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ENVIRONMENTAL AUDIT REPORT
OLKARIA III GEOTHERMAL POWER PLANT

2010

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ACRONYMS

CAP	Corrective Action Plan
CSR	Corporate Social Responsibility
DIT	Directorate of Industrial Training
DOHSS	Directorate of Occupational Health and Safety
EA	Environmental Audit
EHS	Environment Health and Safety
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act, 1999
EMP	Environmental Management Plan
EMR	Electromagnetic Radiation
EMS	Environmental Management Systems
FD	Fisheries Department
GPS	Global Positioning System
IEA	Initial Environmental Audit
IPP	Independent Power Producer
KEBS	Kenya Bureau of Standards
KenGen	Kenya Electricity Generating Company
KPLC	Kenya Power and Lighting Company
KWS	Kenya Wildlife Service
LNRA	Lake Naivasha Riparian Association
LNGG	Lake Naivasha Growers Group
LNMC	Lake Naivasha Management Committee
LNMP	Lake Naivasha Management Plan
MOU	Memorandum of Understanding
MP	Management Plan
NCG	Non Condensable Gas
NEMA	National Environment Management Authority
NMC	Naivasha Municipal Council
ODC	Oserian Development Company
OEC	Ormat Energy Converters
PPA	Power Purchase Agreement
PPE	Personal Protective Equipment (Clothing)
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

1.0 EXECUTIVE SUMMARY

Since the year 2000, Orpower 4 Inc. has operated a geothermal power station on the south western slopes of Olkaria hill, 5 km south of Lake Naivasha, 60 km from Naivasha town, and approximately 125 km to the north west of Nairobi (Figure 1). The power station initially generated 12MW of electricity, which was boosted to 48 MW of electricity (48MWe) in 2004. The power is sold to the Kenya Power and Lighting Company Limited. The power station is run by 28 employees who are housed approximately 30 kms away from the power station. There are also 2 students on attachment. Security, gardening, cleansing and other services are contracted out to the local community and to other service providers.

The Olkaria III geothermal resource occurs partly within Hell's Gate National Park (gazetted in 1984), and partly in Maiella - Ngati and Kongoni farms. It falls within the zone gazetted as a geothermal resource area in 1971. There are numerous scenic sites and a Ramsar site (Lake Naivasha) close to the project site. Wildlife, fumaroles and hot springs are major attractions in the Olkaria area, as are the flower- growing farms.

The Olkaria III power station covers an area of approximately 11.9 km², in the southwest field, and is one of 7 designated fields in the Greater Olkaria geothermal area. The other fields are Olkaria East (I); Olkaria Northeast (II); Olkaria Northwest; Olkaria Central; Olkaria Southeast; and Olkaria Domes, of which Olkaria I and Olkaria II are operated by KenGen. Orpower 4 Inc staff are housed on 7.5 acres of land at the Staff Housing Estate near the shores of Lake Naivasha approximately 19 km from the project site.

Socio economic, Environmental, and Health and Safety Issues

Orpower contributes to the electricity in Kenya that is needed for industrial and other uses, and to revenues of the exchequer through taxes paid. Orpower directly employs 28 permanent workers, and many others indirectly through suppliers and contractors. The local community benefits from social programmes such as support to schools, bursaries to needy children, and provision of transport.

Environmental concerns are centred around impacts on the Wildlife, the hydrology of Lake Naivasha, the flowers farms, and on the local Maasai community in terms of socio - economics and health.

Other concerns are on the loose soils, which are susceptible to erosion, hazards of volcanic eruption and earthquakes, noise emissions during plant operation, changes in the water table, emission of electromagnetic radiation through the high tension power lines, air pollution from H₂S and CO₂, disposal of spent brines, and dust emissions.

Health and safety concerns for workers in the plant centre around fire hazards from pentane, electrical faults, machinery, falling objects, electrocution and electromagnetic radiation, scalding from the geothermal fluids through exposed (un insulated) pipes, or through leaks in the pipes, exposure to H₂S, high noise levels at the generators, and waste

disposal. Transportation of workers and local community members can also be a source of safety concerns. The concerns for a good working environment (adequate lighting and ventilation) which have been highlighted as concerns in past Environmental Audits have been addressed.

So far, there have not occurred any unforeseen environmental impacts. Orpower 4 Inc has closely implemented the Environmental Management Plan prepared for the project by Professor Tole and Colleagues (2009). The EMP has been monitored over the years through Environmental Audits carried out in 2004, 2005, 2006, 2007 and 2009. The company holds regular consultations with the KWS, the Lake Naivasha Riparian Association, and the local community representatives to address issues of environmental and community concern. Health and safety concerns are addressed through the company's "Environmental, Health and Safety Policy" document, the "Safety Manual", and the designation of an Environment Officer, a Health and Safety Officer, and a Health and Safety Committee. Training and sensitization of workers on environmental as well as on health and safety issues are undertaken as continuous and ongoing processes.

There is a signed Memorandum of Understanding between Orpower 4 Inc. and KWS that covers environmental management and research and confirms Orpower 4 Inc.'s support to KWS's Park Management team in Hells gate Park. The MoU is monitored through monthly review meetings, and any emerging issues addressed.

Monitoring of environmental and health and safety issues, as well as of incidents and accidents is adequate, as it is adopted as a continuous activity.

Recommendations

1. Orpower 4 Inc. should continue to regularly monitor concentrations of H₂S, noise levels, and leakage of brine and steam.
2. Regular inspection for malfunctioning systems and structures, and their immediate repair should be continued.
3. Leaking pipes should be repaired immediately.
4. Disposal of steam trap fluid can still be further improved.
5. Regular fire and safety drills should be conducted to ensure preparedness of staff.
6. The Health and Safety Committee Members should continuously receive training and be in a position to train other workers, according to the OSHA (2007) which requires "Provision of information, instruction, training and supervision necessary to ensure safety and health" by employers.
7. Daily patrols and inspections of the plant area should continue.

8. Regular removal and proper disposal of solid waste should be continued.
9. Monitoring of the status of flora and fauna, and re-vegetation of degraded sites should be continued in collaboration with KWS.
10. Interaction with the local community and assistance to community projects should continue, using established formal structures.
11. Sustainability of community projects should be built into all the initiated projects, as recommended in the Environmental Audit report of 2009.

2.0 DESCRIPTION OF THE PROJECT

2.1 The Need for the Project

Peak demand for electricity in Kenya is currently very close to the total effective installed capacity of 1330MWe. Most of the electricity comes from hydroelectric power stations. Geothermal power generation stands at only 202MWe currently, despite the existence of a potential to produce 7,000 to 10,000 MWe from geothermal energy in Kenya. The Geothermal Development Company was formed through the Energy Act of 2006 to spearhead further development of geothermal energy in Kenya. Orpower 4 Inc has operated the Olkaria III geothermal energy power plant since the year 2000, when it started generating 13.6 MW of electricity for sale to Kenya Power and Lighting Company Limited (KPLC) under a Power Purchase Agreement (PPA). This was expanded during 2007 and 2008 to an installed capacity of 55MWe. The production is at about 48MWe net currently. The power plant has maintained availability and load factors greater than 98% since commissioning.

2.2 Geographic Setting

The Olkaria geothermal field is located approximately 125 km to the north west of Nairobi, south of Lake Naivasha (Figure 1). . The Olkaria geothermal area covers an area of 75 km², and has the potential to produce at least 400Mwe. The Olkaria III concession comprises the southwest field, located approximately 5 km south west of Lake Naivasha. It is one of 7 designated fields in the Greater Olkaria geothermal area, and covers an area of approximately 11.9 km². The other fields are Olkaria East (I); Olkaria Northeast (II); Olkaria Northwest; Olkaria Central; Olkaria Southeast; and Olkaria Domes. KenGen operates a 45 MWe power plant at Olkaria I, and a 70 MWe power plant at Olkaria II. Another 35 MWe unit is being added (Unit 3) to increase generation in Olkaria II to 105 MWe by 2010. The Oserian Development Company (ODC) generates 2MWe for its flower growing operations.

The Olkaria III geothermal resource area includes parts of the Hell's Gate National Park, Maiella - Ngati and Kongoni farms, within the zone that was gazetted as a geothermal resource area in 1971. The geothermal field is in close proximity to Lake Naivasha, flower-growing farms, scenic sites, and unique wildlife. The Park has an area of 68 km² and is situated 1,560 – 2,187 metres above sea level.

The Olkaria III field is located on the south western slopes of Olkaria hill, the highest feature in the area. Like Olkaria east and northeast fields, land use in Olkaria west field is predominantly reserved for wildlife under the management of KWS, grazing by Maasai herds of sheep, goats and cattle, and flower farming. Most of Maasai homesteads are found to the south and southeast of the Olkaria III field, while flower farming is found to the north. Private residences and tourist hotels are mainly located to the north of the field along the shores of Lake Naivasha.

2.3 Technical Description

Geothermal energy is energy from the depths of the earth, in the form of heat or high pressure steam. In suitable areas, geothermal energy is a renewable indigenous resource that requires minimal engineering and material inputs once it has been set up.

Pressurised steam (or other suitable vapour in the case of binary generating facilities) can be used to drive turbines, coupled to a generator that generates electricity. In binary systems, geothermal heat is used to vaporise and pressurise a secondary motive fluid such as pentane, which then drives the turbines. This is the process used at the Orpower 4 Inc facility.

The Olkaria III project has constructed well pads ranging in size between (100 x 70)m and (280 x 150)m on which production and re-injection wells have been drilled and tested. It is from the production wells that high temperature pressurised steam is tapped and transported through metallic pipes for utilisation at the facility. Some of the pads and wells have been set aside to be utilised in the future.

Steam from the wells is separated at the separator, with the brine being used to preheat the motive fluid that drives the turbines, followed by vaporisation of motive fluid by the total steam flow. There are a total of six OEC units. In the OEC unit, power is generated by turbines, driven by a motive fluid (pentane), operating in a closed Rankine cycle.

Geothermal fluid is gathered using metallic pipes and directed into a separator, where steam and water are separated. Dry steam from the separator is directed to the vaporiser, a heat exchanger where heat is transferred to the motive fluid that turns the first turbine and thereafter to the second turbine. Geothermal brine is directed to a pre-heater, where the motive fluid is heated up and channelled to an evaporator. Then the waste fluids are directed to the re-injection well.

Both the spent steam (steam condensate) and the geothermal brine are re-injected in wells OW307 and OW401 to the south of the field. It is estimated that over 95% re-injection is achieved in the Olkaria III (EG and EGAU) project. Total fluid flow rate is estimated at approx 400 - 500 tonnes/hour, consisting of 160 to 200 tonnes/hour steam and 240 to 300 tonnes/hour brine, with a 4 - 5% non- condensable gas fraction by weight of total fluid flow. The non-condensable gases are piped to the Oserian Development Company farms to boost flower production. Occasionally, the NCGs are discharged into the atmosphere.

The power generated at Olkaria III is transmitted through a 220 kV transmission line owned by KPLC. The line runs from the power plant through the western boundary, to join the KenGen line within Hell's Gate National Park.

Orpower 4 Inc. has constructed approximately 36 housing units for use by plant operators. These houses are constructed at a 7.5 acre site near the shores of Lake Naivasha (Figure 1).

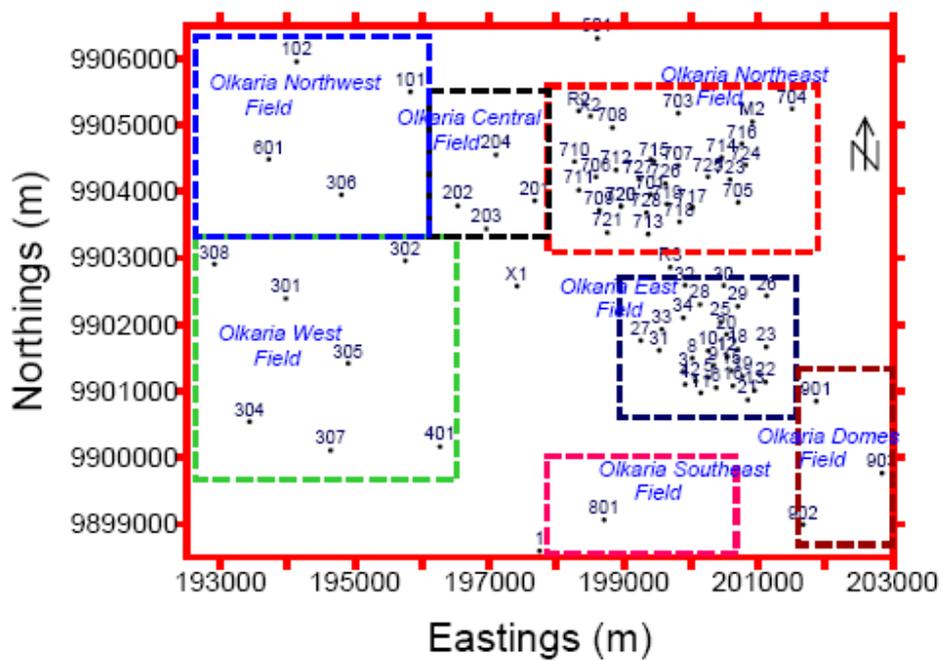


Figure 1 Location of the Olkaria geothermal field (KenGen, 2004)

2.4 Summary of the Technical Description

2.4.1 Raw Materials: The raw materials constitute the geothermal fluids (high temperature steam and brine) and the heat and pressure contained therein. Pentane is used as a motive fluid in a closed cycle, so that it is recycled, and there is little loss or waste of pentane. The vaporisers, turbines, generators, condensers, and pipes are part of the machinery necessary to convert the heat contained in the geothermal fluid into electricity. Petroleum products (oil, diesel, greases and lubricants) are used for transport and lubrication of moving plant parts. Water for plant operations and office use is abstracted from Lake Naivasha using the KenGen permit and also purchased from mineral water companies. Office furniture, equipment, and stationery are used for management operations. Human labour is also an important “raw material” input in the operations.

2.4.2 Products: The products are electrical energy, which is sold to the Kenya Power and Lighting Company Limited, and Carbon dioxide gas, which can be sold to flower growing companies, and possibly to soft drinks manufacturers.

