigenous trees and local community should support this effort by avoiding destroying the forests through charcoal burning and other related forest clearing activities

Concern 2

Gabriel Kuogoini noted that he supports the project but was concerned about the GDC promise of employment for the youth which has never been fulfilled. In addition, he wanted to know whether with the generation of power by GDC electricity connection cost will reduce.

Response

In response to this, the GDC representative noted that the electricity generated will be supplied to the main grid and will therefore not be for local consumption however. He informed the meeting that the company has helped and will continue to help increase electricity connection by installation of transformers as geothermal drilling and power transmission require. By extension, communities in the surrounding will definitely benefit by being within the optimum radius for electricity connectivity.

The chairman Nakuru north District Sacco informed the meeting that through his office, many youths have been employed not only by GDC but even by other companies. However, he reiterated that since GDC started its operations, 400 youths have been employed and that currently 114 youths are on GDC payroll as employees working in the various sections of construction.

Concern 3

Mr Moses Kinko was concerned about the odour coming from the steam in the already drilled wells which allegedly causes headache and respiratory problems among community members and also led to poor crop production. He also requested GDC to help in the construction of roads in the area and drilling of water. Ms Anne Wandia added that the odour has increased the cases Asthma in the area.

Response

With regard to the odour, consultant said it could be because of hydrogen-sulphide. Although the gas may be smelled several meters away from wells the gas concentration based on available data is undetectable a few meters away from production wells. The gas concentrations away from the wells are thus within the World Health Organization (WHO) limits that are harmful to health. However, to reduce its effects on workers GDC has a comprehensive health and safety policy to protect its employees who also work in shifts to reduce any chances of being affected.

With regard to water, Mr Wentangula added that GDC is committed to CSR activities and for this reason has bought a water drilling machine which will reduce the cost of drilling boreholes for the community. In addition, he also noted that since heavy machinery will be transported to the various sites the roads leading to the site will have to be tarmacked not only for the benefit of the community but also the company.

Concern 4

Mrs Rodah Obadiah noted that employment in the past has not been fair and that all unskilled labour should be sourced from the local area.

Response

In his response, the area District Officer informed members that the youth should join the Nakuru north youth sacco which is helping the youth in acquiring jobs not only in GDC projects but in many other projects in the area among other benefits such as saving for the future.

Concern 5

Mary Njoroge the District Gender Development officer was in support of the project but wanted to know the CSR activities that will be incorporated. She further noted that Women in the District have also formed a Sacco and should therefore be considered in employment and company tenders.

Response

Mr Wetangula of GDC in his response noted that the company is engaged in many CSR activities such as drilling of boreholes, tree nurseries, and road repairs among many others. In addition, he noted that the current CSR plan is to construct an education centre. In relation to women winning tenders, he noted that the scope of the current works is too big and therefore cannot be done by small groups. However, he promised that in future when there are tenders within their scope, they would be given a priority.

Concern 6

Mr Waweru on his part wanted to know the place of old men in the community since a great emphasis has been placed on the youth. He further sought to know whether there will be any compensation for persons whose land will be affected by the development.

Response

Mr Wetangula in his response informed the meeting that men have not been left out since all the materials used in the construction and which is locally available will be sourced from the local area therefore giving the old men a chance to participate in the projects initiated by GDC. In terms of compensation, he reiterated that KETRACO, the company contracted to supply power to the main grid will have a comprehensive compensation package in line with its policy.

Concern 7

Mr Maina wanted to know whether the geothermal drilling causes climate change since the area is experiencing above normal rainfall

Response

Mr Wetagula in response noted that the rains are heavy in the whole country leading to bursting of river banks, lakes among other water bodies.

Comments in Support

Comment 1

Mr John in support of the project noted that the project should be initiated since it will be beneficial to the local area both socially and economically.

Comment 2

Mr David Njuguna of the MP's office, in support of the project noted that it will benefit the community through employment and corporate social responsibility projects which will empower the community in many ways.

