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- ContourGlobal KivuWatt Ltd ESIA
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Acronyms

ABS	America Bureau of Shipping
BOD	Biological Oxygen Demand
BRA	Bilateral Regulatory Authority
CA	Concession Agreement
COA	Compensation Advisor Ombudsman
CDP	Community Development Programme
CDM	Clean Development Mechanism
CFD	Computational Fluid Dynamic Model
CLWD	Community Liaison Working Group
COD	Chemical Oxygen Demand
DRC	Democratic Republic of Congo
EDA	Endemic Bird Areas
EMMP	Environmental Management & Monitoring Plan
EWG	Expert Working Group
ERP	Emergency Response Plan
ES	Environmental Statement
ESD	Emergency Shut Down
ESIA	Environmental & Social Impact Study
FAO	Food and Agriculture Organization
FEED	Front End Engineering Design
GCA	Gas Concession Agreement
GCS	Green and Clean Solutions
GEF	Gas Extraction Facility
GHG	Green House Gas
GI	Ground Investigation
GIS	Geographical Information System
GoR	Government of Rwanda
GPN	Good Practice Note
GPS	Global Positioning System
HAZOP	Hazard and Operability Study
HFO	Heavy Fuel Oil
IFC	International Finance Corporation
IMP	Influx Management Plan
ILO	International Labour Organization
ISO	International organization for standardization
KMP	Kibuye Master Plan
KP1	Kivu Pilot 1
MLS	Marine Landing Site
MTR	Mandatory Technical Requirement
MINAGRI	Ministry of Agriculture & Animal Resources
MININFRA	Ministry of Infrastructure
Mt	Metric Tonnes

MW	Mega Watt
NGO	Non Governmental Organization
OP	Operational Policies (of the World Bank)
OPIC	Overseas Private Investment Corporation
OSHMS	Occupational Safety and Health Management System
PAP	Project Affected People
PCDP	Public Consultation and Disclosure Programme
P&IDs	Piping and Instrumentation Diagrams
PPA	Power Purchase Agreement
PPAH	Pollution Prevention Abatement Handbook
PPE	Personal Protective Equipment
PIIM	Project-induced In-Migration
PSV	Pressure Safety valve
RAP	Resettlement Action Plan
RDB	Rwandan Development Board
REMA	Rwandan Environmental Management Agency
RWF	Rwandan franc
RWG	Rwandan Working Group
SADC	South African Development Community
SCADA	Supervisory Control and Data Acquisition
SOCIGAZ	Société de Controlee de l'Exploitation du gaz Méthane du Lac Kivu
SDV	Shut Down Valve
SOP	Standard Operating Procedures
UCB	Union Chemique Belge
USEPA	United States Environmental Protection Agency
VCT	Voluntary Counselling and Testing
VOC	Volatile Organic Carbon
W	Wedderburn Number
WHO	World Health Organisation

Executive Summary

ContourGlobal established KivuWatt Ltd on June 9th 2008 to develop a power generation project located at Kibuye, Rwanda. The project will cost approximately US $ 300-350 million to develop and construct and is projected to begin to distribute power in the 4th quarter of 2010. This will be the single largest foreign investment in Rwanda to date. The KivuWatt project will generate 100MW of electrical power using methane (CH_4) gas extracted from the deep waters of Lake Kivu as fuel.

The KivuWatt project involves the development of a Power Plant and a Marine Landing Site (which is effectively a port) onshore and four offshore Gas Extraction facilities (GEF). The gas extraction facility itself will be located on a portion of Lake Kivu on the Rwandan side of the border which has been made available by the Government of Rwanda ("GoR") per the terms of a Concession Agreement with ContourGlobal KivuWatt Ltd.

Gas extraction will be conducted in compliance with the "Lake Kivu Gas Extraction: Basic Principles, Mandatory Requirements and Guidelines for the concessionary Design and Operation of Gas Extraction Plants" (version 10 published 18th February 2008) – "the Mandatory Guidelines". These guidelines were produced jointly by the governments of Rwanda and the Democratic Republic of Congo and were established by a panel of international experts that determined the restrictions that should apply to the Kivu Pilot 1 (KP1) project, the first methane gas extraction project in Kivu, that is currently operating at Gisenyi.

Whilst the Mandatory Guidelines are a legally binding requirement of the Concession Agreements, revisions to the document have been prepared since 2008 culminating in "Management Prescriptions for the Development of Lake Kivu Gas Resources" (17 June 2009). The project will meet those elements pertaining to lake stability and the environment in both documents.

All of the power output will be sold to Electrogaz, the State owned company which is investing heavily to strengthen their transmission/distribution system to accommodate the new generation capacity.

Rwanda suffers from a serious energy deficit which is constraining economic development. As of 2008 only 6% of the population had access to electricity. By the year 2020, Electrogaz, intends to extend coverage to 36 or 40 percent of the country's households and the KivuWatt project will play an important part in meeting that target.

ContourGlobal KivuWatt Ltd has a Power Purchase Agreement and Concession Agreement signed by ContourGlobal KivuWatt Ltd and Electrogaz. Both agreements contain environmental conditions applicable to the development.

The KivuWatt project presents an opportunity for generation of 100MW of low cost electricity that compares favourably with generation from other sources.

The "do nothing" [1] scenario is not an option in this case due to the need to reduce gas levels in Lake Kivu in order to avoid the hazardous consequences of a future gas eruption with the possibility of a large number of fatalities as happened at Lake Nyos in Cameroon. The conclusion of the Expert Committee (2006) was:

'The irrefutable conclusion by the Expert Committee is that from the point of view of risks, the environment and economics, the only viable action is to produce the methane gas in Lake Kivu and use it for power production. To do nothing is clearly unacceptable because of the risk, and to vent the lake instead of producing gas is worse from all points of view'.

The project will contribute to lake stability and contribute to averting a humanitarian disaster by reducing levels of gas in the lake.

In addition to continued constraints on energy supply in the absence of the project, a number of other benefits would be forgone including national and local economic development. The importance of this project for reasons of community safety and community development cannot be over emphasised.

The context

Situated in the East African Rift Zone between Rwanda and the Democratic Republic of Congo (DRC), Lake Kivu has a surface area of approximately 2400 km^2 and a maximum depth approaching 500 metres. The lake contains large concentrations of naturally occurring methane and carbon dioxide held in solution by the stable density gradients at depth in what is believed to be a unique environment due to the presence of methane.

Natural conditions within the lake have resulted in the formation of discrete density gradients and a marked stratification has been delineated by scientists studying the lake. Scientific studies since

[1] The "do nothing" scenario presents the situation in the absence of the project and is required to be considered as part of an ESIA.

the discovery of the gas in 1936 have enabled delineation of several key zones or layers. Of key importance to the project are the Biozone, the oxygenated surface layer containing biological life (from surface to 60m), and the Resource zone (below approximately 260m depth) which contains the methane resource. The highest concentrations of methane are encountered below 310m depth.

Predictions of when the lake will become saturated with the dissolved gases range from 50 – 200 years. At this point a potentially catastrophic gas eruption could occur, endangering the lives of approximately 2 million people living on the lake's shore. However, the timing of a cataclysmic eruption could be triggered by a volcanic event at any time and this increases the urgency of taking action to degas the lake. The impact of such a risk was highlighted by a similar eruption from Lake Nyos in Cameroon in 1986 with the loss of over one thousand lives.

To reduce the chance of a similar eruption, plans were developed to harvest the methane for power generation which would both reduce gas concentrations and provide a means for improving living conditions through provision of cheap electricity. The concept has been tested on a small scale with sufficient gas being extracted to provide fuel for the boilers of a Gisenyi brewery for more than thirty years. Methane for use in power generation is considered a positive risk mitigation strategy as it will divert a lethal natural phenomenon to a use which is economically beneficial to Rwanda.

The Rwanda Government entered into discussions with several companies to progress the commercial extraction of gas for power generation. The ContourGlobal KivuWatt Ltd project is the first of these projects to be taken to the production phase.

The project

The project is located on Lake Kivu close to Kibuye in the Western Province of Rwanda, approximately 85 km south west of the capital Kigali.

The location of the Power Plant near Kibuye is a direct function of the gas concession area and represents the most practically feasible location from which to exploit the gas resource available in the aforementioned gas concession area. Moreover, the site for the Power Plant was designated specifically for that purpose as an industrial zone in the approved Kibuye Master Plan and has the following advantages:

- The site is government owned land located in a sparsely populated area without any dwellings or other constructions within the site boundaries. The nearest residential dwelling is 450m south-east (and upwind) of the Power Plant.

- There are no important ecological areas within or adjacent to the site.
- The site is in proximity to both the concession area and also to the Electrogaz grid connection and transformer station.
- The site is located in deep water with reasonable access to the lower resource zone and outside the areas considered unsuitable for deep gas extraction.

The ContourGlobal KivuWatt Ltd concession is located within the Rwandan border and is not anticipated to impact the DRC's right to extract methane within their own borders.

The project facility comprises three separate components: the off-shore extraction GEFs, the Power Plant site and the Marine Landing Site (MLS).

The gas extraction process consists of abstraction of the gas rich water from the resource zone at a depth of 355 metres. The gases are separated from the water and the gas stream is 'washed' to remove Carbon Dioxide (CO_2) and Hydrogen Sulphide (H_2S), purifying the methane which is then compressed and pumped along submerged pipelines to the shore where it is burned in gas engines to produce electricity.

The technical complexity of the process is heightened due to the volumes of water required, the reliance on the principle of "gas lift", the remote nature of the lake and the potential risks associated with the natural lake conditions should lake stability be compromised and a gas eruption occur.

The on-shore Power Plant will comprise a series of gas engines that will convert the methane to electricity which will then be supplied to the grid.

The Marine Landing Site (MLS) will be on low ground which will be engineered to provide the construction facilities, a wharf and a slipway. The MLS will be used for construction of each of the four GEFs. Once the GEFs are constructed and launched into place, the MLS site will be handed over to the Government of Rwanda for use as a general port and for boats used for security patrols for ContourGlobal KivuWatt Ltd.

The GEFs will be partially fabricated into flat packed panels in Mombasa and transported to site. 700 tonnes of steel is being imported for the construction of each GEF. The GEFs will be built in the shed on the slip way and launched onto the lake. Each will be moored at the fitting out area for remaining construction and testing of the main production equipment before being moved to a shallow anchorage for '*wet fitting'* of suspended equipment and then towed to its permanent moorings in the lake.

The main GEF fabrication workshop will be erected over the upper portion of the slipway. The shed will be a steel portal frame with apex roof and the structure will be open on all sides for crane/plant access. 50 tonnes of steel for the shed will be imported from Mombasa. Other smaller workshops will be formed from shipping containers as required. The workers compound will be constructed of pre-fabricated housing modules.

The project will be implemented in two stages:-

1) Phase I will produce 25 MW of power from one GEF with a connecting pipeline of approximately 13km and three gas engines operating at the Power Plant. Construction of the Phase I infrastructure has already commenced with clearance of the site and civil works for raising of the MLS. The first power will be distributed towards the end of 2010.

2) Phase II will provide an additional 75 MW of power to give a total of 100 MW through the addition of three GEFs and a further nine gas engines at the Power Plant. Construction of Phase II is scheduled to begin towards the end of 2010 and full production capacity is programmed to be achieved in 2013. The project is designed in a modular way and allows for design changes identified during the initial operation of the Phase I GEF.

The Environmental Statement

This Environmental Statement (ES) is prepared by SKM at the request of ContourGlobal KivuWatt Ltd. The ES addresses proposals for the development of the KivuWatt Project and is the output of the Environmental and Social Impact Assessment (ESIA) process.

A separate ES has been prepared by a local consultant, Green and Clean Solutions, and this has been submitted to the Rwandan Development Board (RDB) for approval. The RDB has formally advised a "*no objection*" for the on-shore activities and is in the process of reviewing supplementary information provided by ContourGlobal KivuWatt Ltd in respect of off-shore activities. The Environmental permit is expected to be issued in early November 2009.

The project is assessed against a number of environmental regulations and requirements including those of the GoR, Overseas Private Investment Corporation (OPIC) and the International Finance Corporation (IFC).

It should be noted that the Concession Agreement held by ContourGlobal KivuWatt Ltd includes legally binding requirements for the project to comply with. "The Lake Kivu Gas Extraction: Basic Principles, Mandatory Requirements, Guidelines for the Concessioning, Design and Operation of

Gas Extraction Plants", Version 10 (February 2008), the "Mandatory Guidelines". The Mandatory Guidelines have since gone through a number of reviews and iterations culminating in "The Management Prescriptions for the Development of Lake Kivu Gas Resources" (June 2009) and hereinafter referred to as "The Prescriptions".

The format of the ES reflects the OPIC structure for reporting and the social and environmental aspects to be addressed including:

- Physical environment which examines the context or setting of the site including climate, topography and the geology of the site together with natural hazards.
- The biological environment which presents the baseline for terrestrial and aquatic ecology and protected areas. (Note that although fisheries are part of the biological environment their significance in this instance is principally economic and they are therefore addressed separately).
- Lake stability is part of both the physical and biological environments but is presented as a separate chapter due to the unique nature of Lake Kivu and its centrality to the ESIA. This section includes an assessment of the modelling results and compliance with the mandatory guidelines.
- The section on the human environment presents the social and economic context and baseline and assesses the potential positive and negative impacts of the project. Mitigation measures to address impacts are presented and residual impacts are identified.
- The section on environmental quality describes the baseline, potential impacts, mitigation measures and residual impacts in respect of air, noise, water, soil and waste management.
- Occupational and community health and safety and potential impacts arising from routine, accident and emergency situations are considered for on- and off-shore activities. Mitigation measures are identified where needed.

The principal findings of the ESIA are as follows:

The biological environment

Rwanda has a very diverse and rich biodiversity with high endemism. However, despite Rwanda's overall high levels of biodiversity there are no important or protected ecological areas in or close to the site. The nearest protected area is the Nyungwe forest which is almost under 20km south of the site. The Power Plant site itself was formerly bush but has been stripped of vegetation. The MLS was degraded wetland used for subsistence farming but has also been cleared. Given the absence of

existing ecological data and the fact that all vegetation and habitat were stripped from these areas, site ecological issues are not considered significant.

Unlike most of the African Great Lakes, aquatic biodiversity is low due to the unique nature of the lake and its origins. There are only 30 species of fish, five of which have been introduced. However the lake's ecosystem sustains fisheries that are a major local economic activity and an important source of protein for riparian communities. This economic importance is assessed in the fisheries section of the report.

Lake Stability

Lake Kivu has a range of very unusual features many of which relate to its origins and which require some understanding before any potential impacts can be properly assessed. The geographical location, geological formation, hydrological regime and nearby vulcanicity all play a part in making Lake Kivu a unique environment. The waters of the lake are stratified to an unusual degree with very little vertical mixing either by wind forcing or differential cooling of warm surface waters in the winter. This is partly due to the venting of carbonated water of volcanic origin into the lake creating a dense lower layer that is difficult for any conventional mixing mechanism to disturb. The high levels of carbon dioxide in the vent water increases the density of the lower lake water and maintains the stratification. Because there is no mixing the deeper layers have become anoxic (starved of oxygen) leading to an oxygen debt.

The upper waters of the lake between the surface and some 60m on average are, however, well mixed and this is due to the effect of the wind. These waters are well oxygenated and able to support the lake's biology, which despite the overall poor diversity of the lake nevertheless supports an important local fishery. This layer is also stable and is referred to as the biozone. However, it is species poor in comparison with other Great Lakes in Africa and this is due to the fact that the nutrients required for successful biological production are effectively locked in the deep water layers through the stratification effect. When the animals and plants in the biozone die they fall to the bottom of the lake and are decayed by bacteria but this occurs in the absence of oxygen and so methane is produced as a bi-product of the digestion process. It is the build up of methane, in exploitable quantities, in the carbonated deep waters that is the unique feature of Lake Kivu.