2.4.3 Wastes: These include the spent geothermal fluid, waste geothermal gas, waste heat, electromagnetic radiation, waste water, garbage, and sewage.

2.4.4 Technical Activities, Processes, and Operations: Once the geothermal resource has been proved and the plant set up, activity outside the main plant location consists of occasional inspection and testing of wells by contracted parties. The power plant consists of a vaporiser in which pentane is evaporated using heat from the geothermal fluid. The pressure of the vaporised pentane drives turbines that are coupled to a generator that converts the mechanical motion of the turbine into electrical energy. The electrical energy is transformed into appropriate voltage and transported via high- tension conductors to the KPLC distribution network.

All the technical processes are controlled from a central control room. Services to the technical personnel include administrative (communication, secretarial and financial), repair and maintenance, transport, security, gardening, and cleaning. There also occasional contracted consultancy services on a need basis.

2.5 Objective, Scope, and Criteria of the Audit

2.5.1 Objective: To review and assess the activities of the project, and its impacts on the environment and the community since the last environmental audit (compared to the environmental management plan) and to make recommendations for mitigation of any adverse impacts for the next one year.

2.5.2 Scope: There have been five previous environmental audits which have reviewed impacts of the plant on the environment. The reviews have included impacts of the project on the health and safety of the workers, wildlife, and the surrounding indigenous communities, as well as on the flower- and wildlife ranch- farmers, and on Lake Naivasha. The impacts have been compared to the Environmental Management Plans

made in the initial Environmental Impact Assessment Study (Tole and Colleagues, 2000), and the immediately preceding Environmental Audit. This audit reviews the situation since the last Environmental Audit prepared by Prof. Mwakio P. Tole and Colleagues (2009).

2.5.3 Criteria: This report is prepared on the basis of field and literature surveys. The Environmental Audit Reports of 2004, 2005, 2006, 2007 and 2009 have been consulted.

Field visits were conducted on various days between 27th September and 8th October 2010 to gather information, and interview the workers and the Maasai Community. All the operation sites (plant, switch yard, control room, administrative office, store, garage, well heads) and sensitive park areas were inspected during the visit.

2.5.4 Audit Team Members: These were Prof. Mwakio Tole, Coordinator of the study, and Physical and Chemical impacts expert; Prof. William Aino Shivoga, Biological impacts expert; and Ms. Charity Konana, Socio-economic impacts expert.

3.0 LEGAL AND REGULATORY FRAMEWORK

3.1 Introduction

Environmental Audits have been a legal requirement since 2004 for firms, industries, warehouses, factories, petrol stations, power stations, quarries, mines and all projects specified under schedule 2 of EMCA (1999). The Orpower 4 Inc Olkaria III project has submitted previous Environmental Audits to NEMA for 2004, 2005, 2006, 2007 and 2009. This Annual Environmental Audit report for 2010 therefore examines the status of the environment in the Olkaria III geothermal power plant since the 2009 audit, to ensure that Orpower 4 Inc. meets its legal obligations under EMCA (1999).

3.2 Policy

All geothermal resources are vested in the Government (Geothermal Resources Act). The government of Kenya created the Geothermal Development Company through the policy paper on energy (Sessional Paper No. 4 of 2004) which was later actualised in the Energy Act (No. 12 of 2006) on realisation that the vast potential in geothermal energy in the country was taking long to be utilised. The Geothermal Development Company became fully functional in 2009 to fast track the generation of electricity from geothermal resources in Kenya. It has the mandate to:

- Promote rapid development of geothermal resources in Kenya through surface exploration and drilling for steam.
- Avail steam to power plant developers for electricity generation.
- Manage the geothermal reservoirs (where steam has been harnessed) to ensure constant supply of steam for power generation
- Promote alternative uses of geothermal resources other than electricity generation. (These include green house heating, drying of grains, pasteurizing milk, cooling and heating of rooms, among others)

The Geothermal Development Company has set itself ambitious targets to:

- Develop at least 3,000 MWe in the next 10 years
- Develop at least 5,000 MWe by 2030
- Lower the cost of electricity in Kenya by providing fuel (steam) to power generators.

The strategies to be adopted by the Geothermal Development Company include:

- Undertake exploration, appraisal and production drilling in all fields in order to mitigate upfront risks associated with geothermal development that deter private sector participation.
- Facilitate early generation of electricity through the provision of steam to KenGen and IPPs and thus ensure that electricity becomes available faster

- Attract capital for accelerated development by opening up opportunities for private sector participation
- Promote alternative uses of geothermal energy

The Kenya Government is equally committed to conservation of the environment, wildlife and other natural resources (Environmental Management and Coordination Act, Wildlife Conservation and Management Act, Forest Act). The control of all wildlife conservation areas is vested in the Kenya Wildlife Service (KWS). The fact that geothermal resources are located in wildlife conservation areas brings to the forefront the need to carefully balance resource development and utilisation on the one hand and natural resource conservation on the other.

The Government is also committed to protection of the health and safety of employees in the workplace (Employment Act, Occupational Safety and Health Act, Work Injury Benefits Act). Factories and industries are required to operate in a manner that does not compromise the health and safety of the workers. The Environmental (Impact Assessment and Audit) Regulations (2003) have been gazetted to guide the conduct of Environmental Impact Assessments and Environmental Audits in Kenya. The preparation of this Environmental Audit Report is guided by these Policies, Regulations, and Principles.

3.3 Legal and Regulatory Framework

The Olkaria III geothermal power plant is located in Naivasha County within the Rift Valley of Kenya. It is partly located within the Hell's Gate National Park, which was gazetted as a National Park in 1984. Prior to that, the land on which the plant is located had been declared a Geothermal Resource area in 1971. KenGen operates two geothermal Power Stations in the area that generate a total of 150 MWe and Oserian Development Company two small power plants that each generate 2MWe in the Olkaria area.

The Geothermal Resources Act (1982) vests all geothermal resources in the Government, and the minister in charge of energy affairs can declare any area a geothermal resources area through a gazette notice. The minister also authorises the search for geothermal resources (prospecting license renewable annually), and also grants a geothermal resources license for a maximum period of thirty years for exploitation of geothermal resources. The Geothermal Development Company a parastatal organisation has been set up to spearhead the exploration, assessment, and development of geothermal resources in Kenya.

A by-product of geothermal exploitation may be recovered by modifying the geothermal license to include provisions of the Mining Act (Cap 306). The Geothermal Resources Act also provides for supervision of activities, so that there is no harm done either to the environment or to the workers in a geothermal license area, and for compensation for land - owners and for injury/ damage to land. The Geothermal Resources Regulations (1990) prohibit entry into an area declared to be a National Park under the Wildlife (Conservation and Management) Act, Cap 376, except by the express authority of the

competent authority (Kenya Wildlife Service in this case). It is the responsibility of the Minister in charge of energy matters to seek and secure such authority. The Olkaria III area was declared a geothermal resources area under legal notice No. 16 dated 4th February, 1999.

The Electric Power Act (1997) opened the generation of electricity to the private sector. Under the Energy Act (2006), players in the energy sector were unbundled, into regulators (Energy Regulatory Commission); Power Producers (KenGen and Independent Power Producers); Transmission Company (Kenya Transmission Company – KETRACO); and Distribution company (Kenya Power and Lighting Company). Parastatals under the Ministry of Energy now include: Kenya Power and Lighting Company Limited (KPLC); Kenya Petroleum Refineries Limited (KPRL); Kenya Electricity Generating Company Limited (KenGen); National Oil Corporation of Kenya (National Oil); Kenya Pipeline Company Limited (KPC); Energy Regulatory Commission (ERC); Rural Electrification Authority (REA); Energy Tribunal; Geothermal Development Company (GDC); Kenya Electricity Transmitting Company (KETRACO).

The Environmental Management and Coordination Act (1999) established the National Environmental Management Authority to manage all matters dealing with the Environment in Kenya, including the conduct of Environmental Impact Assessments and Environmental Audits for projects deemed to have potential adverse impacts on the environment. Geothermal Energy Projects are listed under subsection 4(d) of the Second Schedule, as among projects that are required to undergo Environmental Impact Assessment. The Environmental (Impact Assessment and Audit) Regulations (2003) have been gazetted to guide the conduct of Environmental Impact Assessments and Environmental Audits in Kenya. Other relevant regulations by NEMA include: The Environmental Management and Coordination (Conservation of Biological Diversity and Resources, Access to genetic Resources and Benefit Sharing) Regulations (2006); The Environmental Management and Coordination (Water Quality) Regulations (2006); and The Environmental Management and Coordination (Waste Management) Regulations (2006).

The Water Act (2002) established the Water Resources Management Authority with powers to conserve and allocate water resources. Discharge of trade effluents requires a permit from the licensed Water Services Provider for the given area.

The Occupational Safety and Health Act (OSHA) 2007 repealed the Factories Act (Cap 514) and came into force on 26th October 2007. Employers are required by OSHA to ensure that a place of work is safe and free of risks to health, to immediately stop any operation where there is an eminent and serious danger to safety and health and evacuate all persons employed. The occupier of a work place also has a duty to prepare a general safety and health policy statement and set out ways of carrying it out (an occupier is defined to mean the person(s) in actual occupation of a workplace and this includes an employer). In addition, the employer is required to establish a safety and health

committee at the workplace and to cause a safety and health audit of the workplace to be carried out every 12 months by a safety and health advisor.

The Employment Act, 2007 sets the fundamental rights of employees and provides the basic conditions of employment of employees. It also regulates the employment of children.

The Work Injury Benefits Act (WIBA), 2007 provides for compensation for employees for work related injuries and diseases contracted in the course of employment. It requires all employees to be insured by the employer against injuries in the work place unless exempted by the Minister. In addition, an employer carrying on business in Kenya should be registered with the Director of Occupational Safety and Health Services (the “Director”). WIBA came into force on 2nd June 2008.

In addition to the Wildlife (Management and Conservation) Act, the Geothermal Resources Act, the Electric Power Act, the Factories Act, and the Environmental Management and Coordination Act, the Water Act, other relevant legislations include the Mining Act, the Employment Act, the Forest Act, the Local Government Act, the Agriculture Act, the Physical Planning Act, the Public Roads and Roads of Access Act, the Land Acquisition Act, and the Public Health Act (Cap 242).

A Memorandum of Understanding (MOU) between KPC and KWS has guided geothermal operations at the Olkaria geothermal field, so that exploitation of the geothermal resource is carried out under conditions that protect the wildlife. Orpower 4 Inc. has also been guided by the terms of the MOU between KPC and KWS, and the terms of its agreement with the KWS with respect to the field and plant management.

3.4 Orpower 4 Inc Company Policies

Orpower 4 Inc has an “Environmental, Health and Safety Policy”, which is communicated to every employee upon joining the company’s employment. The company also has a “Safety Manual for the Plant Operation and Maintenance”. There is a Safety Officer, who is in charge of safety and safety procedures at all times for employees, contract workers, and visitors to the plant. The Safety Officer, who doubles up as the plant electrician, also ensures that the right procedures are followed daily to prevent injury and damage to equipment. The lead operator serves as the Safety Officer for the day, and is in charge of managing incidences and first aid.

Orpower 4 Inc. also has an Environment Officer who is in charge of environmental protection within and outside the plant. She is active in planting trees, and inducting new employees on issues of environmental protection.

There is a Safety manual, plant maintenance manual and schedule, Safety programme, and a time schedule for worker training on health and safety issues.

The plant is inspected periodically in accordance with the Occupational Safety and Health (OSHA) Act 2007.

3.5 Acceptable National and International Standards

Standards of The Kenya Bureau of Standards (KEBS) and of the Ministries of Works, Industry, and Labour are used for plant and work environment requirements. NEMA and the Ministry of Water have gazetted Water Quality Regulations (2006) with standards for emissions of waste waters in Kenya. Further, NEMA has gazetted Waste Management Regulations (2006). Other standards include those of the WHO for environmental emissions. Plant safety regulations conform to the United States Occupational Safety and Health Administration (OSHA) requirements, where Kenyan requirements are lacking. The International Finance Corporation (IFC) also has issued Environmental, Health, and Safety General Guidelines (2007) which cover all aspects of human health and safety (EH&S), including EH&S Guidelines for Geothermal Power.

4.0 REAL AND POTENTIAL IMPACTS OF THE PROJECT

Below are outlined some of the areas of the environmental concern due to the operation of the Olkaria III geothermal power station.

4.1 Impacts on soil erosion

Bare soils that highly susceptible to erosion. Planting of trees is recommended to counter this potential threat, and at the time of the audit, rains had resulted in vegetation cover for the soils.

4.1.1 Civil Engineering Works

Most areas that had been excavated during plant construction had been replanted with grass and other vegetation. This is a continuous activity, and is supported by a nursery within the plant site.

4.1.2 Waste Water

Waste and storm waters are collected and discharged in a way that guards against gully erosion.

4.1.3 Roads

Run-off from roads has the potential to cause erosion either in the drainages that run parallel to the road or where concentrated run-off is discharged from culverts. Maintenance and use of unpaved roads also causes dust, noise, and fuel fume emissions.

4.1.4 Laying of Additional Pipes

Clearing of vegetation for the purpose of laying and maintaining pipes also contributes to soil erosion.

4.2 Noise impacts from the Olkaria III power plant

Noise is generated during operation of the power plant. Noise levels are highest close to the turbines (up to 105 dB (A) recorded), generators (up to 100 dB (A)), feed pumps (93 dB (A)), condensers (up to 86 dB (A)) and air compressor areas (up to 82 dB (A)). In these areas the use of ear protection is mandatory. The new plant has been built lower noise levels compared to the old plant.

Noise levels decrease with distance away from the plant, to background levels of 37 – 43 dB (A).