Comment 3

Magena Samwel chairman youth Sacco was also in support of the project noting that it has a great capacity to employ the youth. However, he encouraged parents to educate their children and provide them with technical courses so that they can take up gainful employment.

Min/7/13 District Commissioners Remarks

The Area District Commissioner Mr Geofrey Kithai thanked GDC for the various development initiatives in the area. However, he challenged GDC to be keen on meeting the community needs through CSR activities such as provision of an ambulance to the local dispensary a request that the community has already placed with GDC, installation of electricity transformers in order to increase electricity connectivity and drilling of boreholes for the community. In addition, hailed the youth Sacco for the good work it is doing but challenged it to have very good feedback mechanisms to its members in order to boost members' morale. Finally, he informed the community to have good reporting and management of issues of problems and challenges that they face so that they are dealt with efficiently and in a timely manner.

Min/8/13 Way forward

All the members unanimously agreed to the project idea noting that the importance outweighed the negative effects.

Min/9/13 AOB

There not being any other business, the meeting was adjourned with a word of prayer from pastor Robert Mungai at 2.45pm

Prepared by:..... .....

Secretary Date

Approved for Circulation..... .....

Chairman Date

APPENDIX 7.2 : ATTENDANCE LISTS OF THE LAND MAWE CONSULTATIVE FORUM

THE PROPOSED 90 MWe MENENGAI MODULAR POWER PLANTS PROJECTS, NAKURU COUNTY

ENVIRONMENTAL IMPACT ASSESSMENT DATE ---18/9/13---

S. No.	Name	Mobile No.	ID No.	Role in the Community	Comment	Signature
1.	Susan W. Mutua	0720 658834	20396647	Member	Project Lendelee	
2.	Peter K. Kimani	0721527390	11523389	CHIEF	Will be of help.	
3.	KABUGI ABRAHAM RONNIE	0725687108	0475569	CEO-YOFASD	Support the project	
4.	Moses Kimeu	0720409623	9860538	ASST. CHIEF	A Noble Project	
5.	EUNICE W. KAMAU	0724275306	9814168	ASST-CHIEF	SUPPORT THE PROJECT	
6.	SAMWEL K. NJOROGE	0724949793	24275275	member	Support the project	
7.	ZACHARIAH K GAITHURU	0723611446	7401323	MEMBER	SUPPORT THE PROJECT	
8.	PETER G. GATHORO	0725756887	5751025	MEMBER	OK	
9.	DUNCAN N. WAMAITHA	0721-836197	4269899	CHW	I support the project	
10.	GEORGE KIMUNDUI	0726242804	5250920	FARMER	OKAY	
11.	Samuel Maina	0718286656	5794444	CHIEF	ok	
12.	John Kamau W.	0722542585	23201455	Church Elder	Continue to work	
13.	Gabriel Kiugwini	0716 373936	04632 53	Chief Elder	Continue to work	
14.	BETHUEL KAMAU	0720634588	10155412	School chairman	Keep up	
15.	LILIAN WANJIRU	0716387480	23183100	CHW	continue to work	
16.	MOSES KIMEU	0720409623	9860538	Asst Chief	Keep it up	

THE PROPOSED 90 MWe MENENGAI MODULAR POWER PLANTS PROJECTS, NAKURU COUNTY

ENVIRONMENTAL IMPACT ASSESSMENT DATE 18/9/13

S. No.	Name	Mobile No.	ID No.	Role in the Community	Comment	Signature
1.	LEAH KAMAU	0712471346	23411444	W. LEADER		
2.	JOEL MANJA	0725521685	12831127	CHW.	Attended	
3.	CATHERINE MWANGI	0714358856	25199123	Pharm Tech.		
4.	MARY W. NJOROGE	0722234475	4664373	GOK officer	attended	
5.	Hamisdag K. Kibe	0726237225	2315832	Secretary	attended	
6.	Isaac M. Kinyanjui	0725923842		CHAIRMAN	attended	
7.	Charles Mburu	0717383664	6711358	Secretary	attended	
8.	Jethro Karanja	0723564729	4862388	C. LEADER	Good project	
9.	Stephen Kamau	0722390617	1081494	Businessman	Attended	
10.	Patrick N. Kariuki	0725322142	4672375	Farmer	Elder	
11.	John Kareri Wamuyu	0720118683	5381385	Elder	attended	
12.	Kigondu Kinyanjui	—	—	Elder	attended	
13.						
14.						
15.						
16.						