The stability of the lake is demonstrated by the marked zoning and the zones are defined by a number of density gradients. Clearly any attempt to exploit the methane from the lower resource zone in the very deepest waters of the lake must be done without risking destabilisation of these

zones and without affecting the sensitive, and extremely restricted, biozone. The integrity of the lake stability layers must be maintained in order to prevent lethal gases escaping to the atmosphere, or contaminating the biozone. Maintaining this integrity is also essential to reduce the risk of explosion to a minimum. The potential impacts have been identified by the Expert Committee (2006) and are embodied in the Mandatory Guidelines (2008). Therefore in respect of the KivuWatt development these potential impacts have been identified by the Expert Committee as:

- Moderate, local eruption triggered by puncturing of the lake bed and subsequent release of gases but where the stability forces in the lake bring the localised eruption under control. The potential scenarios here include damage to the lake floor through the anchoring mechanism of the GEFs and accidental release of heavy objects.
- Moderate local eruptions or potentially large eruptions through the raising and re-injection system in the deep water. Risks associated with this circuit would be associated with the destabilisation of the deep water layer leading to release of gases into the upper density layers through re-injection of degassed water and release of gases into the wrong density layer in the event of pipeline breakage in the riser system. This would be particularly significant if nutrient rich, oxygen poor, deep water were to egress into the biozone. In theory a large part of the lake could be emptied of gas content but in reality this would be slowed by the capacity of the pipe and the shut off systems installed.
- Impacts on the biozone could occur from the release of the wash water, containing H_2S and CO_2, into the base of the biozone. This may mix with the upper, oxygenated, layers and have a localised effect on the lake biology.
- Additional impacts could arise from the intake of deep lake sediments through the raw water riser.
- The design of the anchorage system has been proposed and is in the final design stage. Of paramount importance is the location of the anchorage points and a sea bed survey will be conducted immediately prior to placement in order to avoid any sensitive areas on the seabed (e.g. CO_2 vents) which may lead to localised gas release if punctured. The data from the lake bed survey will inform placement methodology. However it should be noted that it is planned to set the anchors as soon as practicable and to allow them to settle in prior to the physical mooring of the GEF to avoid bottom disturbance and water withdrawing at the same time.

A hydrodynamic model has been constructed which has significantly reduced the level of uncertainty surrounding the assessment of the possible impacts that the removal of gas from deep water resources may have on both the stability of the density layers and the water quality. The

model is a complex 3D Computational Fluid Dynamic Model (CFD) as recommended by the Expert Working Group and the validation of the model showed a good match between the observed and predicted density layers in the lake – thus indicating that the model outputs can be considered accurate. This model encompassed four studies designed to:

- Understand the behaviour of the degassed water on re-injection into the deep water layer.
- Confirm that the fully gassed water from the resource zone will continuously flow into the raw water riser.
- Determine the physical dimensions of the wash water plume on recharge to the lower biozone.
- Determine the fate of the chemical composition and temperature of the wash water plume in the biozone.

The results of the modelling studies show that the design conforms to all the elements of the Mandatory Guidelines concerning the stability of the lake. In particular:

- The raw water intake and the degassed plume respect the conditions of laminar flow.
- The degassed plume will not penetrate the density gradient and will have a very limited dispersion in the localised vicinity of the discharge pipe – 165m horizontally and 42.3m vertically – until the plume cannot be distinguished from the ambient water. The absence of currents in the deep water means that the plume remains local.
- The partial pressure of the degassed water is comparable with the receiving water and effectively floats above the lower density gradient – thus maintaining the density gradient and no dilution of the gases in the Lower Resource Zone.
- The raw water intake and the degassed water discharge do not mix and there is no short circuiting.
- The laminar flow into the raw water riser ensures that sediments will not be taken in with the water.
- The wash water plume can be detected up to 67.5m from the discharge point and extends almost 13m vertically before it is indistinguishable from the ambient water. Therefore it remains localised.
- The wash water has no effect on the density gradient in the biozone.
- The partial pressure of the dissolved gases in the wash water is significantly lower than the saturation pressure and this means that there will be no risk of effervescence from the discharge plume.

- The temperature of the wash water shows a slight elevation of 1ºC above ambient close to the discharge and at the surface but its elevation is within the normal ranges found within the lake and so is not an issue.
- The distribution of CO_2 in the wash water also shows a slight elevation in the vicinity of the discharge pipe but the effects are limited the area of the plume i.e. no more than 70m from the discharge point and inside the exclusion zone.

Hydrogen sulphide (H_2S) was not modelled and it is uncertain how much of this will oxidise in the relatively oxygen poor depths of the lower biozone. The accumulated H_2S could be brought to the oxygen rich surface layers through normal mixing with the thermocline by wind action and could lead to localised fish kills within the exclusion zone. We are unable to asses this further and ContourGlobal KivuWatt Ltd will need to monitor this situation. In all other respects the precautionary measures outlined in the Mandatory Guidelines (2008) have already been accommodated within the plant design. Therefore, provided that these measures are put in place there should be no residual impacts on the lake stability of the biozone. To that end the mitigation measures are designed to reduce the level of uncertainty and to comply with the measures set out in the Mandatory Guidelines (2008).

Nevertheless, the design and the assumptions promulgated by the Expert Committee have only been tested by the predictive model. It is essential, therefore, to establish and maintain a comprehensive monitoring programme as included in the Environmental Management and Monitoring Plan (EMMP) (Appendix A) throughout the construction and operational Phases so that the impact predictions can be verified.

Fisheries

Of the current socio-economic uses of the lake the most prominent is fishing. The current catch is estimated at around 3,300 Mt per year and the overwhelming majority of the catch (3,000Mt) comprises the small freshwater herring *Limnothrissa miodon*, known locally as isambaza. This species was introduced from Lake Tanganyika around 1960 and exploits the open waters of the lake. The remainder of the catch is riparian in nature and is dominated by *Tilapia*. Fish farming is underdeveloped around the lake although there are proposals to increase the contribution of farmed fish in the coming years.

The fisheries sector in the Karongi district and in Kibuye in particular, is considerably well organised as fishermen have formed cooperatives and associations. These organisations facilitate the communication between its members and with the authorities. According to government

records there are 353 registered fishermen operating 104 registered boats in the district organised into 5 fishing cooperatives. Technically all fishermen should be licensed by the authorities but a small minority operate without a permit.

There are two main fisheries. Fishermen in dugouts operate close to shore, use gillnets and their most valuable catch is tilapia. Fishermen on the larger boats operate offshore, using large purse seine nets to catch isambaza. They operate at night using light to attract the fish shoals to the boats. The monthly average income of an individual fisherman is around $25 USD (or approximately 15,000 RWF).

The majority of the landings take place in the morning so that the catch can be taken to the markets and sold on the same day. Losses are high as there is no means of preservation. However, fish that are not sold are processed, i.e. frozen or sun dried and either sold for fish meal or, in the case of isambaza, sold directly for human consumption in Kigali at a premium.

A large share of all isambaza caught within and around the areas where the project will be implemented is landed in Kibuye. The annual catch of isambaza was estimated at around 370 Mt per year and represents both an important source of income and a valuable food resource. In fact in most cases this is the fishermen's only source of income. The near shore fishery, although less important economically, is still an important source of protein and provides a degree of food security for the local community.

The potential impact of sediment runoff during the construction works was identified as a potential impact, as were general spillages into the lake from various contaminants including oil, solvent etc. These contaminants could affect the spawning and nursery grounds of the tilapia as they nest in the shallow waters around the lake edges.

The potential impacts associated with the operational Phase paralleled those concerning the general lake stability issues and water quality in the biozone:

- H_2S and CO_2 contribution to acidification of the water leading to a potential change in structure of phytoplankton (principally diatom) communities. The modelling suggests that any effects from this could be localised around the discharge pipe and within the exclusion zone. Nevertheless the issue concerning the oxidisation of the H_2S in the oxygen poor waters of the lower biozone remains uncertain and the possible impact, although reduced in terms of area, could still result in fish deaths. Therefore the fish populations in the vicinity of the GEFs will require monitoring.

- Ammonia, iron and phosphates from deep water ingress could contribute to the eutrophication of the lake. However this is not an issue as the deep water will be returned to the upper resource zone and will not come into contact with the biozone. Therefore the effect of nutrient enhancement on the biozone can be discounted.

Mitigation measures concerning the physical and chemical properties of the lake also apply in terms of the biological function and this is because these three aspects are intimately linked. Therefore the points raised concerning lake mitigation apply equally to impacts on fisheries.

Some mitigation measures are also proposed for reduction in possible light pollution around the GEFs as this will attract fish to the structures. However, it is also appreciated that this may be a positive benefit as the exclusion zones around the GEFs would effectively act as a protection zone and may be of unexpected conservation benefit.

As with the physical and chemical properties of the lake, it is expected that the mitigation/design measures will be sufficient to prevent any major residual impacts on the biological function of the Lake, but the actual situation requires careful monitoring in order to validate the assumptions of the Expert Committee and the impact predictions.

The Human environment

Kibuye is the 9th largest town in Rwanda with a population of 45,000 people. 44% of the population is below the age of 15 and there are high levels of poverty, illiteracy and HIV/AIDS. 66% of the economically active population has an income equivalent to US $ 18 per month and the Province is one of the poorest in the country. The majority of household derive their income from fishing and/or farming.

The significant socio-economic impacts associated with the project are as follows.

Potential & actual adverse socio-economic impacts:

- Loss of agricultural land and economic displacement of 27 farmers. Loss of fodder production for the Gasura Primary school cow. Although the farmers have no legal right to the land and have been compensated by the GoR, the compensation is insufficient to address loss of livelihood and ContourGlobal KivuWatt Ltd is looking to provide additional transitional support and will prepare a Resettlement Action Plan (RAP) for this purpose. The RAP will be prepared by Consultants with experience of social assessment and RAP preparation in Africa and ContourGlobal KivuWatt has contacted USAID in Kigali for further guidance on RAP in Rwanda.

- Restricted access to certain parts of the lake by the establishment of 500m exclusion zones around the GEFs, the re-injection areas and the Power Plant for safety reasons.
- Increase in the incidence of HIV/AIDS due to a rapid influx of male construction and operational workers.
- Road safety concerns due to construction vehicle movements.
- Noise and dust from the construction site with possible effects on a nearby market.

Potential beneficial socio-economic impacts

- Job creation and training for local workers.
- Local and national economic development.
- The project will benefit the local economy both directly and indirectly. The economic effects have not been fully calculated but they will clearly be significant as there will be provision of jobs and the opportunity for provision of contracts and services to local businesses both during the construction Phase of the project and when the plant is operational. There will be approximately 200 personnel hired during the construction period and approximately 100 persons hired over the course of the operation of the plant.

Potential and actual adverse impacts will be addressed through:

- The development of the RAP.
- Production of an HIV/AIDS good practice plan in line with IFC Good Practice Note (GPN) advice.
- Controls on construction activities to reduce safety and nuisance risks such as prevention of dust generation, spillages to ground and waste management.

Once these actions are fully implemented the residual adverse effects on the local community are considered to be negligible or minor.

Environmental Quality

Environmental quality is assessed in respect of potential impacts on air, soil and water and arising from the generation of noise and of solid and liquid wastes. Noise and air emissions were modelled to predict impacts. The results of both models show that there will be no significant impacts on local residents due in part to topography, the distance of the nearest receptor and the choice of

technology used. Indeed the plume is predicted to disperse over the lake, away from the nearest residential area.

Impacts on soil and water can occur during construction unless properly managed. A management plan for these activities has been prepared by Green & Clean Solutions and issued to the contractor for implementation. A waste management plan to address safe disposal of wastes during operation will be prepared. Wastes that cannot be recycled locally or composted will be transferred to a managed waste facility in Kigali by a licensed and government approved waste contractor.

Once the suggested mitigation measures are implemented the residual impacts are considered to be negligible.

Occupational and community safety

Potential safety impacts are principally associated with construction activities and these will mainly affect workers. There are however also potential worker community safety issues in respect of the preservation of lake stability and the need to ensure protection from gas releases, fire or explosion. Community safety can also be affected by heavy vehicle movements in and around the site.

To ensure safety off-shore, ContourGlobal KivuWatt Ltd has undertaken a Hazard & Operability Study (HAZOP) and will institute automated detection, warning and shut down systems in the event of gas releases or other risks. The gas extraction and pipeline gas transport system can be shut down and restarted in a short time. The re-injection system will also be monitored and it too can be shut down.

The 500m safety exclusion zones around the GEFs and the re-injection points will prevent boat users from straying close to these facilities. The location of the submerged pipeline will be clearly marked by buoys and lights although boats can safely cross the pipeline so as not to hinder access to fishing grounds.

An Emergency Response Plan (ERP) will also be developed by ContourGlobal KivuWatt Ltd for the Power Plant and gas extraction facilities in early Summer 2010 prior to commissioning and both facilities will have occupational health and safety management systems for routine activities. The ERP will be developed and in place prior to the commissioning of operations and will include systems for warning and safe evacuation of staff and local people.

The major safety issue is of course the issue of lake stability and this will be addressed by adherence to the Mandatory Guidelines, as legally required by the Concession Agreement and also by adherence to the safety and environmental requirements of the subsequent Prescriptions.

Once the suggested safety design mechanisms and management systems are implemented the residual impacts are considered to be minor.

Consultation with the local community and other stakeholders (e.g. Rwandan Government officials, local businesses) has been undertaken and the outcomes of the consultation taken into account in assessing impacts and developing mitigation. There is an overwhelming level of support for the project both locally and nationally and an expectation of the contribution to economic development. There are also high expectations of the project and in particular the benefits that will accrue from job creation, training and the provision of a secure supply of low cost electricity. However there is also concern that this be done without incurring unacceptable environmental and social impacts.

Environmental Management & Monitoring Plan (EMMP)

This statement includes an EMMP that addresses all impacts and provides the means to monitor that impacts are as predicted, to provide reassurance as to compliance with legal, corporate and OPIC requirements and to allow detection of emerging issues. The EMMP addresses all anticipated impacts in respect of air, noise, water, soil, waste, lake stability, community consultation, and RAP and worker safety. The EMMP references the relevant standards and regulations (Rwandan and IFC) that will apply to all Phases of the project and includes the roles and responsibilities of the different parties involved in the design and implementation of the project.

Cumulative Impacts and trans boundary issues

Cumulative impacts of both processes of the project and in the context of the lake as a whole were assessed with the following conclusions:

- The extraction of gas from the Rwandan concession area is not expected to affect agreements with DRC or the availability of methane to the DRC concession areas.

- Trans-boundary issues are limited to potential air quality issues or gas escapes. Due to control systems in place, the risks associated with these issues are considered to be low.

1. Introduction

1.1. Overview

ContourGlobal established KivuWatt Limited on June 9th 2008 to develop a power generation project located at Kibuye, Rwanda. The project will cost approximately US $ 300-350 million to develop and construct and is projected to begin to distribute power in the 4th quarter of 2010. This will be the single largest foreign investment in Rwanda to date. The KivuWatt project will generate 100MW of electrical power using methane gas extracted from the deep waters of Lake Kivu as fuel.

The KivuWatt project involves the development of a Power Plant and a Marine Landing Site (which is effectively a port) onshore and four Gas Extraction facilities (GEF). The GEF will be located on a portion of Lake Kivu on the Rwandan side of the border which has been made available by the Government of Rwanda ("GoR") per the terms of a Concession Agreement with ContourGlobal KivuWatt Ltd.

Between 1994 and 2000, the Government of Rwanda ("GoR") embarked on an aggressive economic development plan. It quickly became clear the country's electricity deficit was more serious than anticipated. The customers at the few connections that existed suffered from unreliable service and high electricity prices. The Government of Rwanda worked to reform this situation and to expand capacity. GoR views modern energy as a critical driver of the country's national, social, and economic development efforts. In common with many African countries, Rwanda has seen little to no investment in its energy sector for the last 25 years, and as of October 2008 only six percent of the population had access to electricity. Rwanda's domestic power supply currently comes mainly from hydropower, a recently commissioned diesel Power Plant, a small amount of solar energy and costly small diesel-fired engines. The latter are needed to ease the energy crisis and bridge the gap between spiralling energy demand and limited supply,

By the year 2020, Electrogaz intends to extend coverage to 36 or 40 percent of the country's households and the KivuWatt project will play an important part in meeting that target.