Table 1 Noise Levels at the Olkaria III plant

Site	Measured Noise Levels						Notes
	2004	2005	2006	2007	2009	2010	
Condenser Area at the plenum	97 – 111	89	89	77 - 87	77 - 86	90	Designated Ear Muff Area
Outside Condenser Area	97 – 102	86	87	76			Designated Ear Muff area
Turbine/ Generator Area	97 – 102	101	101	98 - 104	73 - 100	74 – 100	Designated Ear Muff Area
Transformer Area	81 – 82	80	81	77 - 82		62 – 69	Designated Ear Muff Area
Outside Control Room	80 – 81	81	62	68		67	Designated Ear Muff Area
Inside Control Room	55 – 70	70	58	<68	41 - 61	59	Ear Muffs Not Required
Gate Area	68 - 70	70	68	70	63 - 67	64	Ear Muffs Not Required
Outside Guard Room	56 – 57	57	59	<68		64	Ear Muffs Not Required
Outside Stores	71 – 75	68	58	76		70 – 73	Ear Muffs Not Required
Open Area Outside Site Office	64 – 67	67	67	<68			Ear Muffs Not Required

4.3 Fire Hazards

Dangers of fire hazards arise from electrical short circuiting, lightning, and from the storage and use of pentane motive fluid.

The motive fluid is n-pentane, C₅H₁₂. Because of being flammable, a water wetting down system and fire extinguishers are deployed in the station. Cigarette smoking is not allowed inside the power station compound.

There have not been any reported incidents involving fire hazards in the plant thus far. Fire and safety training was conducted for all employees in February 2010. This training can be done in-house by the Health and Safety Committee members.

During the training, a fire drill was held at the plant. It is important that a fire drill is held every year.

Fire extinguishing equipment is maintained by an external contractor according to the manufacturer recommended schedules.

4.4 Seismic and volcano hazards

The Olkaria hill is a volcanic feature, with volcanic eruption in the general area having occurred within the last 300 years (Clarke, M.C.G. and Woodhall, Allen, and Darling, 1990). Simiyu and Keller, (2000) show that there is very little risk of a potentially destructive (magnitude $M_c > 5$) earthquake occurring within the geothermal field in a period of less than one century. However, given the magnitude of the investment, and the potential damage that could arise, it is recommended that earthquake monitoring be conducted regularly, as this will also serve to monitor and provide early warning of the possibility of a volcanic eruption in the Olkaria area.

Orpower is seeking assistance from other experts on monitoring and assessment of seismic activity, particularly that which may be associated with the Olkaria hill.

4.5 Geothermal Brine

The geothermal brines from the Olkaria III field have Total Dissolved Solids concentrations in the range 2000 to 4000 ppm, consisting mostly of Na, CO_3 , SiO_2 , Cl, SO_4 and K. Boron and fluoride concentrations in the brine are well above acceptable levels, and therefore leakage of the brine must be avoided.

Although approximately 95% of the geothermal fluid is re-injected, leakages of the geothermal fluid along corroded pipes should be monitored and repaired immediately. Steam traps along the piping direct the condensate into the soil.

4.6 Air Quality

Non-condensable gases are piped to Oserian Development Company for use in their flower growing operations. Occasionally, they are released to the atmosphere. The main gases of concern are H_2S , CO_2 , CH_4 , and Radon. Dust in the atmosphere can also be of concern.

4.6.1 H₂S Emissions

During the audit, spot H₂S concentrations in open plant area were found to range from 0.013ppm to 0.38ppm. The high values were at the steam vent sites. Predictably H₂S concentrations were highest in areas that were downwind of the plant.

4.6.2 CO₂ Emissions

CO₂ is piped to Oserian Development Company for enhancing flower growth. This is a commendable partnership, which helps to reduce (or at least delay) the emission of green house gases into the atmosphere. The partnership should be continued. Ambient CO₂ measurements were conducted in January 2010 by SGS Environmental services. However, these values were not made available during this audit.

4.6.3 CH₄ Emissions

Approximately 0.00043 tonnes/hour, or 3.8 tonnes/year are piped to Oserian Development Company as part of the NCGs. As there is no likely use of CH₄ in flower growth, it is assumed that the gas is released to the atmosphere.

4.6.4 Radon Emissions

Radon emissions around the power station ranged from 3.1 – 8.2 Bq/m³ in 2008, compared to background levels of 3 Bq/m³ and between 1.1 and 2.1 Bq/m³ in 2009. Radon emission measurements were not made available during this audit. Although it is not a project emission it should be monitored since it is a source of exposure to radioactivity for the workers.

4.6.5 Dust Emissions

Atmospheric dust levels were measured in January 2010 by SGS Environmental Services, who concluded that the concentrations of dust in 3 locations within the plant area were within the WHO Air Quality Guideline values. These measurements were not made available during this audit.

4.7.0 THE BIOLOGICAL ENVIRONMENT

This section describes an Environmental Audit on Biological Environment carried out in September 2010 on operational activities of the Orpower 4 Olkaria III.

The Olkaria III area is partly located within the Hell's Gate National Park. The Park has an area of 68 km² and is situated 1,560 – 2,187 metres above sea level. The park has some sensitive habitats, significant natural sites, and some unique and rare species of plants, wildlife and a variety of birds. Lake Naivasha, a Ramsar Conservation site is located 5 km from the geothermal site. This calls for special attention to preserve and protect the sensitive environment. The Narasha seasonal wetland, used as pasture by the Maasai, is located within 1 km of the project site.

4.7.1 The Terrestrial Environment

4.7.1.1 The Flora

The floral checklist in the vicinity of Olkaria III Geothermal Power Plant in September 2010 is shown in Appendix 6. The area falls into Agro-Ecological Zone 5, with heterogeneous open bushland and bushed grassland vegetation dominated, in most places, by *Tarchonanthus comphoratus* (Leleshwa) thickets. This is the characteristic unique vegetation type found, often on stony hills, in volcanic soils of recent origins. The vegetation type is found in a variety of habitats in the arid and semi-arid districts of the Kenyan Rift Valley, including Nakuru, Baringo, Laikipia and Kajiado.

This year, the area has experienced adequate rainfall, and as a result, there is a significant change in its vegetation. The vegetation is currently dominated by *Tarchonanthus comphoratus* (Leleshwa) thickets with scattered *Acacia drepanolobium*, undergrowth bushes and grasses (Plate 4.7.1).

4.7.1.1.1 The Plant Associations

From photographs and ground reconnaissance of the area near the Olkaria III Geothermal Power Plant, the following distinct floral associations are discerned:

- A. Open Shrubland
- B. Bushed Shrubland
- C. Bushland
- D. Bushed Grassland
- E. Sensitive Unique Floral Habitats: Drainage gorge forests, Rock Outcrop and Barren Land and Steam Vents

The associations merge into one another with boundaries either dictated by change in topography, soil type, drainage patterns, rock structure, occurrence of steam vents, or burned bare rocks.



Figure 2: Plant associations near the Olkaria III Geothermal Power Plant in September 2010

A. The Open Shrubland

This association is typical of the disturbed cleared sites for the construction of roads, drilling camps and power plant. Due to the persistent drought in the area, the open shrubland vegetation has dried. Members of the Solanaceae family including *Datura stramonium*, *Nicotiana glauca*, *Solanum incanum* and *S. nigrum* that normally dominate the open shrubland were not observed in September 2010. Other common plant species of the disturbed areas including *Achyranthes aspera*, *A. aspera varisicula*, *Amaranthus hybridus*, *Tagetes minuta*, *Ricinus communis*, *Portulaca oleracea*, *Calotropis procera*, *Rumex usambarensis* and *Urtica massaica* were also not observed. This plant community normally mainly consists of opportunistic weed species, which take advantage of the cleared disturbed areas with the potential to become a nuisance. In September 2010, it was observed that Kikuyu grass, *Penisetum clandestinum* (= *P. kikuyorum*) planted for restoration at cleared areas at the new site by the management of Opower 4 Inc. has got established (See Plate 4.3.3). In addition, efforts by the Opower 4 Inc. of planting Leleshwa (*Tarchonanthus comphoratus*) and *Acacia xanthophloea* to restore vegetation in some of the cleared areas at the old site is successful. This is because of there has been rainfall most of this year in the area.



Figure 3: Grass planted by Orpower 4 Inc. to restore the cleared site to the south of the new plant.

B. Bushed Shrubland

This plant community which is normally characteristic of recently burned fertile Leleshwa (*Tarchonanthus comphoratus*) bushlands and cleared Maasai cattle *bomas* was observed in September 2010 because of rainfall increase. *Urtica massaica* (stinging plant) and *Solanum incanum* were observed. In addition other plant species normally associated with this vegetation type including *Galinsoga parviflora*, *Tagetes minuta*,

Vernonia laesiopus, *Amaranthus hybridus*, *Fuerstia africana*, *Commelina benghalensis*, *Datura stramonium*, *Calotropis procera*, *Nicotiana glauca*, *Cucumis ficifolius*, and *Zebrina scabra* Had started to develop.

C. Bushed grassland/Bushland

A recent vegetation survey carried out in September 2010 shows that *Tarchonanthus comphoratus* and *Hyperrhenia hirta* with scattered *Acacia drepanolobium* currently dominate the Leleshwa bushland plant community near Olkaria III Geothermal Power Plant. The association occurs on hill slopes of the proposed site between the bushed shrubland and the drainage gorge forests. This vegetation occupies the largest area around the Olkaria III Geothermal Power Plant. Other plant species associated with this community are *Hypoestes aristata*, *Euphorbia crotonoides*, *E. prostrata*, *Aspilia massambicensis*, *Achyranthes aspera varisicula*, *Asparagus africanus*, *Gloriosa superba*, *Onithogalum gracillimum*, *Ocimum gratissimum*, *Crotolaria laburnifolia*, *C. balbi*, *Indigofera arrecta* and a few grass strands of *Hyperrhenia hirta*, *Rhynchelytrum repens*, *Themeda triandra*.

D. Sensitive Unique Floral Habitats

Recent vegetation survey in the September 2010 show that the sensitive floral habits had not been affected and the gorges and luggas are wet because of rainfall in the area. Otherwise the vegetation around the luggas, gorges and steamvents are still the same. Steam vents and the drainage areas, gorges and luggas, are unique habitats with rare plant associations not normally found in Agro-Ecological Zone 5 of Kenya. Steam vents create peculiar geological soil and rock formations, very high temperatures and sauna-like high humidity conditions, which impose several species of pteridophytes and orchids that normally are not associated with this ecological zone. Also unusual is the occurrence of woody plants (*Ficus* and *Syzigium* species) and pteridophytes (e.g. *Lycopodium cernuum*) on rocky/soil formations surrounding the outlets of the underground steam in the area. A sedge, *Fimbrisyliis exilis* (Family: Cyperaceae) grows in the steam vents, and is a good indicator of the presence of steam vents. Other unique species that are common to this area include the pteridophytes, *Dissotis senegambiensis*, *Ophioglossum rubellum*, *Dicranopteris linaeris* and *Pleopeltis macrocarpa*.

Other rare and peculiar plants associated with the steam vents in the area are the orchids species (Family: Orchidaceae), *Angraecum humile*, *Ansellia gigantea* and *Pteroglossaspis ruwenzoriensis*. These are very highly valued plants by the florists. Because they are over-exploited, some of the species of orchids are threatened with extinction and therefore the plants and their unique habitats need to be protected. Sinclair Knight and Partners (1994) made similar observations in their earlier environmental assessment studies in the area.

Gorges and luggas (drainage areas) near the Olkaria III Geothermal Power Plant have plant species peculiar to the ecoclimatic zone 5. The species associated with the seasonal streams forest areas include *Dombeya burgessia*, *Maerua triphylla*, *Olea africana* (=O.

europaea), *Grewia similis* and *Ficus* spp. A fern, *Cheilanthes multifida*, occurs in a gorge extending only 50 m from the hot volcanic Hell’s Kitchen near the powerful well 301. These unique sensitive habitats and significant natural sites in the area need to be conserved.

4.7.1.2 The Fauna

Hell’s Gate National Park, within which the Olkaria III Geothermal Power Plant is located, is a habitat for a variety of wildlife and many species of birds and insects. The cliffs in the park are nesting/roosting sites for many birds of prey including the rare Lammergeyer, Griffon vulture, and the magnificent Verreaux Black eagle. Lammergeyer or Bearded Vulture (*Gypaetus barbatus*) were known to be breeding in the park as early as 1914, but were last seen in 1984 (Hell’s Gate National Park Management Committee).

The Hell’s Gate National Park mammal and bird’s checklists are given in Appendices 7 and 8, respectively. Wildlife censuses carried out recently show decreases in the populations of most animal species in Hell’s Gate National Park (Figure 7). None of the mammals show an increase in their population in the park over the same period. It should be noted that the decrease in the wildlife population cannot be attributed to the development of geothermal power plants in the Hells Park National Park. Figure 7 show that between 2007 and 2008 the mean wildlife population in the park has reduced from 939 to 552. The decrease in the wildlife is probably due to migrations and/or mortality due to persistent drought currently being experienced in the area. The effects of differing and changing demographic parameters commonly manifest themselves in the fluctuations inherent in natural populations (Delany, 1982).

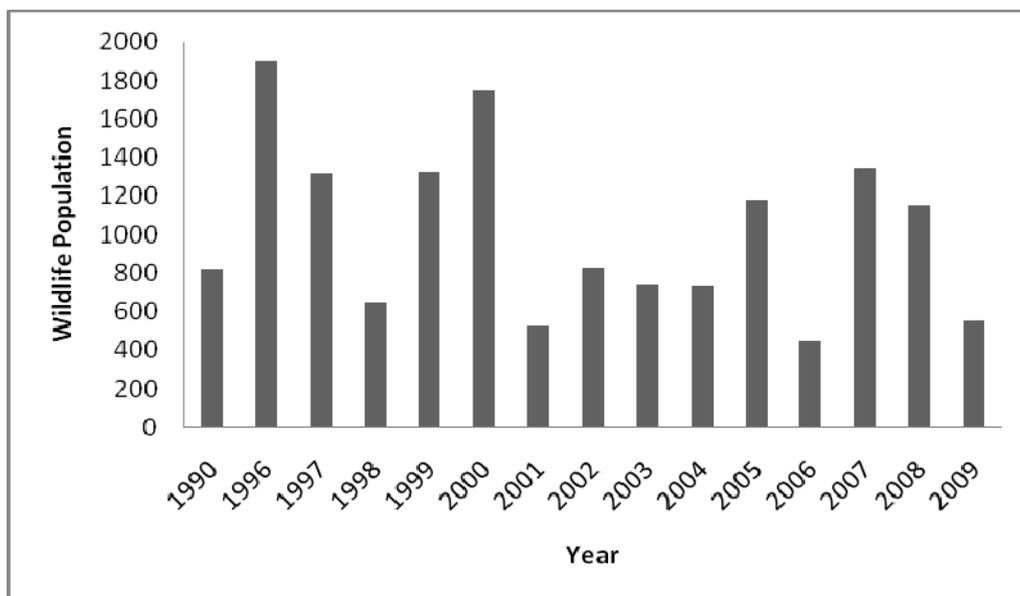


Figure 4. Annual variation in mammal populations in Hell’s Gate National Park between 1990 and 2009.