THE PROPOSED 90 MWe MENENGAI MODULAR POWER PLANTS PROJECTS, NAKURU COUNTY

ENVIRONMENTAL IMPACT ASSESSMENT DATE ----------

S. No.	Name	Mobile No.	ID No.	Role in the Community	Comment	Signature
1.	Rodah J. Yator	0721743155	4012170	C.D.F Rep.	Welcome.	Yator
2.	Joseph M. Gitanga	0712253548	11187059	ASST. CHIEF.	Appreciated	
3.	DANIEL OLE DIKIR	0720805398	1037167	FARMER	Appreciated	
4.						
5.						
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ENVIRONMENTAL IMPACT ASSESSMENT DATE ---18/9/13---

S. No.	Name	Mobile No.	ID No.	Role in the Community	Comment	Signature
1.	ARISTIDES K. NGUGI	0722261927	10270745	ASS CHIEF MWAKIMU	Informative meeting	
2.	ESTHER MILGO	0720818591	9558002	ASS-CHIEF KIRIMA	WELL INFORMED	
3.	Bosco Mathanga	0720531925	9370089	Leader	Information is power.	
4.	Pst Robert Mungai	0723944746	17502300	Pst & CHC	Timely educa	
5.	Lucy Gathuku	0722264130	22985322	CHC	Good info.	
6.	JONES N. KARIUKI	0722593600	10350 41	Snr Chief	Good interaction	
7.	TITUS N. MUIRU	0720254273	13501131	CHIEF	recommendable	
8.	JAITHATH K. MUIRURI	0725828294	22920071	M.O.A.	feely information	
9.	PHILIP NYAITE	0722560941	0398252	TEACHER (RTD	EDUCATIVE	
10.						
11.						
12.						
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16.						

APPENDIX 7.3 MINUTES OF PUBLIC AND STAKEHOLDERS FORUM HELD AT KABARAK GDC PLOT IN THE PROJECT AREA

PUBLIC CONSULTATIVE FORUM FOR THE PROPOSED CONSTRUCTION OF 90 MW MENENGAI MODULAR POWER PLANTS HELD NEAR KABARAK IN MAKUTANO LOCATION, MOROP SUBLOCATION, NAKURU COUNTY, ON 19TH SEPTEMBER 2013 STARTING FROM 11.30 AM

AGENDA

1. Prayers ka
2. Introduction
3. Chairman's remarks
4. Brief from the GDC representative
5. Brief from the consultant
6. Views from the public
7. Remarks from the District commissioner
8. Way forward
9. AOB

Attendance: List attached

MIN/1/13: Prayers

The chairman, Mr Jonathan Koech, Senior chief, Makutano location, called the meeting to order at 11.30 AM. He then requested Pastor Korir who said a word of prayer.

Min/2/13: Introduction

The chairman informed participants that the meeting was convened to enable them participate in the Environmental impact Assessment of the proposed GDC 3 × 30 MW Menengai Modular power plants. He welcomed members to the meeting and asked them to make self introduction stating their names and their respective roles in the community. The list of members is attached.

Min/3/13 Chairman's remarks

The chairman in his opening remarks thanked all members for attending the meeting. He also thanked GDC for identifying the area for implementation of the various projects and for updating the community on the upcoming projects. In addition, he thanked GDC for the various Social Corporate Responsibility projects initiated. He informed the members present of the importance of their participation in projects that are being initiated in the area and encouraged members to freely express their concerns.