ContourGlobal KivuWatt Ltd has a Power Purchase Agreement (PPA) and a Gas Concession Agreement (GCA) signed by ContourGlobal KivuWatt Ltd and Electrogaz and backed by GoR. Both contain environmental conditions applicable to the development and these conditions are summarised in section 3.

1.2. Site and Location

The project is located on Lake Kivu close to Kibuye in the Western Province of Rwanda, approximately 85km south west of the capital Kigali as shown in Figure 1 – please note that all referenced Figures are included in section 13.

The Concession area and the location of the off-shore facilities are shown in Figures 2 and 3 respectively and the on-shore details in Figure 4..

The project facility comprises three separate components: the GEFs, the Power Plant site and the Marine Landing Site (MLS).

The on-shore Power Plant will comprise a series of gas engines that will convert the methane to electricity which will then be supplied to the grid.

The MLS will be on low ground which will be engineered to provide the construction facilities, a wharf and a slipway. The MLS will be used for construction of the GEFs. Once the GEFs are constructed and launched into place, the MLS site will be handed over to the government of Rwanda for use as a general port and for boats used for security patrols for ContourGlobal KivuWatt Ltd.

For ease of reference the following location terms will be used in the report:

- The ***production area*** means the legally agreed concession area where the GEFs are located.
- The ***site*** means the combined on-shore facilities, i.e. the point where the pipeline comes ashore, the Power Plant and the MLS.
- The ***MLS*** means only that part of the site used for the construction of the GEFs.

The environmental and social context of the site is described more fully in sections 5 and 8.

1.3. The Environmental Statement

This Environmental Statement (ES) is prepared by SKM at the request of ContourGlobal KivuWatt Ltd. The ES addresses proposals for the development of the KivuWatt project and is the output of the Environmental and Social Impact Assessment (ESIA) process.

A separate ES has been prepared by a local consultant, Green and Clean Solutions, and this has been submitted to the Rwandan Development Board (RDB) for approval. The RDB has formally advised a "*no objection*" for the on-shore activities and is in the process of reviewing supplementary information provided by ContourGlobal KivuWatt Ltd in respect of off-shore activities. Please note that the Rwandan regulations refer to EIA and not ESIA.

The Environmental permit is expected to be issued in early November 2009.

The objective of this second ES is to ensure compliance with OPIC requirements, as outlined in the OPIC Environmental Handbook, 2004, for environmental assessments of OPIC financed projects.

Environmental Management & Monitoring Plan (EMMP)

This statement includes an EMMP that addresses all impacts and provides the means to monitor that impacts are as predicted, to provide reassurance as to compliance with legal, corporate and OPIC requirements and to allow detection of emerging issues. The EMMP addresses all anticipated impacts in respect of air, noise, water, soil, waste, lake stability, fisheries and community and worker safety. The EMMP references the relevant standards and regulations (Rwandan and IFC) that will apply to all Phases of the project and includes the roles and responsibilities of the different parties involved in the design and implementation of the project.

1.4. Content & format of the ES

The content of the ES is based on the requirements specified in the OPIC Environmental Handbook including:

- An executive summary.
- Section 1: Introduction.
- Section 2: Project description and information on the project sponsors and contractors.

- Section 3: Policy, legal and administrative framework.
- Section 4: ESIA methodology.
- Section 5: Physical Environment.
- Section 6: Biological environment.
- Section 7: The Lake.
- Section 8: Human environment.
- Section 9: Fisheries.
- Section 10: Environmental Quality.
- Section 11: Occupational health and safety.
- Section 12: Summary of impacts.
- Section 13: Maps, plans and drawings.

A set of appendices are attached that include author and technical information as well as the Environmental Management & Monitoring Plan (EMMP) and other relevant information.

The format of the report differs from that recommended by OPIC in that baseline, impact assessment, mitigation and residual impacts for each of the social and environmental issues addressed are included in a single sub-section to ensure flow and readability. However all of the OPIC requirements as to content are met.

2. Project Description

2.1. The Mandatory Guidelines

The engineering design parameters of the KivuWatt project have been formulated to fully comply with the Ministry of Infrastructure, Republic of Rwanda and Ministry of Hydrocarbons, Democratic Republic of Congo's Lake Kivu Gas Extraction: Basic Principles, Mandatory Requirements and Guidelines for the Concessioning, Design and Operation of Gas Extraction Plants (Version 10) *"The Mandatory Guidelines";* a copy of this document is attached in Appendix E. This version has been adopted by the Government of Rwanda as the principal document governing gas extraction facilities in the Lake applicable to the project and included in the Concession Agreement held by ContourGlobal KivuWatt Ltd. Version 10 recognises the requirements for maintaining the density gradient of the lake and minimising potential environmental impacts while at the same time focussing on the paramount issue of long-term public safety. Subsequent versions of the guidelines do not provide any further instructions on public safety or environmental issues. Nevertheless, the KivuWatt project is largely compliant with subsequent versions of the guidelines. Similarly the various amendments to Version 10 include plans in relation to the different resource zones e.g. upper resource zone (Plan A1), lower resource zone (Plan A2) and Plan B for the lower resource zone do not in fact have any relevance to the stability of the density layers in the lake but are designed to make maximum commercial use of all the resource zones. A full discussion of the issues is presented in the section on Lake Stability (Section 7). However it is important to note that the Expert Working Group (IFC/World Bank, May 2009) and all preceding documents including the Mandatory Guidelines Version 10 recognise that the following order of priorities should always be respected:

1. Public Safety
2. Environmental Impact
3. Maximum use of the Resource
4. Commercial optimisation of profits.

This document focuses on the first two of these priorities.

Reference to the Version 10 Mandatory Guidelines has been made throughout this document in the relevant sections. The impact assessment and mitigation sections describe how the process design meets the various guidelines.

2.2. Lake Kivu

Situated in the East African Rift Zone between Rwanda and the Democratic Republic of Congo (DRC), Lake Kivu has a surface area of approximately 2400 km² and a maximum depth approaching 500 metres. The lake contains large concentrations of naturally occurring methane and carbon dioxide held in solution by the stable density gradients at depth in what is believed to be a unique environment due to the presence of methane.

Natural conditions within the lake have resulted in the formation of discrete density gradients and a marked stratification has been delineated by scientists studying the lake. The lake has been the subject of a number of scientific studies since the discovery of the gas in 1936 enabling delineation of several key zones or layers as indicated in Figure 5 shows the stratification of the lake. These zones are discussed in detail in subsequent sections, but of key importance to the project are the Biozone, the oxygenated surface layer containing biological life (from surface to 60m), and the Resource zone (below approximately 260m depth) which contains the methane resource. The highest concentrations of methane are encountered below 310m depth.

Predictions of when the lake will become saturated with the dissolved gases range from 50 – 200 years. At this point a potentially catastrophic gas eruption could occur, endangering the lives of approximately 2 million people living on the lake's shore. The impact of such a risk was highlighted by a similar eruption from Lake Nyos in Cameroon in 1986 with the loss of over one thousand lives.

To reduce the chance of a similar eruption, plans were developed to harvest the methane for power generation which would both reduce gas concentrations and provide a means for improving living conditions through provision of cheap electricity. The concept has been tested on a small scale with sufficient gas being extracted to provide fuel for the boilers of a Gisenyi brewery for more than thirty years. Methane for use in power generation is considered a positive risk mitigation strategy as it will divert a lethal natural phenomenon to a use which is economically beneficial to Rwanda.

The Rwandan Government entered into discussions with several companies to progress the commercial extraction of gas for power generation. The ContourGlobal KivuWatt Ltd project is the first of these projects to be taken to the production Phase.

In forming the Mandatory Guidelines the GoR and DRC divided Lake Kivu into a number of gas concession areas as indicated in Figure 2. The site selection for the on-shore facilities was determined by the need to be in proximity to the gas concession area as detailed in the Gas Concession Agreement (GCA). The GCA refers to the "*southernmost of the gas concession areas on the Rwandan side of Lake Kivu*" as indicated within the Mandatory Guidelines.

The location of the site near Kibuye is a direct function of the gas concession area and represents the most practically feasible location from which to exploit the gas resource available in the aforementioned gas concession area. Moreover, the site for the Power Plant was designated specifically for that purpose as an industrial zone in the approved Kibuye Master Plan and has the following advantages:

- The site is government owned land located in a sparsely populated area without any dwellings or other constructions within the site boundaries.
- There are no important ecological areas within or adjacent to the site.
- The site is in proximity to both the concession area and also to the Electrogaz grid connection.

2.3. Proposed development

The gas extraction process consists of abstraction of the gas rich water from the resource zone at a depth of 355 metres. The gases are separated from the water and the gas stream is 'washed' to remove CO_2 and H_2S, purifying the methane which is then compressed and pumped along submerged pipelines to the shore where it is burned in gas engines to produce electricity.

The technical complexity of the process is heightened due to the volumes of water required, the need to use the lifting power of the gas laden water, the remote nature of the lake and the potential risks associated with the natural lake conditions.

The project engineering design specifies several key infrastructure components to the proposed development:

- Four Gas Extraction Facilities (GEFs) offshore.
- A Power Plant site with marine maintenance facilities onshore.
- A Marine Landing Site (onshore) to assemble and launch the GEFs.

The project will be implemented in two stages:

1) Phase I will produce 25 MW of power from one GEF with connecting pipeline and three gas engines operating at the Power Plant. Construction of the Phase I infrastructure has already commenced and the first power is expected to be distributed towards the end of 2010.
2) Phase II will provide an additional 75MW of power to give a total of 100MW through the addition of three GEFs and a further nine gas engines at the Power Plant. Construction of Phase II is scheduled to begin towards the end of 2010 and full production capacity is programmed to be achieved in 2013. The project is designed in a modular way. This allows for design changes identified during the initial operation of the Phase I GEF.

The on-shore and off-shore infrastructure and technology are discussed separately in the following sections. Discussion of the offshore facilities will focus on the Phase I GEF as the same will apply for each Phase II GEF. Following construction and deployment of the GEFs, ownership of the Marine Landing Site will be transferred to the GoR.

2.3.1. Off-shore Infrastructure and Technology

The off-shore gas production facilities include a GEF and an export pipeline from the GEF to the shore. The GEF supports the majority of equipment for lifting, separating and processing the gas. The Phase 1 GEF is proposed to be located approximately 13km west of the Power Plant site (see Figure 3) in approximately 365 metres of water. The subsequent locations of the Phase II GEFs is not yet fixed so the locations shown in Figure 3 are approximate. Phase II GEFs will be located in deeper waters and the location will be decided following a lake bed survey to establish the most appropriate location for the GEFs.

Key components of the offshore facilities as described in the Antares Offshore Front End Engineering Design (FEED Report) commissioned by ContourGlobal KivuWatt Ltd are summarised as follows (see Figure 6):

- *Raw Water Riser:* This riser is used to lift the gas water from a depth of 355 m by auto-siphon method. The siphon is described in detail in section 2.3.1.1 and is designed to produce a laminar flow through the pipe as required by the Mandatory Guideline (MTR) which states that water extraction and re-injection must be done horizontally. Equipment must be designed to reliably prevent, for the design lifetime of a facility, the accidental deviation of re-injection flows away from the horizontal, and/or their redirection into vertical flows, at the point of re-injection. The modelling results (see section 7) clearly demonstrate that the design supports a laminar flow. As water rises the reduced ambient pressure within the riser causes the gas to come out of solution. The lifted water and gas mixture is fed into a subsea separator.

- *Subsea Separator:* The separators are used to separate gas from water and this wet gas is brought to the separator though the Raw Water Riser. The water removed from the separator is returned back to the lake at a depth of 280 m, into the upper reaches of the resource zone through the Degassed Water Downcomer.
- *Process Equipment*: Wet gas from the subsea separator is compressed and fed into the wash tower where the gas is cleaned or scrubbed of the CO_2 and H_2S creating a high purity methane which is then dried, compressed and sent to shore via a semi-submerged pipeline. To provide for this, the process equipment located on the deck of the Barge will consist of a raw gas compressor, water wash pumps, wash towers, sweet gas compressor and dryer unit including all of the associated interconnection piping and electrical and controls and safety interlock systems to provide a fully functioning gas processing facility."
- *Export pipeline*: The fuel gas is transported to the onshore power generating facilities via a submerged 'floating' pipeline 20 metres under water. Preliminary design has allowed for a 5-inch (127 mm) ID pipeline which will be buoyed at the surface along its length and then weighted to maintain the correct depth. The pipeline connects to the GEF via a lazy S riser system. The riser is designed to accommodate the expansion and contraction motion and to decouple the GEF motion from pipeline motion.
- *GEF construction*: The GEF will be all steel construction (built to ABS Rules for Building and Classing Steel Vessels for Services on Rivers and Inter-coastal Waters) capable of providing a stable platform for the extraction process. The GEF will be built on a slip way at the Marine Landing Site, launched and fitted out at the MLS
- *Buildings:* The buildings on the GEF will consist of the control room, with electrical gear, office space, workshop, galley and break room.
- *GEF Mooring*: The GEF will be equipped with a spread mooring system and will be anchored by a four- point mooring system based on the known 100 year storm conditions. Each of the mooring lines will have a pretension o*f 222 kN* (50 kipf) in order to limit the vessel excursion to 10% of water depth. In order to comply with Mandatory Guideline G8 concerning the placement of anchorage systems the Contractor will conduct a lake bed survey of potential placement areas prior to placement in order to ensure that they do not place the anchors in sensitive areas such as CO_2 vents.
- *Flaring and emergency systems:* low-pressure emergency flaring will be provided to incinerate H_2S and CO_2 during system start-up and will be designed to safely handle maximum overpressure events. Emergency systems including fire and gas detectors, extinguishers and an emergency shutdown (ESD) system are intrinsic to the GEF design. A SCADA system will

transmit critical process data to shore and will be connected into the ESD shutdown systems both onboard and onshore.

Other onboard facilities, utilities and GEF dimensions are summarised in Table 1.

Table 1 GEF facilities

GEF Facilities	GEF Utilities	GEF Dimensions
▪ Power Generation: Two 60% gas engine generators and black start generators will provide power on the GEF. ▪ Gas dew point control ▪ Navigation aids, batteries and solar panels ▪ Crane ▪ Diesel storage tank and pump (for the black start generator)	▪ Utility water system ▪ Instrument air system ▪ Sewage treatment system ▪ Diesel storage system ▪ Fuel gas system ▪ Waste water system ▪ Closed drainage system and oil water separator.	▪ Length: 64 metres ▪ Breadth: 25 metres ▪ Depth 4.0 metres ▪ Draft (max) 2.5 metres ▪ Deck Loading 5.0 tonne/m² ▪ Lightship Weight 600 tonne

The diesel storage tank for the GEF will hold 6400 litres of fuel. Fuel will be transported to the GEF and crews will use a powered pump on the maintenance vessel to transfer the fuel from the vessel to the steel storage tank.

Table 2 gives atmospheric emission limits applicable to operation of the gas/diesel engines on each GEF, in accordance with IFC guidelines.

Table 2 IFC emission guidelines applicable to gas/diesel engines on GEFs

Parameter	Units[1]	Gas firing	Diesel firing
NO_x	mg/Nm^3	200	1,850[2]
CO	mg/Nm^3	n/a	n/a
SO_2	mg/Nm^3	n/a	<3% sulphur in fuel
PM	mg/Nm^3	n/a	100

Notes:
1) All concentrations at reference conditions 101 kPa, 0ºC, dry, 15% oxygen
2) If bore size diameter >400mm. Limit is 1,460 mg/Nm^3 if bore size diameter is <400mm, or 1,600 if justifiable to maintain high energy efficiency.