Nevertheless, it is important noting that the recent wildlife censuses in Hell’s Gate National Park (2005-2006) show a high drop in the population of most species, wildlife numbers in the neighbouring private game ranches, for example Kongoni Game Valley, Oserian Wildlife Sanctuary and Oserian Game Corridor have greatly increased during the same period (Table 11).

Table 2. Disparity in Wildlife Populations in Hells Gate National Park and the Neighboring Private Game Ranches

Date of Census	Hells Gate National Park	Kongoni Game Valley	Oserian Wildlife Sanctuary	Oserian Game Corridor
April 2001	698	689	4316	1043
September 2001	387	356	4357	-
April 2002	-	114	4591	1000
September 2002	827	246	4857	645
October 2003	744	227	4287	1367
March 2004	-	658	4525	777
September 2004	737	313	4614	1093
April 2005	789	644	5194	1402
October 2005	574	490	5016	1177
April 2006	424	490	4849	1629
September 2006	482	490	6309	1156
Acreage	16,000	800	18,000	3,000

According to the Kenya Wildlife Service (KWS), the construction of roads and laying of pipelines for the KenGen Olkaria Geothermal Plant has isolated a group of Maasai giraffes, buffaloes and the rare Chanler’s mountain reedbuck from the rest of the park. The animals now move between Hobbly Volcano and the power plant site. Though, little evidence has been mustered in support of the premise that subdivision of wildlife habitat to small units automatically increases rates of extinction of the affected animals, rates of extinction can be unacceptably high in very tiny isolated reserves (Gilbert, 1980; Boecklen and Gotelli, 1984, Boecklen and Simberloff, 1987).

4.7.1.3 Sensitive Habitats

The Hobbly Volcano, the Olkaria Hill and the Hell’s Kitchen, near the geothermal power plant site, are sensitive habitats and important natural sites hosting some rare or endangered wildlife species. The area is covered with young volcanic rocks, from recent volcanic activity of the Olkaria, with sparse vegetation dominated by *Erica arborea*, which forms an ideal camouflage background for the Chanler’s mountain reedbuck (*Renduca redunca*). A rare leafhopper insect (*Platypleura sp.*, Family: Cicadoidea) with a high pitched-cricket sound is found in association with the Leleshwa bushes near the Hell’s Kitchen only 100 m from well 301 of the Orpower Geothermal Power Plant.

4.7.2 BIOLOGICAL IMPACTS

The development of Orpower Geothermal Plant has a number of impacts on the biological environment. Construction of the power plant site, the road, accommodation camps for workers, site for storage of equipment, drilling pad sites, and pipe ways have

resulted in clearing of vegetation in virgin areas of Hell's Gate National Park. Wildlife can no longer be able to use most of these sites for feeding and breeding, due to the power plant operations. Test drilling in promising areas normally require an access road for a drilling rig, and clearance of about 1000 m² for each drilling (El-Hinnawi, 1981). In addition, lighting, noise, airborne effluents (e.g. dust, hydrogen sulphide, carbon dioxide, sulphur dioxide etc.), liquid effluents, thermal discharges and power transmission lines will change the environment in the vicinity of the power plant.

Hydrogen sulphide (H₂S) is the main airborne effluent of real concern in the Olkaria geothermal fields at the present. Although H₂S is a poisonous gas at high concentrations, the main problem in geothermal development is simply its objectionable smell. Sub-ppm levels do not appear to present a health problem, and communities in New Zealand are known to have lived for generations with local air containing 0.01 - 0.1 ppm (El-Hinnawi, 1981). As H₂S is a heavy gas, it tends to concentrate around geothermal plants in enclosed areas. It becomes a health hazard at concentrations of over 10 ppm. Since Orpower Geothermal Plant is sited on a hill, this problem is likely not to occur, as the H₂S will likely have been oxidised to SO₃ by the time it reaches ground level at the bottom of the hill (see Appendix 12).

As was observed during the April 2007 Environmental study, Orpower 4 Inc. still has an environmentally friendly agreement with the Oserian Flower Company, in which the power plant supplies most of the non-condensable gases (e.g. CO₂, SO₃, H₂S), a by product of geothermal energy production, to the flower company. The gases are used for heating and "foliar fertilization" of the flower. An interview with the Oserian Flower Company management revealed that flower growth as indicated by stronger clean leaves, stems and flowers. The use of the non-condensable gases (e.g. CO₂, SO₃, H₂S) for heating and "foliar fertilization" of the flower in greenhouses removes the greenhouse gases from the atmosphere. This will over the long time probably have positive implications on global warming.

Pipe line and power line right-of way will have impacts on wildlife habitats. Shear clearing through the characteristic Leleshwa bushland around power plant is not consistent with good forestry and wildlife management practices.

4.7.2.1 Impacts on Flora

As the intensive development of the power plant in Olkaria III is associated with clearance of land of soft hydrothermally altered rocks, some plant associations have changed. There has been a conversion from Leleshwa bushland to open shrubland and bushed shrubland dominated by opportunistic weeds typical of cultivated and disturbed fields. The significant impacts accruing from the development of the geothermal power plant on the flora in the area include:

- Replacement of Leleshwa bushlands with open shrubland and bushland shrubland. This could lead to a loss of some plant species typical of the bushland vegetation.
- Invasion of the cleared construction sites and road sides with opportunistic weed plants e.g. *Datura stramonium*, *Nicotiana glauca*, *Solanum incanum*, *Tagetes*

- minuta*, *Ricinus communis*, *Portulaca oleracea*, *Calotropis procera* etc. This is likely to change the physiognomic characteristics of the vegetation in the vicinity of the geothermal plant.
- Dust from the construction sites and roads settle on plants and interfere with their photosynthetic capacity, thus lowering their productivity with the likelihood of stunting their growth.
 - Sites for the construction of the access roads, drilling pads, drilling camp, steam pipe and power lines right-of-way and areas for the storage of pipes require a large area of land which has to be cleared of vegetation.
 - Likely loss of biodiversity, especially the rare and unusual floral species unique to the ecoclimatic zone 5, for example species of orchids, woody plants, pteridophytes, ferns and sedges.
 - Depending on the quantities produced and weather conditions, gaseous effluents such as hydrogen sulphide (H₂S), sulphur dioxide (SO₂), ammonia (NH₃) and carbon dioxide (CO₂) released in escaping steam are likely to have some impacts on the vegetation of the area in the long term. Work by Thompson and Kats (1978) showed that constant exposure to H₂S concentrations of 0.3 ppm or over affected the foliage and growth of California buckeye, lettuce, alfalfa, sugar beet, grapes, ponderosa pine and Douglas fir. However, low concentrations of H₂S at 0.1 and 0.03 ppm had little effect, and actually stimulated the growth of the field crops. A number of studies (EPA, 1977; El-Hinnawi, 1981) indicate that some plant species show significant tolerance to foliar concentrations of most of the gaseous effluents associated with geothermal power production. Studies done at the KenGen Olkaria east area on the impacts of H₂S on flowers showed no deleterious impacts. The long-term effects of sustained exposure to the current levels of H₂S, SO₂, NH₃ and CO₂ on the local natural vegetation, and on the possibility of formation of acid rains near the Orpower Geothermal Plant needs further investigation. Marani (1995) however showed that there was no acid rain induced by H₂S emissions from the current KenGen power plant at Olkaria east.

4.7.2.2 Impacts on Fauna

The development of Orpower Geothermal Plant in Hell's Gate National Park has many potential impacts on the wildlife in the park. Foremost among them is the loss of their natural habitat and migration route areas which have been used for the construction of the access roads, drilling pads, camp sites, pipe lines, power transmission lines and sites for storage of construction material. It is possible that some important wildlife feeding and breeding/nesting sites have been disturbed. It is worthwhile noting that the development of the power plant, KenGen Power Plant and the fencing of the Kongoni Ranch, has led to isolation of a group of giraffes, buffaloes and the rare mountain reedbuck from the rest of the wildlife population in the park. Furthermore, recent censuses show a decline in wildlife population in the park. In summary the likely impact of the geothermal power plant on fauna include:

- Loss of some habitats of some rare wildlife species (e.g. the mountain reedbuck) which might put them in danger of becoming extinct.

- Noise during construction, testing of the wells and the operation phase of the project is likely to have adverse effects on wildlife. Currently the mountain reedbucks are found in the Hobbley Volcano area instead of their normal home on the Olkaria Hill.
- Transmission power lines and steam pipes are likely to interfere with wildlife migration routes and/or isolate some populations in the park. This could interfere with breeding patterns of some wildlife and the roosting/homing behaviour of some important birds prey e.g. the Ruppel's Griffon Vultures, which travel long distances to feed during the day, but return in the evening to their nests on the Vulture Cliffs in the park.
- High-voltage transmission lines are likely to have adverse effects on wildlife and human beings in the area. There is some evidence to indicate that behavioural modification may occur among waterfowls when crossing a wetland area (El-Hinnawi, 1981). This could result in the absence of birds covering an area of 1 km of the transmission lines. The swaying of the lines in the wind, their reflective properties and the humming of the lines probably scare away the birds. Transmission lines can have an effect on migratory birds using magnetic homing. According to James (1977), electric fields associated with transmission lines can produce a charge on animals or human beings within the range of its influence.
- Gaseous effluents e.g. H₂S, SO₂ and NH₃ which may cause or exacerbate certain diseases in human beings are likely to have similar effects on wildlife around the power plant.
- Loss of unique sensitive habitats and scenic natural sites, along with their associated unique fauna (e.g. the leafhopper insect, mountain reedbuck), for example parts of the Olkaria Hill and the Hell's Kitchen near the Orpower Plant. This would further endanger the survival of the already threatened species.
- The geothermal plant will reduce the aesthetic and natural value of the landscape and this is likely to scare away the wildlife. It is noticeable that mountain reedbucks have moved from their normal home on the Olkaria Hill, near the plant, to the Hobbley Volcano area.

The proposed expansion phases of Orpower 4 Inc power plant within the fenced and cleared area will have less environmental impact.

4.7.2.3 Impacts on Lake Naivasha

- Abstraction of water from Lake Naivasha catchment for drilling purposes is likely to have an effect on the hydrology of the area over the long term as the number of companies producing geothermal power increase. Past studies show that there is no link between the Lake Naivasha waters and the geothermal fluid drawn from the wells.
- The construction of more staff houses near the lakeshore could have adverse pollution effects on the lake.

4.7.3 MITIGATION OF BIOLOGICAL IMPACTS

Given that the location of the Orpower Geothermal Power plant is partially in the Hell's Gate National Park, it is very important to put in place measures to mitigate and monitor significant impacts of the development of the plant on the biological environment. This is to ensure the co-existence of the power plant and the game park.

On the positive side, the combination of a national park and a geothermal power station enhances tourism in the area, since some tourists come specifically to view the geothermal power station. The following mitigation measures are recommended to ameliorate adverse biological impacts.

- Significant and unique natural sites e.g. the Hobbley Volcano and the Hell's Kitchen need to be gazetted as "Protected Areas of National Importance". Kenya Wildlife Service should spear head this.
- The Kenya Wildlife Service and Orpower 4 Inc Environmental Management Agreement in respect of Orpower's Project in Hell's Gate National Park has been in operation since 2001. General Principles: Orpower agrees to co-operate with KWS in the management of the environmental resources connected to the Relevant Operations within Hell's Gate National Park so as to enhance its conservation and adequate protection.
- Kenya Wildlife Service should map out important breeding and nesting sites for rare and important migration routes for wildlife in all of the Hell's Gate National Park. This will minimise the conflicts between wildlife conservation and development of geothermal power plants in the area now and in the future.
- Monitoring of the significant impacts predicted in this and other studies should be carried out on a long-term basis, to ensure that the right mitigation measures are put in place to minimise the negative effects on the environment.
- Frequent meetings between all stakeholders – KWS, KenGen, Lake Naivasha Riparian Association and the local Maasai communities are now held on frequent basis. Hell's Gate/Longonot National Parks Minutes of the Management Committee Meetings held on 11th February 2010 and on 29th April 2010 are available at Orpower Office. To conserve the beautiful natural landscape in the park, the Orpower Company has planted Fever Tree (*Acacia xanthophloea*) around the Orpower Geothermal Plant (Plate 4.3.4). This is a large, tall *indigenous tree* reaching 25 m or more. The tree is fast growing, and attractive as an ornamental and could be a good camouflage for the geothermal power station.

4.7.3.1 Flora

- Areas with endemic and/or rare plant species e.g. some selected steam vents/fumaroles need to be set aside as "Protected Areas" where development of geothermal power plants should not be allowed.
- Clearing of drilling pad sites, pipe ways, plant station, and access ways should be kept to a minimum.

- The areas cleared for the drilling campsite and storage of pipes should be rehabilitated after the drilling by removing the camp structures and replanting the area with Leleshwa bushland vegetation.
- Replanting of the indigenous species that were cleared should be done immediately, to avoid invasion by opportunistic pioneer species.
- Exotic species should not be introduced into the area.
- Floral species should be investigated every 2 years to monitor any changes in species composition and abundance of vegetation in the area.
- Investigation of the long-term effects of consistent exposure of the local natural vegetation to the gaseous effluents e.g. H₂S, SO₂, NH₃ and CO₂, and the possibility of formation of acid rain near the Orpower Geothermal Plant should be started immediately.
- The proposed expansion phase should be restricted within the perimeter of the fenced and already cleared area to further mitigate on the impacts.
- The Tree nursery at Orpower Geothermal plant needs to be improved. There is need for the Environmental Officer to train the women from Narasha Community Development who are contracted to take care or seedlings in tree nursery techniques. Seedlings have been grown and used to rehabilitate the site, some still being tendered in the nursery.