Min/5/13: Brief from GDC representative

The GDC representative Mr. Gabriel Wetangula welcomed members present to the public consultative forum and introduced other GDC representative present. He informed participants that GDC has been drilling and testing geothermal wells within the Mengai Caldera since the year 2010. The initial target was to start generating electricity by the year 2017. However, the government has issued a new directive requiring that 90 MW of electricity be generated from Menengai field by December 2014 in order to support efforts of achieving Vision 2030. He noted that the works will be in three phases which will work simultaneously viz the power generation plants each producing 30MWe, construction of steam highway and electricity transmission line.

Power plants will be constructed by three separate companies that will tenders opened recently, while GDC supported by the Government will develop steam collection pipelines. The Kenya Electricity Transmission Company (KETRACO) will construct power transmission lines, which is within their mandate. Mr Wetangula emphasized the role of Environmental and Social Impact Assessment in sustainable geothermal development and hence the need for public and stakeholders to be involved in decision making. He therefore encouraged members to freely express their positive and negative concerns for the proposed project.

Min/4/13 Brief from the Consultant

Dr. Gelas Muse on behalf of the Consultants informed the meeting that the need to conduct EIA is as per EMCA 1999 (revised 2008), section 58, that requires all proposed projects that may have significant impacts on the environments must carry out EIA in order to safeguard the environment from adverse impacts. Public participation in the EIA process is a legal right and therefore their presence and active participation is valuable. The consultant encouraged members to freely express their concerns regarding environmental, social and health issues associated with the proposed project.

Min/6/13: Views from the public

The Chairman opened the floor for the community to present their concerns. All contributors were asked to identify themselves and to ensure they were brief to give room for many people to contribute. The concerns raised as well as the response are given below:

Concern 1

Pastor Korir noted that he supported the project but wanted to know when GDC will start employing the youth, where the geothermal drilling will be done and whether there will be a reduction in electricity cost once the plant is operational. His sentiments were supported by Gabriel Munga who wanted to know how the community will benefit from the electricity generated since the community is at the source.

Response

Mr Wetangula of GDC in his response noted that the electricity generated will be supplied to the maid grid and then distributed to consumers by Kenya Power Company. It is therefore the responsibility of Kenya Power Company to fix the prices. However, if Geothermal electricity is generated in large quantities, then the prices may go down not only in the area but in the whole country. In addition, he informed the meeting that the company has helped and will continue to help increase electricity connection by installation of transformers. He also informed the meeting that the drilling is being done in the Menengai crater. On employment, he informed the meeting that the company has employed and will continue to employ persons from the local area on casual basis once the opportunity arises.

Concern 2

Mr Wilson Maranga Chief Kiamunyi location noted his support for the project but wanted to know if the company has any plans to provide water as a CSR activity. In addition, he also wanted to know plans underway to employ the youths.

Response

Mr Wentangula, the GDC noted that the company is committed to CSR activities and for this reason has bought a water drilling machine which will reduce the cost of drilling boreholes for the community.

On employment, the chairman Rongai District Youth Sacco informed the meeting that through his office, many youths have been employed not only by GDC but even by other companies. However, he reiterated that since GDC started its operations, 51 youths have been employed and are on GDC payroll as employees working in the various sections of construction.

Concern 3

Pastor Ndai was concerned about the odour coming from the steam in the already drilled wells which has increased the cases flew, Headache and Asthma in the area therefore increasing the cost of medication.

Response

With regard to the odour, consultant said it could be because of hydrogen-sulphide. Although the gas may be smelled several meters away from wells the gas concentration based on available data is undetectable a few meters away from production wells. The gas concentrations away from the wells are thus within the World Health Organization (WHO) limits that are harmful to health. He pointed out that likely effects would be to those exposed at the test wells. However, to reduce its effects on workers GDC has a comprehensive operational occupational safety and policy to protect employees. With regard to effects on crops he noted that suplhide is anti-fungal and the CO2 present in the steam is used by crops in the photosynthesis process and that is why geothermal steam is used in floriculture by firms such the Oserian in their greenhouses.