2.3.1.1. Auto-siphon Process

The auto-siphoning process is based on a principle of gas lift, a technology well understood and used in oil and gas extraction processes. To initiate the process, (refer to figure 6) an auto-siphon pump located on the barge is activated removing water from the separator vessel and injecting this into the degassed water downcomer. As this occurs, gas laden water from the lower resource zone, is moving upward through the riser pipe. At approximately 170 metres below the surface, gas in the form of bubbles, will start to liberate from the water creating a less dense mixture which then continues to flow up to the top of the riser and into the separator vessel, where gas will flash or come out of solution. The gas is collected at the top of the separator and piped up to the deck of the barge where it will be compressed, washed, dried and shipped to shore. Once the gas lift process is underway, the auto siphon pump can be turned off and the flow becomes self sustaining until either the inlet or outlet valves to the separator are closed. As the water enters into the separator from the riser side, continual displacement forces the degassed water out the other side of the vessel where it flows downward to the upper resource zone. To insure that the degassed water is safely returned and remains within this zone, a density matching system has been employed based on the regulation of the separator pressure to assure the correct water density is maintained. The pressure in the separator is regulated via a control valve at the inlet of the raw gas compressor.

Gases contribute the following percentages to the total mass of the raw water in the riser $C0_2$ 0.1825%, CH_4 0.0293%, N 0.00130%, H_2S 0.00083%.

The gas steam removed in the separator will be $C0_2$ 69.36686%, CH_4 28.1163%, N 1.29371%, Water (H_20) 1.08623%, H_2S 0.13177%.

The gas steam coming out of the wash towers will be between 85-90% of the methane, creating a maximum composition of the fuel gas to be approximately 90% CH_4, 2.75% $C0_2$ and 6.9% N_2.

The entire system is balanced due to the pressure differential driver and flow is controlled by the operating pressure in the separator. Note that a small priming pump located at the top of the raw water riser initiates the flow at system start up.

Sweet gas will be odorised with mercaptan on the GEF before the gas is transported to the Power Plant via the submerged pipeline. The odorant will allow for leak detection and to assure a safe and quick shutdown of the system should a leak occur. The odorant system is a self contained skid mounted unit containing a 250 gallon storage tank and instrumentation and the necessary controls to allow a small bypass stream of gas from the main stream to be routed through the pre-packaged unit in which the odorant where it will be injected with a small amount of odorant prior to the

bypass stream being returned to the main stream. The storage tank will be fitted with an alarm system that will detect any deviation from the normal operation.

A Material Safety Data Sheet (MSDS) will be provided on the GEF for safety reasons and will specify the nature of the hazard, ventilation requirements, PPE to be used in the event of a spill and methods for dealing with spills by containment, neutralisation, absorption and disposal of absorbed material. Requirements of the MSDS will be in place prior to the tank being filled. The tank will be refilled approximately once every two weeks

Onshore Infrastructure and Technology

The onshore facilities consist of a Power Plant and Marine Landing Site. Power generation and long term operational technology, will all be based at the Power Plant site. The Marine Landing Site will only contain the necessary equipment to construct the GEFs before being handed over to the GoR.

2.3.2. Power Plant Site

There will be several buildings associated with the Power Plant, namely the engine hall, administration building, substation control building, workshop building and guard house. Also present on the site will be the lay down area used to store the equipment prior to installation and an area dedicated for a future switchyard. The layout of the Power Plant is illustrated in Figures 7a and 7b. Figure 7c provides a detailed key to the layout.

The Phase I engine hall is at the south western end of the site with an adjacent utility block to the north west side and the stack to the east. The administration building, workshop and sewage treatment facilities are located at the far north western end of the site. The lay down area for the incoming pipeline is located at the far north western end of the site. Phase II engines will be constructed adjacent to the utility block in the same configuration as the Phase I engine hall.

The workshop building will also be steel framed. It will contain: a main workshop, storage warehouse, electrical workshop, changing rooms, office space and amenities. The administration building will be steel framed and contain a conference hall, office space and amenities.

Facilities required to maintain operation of gas gathering facilities include marine support/maintenance vessels and associated dock facilities to facilitate the movement of persons and equipment offshore.

Other facilities present on site will include: Oil/water separators, safety equipment including a fire water pump system, and space set aside for a gas filtering station.

The engine halls will be steel framed with roof apex approximately 10m above formation level. Mechanical utility will be fixed above the roof on steel framework. The stack will be located approximately 15m to the east of the gas engine and will also be formed within a steel frame.

Provisional stack heights of 20m were determined from known emissions monitoring data from gas engines typically employed at this type of installation. The potential stack heights are considered further in the air quality modelling exercise undertaken as part of this study. Phase I will utilise three gas engines with a combined net capacity of approximately 25MW. A further three blocks of three engines each, for a total of nine engines will be added during Phase II to produce the 100MW total proposed output. A final supplier for the gas engines has yet to be appointed to the project; Finnish manufacturer Wärtsilä (the most likely contractor to be appointed although this has yet to be finalised) produces engines typically utilised for methane gas power generation applications. The main specifications of the Wärtsilä type engine which may be used for the project are as follows[3]:

- Type of Unit - 20V34SG
- Number of cylinders - 20
- Arrangement of cylinders - V
- Power output (kW/cyl) - 450
- Bore (mm) - 340
- Stroke (mm) - 400

Unit rated speed (RPM) - 750

Table 3 gives atmospheric emission limits will apply to each of the main power plant engines, in accordance with IFC guidelines.

Table 3 IFC emission guidelines applicable to spark ignition gas engines

Parameter	Units	Gas firing
NO_x	mg/Nm^3	200
CO	mg/Nm^3	n/a
SO_2	mg/Nm^3	n/a
PM	mg/Nm^3	n/a
Notes: All concentrations at reference conditions 101 kPa, 0ºC, dry, 15% oxygen		

[3] All data refers to ISO 3046 condition

An access road was constructed for the Power Plant site prior to commencement of this project. A bitumen impregnated gravel road will lead from the main access road down to the lay down area, which will be surfaced with gravel along with remaining flat external areas of the site.

2.3.3. Marine Landing Site

The Marine Landing Site will consist of four major areas comprising:

- Slipway (and construction shed) adjacent to the lake in the western portion of the site.
- Main fit out platform and mooring further to the west on the lake.
- Site office, workshops, stores and generator in the central area.
- Workers living compound at the eastern end of the site.

A community jetty will also be constructed adjacent and to the west of the MLS to serve the local Friday market.

The workers camp will house approximately 100 people at full capacity in a series of prefabricated houses. Electricity will be supplied by a generator located within its own shed. Water and sewage treatment facilities will also be included.

2.3.4. Construction (Onshore)

2.3.4.1. Power Plant Site

The following activities are envisaged at the Power Plant site:

- Preparation of the site (civil engineering works, predominantly excavation and levelling).
- Construction of foundations for engines, transformer sub-station and site buildings.

Construction of the Power Plant site will involve significant civil engineering works to form the base platforms for the various facilities. It is anticipated that on completion of the civil works, 25,000m³ of hard rock material will have been removed and transferred to the MLS for use as fill. This work is already largely completed.

Once the base levels have been formed gabion fill retaining walls will be installed against the steeper cut faces prior to formation of the engine and building foundations. After foundations are set, construction of the engine housing, site buildings, pipeline lay down area and transformer sub-station can begin.

2.3.4.2. Marine Landing Site

The following activities are envisaged at the Marine Landing Site:

- Preparation of the site (civil engineering works).
- Preparation of launch ways.
- Building of quay walls.
- Construction/fabrication of buildings.
- Temporary moorings of the GEF during outfit.

The jetties will be constructed using a sheet pile and backfill method. Where possible materials cut from the Power Plant site will be utilised as fill. The concrete slipway will be formed and prepared by placement of fill materials onto the existing farming land to build up to the required levels then finished with a 250mm compacted aggregate base and 250mm reinforced concrete surfacing. Similar finishing will be used for the quay.

There will be approximately 550-600 cubic metres of concrete onsite that will make up the slipway and pile cap predominantly, but also form smaller structures. Estimated aggregates for the base and concrete requirement are 550m³ (locally sourced); approximately 165 tonnes of cement (also locally sourced) will be required using 88m³ of mixing water from the lake. 220 tonnes of sheet piling for the quay walls will be imported.

The main GEF fabrication workshop will be erected over the upper portion of the slipway. The shed will be a steel portal frame with apex roof and the structure will be open on all sides for crane/plant access. 50 tonnes of steel for the shed will be imported from Mombasa. Other smaller workshops will be formed from shipping containers as required. The workers compound will be formed from five flat pack imported prefabricated units approximately 5-6m^2 x 4m each.

In terms of programme, upon completion of the civil works the slipway and shed will be formed first; followed by the workers camp. Piling will begin on arrival of piling rigs and will continue in parallel with the beginning of GEF fabrication.

The GEFs will be partially fabricated into flat packed panels in Mombasa and transported to site. 700 tonnes of steel is being imported for construction of each GEF. The GEF will be built in the shed on the slip way and launched onto the lake. It will be moored at the fitting out area for remaining construction and testing of the main production equipment before being moved to a shallow anchorage for '*wet fitting*' of suspended equipment and then towed to its permanent moorings in the lake.

The GEF location is intended to be fixed, but in the unexpected event that it is required e.g. if lake bed conditions are found to be unsuitable for anchoring it is possible to move the GEF to an alternate mooring.

Equipment used during the construction of the MLS will include, but not be limited to the following: cranes, excavators, a back hoe mechanical digger, compaction equipment (likely to be a 2 tonne roller). Other equipment includes welding and cutting (including grinding) gear and general metal work, carpentry, masonry and electrical tools.

2.3.5. Construction (Offshore)

Limited construction will take place offshore: only fitting of the suspended components of the GEFs and deployment and attachment of the pipelines. This will all be achieved through use of a support/maintenance vessel.

At this stage only the location of GEF 1 for Phase I is fixed and the locations shown in Figure 3 are based on the best information that we have at the time of compiling of the ES. The final locations of the remaining GEFs will be based on additional lake bed surveys to determine the optimum depth and location for gas extraction.

2.4. Project alternatives

Project alternatives considered in the ES include the utilisation of methane in comparison with other energy sources and also in respect of the technology selected. The "do nothing" scenario is also considered.

2.4.1. Alternative energy sources

Rwanda's energy demand is characterised by low consumption of commercially generated energy with a severe and increasing shortage of capacity and high dependence upon firewood and charcoal. The energy market is also constrained by the low incomes and purchasing power of a large proportion of the population particularly in rural areas.

Other potential sources of energy include renewables, biomass and geothermal although there are constraints associated with each including:

- Limited wind potential.
- The high cost of solar power (in comparison with e.g. the use of methane).
- The possibility for hydro power is limited to small-scale generation in rural areas.
- The feasibility of geothermal power is being studied for the Cyangugu and Gisenyi areas and it is estimated that there is the potential for generation of 170-300MW. However, the timescale for this is some way off.
- The growing of biomass for power generation will compete with current high land use for agriculture and the effects of use of wood, charcoal and crop residues as used by 95% of the population at present has already resulted in loss of trees on hillsides leading to soil erosion and loss of arable land.
- Current use of power generated from diesel fuel oil is expensive in comparison with the use of lake methane.
- Use of heavy fuel oil (HFO) can generate emissions dependent upon the quality of the fuel and emissions control systems.

The KivuWatt project presents an opportunity for generation of 100MW of low cost electricity that compares favourably with generation from other sources.

2.4.2. Alternative technology

The main project design involves tapping the deep waters by a gaslift, improving the methane gas concentration by water washing under pressure, and piping the gas onshore where it fuels a Power Plant to generate electricity.

During the preliminary design of the gas extraction installations, different physical arrangements were taken into consideration:

- Offshore installation, with the gas scrubbers and gas – liquid separator located offshore, on a floating platform;
- Onshore installation with the gas scrubbers and gas – liquid separator located onshore, and;
- Semi-offshore installation with the gas scrubbers located onshore and the gas liquid separator located off-shore, on a floating platform.

The advantages and disadvantages of each were considered before making the final selection (Table 4).

Table 4 Design Options

Option	Advantage	Disadvantage
Off-shore extraction and treatment on GEF	Open choice of site on the lake. Maximum reduction in all piping. Number of extraction installations unlimited. Mobility of harnessing stations. Preservation of extraction columns due to the lack of friction on lake bottom. Less loss of capacity and less risk of blocking because of the vertical nature of the columns. Increased yield if the separator is located at depth.	Added investment for the design and manufacture of the GEF. Transport of workers and maintenance material by boat. Presence of a purified gas pipeline under the lake surface. In the scenario where the separator is on the GEF, (i.e. not at depth) then the yield will not be increased but will instead be equivalent to the onshore solution thereby nullifying any advantage of the offshore solution.
Extraction and treatment on-shore	Pressure equivalent to immersed solution. Ease of access for subsequent work. Ease of access for personnel No sunken cables.	Prohibitive cost of the trench protecting the entire installation. Scarcity of sites likely to comply with the requirement of such a solution. Low pressure in the separator a large amount of gas to be processed, proliferation of machinery/equipment. Energy cost of the extra maintenance. Taken together, these are serious inconveniences associated with an entirely onshore solution for the installation. Corrosion of the pipe to shore from the entrained H_2S. Lengthening of the harnessing and suppression columns Serious charge loss due to the profile of lake bed Scarcity of sites with sufficiently sloping sides

Semi-offshore	Preservation of extraction columns due to the lack of friction on the Lake's bottom. Less loss of capacity and less risk of blocking because of the vertical nature of the columns. Increased yield due to the separator being at depth.	Presence of an unrefined, potentially corrosive gas pipeline under the Lake's surface. Separation of the station into two distinct units resulting in the doubling of security, service and maintenance personnel. Large volumes of raw gas to compress and send ashore increasing capital and operating costs for additional compressive power. Choice of lake site dependent on where treatment plant could be established onshore. Note : in the event that the separator is on the GEF, the yield would be equivalent to the onshore solution and the main advantage of the offshore solution would be lost.

2.5. The "*do nothing*" scenario

The "*do nothing*" scenario is not an option in this case due to the need to reduce gas levels in the lake in order to avoid the hazardous consequences of a spontaneous future gas eruption with the possibility of a large number of fatalities. The conclusion of the Expert Committee in 2006 was:

'*The irrefutable conclusion by the Expert Committee is that from the point of view of risks, the environment and economics, the only viable action is to produce the methane gas in Lake Kivu and use it for power production. To do nothing is clearly unacceptable because of the risk, and to vent the lake instead of producing gas is worse from all points of view'*

Whilst this could be prevented by venting, as happens currently in Cameroon, there are environmental consequences associated with venting as both CO_2 and methane are greenhouse gases (GHG) and methane is a 21 times more potent GHG than CO_2.

While it is generally accepted that such a cataclysmic event could occur sometime in the next 100 years given the estimated build up of gas, it is also possible that unpredicted volcanic activity could mean that the cataclysmic event could happen much sooner than predicted (IFC/World Bank, 2009) and means that gas extraction should be considered sooner rather than later .

In addition to continued constraints on energy supply in the absence of the project, a number of benefits would also be foregone including:

- Major investment in Rwanda.
- Economic development, and in particular development in one of the poorest Provinces of Rwanda.
- Employment opportunities and skill development.
- Revenue generation.
- Business expansion.
- Extension of the rural electrification project.
- The opportunity to reduce pressure on woodlands.

2.6. Project sponsors & contractors

Information is provided on the project sponsor, ContourGlobal KivuWatt Ltd, and the contractors that are involved in the design, construction and management of the project in Appendix B.

3. Policy and legal review

Rwandan policy and legal requirements and international environmental agreements and standards and guidance such as those developed by the World Bank, IFC and OPIC that are relevant to the project are each discussed in turn.