Both Orpower 4 Inc. and KWS concur that measures aimed at sustaining the environment should be implemented for their mutual coexistence in the area.



Figure 5: The trench to the south of plant that is being rehabilitated by Orpower 4 Inc.

4.7.3.2 Fauna

- Sensitive habitats e.g. Hell's Kitchen and the Olkaria Hill should be preserved and

- avoided as sites for construction. This will protect the endangered wildlife species (e.g. the leafhopper insect and the mountain reedbuck). This has been done.
- Identified animal movement/migration pathways should be kept open. Steam/water pipes should either be buried, or made with high loops at these locations. Routes have been identified by Kenya Wildlife Service in collaboration with Orpower.
 - Overhead power transmission lines should be well coordinated and planned so as not to disturb the natural scenery of the park and not to interfere with movements of birds. The planning of the overhead transmission lines has been done by Kenya Wildlife Service in collaboration with Orpower.
 - Pipes should be painted with natural camouflage colours so that they blend with the surrounding. This has been done successfully
 - Pipes should be insulated so as not to scald animals. This has been done.
 - Power transmission line routing should be planned in such a way as to reduce their impact on the wildlife migratory routes. For example, the lines should not impinge on areas valued as routes for migratory birds, nesting/breeding sites, or important historic or touristic sites. The routing of the lines should be planned in such a way as to cover a minimum distance within the park. The Orpower high-voltage transmission line should be linked immediately to that of the KenGen before joining the national grid. KWS should be consulted in the planning of routes for the lines. This has been done.
 - Dust reduction measures on roads should be implemented to mitigate against dust, which causes poor visibility, and may result in animals being knocked down by vehicles.
 - Limit the speed of vehicles to 40 km/hour within the park area. This has been done and road signs with 40 km speed limit placed along the road leading to Orpower Inc.
 - Limit noise, especially at night. The new plant has low noise.
 - Limit light shining away from the plant operations at night. All lights face towards the plant.
 - Areas where animals can be exposed to drilling or geothermal fluids should be fenced, while ensuring that fences do not enclose small animals. Fences should also not be placed in known migration routes of animals. Fencing has been done.
 - Animal species composition and abundance should be monitored at least every two years. This is carried out twice a year in collaboration with Kenya Wildlife Service.

Both Orpower 4 Inc. and KWS concur that these measures should be implemented for their mutual coexistence in the area.

4.7.3.3 Aquatic Environments

Prominent water bodies are Lake Naivasha (a Ramsar site), and Oloiden and Crater lakes, and the seasonal Narasha wetland, located 4 km from the project site. The LNRA, of which Orpower 4 Inc. is a member, has been enforcing sustainable ecosystem management. An analysis of the Narasha wetland waters in July 2010 by Chemical and Industrial Consultancy Unit of the University of Nairobi showed that there were high values of fluoride (2.90 ppm), sulphur (2.60 ppm), potassium (30.35 ppm) and silicon (20.5 ppm). Monitoring of these parameters is important to secure the health of people and animals that use the water of the wetland. The high levels could be attributed to evaporation, surface flow through volcanic soils.

Proper treatment of wastes from the staff houses, as is the current practice, is crucial to avoiding pollution of Lake Naivasha from solid and liquid domestic waste.

- Staff houses should not be constructed too close to the water edge.
- No waste should be disposed of near the lake.
- Waste storage facilities should be designed to cope with periodic breakdown in municipal or private waste collection systems.

4.8 Social Impacts

4.8.1 Narasha Primary School

The Narasha primary school has 385 students. The school has a nursery and classes from standard 1- 8. The school has 5 teachers employed by Orpower IV and 5 teachers from the Teachers Service Commission (TSC). The first standard 8 class graduated last year (2009). The Constituency Development Fund (CDF) was also used to build class 8. There are 120 children in nursery, 23 in standard 8 and 242 children in the rest of the classes. The teachers at the school use a matatu which is allowed in by KWS at Hell's Gate Park. Also company transport (bus) is sometimes used. The teachers do not pay transport charges for the matatu. Elsamere built 2 classrooms; LATF built 2 classes while Orpower IV built classes 1 and 2 at the school.

The Narasha primary school had the following concerns:

- Parents at the Narasha community are not so positive about education and are therefore not helping the children to get an education.
- The school feeding programme offered by Orpower IV is not regular and sufficient. As a result, children go for lunch at home and do not come back to school. About 4 bags of maize and 3 bags of beans are usually given by Orpower IV. According to Orpower IV, the school makes requests for a given period and that is what the company approves. Delays in timely supply of maize and beans arise when the school have not made the request or not made it on time
- Absenteeism of the children because of herding.

- The administration block is not secure since it is made out of iron sheets. In addition, the nursery requires improvements.
- The school does not have enough books, desks, chairs or even a computer. Furthermore, the parents from the Narasha community are not able to buy supplementary books. In addition, the school at one time had borrowed desks from the African Harvest Mission church which is built in the school compound.
- The administration block has two snakes which are difficult to remove.
- The school does not have a fence so that children can feel more secure. In addition it is government policy to fence schools.
- The school would like to grow trees so that it can be a conservation centre and to also show the Narasha community how to do farming (maize and vegetables) and establish a tree nursery. However, since the school is not fenced, it was felt that livestock and wildlife (monkeys, buffalo and giraffe) will interfere with these activities. The conservation centre will further assist the community during times of drought when a lot of their livestock die.
- The girl child is endangered since they are married at an early age. Only 2 girls sat for KCPE last year (2009). However since they did not do very well, it was feared that they would be given for marriage if they did not secure sponsorship. Currently the girls are sponsored by Orpower for their Secondary School education.
- The school has a challenge in taking action for the girls who are made pregnant at home. In class 8 there are about 5 girls who are pregnant and in class 4 there is one girl who is pregnant. Furthermore, the school committee supports girls who are made pregnant to get married. The school however says that the girls who become pregnant can go back to school after giving birth with the support of the parents. It was also felt that the women in the Narasha community have no say when it comes to the marriage of the girls.
- FGM which is done during the holidays and in secret. It was however felt that the Narasha community has refused to change this practice. The school however reports this practice to the education office and since it happened at home, it is out of the hands of the school. In addition, the school has no resources to pursue this matter which requires the cooperation of the parents. It was also felt that the elders at the Narasha community follow this old traditions and have more say in the community. Mothers come crying to the primary school however the school feels that there is nothing much they can do about FGM in the community.
- The value of boys and girls in the Narasha community, since sometimes the girls give their heads to the boys as a form of greeting. The school however tries to deal with this issue.
- The water tank and reservoir since it has broken down. As a result children bring water from their homes for use.

- Toilets which are not enough for the children. CDF funds were however used in the construction of toilets for the girls. Earlier the toilets for the girls and boys were together and this is not allowed by the Ministry of Education.
- The school also requires sanitary pads for the girls.
- The high number of teachers who request for transfers since the primary school is in a hardship area.
- Parents from the Narasha community fail to pay the exam fee of KSh. 30 per child required for the two terms. As a result the school sends the children home. Sometimes the children come back after three days or even a week with the exam fees.
- Children do not come with uniforms including shoes and socks. However the school cannot do anything about this.
- Games equipment like balls and nets for the children are lacking.
- The school was also concerned that the teachers hired by Orpower IV are not paid during the holidays yet they have rent to pay. In addition, the teachers hired by Orpower IV are paid a salary of Ksh. 8000. The TSC teachers are paid a basic starting salary of Ksh. 14,000. Untrained teachers are paid Ksh. 5000 while teachers with Early Childhood Certificates are paid Ksh. 7000.
- There are no vehicles for taking children and teachers (especially those with young children) to the hospital if they are sick. As a result, they teachers have to look for a vehicle and pay for it themselves.
- The primary school was also concerned that they have no kitchen, storage space and a qualified cook, since the teachers can loose their jobs if the food is contaminated. In addition, these safety measures are required by the Ministry of Education.

4.8.2 Narasha Community

Social Benefits

- Orpower IV has employed 5 permanent teachers at Narasha Primary School (Mr. Cheronno, Mr. Kaleke, Madam Wangechi, Madam Florence and Madam Wafula)
- A dispensary has been proposed near Narasha primary school by the Narasha community. Discussions are going on with Orpower IV. The community will give land for the dispensary. A proposal has been written to Orpower IV, KWS, D.C and Ministry of Health for the dispensary/hospital.
- Orpower IV sent an electrician to put wires at Narasha primary school since the rural electrification process is being done by the government.
- Orpower IV participates in the school feeding programme by providing maize, beans, oil and porridge to the children at Narasha Primary School.
- Orpower IV has sponsored 2 girls.

- Last year (2009), Narasha primary school was ranked 60 out of 145 schools in the area and Orpower IV organized for a party for the school.
- Teachers from the Narasha primary school and community members are given lifts by Orpower IV bus.
- Orpower IV has contracted cleaners and a gardener from the community. The community however desires more jobs for the youth.
- The Narasha community is also requesting for bursary for university education.
- The community would also like a tender for supplying food to the drilling contractors (meat and vegetables) so that the community can further develop.
- The community feels that the elders from the Narasha community should be used to implement initiatives since they do not take sides. In addition, chiefs cannot work without elders.
- The Narasha community desires to work more closely with Orpower.
- During the drought (2006-2008), Orpower IV helped the community by giving food to the children.
- The Narasha community would like tree seedlings.
- The community would also like adult education classes and to be taught in the homes.
- Orpower IV assisted the Narasha women group to get a posho mill. The Naretoi women group would also like a posho mill and a plot for business (duka).
- The community would like assistance to repair the water tank which is broken down.
- The community would also like a tractor for the cultivation of maize, beans and wheat.
- The Narasha community would like chemicals for the cattle dip.
- The community would also like the youth group to be assisted in farming (5 acres) in order to grow tomatoes, fruits, vegetables and water for the crops. The youth group would also like youth and women loans (including networking with CDF). The youth would also like to visit other youth groups in other communities.
- The community would also like education on HIV. Saint Mary's Mission tested the community although they did not educate them on HIV. The community would also like free medical camps.

Most of the issues raised by the Narasha community require community initiative and active participation. Some of the issues are not within the Orpower CSR programme.

4.8.3 Accounts Department

The accounts department at Orpower IV is involved in writing of financial reports, the payment of salaries, all cash transactions and accounts, the writing of VAT reports, filing invoices, purchase orders and the collection of cheques. The department will also be involved in the financial processes during the drilling of 2 wells at the power plant by November, 2010. The 2 members of staff in the department also wear safety shoes in the office.

The concerns from the accountants department included:

- The lack of shelves in the department for storing files. As a result, files are put on the floor. It was felt that putting files on the floor was a health and safety hazard since if there is an emergency, it will be hard for staff to be evacuated.
- The quality of drinking water provided for staff at Orpower IV. Some staff members bring water from home for drinking purposes. However, according to Orpower management, quality drinking water is provided through installed 5 stage Reverse Osmosis system (Davis & Shirtliff). The provided water is regularly tested internally and externally by accredited laboratories and the results are available.

4.8.4 KWS

KWS is concerned with aligning their activities with those of the power plants in order to mitigate wildlife movement. KWS does this by ensuring that the smallest to tallest animals can crawl or jump over pipes respectively. They also ensure that pipes that are knocked by animals are redesigned. KWS is also concerned with livestock movement and at one point had to arrest livestock herders at least twice. KWS is also concerned with waste disposal, power lines, camp sites, workers (including those at the outposts/gates), communities and tourists.

KWS monitors the following from the geothermal power plants:

- Emissions and how they impact wildlife and mitigation measures
- Monitor geothermal activity standards, wildlife and habitat suitability
- Discharges/effluents coming to the park from the geothermal activities

Social Benefits

KWS felt that the following were positive about Orpower IV.

- During the expansion of the Orpower IV power plant from 13.6 MW to 48 MW, KWS felt that there was controlled movement (good arrangement) of vehicles during the construction phase in order to reduce negative impacts.
- Orpower IV has tried to blend in with the environment in all their activities.
- The new circuit of roads developed by the power plant was also viewed as positive.
- The involvement of Orpower IV in community issues was also viewed as positive since they also give good will to the community on behalf of KWS.

- According to KWS more animals cross over near the power plant and no poaching is reported. KWS were also positive that the power plant maintained the old piping route in the same area instead of opening a new area thereby hindering animal movement.
- KWS has an MOU with Orpower IV and their scientists visit the power plant during construction and design activities. As a result they are able to monitor activities and all their concerns raised and impacts monitored.
- KWS were thinking of promoting geothermal tourism so as to gain and further blend with geothermal activities.

Social Cost

KWS were concerned about the following:

- Expansion of geothermal power plants in the park and the future of the park.
- Updates (management plan) on expansion activities/phases of Orpower IV so that they can come up with a monitoring scheme.

4.8.5 Oserian

Oserian is concerned with:

- Geothermal power production- Oserian generates 1.4 MW from the power pressure turbines (like Kengen) and 1.81 MW using the binary system for cold stores, housing estates (for 3000 workers), and green houses. Oserian used existing wells of Kengen for their geothermal production. Oserian may in future sell their geothermal power although this will require heavy investment to increase capacity of the power plant. The technology used by Oserian involves reinjection back to the geothermal field to maintain mass balance.
- Waste heat (steam) from the geothermal power plant is used for heating green houses and to regulate temperature at night when it is very cold.
- Carbon dioxide is used to feed the flowers at night in order for them to produce oxygen at night. However, Oserian feels that more research needs to be done on the continuous use of carbon dioxide on the flowers and the fact that they are not resting at night. They were also concerned about the balance of nature and the carbon dioxide that they are providing to them. Oserian at the moment do not get carbon dioxide from Orpower IV for their green houses.
- Oserian use KPLC power if they are repairing the geothermal power plant. They also have a diesel generator for backup.
- Oserian however feels that they are not sharing the geothermal reservoir with Orpower IV and are therefore not interfering with geothermal production activities.
- Company policies require a closed loop system so that waste is not disposed of and there is recycling.