Concern 4

Mr Joseph was also in support of the project but wanted to know the extent to which steam from the power generation plant could used in green house farming.

Response

Mr Wetangula in his response noted that this will be done through a partnership with farmers near the crater.

Concern 5

Mr Maina Martin was concerned about the poor state of the roads in the area and wanted to know what role GDC in maintaining roads and other CSR activities in place.

Response

Mr Wetangula of GDC in his response noted that the company is engaged in many CSR activities such as drilling of boreholes, tree nurseries, and road repairs among many others. In addition, he noted that the current CSR plan is to construct an education centre.

Concern 6

Mr Maina on his part sought to know whether there will be any compensation for persons whose land will be affected by the development.

Response

Mr Wetangula in his response informed the meeting that in terms of compensation, KETRACO, the company contracted to supply power to the main grid will have a comprehensive compensation package in line with its policy.

Comments in Support

Comment 1

Mr Martin Maina, in support of the project noted that it will benefit the community through employment and corporate social responsibility projects which will empower the community in many ways.

Comment 2

Mr. John in support of the project noted that the project should be initiated since it will be beneficial to the local area both socially and economically.

Comment 3

Mr. Richard, chairman youth Sacco was also in support of the project noting that it has a great capacity to employ the youth, but challenged parents to educate their children and provide them with technical skill courses.

Comment 4

Mr. Waweru noted that the project will be very beneficial not only to the local area but to the Nation at large. However, he challenged GDC to drill water for the local community.

Min/7/13 Remarks from the District Officer 1 Rongai District

The Rongai District Officer 1 thanked GDC for the various development initiatives in the area. However, he challenged GDC to be keen on meeting the community needs through CSR activities. He informed the community members to be keen on the indirect benefits from the project which include increase in prices of land, increase in economic activities and even institutions such as universities in the area. In addition, he hailed the youth Sacco for the good work it is doing in enlightening the youths in the area.

Min/8/13 Way forward

All the members unanimously agreed to the project idea noting that the importance outweighed the negative effects.

Min/9/13 AOB

There being no any other business, the meeting was adjourned with a word of prayer from pastor Ndai at 3.45pm

Prepared by:..... .....

Secretary Date

Approved for Circulation..... .....

Chairman Date

APPENDIX 7.4 : ATTENDANCE LISTS OF THE KABARAK AREA CONSULTATIVE FORUM

THE PROPOSED 90 MWe MENENGAI MODULAR POWER PLANTS PROJECTS, NAKURU COUNTY

ENVIRONMENTAL IMPACT ASSESSMENT DATE 19/9/13

S. No.	Name	Mobile No.	ID No.	Role in the Community	Comment	Signature
1.	EVANS MORONGE	0733777349	9314342	A/Chief	Accepts the project	
2.	WILSON MARAGA	0702222412	9148120	ADMINISTRATION	ACCEPTS THE PROJ	
3.	REUBEN D. OMONDI	0721321051	7953152	CHIEF-ADMINISTRATION	I ACCEPT	
4.	DEJER KAHARA	0718868020	8271983	SEC MENENGAI S.SAC	I ACCEPT	
5.	SARAH ANYANGO	0714758773	30099436	V. Chair/Menengai SACCO	I Accept	
6.	RICHARD WACHIRA	0715723946	21965710	Chair/Menengai sacco	I Accept.	
7.	JULIUS NYUGUNA WANYOIKE	0727466711	14647703	Wiring/Electrical	Project to Continue	
8.	Peter Ndai	0725977083	0370402	Poster	A: E.V.	
9.	John. Macharia	0718-943404	0872057	Driver.	I Accept	
10.	Martin Kiche Maina	0720-459-220	10154328	Businessman	I D. Accept	
11.	GABRIEL MUNGAI	0722947526	9315339	D.P.C	Good.	
12.	Godfrey Ngugi	0725911834	5782122	Sec Kabarak Council of Elders	Good	
13.	Joseph S. Mwangi	0725329783	4739946	Chairman Village E.V. Committee..	Good Reports.	
14.	JAMES KAMAU	0728544437	23524841	YOUTH REPRESENTATIVE	Good Reports	
15.	Augustine Kipkech	0723613933	25222624	Youth	well done	
16.	JOHN MWAI		11647669	MUKHILIMA	Good	