Compliance with the legal requirements listed in sections 3.1 and 3.2 is mandatory. Compliance with the requirements of the standards listed in section 3.3 will be required by OPIC. Consequently the ESIA and the project will be designed to ensure compliance with all three sets of requirements.

3.1. Rwandan regulation

The Framework for environmental law in Rwanda is the Organic Law on Environmental Protection, Conservation & management (2005), supported by a series of statutory instruments and subsidiary legislation as follows:

- REMA General guidelines and procedures for EIA (2006).
- REMA Environmental Impact Assessment Regulations (2007).

Other relevant regulations include:

- The Bukavu Agreement (1975). This established the Société de Controlee de l'Exploitation du gaz Méthane du Lac Kivu (SOCIGAZ), a company owned jointly by the Governments of Rwanda and Congo for Lake Kivu Gas. This was further developed in 1998 for the determination of concessions to exploit Lake Kivu gas. The Concession Agreement and the means for each country to protect its resources are covered by this agreement.
- Labour Law (2001) covers health and safety at work and requires training of staff in safe working practices, provision of PPE where appropriate, safer working equipment and premises, reporting of occupational disease and/or accidents. Companies can offer health or medical care dependent upon the size of the company and there is a mandatory requirement to transfer cases that cannot be dealt with in site to the nearest medical centre.
- Buildings Control Regulations (2009) which specify conditions for construction and require prior approval of works.
- Organic law 08/2005 Determining the use and management of land in Rwanda (2005).
- Law 47 on the Organisation of Forestry (1988).
- Decree on easements in relation to the abstraction and use of underground and surface waters (1952).

- Order No 221/116 on bathing water quality which was established for the protection of lakes and rivers.
- Decree on the establishment of the Akagera and Volcanoes National Parks (1934)
- Order RUO 5520/97 which prohibits seine fishing in all lakes except Lake Kivu.
- Order No RUO 52/160 which regulates fishing and prohibits the use of nets with a mesh less than 4cm or to use nets more than 1 km in length. It also prohibits the laying of fixed nets less than 50m from shore.
- Order No 51/162 which prohibits the import, possession, cultivation, propagation, sale or transport of *Eichhornia crassipes* (water hyacinth).

Environmental conditions are also imposed on the project in the Concession Agreement and the Power Purchase Agreement. These apply to emissions, waste management, gas flaring, noise, EIA and permitting requirements and local sourcing of goods and services. These are summarised in Table 5 and are discussed in detail in the relevant section of the report.

There are no specific laws governing discharges to water emissions to air although a bill on the drainage code was developed in 1997 that provided conditions for the collection and drainage of rain water and the collection, disposal and/or treatment of solid waste. It does not appear that this was transposed into law and hence the reference to the application of World Bank standards in the concession agreement.

Table 5 Environmental conditions in agreements

Document	Condition
Concession Agreement	Mandatory guidelines entitled "Lake Kivu gas extraction: Basic principles, mandatory requirements and guidelines for the concessioning, design and operation of gas extraction plants" Version 10 dated February 18, 2008 as amended and in such form as may be issued from time to time, shall apply.
	Flaring shall not be permitted except under certain circumstances such as emergencies, trips, commissioning, maintenance, unplanned outages, start-up, during load variations and when considered necessary for safety.
	The generation license confers rights to use water from Lake Kivu, construct waterways and pipelines, erect buildings and plant and gas production facilities off-shore and erect or lay aerial lines or underground pipelines and cables.
	The project is required to meet environmental standards established by law in Rwanda and, where Rwandan regulations impose lower standards, with the standards of the World Bank EHS guidelines from the 1997 version of the Industrial Prevention and Abatement Handbook and with all recommendations included in the EIA.
	The project shall abide with Rwandan laws concerning labour, health and security and provide acceptable working conditions, living accommodation and access to medical care.
	The project is expected to use all reasonable endeavours to source goods and services locally.
	Technology transfer will be financed through setting up of a local maintenance workshop and provision of staff training
	Environmental benefits associated with the project relating to physical abatement of greenhouse gases including any right, interest, credit, entitlement, benefit, allowance, certificate or registrable right shall be shared 50/50.
Power purchase agreement	Environmental protection limits are set for exhaust gas emission, air quality and for noise. World Bank limits will apply.
	Liquid and solid wastes are required to be treated and/or removed to an authorised disposal site.
	Surface drainage should be designed to avoid erosion of light volcanic soils.
	The gas pipeline from the production area to the processing site will be designed to prevent damage and hazardous emissions to the marine environment.
	Visual changes to the landscape shall be minimised.

3.2. Regional & International agreements

Rwanda is signatory to a number of agreements that include requirements for environmental protection including:

- UN Convention on Climate Change (1992).
- The Basel Convention on Control of Transboundary Movement of Hazardous Wastes and their Disposal (signed 2004).
- The Convention on Biological Diversity (ratified 1996).

None of these conventions will impose any onerous obligations on the project. No transboundary movement of waste is proposed and there are no areas of special diversity that will be impacted by the project. See also section 5.2 for discussions of climate change.

3.3. International best practice & OPIC requirements

Standards customarily required by the financing institutions include those of the World Bank and International Finance Corporation (IFC) as defined in the Environment, Health & Safety (EHS) guidelines and in Operational Policies (OP).

The ESIA will be submitted to OPIC and is required to comply with the OPIC 2004 Environmental Handbook ("The Handbook"). Projects are screened and categorised (A-F) by OPIC depending upon the nature and scale of the project, the sensitivity of the site and the potential for significant effects. KivuWatt is a category A project due to the potential for a catastrophic release of toxic gas. Category A requirements have been followed in developing this assessment.

The Handbook defines the format and content of the report and the monitoring plan and also obliges compliance with host country laws and regulations as well as the appropriate IFC standards.

For this project the relevant IFC standards are:

- EHS Guidelines for thermal Power Plants (2008).
- General EHS Guidelines (2007).
- Performance Standards 1: Social and Environmental assessment and management systems (2007).
- Performance Standard 3: Pollution prevention and abatement (2007).
- Performance Standard 4: Community Health, Safety and Security (2007).
- Performance Standard 5: Land acquisition and involuntary resettlement (2007).

Advice and guidance has been sought from OPIC Environment Unit during the development of this Environmental Statement.

4. ESIA methodology

4.1. Assessment methodology & significance

The methodology developed and adopted for this assessment provides a tool for assessing and evaluating the significance of effects and is based on the following criteria:

- The type of effect (i.e. whether it is positive/acceptable, negative/unacceptable, neutral or uncertain);
- Duration and/or frequency of occurrence (short term/frequent, long term/long return period, intermittent);
- The policy importance or sensitivity of the resource under consideration in a geographical context (whether it is international, national, regional or local, as defined in Table 6).
- The magnitude of the effect in relation to the resource that has been evaluated, quantified if possible, or rated qualitatively as high, medium or low (Table 7).

Both professional judgement and the results of modelling analysis are used to assess the findings in relation to each of these criteria to give an assessment of significance for each effect. Effects are considered to be major, minor or negligible and can be negative or positive. Where positive impacts are identified mitigation is not required.

Table 6 Geographical context and policy importance

Geographical Context	Topic definition
International	Important at global, African or trans-boundary levels
National	Important in the context of Rwanda
Regional	Important in the context of Karongi
District	Important in the context of the Kibuye area.
Local	Important within the site and up to 1km from the site

Table 7 Magnitude Criteria

Magnitude of effect	Negative effects	Positive effects
High	▪ Widespread community concern. ▪ Failure to meet legal compliance requirements. ▪ Fatality or serious health disability. ▪ Severe or possibly irreversible damage to an important ecosystem or resource.	▪ Widespread community benefit. ▪ High contribution to safety or prevention of fatalities. ▪ High level of technology transfer. ▪ Prevents serious damage to an important ecosystem or resource.
Medium	▪ Local community opposition and levels of complaint. ▪ Regulatory concerns. ▪ Lost time injury or short term health effects. ▪ Medium term damage to an ecosystem or resource.	▪ Contributes to local development and economy. ▪ Provides confidence to regulators. ▪ Prevents medium term damage to an ecosystem or resource.
Low	▪ Minor community opposition or complaints. ▪ Able to comply with legal requirements. ▪ Local/minor health effects requiring short-term treatment. ▪ Short-term, minor damage to an ecosystem or resource.	▪ Low level of community support. ▪ Economic benefits not distributed locally.

As a guide a significance table has been developed whereby the combination of importance/ sensitivity and magnitude give the significance of the effect (Table 8).

Table 8 Evaluation of Significance of Effect

Sensitivity of Impact	Magnitude of Impact		
	Low	**Medium**	**High**
International	Minor / Major	Major	Major
National	Minor / Major	Major	Major
Regional	Minor / Major	Minor / Major	Major
District	Negligible / Minor	Minor / Major	Minor / Major
Local	Negligible	Minor	Minor / Major

Environmental, social and safety aspects are discussed in each of the following sections and a summary table of impacts and their significance, based on Table 8, is presented in section 12.

The sections are presented as follows to reflect the principal structure of the OPIC format:

- Physical environment which examines the context or setting of the site including climate, topography and the geology of the site together with natural hazards.
- The biological environment which presents the baseline for terrestrial and aquatic ecology and protected areas. (Note that although fisheries are part of the biological environment their significance in this instance is principally economic and are therefore addressed separately.
- Lake stability is part of both the physical and biological environments but is presented as a separate chapter due to the unique nature of Lake Kivu and its centrality to the EIA.
- The section on the human environment presents the social and economic context and baseline and assesses the potential positive and negative impacts of the project. Mitigation measures to address impacts are presented and residual impacts are identified.
- The section on environmental quality considers the baseline, potential impacts, mitigation measures and residual impacts in respect of air, noise, water, soil and waste management.
- Occupational and community health and safety and potential impacts arising from routine, accident and emergency situations are considered for on- and off-shore activities. Mitigation measures are identified where needed.

The significance of impacts will be addressed wherever applicable in these sections and appropriate monitoring and management actions are provided in the EMMP in Appendix A.

5. Physical Environment

5.1. Site setting

Lake Kivu is located in the Western Rift Valley and has a surface area of 2370 km^2 of which 52% is within the borders of Rwanda (Figure 1). The border with Congo runs through the centre of the lake from north east to south west. The ContourGlobal KivuWatt Ltd concession lies within the Rwanda boundaries. Lake Kivu is approximately 100 km in length and has a catchment area of 7000 km^2 receiving run off from a number of rivers.

Rwanda's altitude ranges from 1000m in the south-west of the country to 4500m in the area of the volcanoes in the north-west. There are three discrete relief ranges:

- The Congo Nile Ridge which rises above Lake Kivu.
- The Central Plateau and volcanoes.
- The Eastern Lowlands.

The relief results in two main watersheds, the Congo and Nile basins, either side of the Ridge. The Congo Basin catchment (which feeds into Lake Kivu) comprises 33% of the territory of Rwanda and 10% of the surface water. The principal rivers, the Nyabarongo and the Akanyaru, run into the Nile basin and are associated with the extensive marshes and numerous shallow lakes in the east of the country.

The project will be located in the Karongi District of the Western Province (reportedly one of the poorest provinces in the country) of Rwanda Figure 8). The nearest town is Kibuye which is located 2km north-east of the MLS and is the headquarters of Karongi District. Kibuye has eleven sectors including Bwishyura in which sector the project is located. Below sector level, areas are divided into cells and the project site is located in the Ruganda cell of Bwishyura sector.

The area around Kibuye is predominantly rural. The heavily indented shoreline of Lake Kivu is hilly with steep slopes (varying between 25 and 50%), rocky outcrops and good vegetation cover. Land north of Kibuye is characterised by intensive subsistence cultivation and little tree cover whereas that to the south, where the onshore facilities will be located, is East African bush and scrub and is sparsely populated. The physical terrain has led to ribbon development on even terrain along ridges, valleys and transport corridors.

The site itself is designated as an industrial zone in the Kibuye Master Plan (Figure 9). There are proposals to develop tourism around the shoreline and island of the lake. These proposals are discussed further in section 8.

5.2. Climate

Because of the high altitude the climate is characterised as sub-equatorial with temperatures between 19 and 22.5 degrees C in the Lake Kivu border region. Average rainfall is between 1100mm and 1200mm with a high degree of humidity around the Kibuye area. Generally there are two rainy seasons and two dry seasons as follows:

- December to February- short dry season
- February to May – long rainy season.
- June to September – long dry season.
- September to December – short rainy season.

Wind direction is predominantly from the northeast and average wind speed is 1.6 m/s, defined as light breeze. However, discussion with local fishermen identified two periods of weather activity, referred to as Umuzirahei and Umukondwe that typically occur annually. These produce strong easterly and westerly winds respectively.

5.2.1. Climate Change

Climate change is assessed from the perspective of the need to mitigate contributions to climate change (e.g. through preventing of greenhouse gas emissions generated by the use of fossil fuels) and/or to building in climate resilience to the project by incorporating adaptation measures so that the project can live with the effects of climate change (for example increased flooding due to higher rainfall).

In the following sections projections of climate change are summarised in respect of changes in temperature, precipitation and run-off (Figures 10 and 12) together with a comment of the confidence of the projections based on agreement between models and the views of the Intergovernmental Panel on Climate Change (IPCC).

5.2.1.1. Temperature

- All of Africa is very likely to warm during this century, with the warming very likely to be larger than the global annual mean warming throughout the African continent and in all

seasons (Figure 11). Rwanda has a smaller value for expected warming in both winter and summer compared to e.g. Northwest and South Africa by the end of the 21st century. (Figure 11).

- These projections are high confidence.

5.2.1.2. Precipitation

- Increases in rainfall are expected in Eastern Africa. By the end of the century, annual mean precipitation in Rwanda is expected to increase slightly (by 5-15%), with increases for Dec/Jan/Feb (DJF) expected at 10-15%, and increases for Jun/Jul/Aug (JJA) by 10-15% (See Figure 10). These increases in mean annual precipitation are robust across a wide range of climate models, with 17-18 out of 21 models indicating increases in annual rainfall for Rwanda. For DJF and JJA, increases in precipitation are also likely, with a majority of models projecting increases (Figure 10, bottom row).
- With high confidence, heavy rainfall events are expected to become significantly more frequent, increasing the risks of localised flooding. Projected increased intensity of rainfall over Rwanda is greater than almost anywhere else globally (Figure 12.
- Furthermore, Rwanda is projected to experience an increase in the number of dry days, leading to increased risk of fire.
- Overall, while annual average and seasonal average rainfall in Rwanda is projected to increase, more of the rainfall will occur in heavy downpours, with extended dry spells in between.

5.2.1.3. Runoff

- Despite the projected increased annual average rainfall, the annual average runoff in Rwanda is projected to decrease, due to the effects of higher temperatures causing increased evaporation and evapotranspiration. (i.e. the effects of rising temperatures on runoff more than counteract the effects of rising rainfall).
- Annual mean runoff is projected to decline by 5% to 10% by the 2030s, compared to the 1961 – 1990 baseline.

The project is a candidate for the Clean Development Mechanism (CDM) as Rwanda is a signatory to the Kyoto Protocol and the project can be said to contribute to reductions in future emissions of methane an extremely potent greenhouse gas. Reductions of emissions of greenhouse gases will be

brought about both by power generation using a clean fuel and the reduction of methane emitted to the atmosphere.

As regards the need for mitigation of the effects of climate change, risks to the project are considered to be low. Despite expectation of increased flooding in some areas of the country the Power Plant will be located on high ground and in any event Lake Kivu is of sufficient size to absorb increased rainfall without significant raising of Lake levels. Increases in dry periods or in temperature are not expected to impact on the operations.

5.3. Topography

The general area of the proposed site is in undulating terrain in the Rwandan lowlands on the eastern banks of Lake Kivu. The Power Plant site is at the northern tip of a hard rock peninsula 3km to the west of Kibuye and is relatively steep sided and elevated up to 68m above the level of the lake.

The area of the MLS is a relatively flat area of some 1 hectare in a low lying depression and was a former wetland that was degraded. This is in a fertile area, which has been cultivated by squatter farmers until very recently.