- Mau forest and the possibilities of replenishing the geothermal reservoirs at Olkaria. As a result, they support WWF in the Mau project.
- The Adopt a Catchment initiative with the Water Resource Users Association in which they participated in June.
- The possibility that ground water may be interfered with during geothermal production activities. Oserian are however aware of studies that indicate that Lake Naivasha flows to Lake Natron and there have been no noticed changes to the ecology.
- Oserian however feels that they are not in an active area for volcanoes, however they have not ruled out the possibilities of this occurring.
- EIA's for their geothermal power plants and got a NEMA certificate which enabled them to clear the ground and trees at the site for the geothermal power plant. No incidences were reported during construction since health and safety issues were taken into consideration and speed limits observed. Oserian also has a health and safety committee.
- The Oserian wildlife ranch is about 18,000 ha and includes the cheetah, leopard, lion, white rhino, antelopes, zebra, warthog, giraffe, birds, insects and reptiles. The ranch borders the flower growing operation which is 4000 ha. Oserian also has a wildlife corridor from Hells Gate National park to Lake Naivasha. Oserian are currently doing research on the possibility of engaging in the carbon markets. In addition, Oserian have won the Total Eco Challenge twice.
- Oserian however felt that Orpower IV did not interfere with their activities during the expansion of the geothermal power plant from 13.6 MW to 48 MW.

4.8.6 Lake Naivasha Riparian Association

The Association is concerned about:

- The lake levels of Lake Naivasha (which is a Ramsar site) which is below that which has ever been recorded since the early 1990s. This year alone the lake has come up to 2.47 m which is 5m lower than it should be. This means that rivers are not flowing into the lake and too much water is being taken out of the lake. In addition, the destruction of trees means that less water is coming into the lake. Population increase is also a contributing factor. Flower farms and geothermal power plants also take water from the lake since they employ and house many people. The Association highlighted the fact that the lake dried up three times about 50-100 years ago and can dry up again since the human race is affecting it.
- Nutrients and alien invasive species which are killing the lake. One of the point sources of pollution to the lake included the satellite villages which have no sewage treatment facility and also have shallow aquifers where pit latrines are established. Nutrient enrichment includes phosphates which the algae love. Red algae cause fish

death due to oxygen depletion. Furthermore, matatus are washed in the lake further compounding the pollution problem.

- Destruction of the natural kidneys (trees) of the planet is also affecting the lake. Papyrus which filters heavy metals can however be used as a solution.
- Buffalo and cattle waste further pollute the lake.
- Mitigation measures which includes a management plan developed by the Lake Naivasha Riparian Association which was gazetted by the government. However, the association was taken to court over the management plan and the case is still on going.
- The Lake Naivasha Riparian Association Board gives water permits and those refused water permits go to Nairobi and Nakuru to obtain these permits. The Association however cannot rescind these permits. The Association however feels that audits need to be done before water permits are given. Flower farms pay for the water which they get from the lake at 50 cents per m³ every month. Flowers have metres to enable payments to be made. Geothermal power plants also participate in ensuring water balance of the lake since water is used for drilling.
- Illegal pumps and the pumping of water at night.
- Boreholes near the lakes.
- Activities affecting the lake which include fishing, boat rides, the growing of crops, tourism activities, human settlement, cattle and wildlife grazing.
- Micro-climates of Naivasha. Oserian have grown more trees which have resulted in more rainfall.
- Geothermal power plants which can alter the structure of rocks and can cause collapse and changes of land surfaces.
- Steam pipes on the surface which interferes with movement of animals and forces them to use new tracks and erosion.
- Birds (vultures) which can touch two wires and die. Configuration of the power lines therefore needs to be done like in South Africa. Flamingoes which migrate to lakes can however also be affected.
- The Association felt that water harvesting and the use of solar panels should be done in the settlements for health purposes and to reduce fuel wood consumption respectively. In addition, if duty is removed from kerosene, this will also help to save forests and the matatus can use it too as fuel.
- The Association has full and associate members which includes the geothermal power plants.
- The local community in Naivasha who need assistance for the catchment wide management plan.
- Payment for Environmental Services which involves putting money in a fund to pay for doing it right (good practices).

4.8.7 Plant Operators

An operator's work involves working both in the office and carrying out the required regular plant inspections.

The plant operators are concerned with the following:

- At the end of every month at midnight they have to go to the motor centre control, and feel that they can be attacked by animals including buffalos and snakes.
- The plant operators felt that more research needs to be done on earthquakes in the geothermal field in order to take the necessary actions.
- Over the 14 hour shifts which include working at night and in front of a computer.
- The operators were also feeling disoriented because of having no weekends.
- The lack of a plant supervisor during the night shift. They have to consult the supervisor by telephone at night, and the supervisor is not always available on phone. This forces them to make decisions which may have repercussions to themselves and the plant.

4.8.8 Mechanical Department

The mechanical department is concerned with:

- The oil skid, turbines, the repair of condenser fans, generators and the workshop.
- The new respirator which Orpower IV had ordered for staff including for welding since the filtering system is better and fits nicely so that breathing is better.

4.8.9 Supervisor of Plant Operators

The supervisor of the plant operators has been with Orpower IV for the last 7 years.

The supervisor for plant operators is concerned with:

- Shifts of the plant operators, visual checks, filling in the logs, prepares and checks reports (trends), approves work permits, prioritize jobs, health and safety issues and examines incidences.
- Oversees plant operations, makes all the necessary decisions and ensures that the power plant is running smoothly. There was a breakdown of one of the units at Orpower IV during the EIA which was being handled.
- Team building activities of the plant operators.
- Troubleshooting although if something has to be sorted out and the one vehicle leaves at night after working for 14 hours then it can be challenging.
- Conflict resolution especially when the new system of having a supervisor for plant operations was put in place and the conflicts that arose on when to report to plant manager and supervisor.

4.8.10 The IT Department

The IT Department is responsible for overseeing all the computer related operations, including internet, server control, software, camera surveillance and telephone lines. The IT Department also disposes the computers after 3 years by donating them to the community, cyber cafes, and schools.

The IT department is concerned with:

- The health and safety challenge for the one (1) IT staff in the department is the fact that his work involves looking at the computer screen for long periods of time. This has resulted in him experiencing pain in the eyes, knees and spinal cord and has had this problem for a long time. In addition, the IT staff sits for long without walking.
- The IT staff feels that because he places the laptop on the server cabinet, then he may be getting a lot of radiation and heat.
- In addition, since the phone is placed behind him, then he feels that he can injure his neck when answering the phone.
- There is need to redesign the work environment, and possibly employ a second IT specialist to be relieving the one in place.

4.8.11 KenGen

KenGen is responsible for the environmental management of the geothermal power plant and includes: drilling, the clearing and rehabilitation of vegetation sites, monitoring of air quality, dust, noise, tree nursery (give out 100,000 tree seedlings every year out of a target of 250,000), safety issues, risk management, interacting with stakeholders, carbon credit issues, giraffe and buffalo loops (steam pipes), provide water for animals in the park, speed limits, earthquakes, hydrogen sulphide (4 ppm) and other gases and mitigation.

Concerns of KenGen include:

- Independent Power Producers and challenges which include: selling of power to KPLC at a higher rate than Kengen, competition for specialized and skilled personnel and geothermal licenses. Due to the expansion of geothermal activities in the area and involvement of different players, one power plant may go into another's license area, especially when using directional drilling.
- Recommendations which includes the coordination of health and safety issues by all geothermal power plants, the issuing of geothermal licenses which should be done by an independent authority/board with experts including the Geothermal Development Company so that it can be non-partisan. In addition, the license

should be based on the geothermal resource area in order to avoid conflicts and the drilling on the same fault line.

- The Geothermal Training Centre which offers courses in environmental impact assessments among others.
- The MOU between KenGen and Orpower IV which needs to be revised because it is outdated.

4.8.12 Environmental Health and Safety Officer

The Environment Health and Safety Officer is responsible for:

Monitoring of air quality (hydrogen sulphide-1ppm), soil analysis (University of Nairobi), water sampling (aquatic labs), corporate social responsibility (includes sponsorship trips for schools and sponsoring a community member for the marathon), health and safety, noise levels, plant and animal monitoring in conjunction with KWS twice a year, weather monitoring (rainfall, air temperature, wind direction and humidity), the new HIV policy (included in a booklet) and implementation (with an NGO-Aphia II and will include VCT medical camps and de-worming) and plant monitoring .

The health and safety committee, which has 6 members (out of the 30 employees), who come from administration, maintenance and operations departments, the plant manager and 2 other appointed members.

Carbon Market- Orpower IV PDD can be found in the UNFCCC website as it still ongoing.

Concerns of the Health and Safety Officer include:

- The seat belts in the bus used by Orpower IV staff. The issue has, however, been sorted out by safety office
- Orpower works with labs registered by Nema which include SGS (who have been contracted for air and EMR monitoring), Quest Laboratories and Aquatic labs. Orpower IV also uses Kengen labs.
- Field visits with maintenance team for monitoring and health and safety issues. Sometimes the maintenance team is working in the sub-station and may not be able to go to the same site to identify the safety issue. It is then the responsibility of the departmental safety representative to ensure safety is adhered to. Therefore scheduling can be a challenge. In addition, when going for field visits staff is required to be in twos and should go with a vehicle because of the wild animals. This can be a challenge if transport is not available.

It is recommended that more transportation be made available

4.8.13 Electrical Section

The Electrical team conducts electrical installation, marking of cables, cable lags, insulators and arrestors.

The electrical Department is concerned with:

- Contractors who have not placed cautionary marks above under cables to indicate size, depth and rating (nature of cables). Orpower IV has many cables that are permanent, and these need to be protected as the geothermal power plant expands.

4.8.14 Instrumentation section

The Instrument team has the responsibility for calibration of equipment. The team is fairly new, and in the process of familiarizing themselves with the power plant functions. When in difficulties, the team consults Ormat when they are in Naivasha, or by email when not physically present. The team faced challenges during placement of a vaporizer in OEC 2, as all instruments had to be taken out and replaced.

4.8.15 Secretary

The secretary is responsible for

- Official calls, booking of appointments, typing letters and organizing lunch and transport.

There were no issues of concern raised by the secretarial staff.

4.9 Mitigation Measures

4.9.1 Narasha Primary School

The stakeholders of Narasha Primary School raised many issues in which they need assistance. However, many of these issues fall under the ambit of the Government. Orpower should discuss with the community on which among the many issues can be taken up by Orpower IV, and which should be handled by other players. The expectations of the stakeholders need to be moderated through thorough in-depth discussions.

4.9.2 Narasha Community

Just as the case with the Narasha Primary School Community, the Narasha Community equally holds very high expectations of what Orpower IV should assist them with. There is need to hold frank and comprehensive consultations, so that all players are clear about what assistance can realistically be provided to the Narasha Community, to avoid unnecessary conflicts.

4.9.3 Accounts Department

- Shelves for putting files should be provided for more efficiency. However, since the office is small, all files that are not for immediate use should be put in the archives.

4.9.4 KWS

- The joint meetings between KWS and Orpower IV to regularly update KWS on their expansion activities/phases should continue, to allay KWS fears about sustainability of the Park in the face of expanding geothermal development.

4.9.5 Lake Naivasha Riparian Association

- According to the Association, Orpower IV needs to plant more and Acacia trees around the housing estate.
- Orpower IV should also promote tree planting around Lake Naivasha as part of their CSR programs.

4.10 Health and Safety Considerations

The work environment was inspected in light of the requirements of the Factories Act and other relevant legislation on health and safety of the workers and visitors.

4.10.1 Main Hazards at the Plant and Existing Management Systems

Table 3 Main Hazards and Management Measures

Hazard	Source or Location	Recommended Safety Measures
Hydrogen sulphide	Wells, Power Plant area	CO ₂ piped to ODC may have some H ₂ S. H ₂ S monitoring, self contained breathing apparatus, gas masks
Fire	Paper, wood, electrical, welding, Pentane, fuel(diesel)	Fire detectors, emergency doors, fire extinguishers with colour coding, connected hose pipes and sprinklers, fire blanket, goggles, fire alarm, regular fire drills, emergency assembly point for head counts, fire protective clothing, fire brigade

		emergency number, property insurance
Noise	Generators, condensers, pumps, Discharging wells, Machines, Welding	Ear muffs, regular inspections, sound proofing office spaces
Liquid waste	Office/bathrooms, brine	Septic Tanks, Re-inject in unproductive wells
Solid waste	Office, plant	Waste separation at source, metals are buried, papers burnt.
Floods	Volcanic soils, heavy rain	Disaster Management Committee including KenGen, ODC and Orpower 4 Inc
Seismic	Natural, drilling and extraction of fluid	Disaster Management Committee
Volcanic	Natural, drilling and extraction of fluid	Disaster Management Committee
Oil spillage	Oil tank, pump, workshop, garage, generator, used oil containers	Containers collect spills at the pump and below the tank, ballast, safety signs, safe disposal
H ₂ S	Wells and pits, plant	Collect and pipe to ODC, rare discharge to atmosphere, monitor weekly
CO ₂	Wells, plant	Pipe to ODC, rare discharge to atmosphere
Electromagnetic radiation	Where the power lines pass. This is the responsibility of KPLC.	Build houses 100-200m away, put up signs, awareness and education, do not graze near the power lines for long
Soil erosion	Steep slopes, wind, heavy rainfall	Plant grass in exposed areas
Pentane	Pentane tanks, OEC units	Stored in labelled container, Fire extinguishers nearby, Fire hose nearby.
Spilled geothermal fluid	Leaking pipes, steam traps	Regular inspection, safe disposal, fence off affected area

4.10.2 Other Hazards affecting Plant Safety and Workers

Table 4 Other Hazards affecting Safety of the Plant and Workers

Hazard	Source	Safety Measures
Hazardous materials i.e. paint, antiseptics	Store	Store keeper's office to be well ventilated and away from hazardous material
Livestock	Herders	Instructed to graze away from the plant
Wildlife	Hells Gate National Park	Members of Hells Gate Management committee, Insulation of pipes
Gullies	Soil erosion	Fill the gullies, dig storm water drains
Snake bites	Surrounding environment	First aid kit, keep the grass short in the working areas
Over speeding	Vehicles	Speed limits, speed bumps, safety belts
Wind	Weather conditions	Plant trees
Dust	Weather conditions, bare ground, vehicle movement	Plant trees, gravel, dust masks, observe speed limits
Stealing of green cladding on pipes	Pipes (green claddings)	Kongoni police station, Narasha community, provide lightning at night, security patrols
Falling objects	Power generation area	Safety sign (hard cap area), insurance (workman's compensation)
Trespassers	Power generation area	Safety signs (authorized persons only), tighten security, fence
Machine Malfunctions	Power generation area	Test/Calibration certificate of torque wrench by Kenya Bureau of Standards, instruments monitored by computer, maintenance work schedule.
Stress	Working environment, few holidays	Orpower 4 Club, Shifts, overtime allowance, employee welfare, introduce a comments box
Untreated water	Lake Naivasha raw water, bore hole water	Bottled water provided for Orpower 4 Inc employees
Slippery table top	Slippery material	Use non slippery surfaces,

		or add a stopper at the bottom of table slope
Chemical spray	Goldsmith flower farm near housing estate	Plant trees as a buffer between the estate/village and the flower farm
Potholes on the road	Wear and tear of road	Fill up with gravel, maintain the road as required.
Tampering with machines and valves	Trespassers	Locals instructed to graze away from the plant, Valves are chained and padlocked, enhanced security patrols.