THE PROPOSED 90 MWe MENENGAI MODULAR POWER PLANTS PROJECTS, NAKURU COUNTY

ENVIRONMENTAL IMPACT ASSESSMENT DATE ---19/9/13---

S. No.	Name	Mobile No.	ID No.	Role in the Community	Comment	Signature
1.	ROWSON KIMBOI	0715157430	30560280	DRIVER	accept	
2.	JOSEPH SIGILAI	0717828740	4409684	Security	accepted	
3.	John Nalsei	0705697506	25926518	farmer	accepted	
4.	Mathew Koech	0702142520	24596854	Business man	accepted	
5.	[illegible]	0715075285 / 1422	11117383	DRIVER	accepted	
6.	Mercy K. CHEPKOECH	0712195448	27071109	youth	good reports	
7.	PATRICK N. MBUGUA	0722947267	11069048	LOCATION LEADER	ACCEPTION	
8.	GABRIEL WETANGULA	0723 827781	12573106	CDC	Good Team of	
9.	SONA'ITHON K. KOECH	0722487691	1339122	CHIEF	Good work	
10.	Jackson Ole Chuta	0722665924	10941758	Coordination of National government	Good Public participation	
11.						
12.						
13.						
14.						
15.						
16.						

APPENDIX 7.5 SAMPLE OF FILLED QUESTIONNAIRES

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY;

DATE: ...19/09/2013....

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex:.....Male.....

ii. Age:.....42 yrs.....

iii. Education level:.....Masters (MBA).....

iv. Your Position in the Organization/Community ---Assistant County Commissioner DNC---

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? Yes/No

ii. Are you aware of the benefits associated with power generation in Kenya? ☑Yes ☐No

If yes, name some of the benefits:

Employement, Power Supply, Water Supply, Environmental Sustainability, Training

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☑Yes ☐No

If yes, name some of them: Air pollution in certain %, Noise, Earth tremors,

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? Yes/No ---yes---

If yes, list the effects:---as Mentioned above---

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

GDC need to carry out Consultative Continous Monitoring till the Project is Stable to reduce the Negative effects

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☑Yes ☐No

If no, give reasons

.....

.....

.....

Tel. No. ---0722 665924---

Thank you for your time

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY;

DATE: 19/9/2013

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex: MALE

ii. Age: 50 TO

iii. Education level: College

iv. Your Position in the Organization/Community 1st CHC

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? Yes/No

ii. Are you aware of the benefits associated with power generation in Kenya? ☑Yes ☐No

If yes, name some of the benefits:

Energy Cost reduction, Supply Source for energy Employment & Development

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☑Yes ☑No

If yes, name some of them:----------

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? Yes/No ----------

If yes, list the effects:----------

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

Planting of trees

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☑Yes ☐No

If no, give reasons

.....

.....

.....

Tel. No. 0723944746

Thank you for your time

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY;

DATE: 18/09/2013

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex: MALE

ii. Age: 88

iii. Education level: FA

iv. Your Position in the Organization/Community ---------- CHIEF

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? ~~Yes~~/No ✓

ii. Are you aware of the benefits associated with power generation in Kenya? ☑~~Yes~~ ☐No

If yes, name some of the benefits:

• Source of Electricity to run our industries, for domestic use etc

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☑Yes ☐No

If yes, name some of them: Environmental destruction, health hazards, awful smells, displacement of wildlife

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? ~~Yes~~/No ----------

If yes, list the effects: As above B(iii)

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

Reafforestation, monitoring level of awful smells, Rehabilitation of habitat.

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☑~~Yes~~ ☐No

If no, give reasons

.....

.....

.....