5.4. Geology

The Geology of Rwanda typically comprises alternating sandstones and shales of the Mesoproterozoic (part of the Pre-Cambrian era) Burundian Supergroup with occasional granitic intrusions. Neogene rift volcanics are common in north and south-western areas. Relatively recent alluvial and lacustrine sediments are associated with the rivers and lakes.

An extract of the geology map of Rwanda (Figure 13) shows that there are several rock types in the area. The peninsula of the Power Plant site comprises quartzites and metaquartzites, dominated by quartzite. Immediately to the east of the site is a small area of carbonate on which some of the nearest dwellings are located (near Ridge Top). In the area of the proposed MLS the geology appears to comprise alluvium over schists, micaschists and phyllonites.

During the site walkover, it was noted that the geology local to the site consists of highly deformed, potentially partially metamorphosed interbedded sandstones, siltstones and shales. At the Power Plant location, the sandstone and shale beds dip steeply to the east away from the lake and are split by a dolerite sill deposit of approximately 10 to 15 metres in thickness.

5.4.1. Geo-hazards

The Lake Kivu area suffers from earthquakes. Therefore seismicity must be considered when dealing primarily with onshore design. Global Seismic Hazard Map and an Africa-Europe Seismic Hazard map show clearly the overall seismic risk in the East Africa Rift System seems to be no higher than in Portugal, Spain, southeast France or southwest Germany. Seismic design criteria will be developed based on information from Rwanda.

There is also volcanic activity in the north of the country. There has in the past been lava inflow into the lake although this is not thought to have impacted on lake stability or safety. This is discussed further in Section 7, Lake Stability.

6. Biological Environment

6.1. Terrestrial ecology

Rwanda signed the International Convention on Biological Diversity in Rio de Janeiro on 10 June 1992 and ratified it on 18 March 1995. This act offered a formal framework that enabled the Government of Rwanda to confirm its commitment for the conservation of its biological diversity since the 1920s with the creation of national parks (Akagera National Park 1934, the Volcanoes National Park 1925) and forest reserves (the Nyungwe Forest Reserve 1933).

There are legal instruments for the legislation of some fields of biodiversity such as forests, aquatic areas; agro-biodiversity referring to agriculture, animal husbandry and fisheries, as well as protected areas. Some of the instruments are old, dating back to the 1930's colonial legacy, and many are unknown to the public or totally ignored

Rwanda has a very diverse and rich biodiversity. It lies at the headwaters of the River Congo and as such at the edge of the 'Zaire Basin', which is an area of high endemism and is part of the 'Equatorial Highlands'. The Zaire Basin and the Equatorial Highlands are listed and recognised as 'Centres of Endemism"; (Kingdom 1990) described these 'Centres' as "land locked islands within a greater Africa". The Albertine Rift is also recognised by Conservation International as part of the 'Eastern Afro-montane' Biodiversity Hotspot and states:

"*The Albertine Rift harbours more endemic mammals, birds, and amphibians than any other region in Africa*"

With respect to birds it is considered by 'Birdlife' to be part of the Albertine Rift Mountains Endemic Bird Area (EBA)[4] and defined thus:

"*BirdLife has mapped every bird species with a restricted range of less than 50,000 km^2, using many thousands of geo-referenced locality records. The areas where these ranges overlap define avian centres of endemism that are termed Endemic Bird Areas (EBAs) by BirdLife International. Many other animals and plants have evolved into unique species in these same areas of endemism. EBAs are also, therefore, excellent indicators of general biodiversity*"

The areas mentioned above extend to a number of countries in the region, including Rwanda and therefore only provide an indicator to the biodiversity contained within the region, generally in

[4] Birdlife International - http://www.birdlife.org/datazone/ebas/eba_programme.html

what remains of the original primary habitat i.e. deciduous or evergreen rainforest. In general the floral groups/habitats in Rwanda can be defined by an East-West divide, the eastern half of Rwanda supports evergreen Afro-montane vegetative ecosystems which can be further subdivided by altitude and moisture; whilst the western half of Rwanda is predominantly a mosaic of evergreen bushland and secondary grasslands with *Acacia* spp. Table 9 details vegetation types in Afro montane habitats.

Table 9 Afro-montane habitats by altitude and moisture

Altitude	Vegetation type	
(m)	Drier	Moister
Up to 1000	Savannah	Equatorial wet forest
1000 – 2000	Savannah, semi-deciduous forest , juniper scrub	Evergreen forest, *Pygeum* dominated forest
2000 – 3000	Savannah and montane forest edge – *Podocarpus, Cyathea, Ocotea, Aningeria*	Montane forest – *Podocarpus, Cyathea, Ocotea, Aningeria* Bamboo forest – *Arundinaria*
3000 – 4000	Sub alpine or Ericaceous zone – *Erica aborea*	Sub alpine or Ericaceous zone – *Erica aborea*
4000 plus	Alpine zone – *Lobelia, Carex, Senecio*	Alpine zone – *Lobelia, Carex, Senecio*

The sites for the terrestrial operations i.e. Power Plant and MLS are located at an altitude of approx 1500m. The site therefore lies within the centres of endemism, but the little vegetation present on site had been altered by human intervention to form an area of modified scrub and grassland and is therefore considered to be unlikely to have formed an important habitat for endemic or vulnerable species. The site has subsequently been completely cleared of vegetation.

Previous studies on this site were carried out in April 2009 and results and findings were presented in a report by GCS Consultants[5].

The vegetation surrounding the onshore development sites, and what was presumably present on site also, comprised secondary disturbed vegetation; acacia scrub and grassland. This vegetative assembly is probably as a result of the clearing of the primary forest for the purposes of agriculture.

[5] April 2009 "Impact Assessment for Gas Extraction and Electric Power Production in Karongi District – Kivu Watt Project" GCS Consultants

From on site observations it appears that the MLS was formerly an area of wetland. However this has long since been degraded having been drained and the land used for agriculture.

As with the flora, very little survey work has been carried out at the development site although it was noted by Green and Clean Solutions (GCS) *"There was no evidence of wildlife within and around the project site during the field visits"*. Common African birds including African pied wagtail (*Motacilla aguimp*) were noted during a site visit by SKM along with various birds of prey including a kestrel species and a forest eagle. We conclude that the GCS comment relates to there being no evidence of significant sensitive or protected species present at the site.

There are two endemic mammals in the area:

- **Congo clawless otter** – This otter has been recorded in Lake Kivu, predominantly around the offshore islands. It is thought by some parties to be just a sub-species of African clawless otter and by others as a full species due to its isolation from other representatives of its genus. The otter's preferred habitat is water surrounded by forest.
- **Ruwenzori otter shrew** – this is an endemic species related closely to the Mount Nimba otter shrew and the tenrecs of Madagascar. This species is nocturnal and highly specialised, hunting invertebrates in montane streams in the primary forest, so it is highly unlikely to be present on the site.

As both sites have been cleared there will be no future impacts on ecology through its development.

6.2. Aquatic Ecology

The lake originated by volcanic activity blocking the reaches of the Rutshuru River and Lake Kivu is in effect a drowned valley. The relatively catastrophic origin of the lake has had a great influence on the biodiversity and this is best exemplified by the fish. Unlike most of the Great Lakes the diversity as such is low. There are only 30 species of fish recorded of which five are introduced. It seems most species were eliminated in the original cataclysm and the present species are developed from the survivors. Nevertheless there is a high degree of endemism with many of the fifteen species of small, cichlid *Haplochromis* being endemic along with species of catfish and a barb. A further feature of the fish fauna is that it has clear similarities with that of Lake Edward and the Nile system and very little with Lake Tanganyika despite its current direct connection. In fact, only one species the small cyprinid, *Raiamas moorei***,** has made its way up the rapids and falls of the Ruzizi from Lake Tanganyika to Lake Kivu.

This type of diversity pattern is also to be seen amongst the planktonic and benthic animals and plants. The lake's ecosystem sustains a major economic activity, fisheries. These natural renewable resources are an important source of protein to the riparian populations and significantly contribute to regional food security.

Aquatic ecology is discussed further in the sections on lake stability (in the context of potential effects in the biozone) and fisheries.

6.3. Protected Areas

There are no protected areas within the site itself or in close proximity to the site with the exception of the 10m riparian exclusion zone along the shoreline of Lake Kivu. This zone is established in the Kibuye Town Planning Master Plan for the protection of the Lake and to allow access and walkways for tourism. As the project site is designated as industrial land (and also for site security reasons) the exclusion zone does not apply to the Power Plant site

The nearest designated site is the Nyungwe forest which is deemed a 'sensitive ecosystem'. It is in south Rwanda on the border with Burundi, and almost 20km from the site, sharing the lake shoreline further south. Nyungwe forest hosts one the largest populations of endemic species in all of Africa. Of the 86 mammal species present, 14 are endemic to the Albertine Rift. Nyungwe is home to 14 species of primates, and two hundred eighty avian species have been identified in the forest, with 26 Albertine Rift endemic species and 121 forest species. There are also 43 species of reptiles, eight of which are endemic. Thirty-one species of amphibians are present, with 15 endemic species. There are innumerable invertebrate species present, and Nyungwe forest is especially known for its abundant butterfly populations, which include 21 Albertine Rift endemic species. The floral community consists of over 1100 species, with 137 endemic species[6].

It is unlikely that this particular development will have an adverse effect on protected areas, although any further work to upgrade the infrastructure, should this be needed, may require a separate assessment to ascertain any impacts.

Wetlands (referred to as swamps in the regulation) are afforded some protection in the law on land use in that certain activities are restricted in these areas. These areas are predominantly Rwandan located in the eastern lowlands although localised pockets of wetlands exist elsewhere. The GIS

[6] Taken from - http://www.dutchmills.nl/rwanda-nyungwe-forest/Species_Present/species_present.html

shows a wetland area 1km north of the MLS however this no longer appears to exist and the GIS unit in Kigali reports that some of the wetland information on the database is no longer accurate.

No evidence was found of unique or sensitive habitats in proximity to the site.

7. The Lake

This section discusses the lake principally in respect of the imperative to ensure lake stability and to protect the biozone. Baseline conditions are presented and potential impacts if the project design were not to comply with the Mandatory Guidelines are assessed. The results of the hydrological modelling of the gas extraction and discharges are then presented to demonstrate that the requirements of the Mandatory Guidelines can be met through mitigation measures incorporated within the project design. Residual impacts are discussed and consideration is also given to cumulative impacts in respect of future exploitation of the gas resources.

Appropriate monitoring programmes to evaluate compliance are proposed in the EMMP.

It should be noted that the Concession Agreement includes legally binding requirements for the project to comply with. "The Lake Kivu Gas Extraction: Basic Principles, Mandatory Requirements, Guidelines for the Concessioning, Design and Operation of Gas Extraction Plants", Version 10 (February 2008), the "Mandatory Guidelines". The Mandatory Guidelines have since gone through a number of reviews and iterations culminating in "The Management Prescriptions for the Development of Lake Kivu Gas Resources" (June 2009) and hereinafter referred to as "The Prescriptions".

Whilst there are differences between these two documents, the project will comply with the requirements for protection of the lake stability of both.

The two documents are included in Appendix E.

7.1. Baseline

7.1.1. Overview

Lake Kivu has a range of very unusual features many of which relate to its origins and which require some understanding before any potential impacts can be properly assessed. The lake originated by relatively recent volcanic activity blocking off the upper reaches of the Rutshuru River which flowed northwards into Lake Edward and which was consequently originally part of the Upper Nile drainage system. Kivu is, in effect, a drowned valley which is 462m at deepest point. As the new lake filled from more local drainage from surrounding mountain ranges it finally spilled over the Lake Tanganyika watershed and now feeds into this catchment area via the Ruzizi River. Hence the overflow from Lake Kivu feeds into the northern basin of Lake Tanganyika and is, in fact, one of the most significant inflows into that lake.

The volcanic nature of the region has had further profound effects on the lake. The waters of Lake Kivu are stratified to an unusual degree with very little vertical mixing. All lakes tend to stratify, however, there is almost always a mechanism to force mixing. In relatively shallow lakes this could be wind shear that might only be powerful enough to cause full vertical mixing during particularly stormy weather – possibly seasonal. For deeper lakes it might be the creation of a warm buoyant surface layer in the summer which cools rapidly in the autumn/winter and descends through the lake to mix it up. Lake Kivu resists any such mechanism partly because of its depth and partly because carbonated water of volcanic origin vents into the lake creating a dense lower layer that is difficult for any conventional mixing mechanism to disturb.

Carbon dioxide molecules are much heavier than water molecules so the density of water is increased noticeably. The absence of vertical mixing within Lake Kivu renders the surface waters poor in nutrients because most of the inorganic nitrogen and phosphorus which would normally drive production remains locked away in the deeper, oxygen depleted, permanently stratified waters.

Only the upper reaches of the waters of the lake are oxygenated. Therefore the sediment at the lake bottom is suitable for anaerobic bacteria which generate methane, as well as carbon dioxide, as waste products of their normal metabolism. Thus the origin of the methane resource within Lake Kivu is thought to be mainly biological. Hydrogen sulphide is also produced as a result of both volcanic activity and the breakdown of sulphites in non-organic substances in the absence of oxygen. The methane and hydrogen sulphide are then trapped within the dense carbonated waters in the highly stable deeper parts of the lake.

The main density/conductivity discontinuity has recently been cited as occurring at 260m depth (Expert Committee 2008). The deeper water has one further unusual feature; the water is warm but still remains dense because of the dissolved salts. In all other lakes temperatures tend to be uniform below the thermocline. So the bottom temperature in Kivu can be as high, or even higher, than at the surface at 25-26ºC. This is almost certainly the result of the warm, saline intrusions from the lake bed.

7.1.2. Lake Structure

In order to understand lake structure and function it is necessary to examine the physical and chemical characteristics of the lake.

7.1.2.1. Physical

The structure of the lake is determined by a number of elements. The main elements are temperature, the concentration of dissolved salts (normally measured as electrical conductivity - µS), the concentration of dissolved gases, pressure and depth.

Lake Kivu is permanently stratified in its superficial layers due to the warming by the sun which causes a thermocline of lighter water floating on the deeper water. This thermocline is permanent and marked by a weak density gradient which lies between -60 m to -120 m with the centre of the gradient at about -85m. This represents the Biozone. In Lake Kivu both temperature and salinity increase markedly towards the bottom such that salinity/conductivity which is very high by Africa lake standards, increases from about 1000 µs to 4000 µs (around 15% sea water concentration) and temperature from 23ºC to 26ºC. This suggests vents of warm, saline water entering the bottom of the lake as a result of volcanic action. The salinity gradient downwards through the region below 100m is not uniform but marked by a succession of more or less discrete layers of increasing salinity and density.

The discontinuities in density are important since they do not only act as barriers to diffusion of solutes but also as stability layers resistant to turbulent mixing, a process of some importance in the present case.

There are at least four peaks of stability layers with most prominent between 60-120m, representing the thermocline and the bottom of the biozone, and an even more pronounced layer at 260m, mostly related to dissolved salts rather than temperature.

Figure 14 shows the relative density gradients in the lake; Figure 15 the vertical profiles of temperature, salinity and dissolved gas and Figure 16 the key water variables.

The major depth zones in the lake used for the project are shown in Table 10.

- **Table 10 Lake zones by depth (taken from Halbwachs)**

Layer (m)	Water (km^3)	Average density	CH_4 (km^3)	Concentration CH_4 (Cg/Cl)	Zone
0 – 60	142	998,352	0	0	Biozone
60 -190	212	999,435	11.5	0.055	Intermediate zone
190 - 260	81	1,000,175	10.5	0.13	Potential resource
260 - 310	47	1,001, 447	16.5	0.345	Upper resource layer
310 - 480	65.5	1,001,882	27	0.411	Lower resource layer
	548	999,789	65.7	0.117	

A number of surveys have been undertaken and the common view of stratification is based on 23 profiles obtained at different localities by Tietze in 1979. These profiles were, however, obtained in February during the dry season when the lake was most stable. There may be some seasonal shifts, particularly when the southern monsoon occurs from August to October with mixing processes are at their height and tilting or internal waves along the discontinuity layers is possible. Changes in surface water temperatures could cause local variation in the depth of the zones: for example the profile conducted by the project at the first GEF site showed the main stability layer at 250m not 260m and that between the upper and lower resource zone at 300-325m. However, these boundaries are both within the accepted range for the zones as documented by the Expert Committee (2008).