5.0 PAST AND ON - GOING CONCERNS OF THE PROJECT

These have been identified in the past as:

- (i) Soil erosion in exposed, steep slopes;
- (ii) Volcano/seismic hazards
- (iii) Noise at the power plant area.
- (iv) Possibility of loss of steaming grounds due to withdrawal of geothermal fluids
- (v) Electromagnetic radiation along power lines
- (vi) Air pollution due to CO₂, H₂S, Rn and particulates
- (vii) Brine discharges: leaks and reinjection wells need to be inspected regularly
- (viii) Dust from vehicles on the road, and bare surfaces in this arid environment
- (ix) Flora: No exotic species should be introduced in the area. Opportunistic species should be removed in cleared areas
- (x) Fauna: Disturbance to wild animals should be kept to a minimum. Structures that may obstruct the free movement of wildlife (such as disused fences, pipes, metal and timber structures) should be removed.
- (xi) Positive impacts on the local Maasai Community should be enhanced, through the provision of jobs, schools, water, and transport facilities. Sustainability should be in-built into the projects.
- (xii) Consultations and collaboration with KWS, Lake Naivasha riparian Association, and KenGen should be enhanced for improved management of the environment.
- (xiii) Orpower Staff: Training on Environmental, Health and Safety issues should be regularized.

These concerns need to be continuously addressed and be kept in check.

6.0 ENVIRONMENTAL AND HEALTH AND SAFETY CONCERNS IN 2009

Table 5 Issues of Concern in the Previous Audit Report

Issue of Concern	Recommendation	Action taken so far
Soil erosion in exposed, steep slopes	Trees planted and re-planted in cleared areas	Ongoing activity
Volcano/seismic hazards	Monitor seismic activity	Not undertaken.
Noise in the power plant area.	Monitor noise levels, provide ear protection for workers and visitors	Ongoing activity
Loss of steaming grounds due to withdrawal of geothermal fluids	Re-inject geothermal fluid, monitor steaming ground activity	Ongoing activity
Electromagnetic radiation along power lines	Keep settlements at least 200 m away, grazers to be warned not to stay close to power lines for extended periods	Ongoing activity
Air pollution due to NCGs (mainly CO ₂ and H ₂ S)	Collect NCGs and sell off CO ₂	NCGs collected and piped to ODC for free. Occasionally discharged to the atmosphere.
Brine discharges	Leaks and re-injection well performance need to be monitored and corrected regularly	Ongoing activity to replace/repair leaking pipes, identify dispose of leaking geothermal brine as appropriate.
Dust from vehicles on the road, and bare surfaces	Plan to pave the road, re-vegetate exposed surfaces	Re-vegetation of bare surfaces an ongoing activity
Flora	No exotic species should be introduced in the area. Opportunistic species should be removed in cleared areas	Ongoing vigilance and consultations with KWS. Monitor abundance and diversity.
Fauna	Disturbance to wild animals should be kept to a minimum. Structures that obstruct the free movement of wildlife (such as disused fences, pipes, metal and timber structures) should be removed.	Ongoing vigilance and consultations with KWS. Monitor abundance and diversity.
Positive impacts on the local Maasai Community	Formalise the community collaboration as part of CSR	Assistance to schools (materials, lunch), needy

		students, transport. Community happy with collaboration so far.
KWS, LNRA, ODC, and KenGen	Consultations and collaboration with these partners	Consultations and collaboration with the partners ongoing
Environmental, Health and Safety issues	Implement and enhance the Company EHS policies and practices. Training on EHS should be ongoing.	Incidents and accidents reported during the review period. More vigilance required

6.1 Incidents and Accidents

There were incidents and accidents during the period under review, none of them fatal. One incident involved a gate swinging back to hit a vehicle. No injuries, but workman hours were lost, and the mudguard had to be reattached. The second incident occurred during offloading of pentane drums from the delivery truck using a crane. A worker was injured while tightening a wrench. One vehicle hit another that was parked next to it near the pentane tank area.

It is recommended that stricter measures be instituted with respect to safety procedures. The incident and accident report board should be properly re-set each time an incident takes place. At the time of the audit, the board did not reflect the four incidents above.



Figure 6 Incident Report Board as at 8th October 2010

7.0 EFFICACY AND ADEQUACY OF THE ENVIRONMENTAL MANAGEMENT PLAN

Orpower 4 Inc. is conscious of its responsibilities to the environment and the health and safety of its workers. This is evidenced by the following facts: -

1. The Company has a document, “Environmental, Health and Safety Policy”, which is communicated to every employee joining the Company, is implemented by managers and supervisors, at all levels, and is available to the public.
2. The Company has a Safety Manual for Plant Operation and Maintenance, which is available to Plant Operators.
3. The Company has a designated Health and Safety Officer and a Health and Safety Committee.
4. The Company has a designated Environmental Officer.
5. Previous recommendations in the “Environmental Management Plan” have been acted upon.

Implementation of the Environmental Management Plan is a continuous process involving monitoring and taking appropriate corrective action. It was noted that some areas have not been regularly addressed as may be required, and this can be attributed to lack of regular inspections to find out where corrective action needs to be taken. Otherwise, the Environmental Management Plan is deemed to be adequate and efficacious. There is need to provide adequate transport to facilitate adequate monitoring of environmental issues by the workers.

It is recommended further that the Environmental Health and Safety Committee members undergo training to upgrade skills to a level that they can train other workers on fire, health and safety issues.

8.0 RECOMMENDATIONS

8.1 Environmental Management Plan

The Environmental Management Plan recommended in previous years continues to be valid, because environmental monitoring and improvement must be a continuous process. The plan is reproduced below.

Table 6 Environmental Management Plan

Environmental Impact	Monitoring Frequency	Notes
Soil erosion monitoring	Every 6 months	
Volcanic/Seismic and subsidence monitoring	Set up station. Review data every 6 to 12 months	Joint venture with others
Noise level monitoring	Randomly. Review data every 6 months	
Water table/ steaming ground monitoring	Inspect and review data every 6 months	
Electromagnetic radiation monitoring	Every 12 months	Responsibility of KPLC
Meteorological/ Air quality monitoring	Meteorological and pollution monitoring continuous. Review data and air quality parameters (H ₂ S, Radon, CO ₂) every 6 months	
Brine discharge monitoring	Inspect visually for any signs of brine discharge every six months. Collect soil, plant materials for chemical analysis	
Dust monitoring	Randomly. Review data every 6 months	
Monitoring of flora	Abundance and diversity every 6 months. Exotics should be destroyed	
Monitoring of fauna	Abundance and diversity annually	
Maasai Community	Socioeconomic status reviewed every twelve months	
Orpower 4 Inc Workers	Environmental education seminars and reviews every 12 months.	
Health and Safety	Prevent incidents and accidents by adopting recommendations above. Continue to monitor incidents and accidents, and report as they occur.	

8.2 Costs

Most of these measures can be done using employees already available, and with minimal additional capital outlays. Transport facilities for the environment Officer need to be enhanced so that transport is always available for environment and safety related issues.

8.3 Time Table

These measures should be implemented within the next six months and monitoring and evaluation continued throughout the year.

8.4 Mechanisms of Implementation

The Plant Manager should oversee implementation of these measures together with the Environment Officer.

9.0 INDICATORS OF ACCEPTABLE IMPLEMENTATION

1. Low or zero H₂S concentrations in the Plant area.
2. Low or zero hospital visits by workers due to work – related health issues.
3. Low or zero accidents and incidences (i.e. the number of man hours of accident free operation increased).
4. Flourishing vegetation around the plant
5. Increase in the number of mammals in the park area. This indicator is, however, dependent on the cooperation among all players in and around the Park.
6. Improved and sustainable livelihoods for the Maasai community

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APPENDICES

Appendix 1: List of Personnel who conducted the Environmental Audit Study

Coordinator of Study	Prof. Mwakio P. Tole, PhD. Professor of Environmental Geochemistry, Department of Environmental Sciences, Kenyatta University
Biological Impacts	Prof. William Aino Shivoga, PhD. Associate Professor of Biological Sciences, Department of Environmental Sciences, Egerton University
Socio-economic Impacts	Ms Charity Konana, MPhil. Assistant Lecturer of Environmental Studies, Narok University College

Appendix 2: List of Interviewees

1. Patrick Mbothie- Headteacher (Narasha primary school)
2. Gladys Bosibori, Accounts Assistant
3. Jesse Githinji, Accounts
4. Nelly Palmeris, Environmental Officer, KWS
5. Jane Wamsogo, Research Scientist, KWS
6. Linda Munyao, Environmental Manager, Oserian
7. Sarah Higgins, Lake Naivasha Riparian Association
8. Sidney Chemuliti, Plant Operator, Orpower 4 Inc.
9. Kennedy Okwirry- Plant Operator, Orpower 4 Inc.
10. Debra Ambayi- Supervisor for plant operators, Orpower 4 Inc.
11. Charles Rapando- IT administrator, Orpower 4 Inc.
12. Felix Kirui- Mechanical, Orpower 4 Inc.
13. Shaa Leperes- Narasha community
14. Damaris Shaa- Narasha community
15. Lucy Jacob- Narasha community
16. Zera Mutunkei- Narasha community
17. Ester Kiraison- Narasha community
18. Elina Kantim- Narasha community
19. Helen Aramat- Narasha community
20. Jonathan Shaa- Narasha community
21. Meshack Mutunkei- Narasha community
22. Ezekiel Parkirre- Narasha community
23. Joel Nkoitiko- Narasha community
24. Jonathan Kasinino- Narasha community
25. Elizabeth Gachau- Environment Officer, KenGen
26. Philip Juma Barasa- Environment Officer, KenGen
27. Hannah Muthoni Macharia- Environment Health and Safety Officer, Orpower 4 Inc

28. Kenneth Njaga, Electrical, Orpower 4 Inc.
 29. Francis Muoki- Instrument, Orpower 4 Inc.
 30. Anne- Secretary, Orpower 4 Inc.

Appendix 3: Floral Checklist near Olkaria III area in September 2010

<u>Taxa</u>	<u>Remarks</u>
ACANTHACEAE <i>Hypoestes aristata</i> (Vohl.) Roem. & Schultes <i>Thunbergia alata</i> Sims.	-Common in dry grassland and bushes -Trailing or climbing in <i>Tarchonanthus</i> bushes
ASCLEPIADACEAE <i>Calotropis procera</i> <i>Sacostema viminale</i> R.Br.	-Poisonous plant, common on the road sites -Stem exudes latex, along seasonal streams
ASTERACEA . <i>Athroisma psyllioides</i> (Oliv.) Matlf, <i>Felicia muricata</i> (Thunb.) Nees. <i>Guternbergia cordifolia</i> Oliv. <i>Tarchonanthus comphoratus</i> L.	-Occurring in grassland along roadside -Dry grassland -Rocky eroded poor grassland -Dominant vegetation in the Olkaria III Geothermal Plant area
CAESALPINACEAE <i>Chamaecrista mimosoide</i> L.	-Near steam vents
CAMPANULACEAE <i>Wahlenbergia abyssinica</i> (A.Rich.) Thulin.	
COMMELINACEAE <i>Aneilema</i> sp. <i>Commelina africana</i> L. C. benghalensis L. C. imberbis Hassk.	-Near steam vents -Yellow flowers -Blue flowers -Near steam vents
CONVOLVULACEAE <i>Ipomea wightii</i> (Wall.) Choisy.	-Browsed by animals
CRASSULACEAE <i>Crassula volkensis</i> Engl. <i>Kalanchoe densiflora</i> Rolfe.	-Associated with mosses near steam vents -Found in bushes and disturbed places
CRUCIFEREAE <i>Erucastrum arabicum</i> Fisch. & Mey.	-Wild vegetable
CYPERACEAE <i>Cyperus giolii</i> Chiov. <i>C. rotundus</i> <i>Fimbrisyliis exilis</i> (H.B.N.) Roem. & Schult.	-Found in wooded grassland -Common on wet ground -Associated with the presence of steam vents
ERICACEAE <i>Erica arborea</i> L.	-Very common on volcanic rocks and cliff edges at Hell's Kitchen and Hobbly Volcano
EUPHORBIACEAE <i>Clutia abyssinica</i> Jaub. & Spach. <i>Euphorbia crotonoides</i> Boiss. <i>E. prostrata</i> Ait.	--Associated with <i>Tarchonanthus</i> undisturbed bushes -Contains milky latex, browsed by wild animals -Has milky latex