Tel. No. 0726277390

Thank you for your time

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY;

DATE: 18-9-2013

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex:.....FEMALE.....

ii. Age:.....54 YRS.....

iii. Education level:.....O LEVEL.....

iv. Your Position in the Organization/Community ---------- C.D.F REP. ----------

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? Yes/No ✓

ii. Are you aware of the benefits associated with power generation in Kenya? ☑Yes ☐No

If yes, name some of the benefits:

---------- Job creation ----------

---

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☑Yes ☐No

If yes, name some of them:---------- headache ----------

---

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? Yes/No ----------

If yes, list the effects:---------- Smelling ----------

---

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

---------- treatment ----------

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☐Yes ✓ ☐No

If no, give reasons

.....

.....

.....

Tel. No. ----------

Thank you for your time

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY;

DATE: .....

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex:.....FEMALE.....

ii. Age:.....34-45.....

iii. Education level:.....SECONDARY....

iv. Your Position in the Organization/Community WOMEN LEADER.

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? Yes/No

ii. Are you aware of the benefits associated with power generation in Kenya? ☐Yes ☐No

If yes, name some of the benefits:

TO HELP THE COMMUNITY WITH LIGTS

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☐Yes ☑No

If yes, name some of them:----------

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? Yes/No ---------NO YES

If yes, list the effects:---------AIR POLUTION.

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☑Yes ☐No

If no, give reasons

.....

.....

.....

Tel. No. 0712471346

Thank you for your time

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY; DATE: .....

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex: PETER N. MWANGI.

ii. Age: 60 YEARS

iii. Education level: FORM FOUR

iv. Your Position in the Organization/Community NRNA CHAIRMAN

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? Yes/No

ii. Are you aware of the benefits associated with power generation in Kenya? ☑Yes ☐No

If yes, name some of the benefits:

WATER ELECTRICITY ROADS.
Create Employment.

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☐Yes ☐No

If yes, name some of them:----------

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? ~~Yes~~/No ----------

If yes, list the effects: High Surface - -

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

Endactation of locals of Conservation of soil

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☐Yes ☐No

If no, give reasons

.....

.....

.....

Tel. No. 0721803266

Thank you for your time

PUBLIC PARTICIPATION QUESTIONAIRRE

PROPOSED CONSTRUCTION OF 90 MWe MENENGAI MODULAR POWER PLANTS, NAKURU COUNTY; DATE: ..18.09.1.2013...

Geothermal Development Company limited (GDC) Plans to construct and install a 3 × 30 MWe Menengai Modular Power Plants Projects within the Caldera. You are kindly requested to give your views on environmental and social benefits of the proposed project by answering the following questions:

A. BACKGROUND INFORMATION

i. Sex:.....FEMALE.....(MARY....WAITHERA KANYAI)

ii. Age:.....35 YEARS.....

iii. Education level:.....FORM FOUR LEVEL (COLLAGE)

iv. Your Position in the Organization/Community ----COMMUNITY HEALTH WORKERS

B. ABOUT THE PROJECT

Part 1 Location

The proposed power plants will be located within the Menengai Caldera.

i. Are you aware of the proposed construction of the power plants projects in Menengai Caldera? ~~Yes~~/No

ii. Are you aware of the benefits associated with power generation in Kenya? ☑Yes ☐No

If yes, name some of the benefits:

① LIGHTENING POWER (Electricity)

② Water Supplies

iii. Are you aware of environmental and health effects associated with the operation of a power generation plant? ☑Yes ☐No

If yes, name some of them:----Smell, pollution of the air.

iv. Are you aware of environmental and health effects associated with the operation of a power generation plant? Yes/~~No~~ ----------

If yes, list the effects:----------

v. Freely express your wishes/suggestions for reducing the effects named in (iv) above (if any)

C: PERSONAL VIEWS/RECOMMENDATIONS

Do you think this project should be allowed to continue? ☑Yes ☐No

If no, give reasons

.....

.....

.....

Tel. No. ~~0712 149 763~~, ~~0734 748 717~~

Thank you for your time