7.1.2.2. Chemical Characteristics

The complex stratification of the lake has a considerable effect on the distribution of chemical solutes and therefore upon the natural functioning, productivity and ecology of the lake. Any significant mixing or influence on water quality can therefore impact the natural function.

The layer above the centre of the thermocline at approximately 85m is the ‘biozone’. As the animals and plants in this surface layer die, in the normal cycle of events, they sink through the thermocline to the bottom of the lake and decay. As they decay, oxygen is used and carbon dioxide is produced but the thermocline above never breaks down and acts as a seal by preventing diffusion of gases so that the oxygen cannot be replaced nor the carbon dioxide discharged. Hence, oxygen has become stripped from all but the surface biozone and carbon dioxide has built up below the thermocline, adding to the magmatic carbon dioxide already in the lake.

Because the main deeper body of water is anoxic (i.e. without oxygen) the organic remains from the surface still rain down but cannot decompose aerobically as this requires oxygen. Therefore in

all but the surface layers the decomposition will be anaerobic and partial, like fermentation. The incompletely broken down organic material will continue to sink and accumulate mainly towards the bottom of the lake and its sediments. The implication of this is that if the water containing such organic material is brought to the surface oxygen will be used to complete the decomposition process. This deeper water, therefore, is not only anoxic it also has an oxygen deficit which means that the processes that would normally require oxygen, e.g. decomposition, cannot be fully completed in the absence of oxygen but the process will immediately move to completion once it does come into contact with oxygen. Therefore the oxygen depleted bottom water would have the capacity to strip the oxygen from the oxygenated surface waters as soon as they came into contact until all the organic material completes oxidation.

In addition, the phytoplankton of the surface waters need inorganic phosphate and nitrogen as essential nutrients to enable photosynthesis. As they die and sink the anaerobic decomposition (N_2) mineralises the components back to inorganic phosphorus and nitrogen. There is, therefore, a constant drain of the inorganic nutrients from the biozone to the deeper layers. A further effect of this is that whilst phosphate (PO_4) remains in the same form, the nitrogen, originally in its oxygenated form of nitrate (NO_3) in the anoxic conditions, is released in its reduced form of ammonium (NH_4). Nevertheless if the nutrient enriched water from below the thermocline is mixed with the nutrient depleted water of the biozone then plant production will be promoted. Beadle (1981) records a communication regarding the early work by the Belgians to set up the first gas extraction plant which states that the surface waters were enriched with plankton where the deeper nutrient rich water was brought to the surface.

Thus in Lake Kivu, Degens at el (1971) recorded NH_4 at the surface at a concentration of 18µM/l and 487µM and 7105 µ M/l at 100m and 440m depth respectively. Similarly the PO_4 concentrations were 0.8, 18.8, and 54.5µM/l at the same depths.

Carbon emerges in its anaerobic form CH_4, methane and it appears that an increasing proportion of the methane which is accumulating comes from this organic source, the remainder comes from the bacterial reduction of magmatic CO_2 stemming from volcanic interaction on the lake bed, but the relative importance of these two pathways of methane formation is difficult to determine (Expert Committee, 2008).

There have been suggestions that methane production within the sediments has recently increased possibly due partly to an increased riparian human population and their nutrient inputs or increased ecological use of resources via the introduction of the sardine or freshwater herring *Limnothrissa*

miodon (Schmid et al 2005). Whatever the reason methane is building up more quickly than previously suggested and therefore the need to extract gas becomes more pressing.

CO_2 concentrations are very high in the lowest zones, and one of the main risks of the lake is that there could be a large-scale escape of the gases due to a traumatic event or excess accumulation that could potentially be catastrophic.

The sediment layers themselves have a role in the distribution of material. It is here that the organic debris tends to accumulate and the sediment water interface is characterised by an iron/humic complex which can play a role in the absorption and release of ions. The sediment surface tends to be iron rich. Under anaerobic conditions released iron can form ferrous sulphide (FeS) when hydrogen sulphide is present.

In summary, carbon dioxide is mainly input from outside the lake and methane is mainly generated within the lake. The generation of methane may have increased in the last 29 years, and the loss of methane through upward diffusive and turbulent transport appears to have decreased. This is a very important conclusion since it has bearing not only on the potential for production of methane from the lake, but it also sends warnings about the future risk of a gas eruption from the lake if nothing is done to lower the gas content as advised by the Expert Committee.

7.1.2.3. Lake Function

In Lake Kivu the stability of the structure and mixing is a crucial process. Increased plankton densities in August to November (coinciding with the season of strong southerly winds) indicates a limited enrichment for layers below the thermocline. This turbulence is mainly confined to the top 60 – 70 m. The Expert Committee (2006) used the Wedderburn Number (W), an index of lake stability particularly in relation to wind disturbance, to examine the general impact of wind on the major discontinuity layers at 80m – 260m. They note that the wind pattern is similar to Lakes Tanganyika and Victoria where wind speed commonly exceeds 10m/sec and sometimes 20m/sec. In Kivu the limited data suggest wind speed of the southerly monsoon winds rarely exceed 10m/sec and the mixing probably goes down to 80m.

Calculating W for the upper discontinuity layer for wind speeds of 5, 10, 15 and 20 m/sec gave W values of 31, 8, 3.8 and 2 respectively, i.e. becoming less stable with increasing wind speed. At the two higher wind speeds the thermocline across the lake would tilt, thereby establishing internal waves which would enhance mixing across the discontinuity at base of the thermocline. It also means that nutrients up-welled above the thermocline would be rapidly mixed across the lake. Similarly, these wind speeds applied to the 260m discontinuity indicates W numbers of 740, 185,

82 and 46. Such high numbers suggest the deep discontinuity layer is exceptionally stable to wind forcing at the surface (Expert Committee 2006). The air quality section of this report presents the wind data currently available and notes that the prevailing wind is north-easterly at an average speed of 1.6m/s. This is lower than the lowest wind speed of 5 ny/s (nautical yards/second) used to calculate the Wedderburn number. If this data is correct it implies that the density gradients in the lake are possibly even more stable than predicted. There are some slow mixing processes in the deeper bodies of the lake. The warm saline water input from the bottom will displace ambient water causing a slow upwelling transport; this inflow will be offset by the outflow of the Ruzizi. It is thus an active process currently in equilibrium (Schmid et al 2000). The estimates of deep water residence time vary between 460 to 1000 years (Schmid et al 2005). Simulations conducted by Schmid et al (2005) further suggested that the water beneath the 260m discontinuity is more strongly decoupled from the processes in the upper part of the lake than previous estimates suggested. This discontinuity layer is, on this estimate, an even more-tight fitting lid on the gas rich water below than previously thought. Nevertheless there is a continuous upwelling of solutes, including methane, up to the surface albeit very slowly.

7.2. Impacts

Section 7.1 looked at those aspects of the Lake which affect or are determined by, the stability of the lake. Here the project and its operation are described in relation to the impacts it may have on lake stability if the design did not comply with the Mandatory Guidelines during the different Phases of the project cycle. (For mitigation measures to address these risks please see sections 7.3 and 7.4). To assess the potential impacts upon the lake and its uses it is necessary also to understand the intention and working of the project in question and to understand what the risks are should the project not advance i.e. *'the do nothing scenario'*.

7.2.1. The Ultimate Stability Event

With the relative confinement of the gases methane and CO_2 below the lower discontinuity the general concern is that eventually the solution of methane becomes supersaturated and would come to be released as bubbles on large scale across the lake. In doing so CO_2 would also be stripped into the bubbles and would contribute the greater volume to the released gas. Once the conditions have built up, this can happen very quickly and result in a physical-chemical rupturing of the stability layers of the lake. Such catastrophic events have been recorded at Lake Manoun in 1984 and Lake Nyos in 1986. Both are volcanic crater lakes in Cameroon. In Lake Nyos the initial eruption in a localised layer broke down other layers which allowed more gas bearing layers to become involved as the density structure was destabilised. Large volumes of gas were released but, in the aftermath

one of the most obvious effects in the lake of the breakdown in structure was the bright ochre colour of the surface water. This was caused by the ejection of bottom water with its high reduced iron content being oxidised to an iron-hydroxide floc. Below 10m depth the water was clear since this water was now anoxic and the iron hydroxide was again reduced. The deeper waters have other properties that need to be taken into account when assessing the potential impacts of raising it in large volumes.

Such potential catastrophic events have been predicted for Lake Kivu. In the Cameroon lakes, where considerable volumes of CO_2 still remained, the problem was solved by venting the water and CO_2 up a vertical pipe acting as a siphon so that the resulting plume of spray into the air would allow the CO_2 to escape. However, it has been decided that in Kivu this is not an option since methane is both flammable and toxic and the volumes would be much higher than in Cameroon (Expert Working Group 2008). Methane and CO_2 are also significant gases implicated in causing climate change so release of large volumes would be unacceptable.

7.2.2. The 'Do-Nothing' Scenario

Clearly there are risks associated with exploiting the gases in the lake and these are further discussed below. However, these risks need to be set into context of the risks associated with the 'do-nothing' scenario. The Expert Committee (2006) set out the possible effects in three size (or effect) categories, these were:

- The moderate, local eruption of the order of magnitude of 100 to 10 000 cubic metres of gas released, potentially affecting persons on the lake or nearest shore and leading to deaths by asphyxiation. The nature of this moderate type of eruption is that some external force causes an eruption to start, but the stability forces in the lake bring the localised eruption under control and stop it from progressing.
- The large eruption of the order of magnitude of 1 cubic kilometre of gas released, potentially influencing all inhabitants in the valley of Lake Kivu in the downwind direction and again leading to fatalities.
- The catastrophic eruption, emptying much of the gas from the lake. A trigger such as a large lava inflow into the lake causes the eruption to start, and it then self-progresses until the waters in the lake have mixed substantially and much of the dissolved gases have escaped. Such an eruption has the potential for killing the entire population in the Kivu region as well as a significant fraction of the inhabitants around northern Lake Tanganyika.

The Expert Committee further evaluated the risks associated with each level of eruption and concluded that the natural build up of methane gas will trigger a catastrophic event which could occur within the next 50-200 years and concluded that the only viable solution is to extract and utilise the methane.

Therefore from this perspective alone the project represents a major positive benefit through the reduction of the risk associated with the catastrophic event and the 'do nothing' scenario is not an option.

7.2.3. Construction Phase Impacts

The majority of the construction works will be completed on land or at the marine terminal and will therefore have no impact on the lake stability.

However, the completed GEFs will be towed into position in the lake and secured by anchors to the lake bed at a depth of 365m for the first GEF, and possibly in deeper water for subsequent GEFs. Each of the four GEFs will be secured by four anchors which will be concrete blocks and which are currently undergoing the final design. The anchors will be set at a depth of 365m or deeper depending upon the actual lake bottom profile and may then sink another 60-100m into the ooze. The current design is one anchor per mooring point with an option being considered to add a second anchor per mooring point; thus there may be four to eight anchors for each GEF depending upon the final design. Mooring arrangement will be with chain at the anchor and synthetic rope towards the GEF and finally a chain from just below the surface to the GEF. Synthetic rope will be kept sub-surface to avoid ultra-violet degradation. Bottom testing is planned using drop weights with a weight in proportion to the actual weight and dimensions of the design to gather data on the degree to which the actual weights will sink into the ooze. This will not determine lake bottom but will indicate depth of ooze and rate of sinking through the ooze and therefore the expected rate of sinking. Furthermore, data from the existing Kivu Pilot 1 (KP1) project will be examined. The KP1 structure has been permanently moored, although in shallower water, for over 12 months and should provide some additional information to inform the final design and placement. All testing as well as the placement of the anchors will be done under very strict and controlled conditions with procedures developed to govern the test anchors and permanent anchoring system.

Anchors will be in place 3 to 6 months before the GEF is in place to allow adequate settling time. The GEF position will be monitored by GPS with alarms when GEF moves out of a predetermined radius. This radius will be calculated to avoid risk of damage to shore pipeline and separator risers. In the event of an alarm the cause of the movement will be investigated and moorings adjusted to relocate the GEF as, or if, necessary. To cover the event of a mooring failure an Emergency

Response Plan (ERP) will be developed that will result in process shutdown and minimisation of any safety or environmental risk. Normal operation procedure will be developed to verify the GEF position and will be regularly checked and to visually inspect onboard chain locks.

The Expert Committee noted that the category of moderate, local eruption can be triggered by accidents caused by the gas extraction project. However, it is difficult to predict exactly what size of initial disturbance or trigger will lead to what eventual size of gas release because there are gradients of force and energy involved for several different triggers. The Committee cite the following as an example of a relatively low-energy trigger:

- Accidentally dropping an anchor or other heavy objects into the bottom sediment which could produce a localized gas release.

The evaluation of risk depends on the concentration of gases, the stability of the lake, and the energy input from a triggering event. Much depends on the nature of the lake bed in the vicinity of the anchors and the method of attachment/placement and so a localized gas release is perfectly possible, although the extent and magnitude of such an impact cannot be properly assessed given that there is no geotechnical information at the present time.

Therefore because the level of uncertainty concerning the possible impact is high, the impact is potentially significant if the design does not comply with the mandatory guidelines.

7.2.4. Operational Phase

The operation of the project can be divided into two components in relation to impacts, the raising/re-injection system and the wash water system using surface water to 'scrub' the methane gas of H_2S and CO_2. In this respect the level of the intake and outlet pipes in relation to the stratification layers is clearly important. There are two types of issues with each circuit, those related to the volume of the water used and those related to the chemical composition of the water. In addition there are two types of risk, those to the wider environment and those to the project.

7.2.4.1. The Raising /re-injection System

7.2.4.1.1. Stability and structure

Water has been raised from Lake Kivu for gas extraction before, as in the small production unit constructed by Union Chimique Belge (UCB) in Lake Kivu and used to power a brewery for 30

years, and the pilot plant KPI. However, two things distinguish the Kivu Watt project, firstly the sheer volume of water involved and secondly the concept of deep water re-injection and balanced densities to comply with the Guidelines.

The volume of water to be raised and then re-injected is substantial. The specifications for each of four GEFs ultimately to be commissioned is to raise 795,000 m^3/day which is equivalent to some 286.2 million m^3 per year. Compared with the 5 million m^3 raised annually by the UCB installation. In fact, bearing in mind that the total volume of the whole lake-wide lower production layer (310m-480m depth) in 65.5km^3, this represents 0.4% of this total volume per year. For the four GEFs it would amount to 1.2km^3/year, i.e. 2.5% of its total volume of the layer. With movements of such volumes of water it is difficult to envisage the extent to which eddies or turbulence develop which might undermine the laminar flow concept required by the Mandatory Guidelines. There are also the possibilities of turbulent interaction between the intake and outlet, including short circuiting, although the Expert Working Group (2006) do consider this unlikely.

If there are greater irregularities in this extraction and injection system than predicted, a number of effects may be produced. Since the water is planned to be extracted from the lower production layer (310m – 480m), under smooth operation the upper zone (260m – 310m) should expand into lower depths whilst the lower zone shrinks. If there is turbulence and other disturbances, weak density layers may break down with the possibility of there being a breakdown in the discontinuity between the upper and lower production layers. Mixing would lead to a mixing of the methane and CO_2 concentration between the two production zones and an overall dilution of the current concentration in the lower zone to one intermediate between these currently found.

It should be noted that the hydrodynamic model (see 7.3) demonstrates that the requirements of the Mandatory Guidelines for laminar flow and preservation of the density layers will be met.