GLEICHENIACEAE <i>Dicranopteris linaeris</i> (Burm.f.)	-Steam vents
LABIATAE <i>P. silvestris</i> <i>P. tenuiflorus</i> (Vatke.) Agnew. <i>Satureia biflora</i> (CD.Don.) Benth.	-Near steam vents -Found in rocky places -Common in dry grassland
LILIACEAE <i>Asparagus africanus</i> Lam. <i>Gloriosa superba</i> L. <i>Onithogalum gracillimum</i> R.E.Fries	-Occur in open vegetation forming low bushes -Brilliant red flowers -Forms a bulb in the ground
LYCOPODIACEAE <i>Lycopodium cernuum</i> L.	-Steam vents
MELASTOMATACEAE <i>Dissotis senegambiensis</i> (Guill. & Perr.) Triana.	-Gorges near steam vents
MORACEAE <i>Ficus ingens</i> Miq. <i>Ficus</i> spp.	-On rocky cliff edges near steam vents -On rocky cliff edges near steam vents
MIMOSACEAE <i>Acacia drepanolobium</i> Harms <i>A. xanthophloea</i> Benth.	-Common on dry rocky hill side in association with <i>Tarchonanthus</i> bushes -Not common, found near dams, gorges and luggas/seasonal streams
MYRATACEAE <i>Syzigium</i> sp.	-Near steam vents on rocky cliffs
OLEACEAE <i>Olea africana</i> (= <i>O. europaea</i>) L.ssp.	-Gorges and Luggas/seasonal streams
OPHIOGLOSACEAE <i>Ophioglossum rubellum</i> A.Br.	-Steam vents
ORCHIDACEAE <i>Angraecum humile</i> <i>Ansellia gigantea</i> <i>Pteroglossaspis ruwenzoriensis</i>	-Associated with humid, hot steam vents -Associated with humid, hot steam vents -Associated with humid, hot steam vents
PAPILIONACEAE <i>Crotalaria laburnifolia</i> L. <i>C. chrysochlora</i> Harms <i>Indigofera arrecta</i> A.Rich. <i>Rhynchosia elegans</i> A.Rich. <i>Trifolium stedneri</i> Schweinf.	-Widespread in bush-land and grassland -Near steam vents -Grassland and bush -Bushland and at the dam
POLYPODIACEAE <i>Pleopeltis macrocarpa</i> (Willd.) Kaulf.	-Steam vents
PORTULACACEAE <i>Portulaca oleracea</i> L.	-Common on sandy and loamy soils

<i>PTERIDOPHYTES</i> <i>Cheilanthes multifida</i> (Sw.) Sw.	-Near steam vents
PROTEACEAE <i>Faurea saligna</i>	-On cliff edges near steam vents
RANUNCULACEAE <i>Clematis brachiata</i> L.	-Wooded grassland/ disturbed ground in association with <i>Urtica massaica</i>
RUBIACEAE <i>Galium spurium</i> L. <i>Pentas lanceolata</i> (Forsk.) Deflers. <i>Rubia cordifolia</i> L.	-Common under fertile bushes -Common in <i>Tarchonanthus</i> bushes -Roots contain orange dye
SAPINDACEAE <i>Dodonaea viscosa</i> (L.) Jacq.	-Found in drainage gorges near steam vents
SCROPHULARIACEAE <i>Cynium tubulosum</i> (L.f.) Engl.	-Near steam vents
STERCULIACEAE <i>Dombeya burgessiae</i> Gerradex.Harvey.	-While flowers massed in umbels, found in gorges and luggas/seasonal streams
TILIACEAE <i>Grewia similis</i> L.	-Gorges and luggas/seasonal streams
URTICACEAE <i>Urtica massaica</i> Mildbr.	-Prolific, stinging herb, invades burned/cleared <i>Tarchonanthus</i> bushes
VERBENACEAE <i>Lantana trifolia</i> L. <i>Lippia javanica</i> (Burm.f.) Spreng.	-Bush edges and on roadsides -Browsed by goats

Appendix 4: Mammal Checklist of the Hell's Gate National Park

<u>HERBIVORES</u>	
Buffalo	<i>Syncerus caffer</i>
Burchell's Zebra	<i>Equus burchelli</i>
Chanler's Mountain Reedbuck **	<i>Rendunca renduca</i>
Grant Gazelle	<i>Gazella grantii</i>
Thompson's Gazelle	<i>Gazella thomsonii</i>
Maasai Giraffe	<i>Giraffa camelopardalis</i>
Kongoni (Coke's Hartebeest)	<i>Alcephalus buselaphus coki</i>
Eland	<i>Taurotraqus oryx</i>
Impala	<i>Apyceros melampus</i>
Warthog	<i>Phacochoerus aethiopicus</i>

Dafassa Waterbuck	<i>Kobus defassa</i>
Klipspringer	<i>Oreotragus oreotragus</i>
Steinbok	<i>Rhaphicerus campestris</i>
Kirk's Dik Dik	<i>Rhynchotragus kirkii</i>
African Hare	<i>Lepus sp.</i>
Spring Hare	<i>Pedetes capensis</i>
Squirrel	<i>Finisciurus sp.</i>
Mole Rat	<i>Tachyorectes plendens</i>
CARNIVORES	
Lion	<i>Panthera leo</i>
Leopard Cheetah	<i>Panthera pardus</i>
Golden Jackal	<i>Canis sp</i>
Silver-backed Jackal	<i>Canis sp</i>
Bat-eared Fox	.
Spotted Hyena	
OTHER MAMMALS	
Olive Baboon	<i>Papio anubis</i>
Rock Hyrax	<i>Heterophyrax brucei</i>
Aardvark	<i>Orycteropus afer</i>
Hedgehog	<i>Erinaceus albiventris</i>

**Threatened/Endangered species

Appendix 5: Birds Checklist of the Hell's Gate National Park

COMMON NAME	SCIENTIFIC NAME
Maasai Ostrich	<i>Struthio cemus</i>
Secretary Bird	<i>Saggtarius serpentarius</i>
Ruppel's Griffon Vulture	<i>Gyps ruppellii</i>
White-backed Vulture	<i>Gyps bengalensis</i>
Nubian Vulture	<i>Torgos tracheliotus</i>
Egyptian Vulture	<i>Neophron percnopterus</i>
Lammergeyer**	<i>Gypaetus barbaus</i>
Augur Buzzard	<i>Buteo rufofuscus</i>
Cocqui Francolin	<i>Francolinus coqui</i>
Scaly Francolin	<i>Francolinus squamatus</i>
Hilderbrandt Guinea Fowl	<i>Francolinus hildebrandti</i>
Helmeted Guinea Fowl	<i>Numida melaegris</i>
Speckled Pigeon	<i>Columba guinea</i>
Laughing Dove	<i>Streptopelia senegalensis</i>
Red-eyed Dove	<i>Streptopelia semitorquata</i>

Ring-necked Dove	<i>Streptopeliacapicola</i>
White-fronted Bee Eater	<i>Merops bullockoides</i>
African Hoopoe	<i>Upupa epops</i>
Harrier Hawk	<i>Polybariodes radiatus</i>
Batleur	<i>Terathopius ecaudatus</i>
African Hawk Eagle	<i>Hieraaetus spilogaster</i>
African Fish Eagle	<i>Haliaeetus vocifer</i>
Long-crested Eagle	<i>Lophaetus occipitalis</i>
Tawny Eagle	<i>Aquila rapax</i>
Verreaux's Eagle	<i>Aquila verreauxii</i>
Whalberg's Eagle	<i>Aquila wahlbergi</i>
Lanner	<i>Falco biarmicus</i>
Peregrine	<i>Falco peregrinus</i>
African Hobby	<i>Falco cuvieri</i>
Fox Kestrel	<i>Falco alopex</i>
Wattled Starling	<i>Spreo sp.</i>
Blue-eared Glossy Starling	<i>Lamprotornis chalybaeus</i>
Red-winged Starling	<i>Onychognathus morio</i>
Superb Starling	<i>Spreo Susperbus</i>
Oxpeckers	<i>Buphagus erythrorhynchus</i>
Rufous Sparrow	<i>Passer motitensis</i>
Speke's Weaver	<i>Ploceus sp.</i>
Schalow's Wheatear	<i>Oenanthe lugubris</i>
Yellow Bishop	<i>Euplectes capensis</i>
Purple Grenadier	<i>Uraeginthus ianthinogaster</i>
Willow Warbler	<i>Phylloscopus trochilus</i>
Rattling Cisticola	<i>Cisticola chiniana</i>
Tawny-Flanked prinia	<i>Prinia sublava</i>
Black-Breasted Apalis	<i>Apalis flavida</i>
Red-Faced Apalis	<i>Apalis rufifrons</i>
Buff-bellied Warbler	<i>Phyllolis pulcheella</i>
Grey- Blacked Camaroptera	<i>Camaroptera brevicaudata</i>
Crombec	<i>Sylvietta brachyura</i>
Dusky Flycatcher	<i>Alsenax adustus</i>
White-eyed Slaty Flycatcher	<i>Dioptornis fischeri</i>
Grey Flycatcher	<i>Bradornis microrhynchus</i>
Chin-Sport Flycatcher	<i>Batis molitor</i>
Hunter's Sunbird	<i>Nectarina hunteri</i>
Scarlet Chested Sunbird	<i>Nectarinia senegalensis</i>
Variable Sunbird	<i>Nectarinia venusta</i>
Bronze Sunbird	<i>Nectarinia kilimensis</i>
Golden-Breasted Bunting	<i>Emberiza flaviventris</i>
Cinnamon-breasted Rock Bunting	<i>Emberiza tahapis</i>
Yellow-rumped Seed Eater	<i>Serinus atrogularis</i>
Brimstone Canary	<i>Serinus sulphuratus</i>
Crimson-rumped Waxbill	<i>Estrilda rhodopyga</i>
Common Waxbill	<i>Estrilda astrilda</i>
Purple Grenadier	<i>Uraeginthus ianthinogaster</i>
Pin-tailed Whydah	<i>Vidua macroura</i>
Ricenow's Weaver	<i>Ploceus baglafeht</i>
Vitteline Masked Weaver	<i>Ploceus velautus</i>
Yellow bishop	<i>Euplectes capensis</i>
Rufous Sparrow	<i>Passer motiensis</i>

Gey-headed Sparrow	<i>Passer griseus</i>
Redwing Startling	<i>Onychognathus morio</i>
Blue-eared Glossy Startling	<i>Lamprotornis chalybaeus</i>
Superb Startling	<i>Sperero superbus</i>
Red-billed Oxpecker	<i>Buphagus erythrorhynchus</i>
Black-headed Oriole	<i>Oriolus larvatus</i>
Diongo	<i>Dicurus adsimilis</i>
Black-lored Babbler	<i>Turdoides melanops</i>
Wood Warbler	<i>Phylloscopus sibilatrix</i>
Brown Woodland Warbler	<i>Phylloscopus umbrovirens</i>
Yellow-rumped Seedeater	<i>Serinus atrogularis</i>
Anteater Chat	<i>Myrmecocichla aethiops</i>
Fiscal Shrike	<i>Lanius collaris</i>
Richard's Pipit	<i>Anhus novaeseelandiae</i>
Rufous-naped Lark	<i>Mirafra africana</i>
Redwing Bush Lark	<i>Mirafra hypermetra</i>
African Rock Martin	<i>Hirundo fuligula</i>
European Swallow	<i>Hirundo rustica</i>
Grey-rumped Swallow	<i>Hirundo griseopyga</i>
Gey Wagtail	<i>Motacilla clara</i>
African Pied Wagtail	<i>Motacilla aguimp</i>
Yellow-vented Bulbul	<i>Pycnonotus barbatus</i>
Horus Swift	<i>Apus horus</i>
Little Swift	<i>Apus affinis</i>
Mottled Swift	<i>Apus aequatorialis</i>
Nyanza Swift	<i>Apus niansae</i>
Nightjar	<i>Caprimulgus sp.</i>
Drdric Cuckoo	<i>Chrysococcyx caprius</i>
Klaas's Cuckoo	<i>Chrysococcyx klaas</i>
Red-chested Cuckoo	<i>Cuculus solitarius</i>
Spotted Eagle Owl	<i>Bubo africanus</i>
Kori Bustard	<i>Ardeotis kori</i>
Crowned Plover	<i>Vanelus coronatus</i>
Crowned Sandpiper	<i>Tringa hypoleucos</i>
Temminck's Courser	<i>Cursorius temminckii</i>
Speckled Mousebird	<i>Colius striatus</i>
Abyssinian Scimitarbill	<i>Phoeniculus minor</i>
Gold-tailed Woodpecker	<i>Campethera cacillautii</i>
Bearded Woodpecker	<i>Thripias namaquus</i>
Plain-backed Pipit	<i>Anthus leucophrys</i>
Black- Backed Puff back	<i>Dryoscopus cubla</i>
Brown- headed Tchagra	<i>Tchagra austrialia</i>
Tropical Boubou	<i>Laniarius ferruineus</i>
Fiscal Shrike	<i>Lanius collaris</i>
Grey- backed Fiscal Shrike	<i>Lanius excubitorius</i>
Stone Chart	<i>Saxicola torquata</i>
Schalow's Wheatear	<i>Oenanthe lugubris</i>
Anteater Chat	<i>Mymecocichla aethiops</i>
Robin Chat	<i>Cossypha caffra</i>
White-browed Robin Chat	<i>Coccypha heuglini</i>

**Threatened/Endangered species

Appendix 6: Results of analysis of soils and Narasha wetland waters (Chemical and Industrial Consultancy Unit, Department of Chemistry, University of Nairobi) July 2010

SER. NO.	PARAMETER	Separator Area	Olkaria Hill	Hill between OW 401 and OW 307	Narasha Wetland
1	VOCs ($\mu\text{g}/\text{kg}$)	208	72.3	52.20	-
2	Arsenic (mg/kg)	0.02	ND	0.01	0.001
3	Sodium ($\mu\text{g}/\text{kg}$)	2.3	0.20	0.12	6.6
4	Chromium (mg/kg)	ND	ND	ND	ND
5	Calcium ($\mu\text{g}/\text{kg}$)	4.9	3.6	0.47	8.95
6	Mercury (mg/kg)	ND	0.001	ND	ND
7	Boron ($\mu\text{g}/\text{kg}$)	6.18	6.94	6.21	0.30 ($\mu\text{g}/\text{l}$)
8	Silicon (mg/kg)	226	318	243	20.5
9	Potassium (mg/kg)	961	590	325	30.35
10	Sulphur (mg/kg)	23	1.50	1.40	2.60
11	Fluoride (mg/kg)	217	109	117	2.90
12	Chloride (mg/kg)	434	61.70	69.30	85.20
13	pH				6.7

ND = Not Detected (i.e. below detection limit of the instrument)