If disturbance from the intake pipe near the bed of the lake occurred it could stir up the bottom sediments which would have physical and chemical consequences. Physically sediment could be sucked into the intake and interfere with the extraction process then re-injected at a layer just below the main discontinuity. Chemically, the delicate surface system of the sediment/water interface could be broken down with release of iron and other metals in particular. Iron in this depth will also exist as iron sulphide. There is also the possibility of trapped pockets of CO_2 being disturbed. However, plant design is such that water is drawn into the riser horizontally at a rate to prevent turbulent flow and there will be sufficient depth of water between the bottom of the riser and the lake bed to prevent sediment being stirred up and drawn into the intake.

According to the Expert Committee (2006), in terms of the potential triggers of a destabilisation event, the main danger from an extraction plant is a ruptured gas extraction pipe below a gas extraction platform. A fracture in the pipe above the bubble formation point (which is approximately -180m), or "two-Phase flow", behaves in the same way as if the gas pressures had reached saturation. This implies that if a ruptured pipe is left undisturbed, gas venting will continue until in theory a large part of the lake has been emptied of its gas content. However, in reality the venting happens at a much slower rate because it is limited by the transportation capacity of the pipe. Moreover, the safety systems proposed for the project include provision for the upper section of the riser pipe to be double walled with leak detection systems that will allow the gas supply pipeline to be closed upon detection of a leak thus limiting the release of gas to the residual amount left in the pipeline (see Hazard & Operability Study discussed in section 11.3.2.1).

The pipeline will hold approximately 171.8m^3 of gas at any one time, so if a pipeline rupture causes complete evacuation of all the gas a maximum of 171.8m^3 of methane will vent into the atmosphere. To put this into context the cataclysmic event (e.g. all the gas escaping from the lake) would result in 200-300 km^3 of gas being vented (i.e. 1 million times greater the volume of the gas emitted from a ruptured pipeline). In section 7.2.2 the moderate, local eruption is described in the order of magnitude of 100 to 10,000 m^3 of gas released, potentially affecting persons on the lake or nearest shore and leading to fatalities. The nature of this moderate type of eruption is that some external force causes an eruption to start, but the stability forces in the lake bring the localised eruption under control and stop it from progressing. Clearly the consequences of such an event would represent a major impact. In order to prevent such events, leak detection and cut-off systems will be installed (see also the HAZOP in section 11.3.2.1). However, below a depth of -180m the gases are still in solution and there would be no risk of escaping gases. The volume of water that could escape will be insufficient to disturb the density layer provided that the system is switched off as soon as any leak is detected.

Thus the conclusion must be that, without the mitigation measures stipulated by the Expert Committee, and which have been addressed through the project design, the project would add to the risk of an eruption that will impact people nearby (or downwind) on the lake and on the closest shore. The potential widespread nature of the effects means that the unmitigated impact is major. Mitigation measures which have been incorporated into the project design to avoid gas release and minimise the risk of explosion are addressed in section 7.3.

7.2.4.2. Water Quality

The raised water, compared to surface water, will be warmer, anoxic, saline, rich in methane, H_2S, and CO_2, have a lower pH and be rich in iron, ammonia and phosphate as well as other inorganic compounds; in addition to being anoxic it carries a large oxygen debt. The composition, and also bearing in mind the volumes involved, is potentially catastrophic for the living ecosystem of the biozone. Measures have been taken to prevent leakages particularly bearing in mind the corrosive nature of the water to the engineering components. (The HAZOP presented in 11.3.2.1 includes measures to prevent/detect and shut down leakages and also to protect equipment from corrosion). In addition, if large volumes escape the water is very dense and will sink rapidly thereby producing a wider mixing and destabilisation of the continuity layers.

Although the density of the re-injected water may have been matched following the removal of methane so that it is re-injected at the same density, its chemical composition will be different. For example, the case of NH_4, at 280m extraction point the concentration is 2722µM whilst at 340m (re-injection) it is 4001µM (Schmid et al 2005).

The Wash Water System

The raised gas rich water having the following percentages to the total mass of the raw water in the riser; C02 0.1825%, CH_4 0.0293%, N 0.00130%, H_2S 0.00083% will be put through a gas separator below the GEF. The gas steam removed in the separator will be $C0_2$ 69.36686%, CH_4 28.1163%, N 1.29371%, Water (H_20) 1.08623%, H_2S 0.13177%. This gas mixture will then be compressed and passed through the wash tower in the GEF where it will be mixed with water extracted from 20m down from the biozone. This washing water will differentially dissolve CO_2 and H_2S thereby leaving a purer methane product with composition of approximately 90% CH_4, 2.75% $C0_2$ and 6.9% N_2.

The wash water will then be returned to a deeper layer in the biozone at around 60m. The volume of wash water required will be around 53,000 litres/min or 76,320 m^3/day. Volumes are therefore much less than the amount of gas rich water raised.

Dissolved CO_2 and H_2S are not inert in water. Under aerobic conditions H_2S dissolves to produce sulphurous acid ($H_2S\ O_3$), some of which will be further oxidised to sulphuric acid ($H_2S\ O_4$). In a similar function, CO_2 dissolves to form carbonic acid, H_2CO_3. The role of CO_2 and H_2CO_3 in water at pH>8, however, is in quite complex equilibrium:

- $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H{+}{+} HCO_3 \leftrightarrow 2H+ + CO_3$

The base reserves of the water, mainly bicarbonate (HCO_3) and carbonate (CO_3), are in equilibrium with the CO_2 and H_2CO_3. As CO_2 dissolves the equilibrium shifts to the right with the consequent production of more hydrogen ions (H+). This causes the water to become more acidic and the pH to fall. Conversely when CO_2 is used in photosynthesis the equilibrium moves to the left and hydrogen ions re-associated with a consequent increase in pH. This equilibrium is the basis of the buffering capacity of the water, i.e. its resistance to change in pH and acidity and is also the main carbon supply

for photosynthesis. The existing pH of the surface waters is highly alkaline at 8.7 – 9.1 and the bicarbonate and carbonate reserves, the 'alkalinity', are also high (Schmid 2005). The waters of Lake Kivu are, therefore, quite well buffered (i.e. can resist acidification) but the addition of large quantities of CO_2 and H_2S with their capacity for acidification will still have an effect. The extent of this effect will depend upon the availability of oxygen, rapidity of dilution/mixing and the final volume of gas in the wash water.

A reduction of the pH will not be life threatening for most animals in the pelagic zone but phytoplankton communities do change composition with the pH of the water. More alkaline conditions tend to favour blue/green algae whilst, neutral conditions favour diatoms and more acidic conditions, green algae. The significance of this is that this may cause a shift in zooplankton composition which, in turn, may affect the diet of plankton eating fish, such as *Limnothrissa.* Potential major changes to the pelagic community could, therefore, result.

Some of the H_2S may remain as the dissolved gas, particularly in the locality of the discharge. In this form it is toxic to most life. In other lakes with H_2S rich water sudden mixing is linked to fish-kills. Although this effect has not been reported in Kivu, it remains a risk. A feature which will tend to maximise the H_2S remaining in its reduced form in solution is that it is being returned at 60m where the profile (Schmid 2005) shows there is already minimal oxygen in the water compared to at 20m, in effect there may not be enough oxygen to convert all the H_2S to sulphurous acid. There is also abundant evidence that mixing of the lake water does take place down to 80m. It is a question of whether the oxidation of H_2S can keep pace with the rate of mixing.

This mixing process down to 80m also means that this wash water composition is quite similar to the composition at which it is re-injected at 60m. For example, chloride concentrations are 0.5µM at the surface and 0.54µM at 60m whilst the equivalent values for phosphate are 0.37µM at both depths (Schmid et al 2005). Thus the impact of these nutrients, at least, will be negligible.

One factor which may be different between the wash water and the lake water is temperature. The raised water is warmer than the surface water and more heat could be gained from the extraction process. If the temperature of the re-injected wash-water is a little higher than the ambient water then it will be lighter and tend to move upwards, thereby promoting mixing which will tend to speed up dispersion but will also diffuse into zones occupied by fish. The general mixing of the lake over the seasons will mean that whatever the depth on reinjection into the biozone, mixing will occur throughout and re-injected water will eventually mix with the upper fish regions. As it is, the fish in the centre of the lake are commonly distributed down to 40m and will occur at 60m.

The Mandatory Guidelines are, understandably, focussed on lake stability issues rather than biological issues. Without the mitigation measures proposed in the Mandatory Guidelines and which have been adopted through the project design, the potential **unmitigated** impact of the washwater on lake stability could be major. Compliance with the Mandatory Guidelines is discussed in more detail in section 7.3.

7.2.5. Decommissioning

ContourGlobal KivuWatt Ltd will operate the plant for 25 years and the plant will be handed over to the GoR. At the end of the life of the plant GoR will be responsible for decommissioning. The Expert Committee recommends that venting should follow extraction. Whenever the economically extractable quantities of gas have been all removed from the lake, the platforms should be used to vent the last parts of the gas from the bottom of the lake.

It is suggested, that any production platform located in the deepest parts of the lake should be made in such a way that at the end of its production life, it may be converted into a venting system functioning by auto-siphoning like in the lakes Nyos and Manoun, but in such a way that water degassed after venting still will be returned to the lake below the biozone.

Table 11 summarises the significance of impacts on the lake stability.

- **Table 11 Summary of significance of potential impacts on Lake stability without design mitigation measures**

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Anchorage system and accidental release of plant	Major	Minor	Minor	√
Raw water riser	Negligible	Major	Minor	√
Re-injection water	Negligible	Major	Minor	√
Ruptured production pipes	Negligible	Major	Minor	√
Sediment contamination	Negligible	Minor	Negligible	√
Wash water extraction	Negligible	Minor	Negligible	√
Wash water return	Negligible	Major	Negligible	√

7.3. The Hydrodynamic Model

7.3.1.1. Background

In order to address regarding the effects of the abstraction and re-injection of large volumes of water on lake stability and of the wash water on the biozone EXPONENT was commissioned to construct a three dimensional (3D) modelling study which has clarified the probable outcomes and confirmed mitigation measures incorporated into the design.

The behaviour of the re-injection water and the wash water has been modelled and this has significantly reduced the level of uncertainty and provided clarity on the behaviour of the plumes. The model included four separate studies intended to provide better information:

Study 1: **Dispersion behaviour of the degassed water on re-injection to the deeper water layers**:

- prediction of the distance from the discharge point where sufficient mixing of the degassed water with the ambient water has occurred and to predict the depth of water at which it can be established that the degassed water has re-stratified.
- confirm that the volume and rate of degassed water discharge will not endanger the integrity of the of the main density gradient (250 to 270 m).
- confirm that the degassed water discharge plume will not penetrate the 200-320 m density gradient and flow into the raw water riser at 350-360 m.

Study 2: **Extraction**

- To confirm that the fully gassed water from the lower resource zone will continuously flow to the inlet of the raw water riser, and to predict how long such continuous flow of fully gassed water from beneath the 320 m density gradient down to the raw water intake at 350-360 m will enable the plant to operate at 100 percent capacity.

Study 3: **Wash Water Pressure Guidelines**

- Determine the physical dimensions (distance and depth) and pattern of the wash water discharge plume to ensure the quantity of gas venting from the wash water discharge at 60 m water depth in the biozone is below hazardous gas concentrations, ensuring that the design meets the environmental, health and safety requirements.

Study 4: Composition and temperature of wash water

- To predict the chemical composition and temperature of the injected washing water to provide input to the environmental assessment of the biological impact of wash water in the biozone.

All predictions concerning the lake stability to date, and by extension the formulation of the Mandatory Guidelines and The Prescriptions have been informed by a combination of expert opinion and reference to a one dimensional model. One dimensional models (1D) can only provide a starting point for predictions when working in a complex multi-dimensional structure such as a deep, highly stratified lake. The use of a 3D model, as here, allows a significant level of refinement over1D model predictions as it can take into account the lake profile and can separate the different density layers within the model. Therefore the results of the 3D model will be more accurate than predictions hitherto.

The model is time based and was run until steady state conditions were encountered; that is, until there were no further changes in the behaviour of the plume. This means that the Figures presented in the remaining sections of this report represent the 'final' state or the state after which no further

changes will occur. It is also relevant to note that there are no deep water currents or circulation that could assist in the spread of the plume at depth.

7.3.2. The Model Setup

The Expert Working Group identified Computational Fluid Dynamics (CFD) modelling as the way to obtain more accurate predictions of the effect of methane extraction plants on the lake stability. The model used was Star-CCM+ (version 4.04) which is a widely used commercial CFD model used for a variety of applications. Full details of the model and the results are presented in Appendix D.

The model was set up using all the available physical and chemical data for the lake published in various reports and papers (Tietze, 1978 & 1981; Halbwachs, et.al. 2002; Schmid et.al., 2004; EWG, 2008). Information from these reports concerning the physical and chemical nature of these is presented in the preceding sections. The technical specifications and calculation of mesh sizes and computational domain are presented in Appendix D.

In order to determine whether the model set up properly reflected the actual conditions encountered in the lake EXPONENT compared the density profile within the computational domain with the EWG-provided density profile. The maximum difference in the -280 to -323m depth range is approximately 0.04 kg/m^3, or 0.004%. This shows that the model was effectively reproducing the known density structure in the lake and this increases the validity of the resulting model queries. Similarly EXPONENT compared the density profile generated from the model for the biozone with the EWG provided density profile. Again the results show that the model is predicting the actual profile of the lake with a high degree of accuracy with the maximum difference in the -30 to -90m depth range of approximately 0.011 kg/m^3, or 0.001%.

The process information fed into the model related to the volume and chemical composition of the raw and degassed water and the wash water. In addition, to quantify the discharge turbulence, a CFD simulation of the degassed water diffuser was performed. The simulation revealed a non-uniform discharge jet velocity profile. The original diffuser design was improved by placing a 45º conical section between the vertical riser tube and horizontal diffuser plate as shown in Figure 17.

The model is based on a single gas extraction GEF but the results can be used to predict the likely cumulative effect of Phase 2.

7.3.2.1. Model Results – Study 1: The Behaviour of the Degassed Water Plume

Figure 18 shows the location of the degassed plume in 3 dimensions in relation to both the raw water riser and the degassed water diffusers. Figure 19 shows the streamlines for the degassed water discharge plume and the deepwater intake flow. The results are discussed in full in Appendix D but in summary the key points are:

- The discharge plume exits the diffusers with horizontal momentum and a density greater than the surrounding water. Neutral buoyancy for the plume is approximately 10m below the discharge depth. The plume flows down until it encounters heavier waters and then spreads horizontally.
- A maximum plume dilution of 95% was selected as the point where sufficient mixing with the ambient water has occurred and the plume is no longer distinguishable. The 95% dilution showed a horizontal spread of 165 m and a vertical penetration of 42.3 m below the discharge point.
- The degassed water remains well above the deepwater intakes and the bottom surface of the plume shows no tendency to be drawn down towards the deep water intakes. Thus there is no possibility of short circuiting.
- The streamlines show that the discharge plume reaches equilibrium in the upper resource zone at a depth of approximately -310m and so will not penetrate the density gradient.
- Even though some deformation of the density gradient is observed as a result of the deepwater intake and degassed water discharge flows, no clear indication of instabilities has been observed in the region surrounding the diffusers and intakes.

7.3.2.2. Model Results – Study 2: Extraction

Figure 19 also shows that the degassed water discharge plume will not induce circulation between the intake at -350 -360m and the degassed water plume. Therefore the model does not predict any dilution of the Lower Resource Zone by the degassed water discharge. The intake risers will withdraw water from the Lower Resource Zone at a rate of 9.2m^3/s (0.29km^3/yr). This is a small percentage of the total volume of the Lake below the density gradient at -320m, which is 62.26km^3. The withdrawal is offset by the inflow from thermal springs that enter the lake below the level of the density gradient which is estimated to be 4.55 m^3/s. The net extraction per year, based on a single gas GEF, is therefore is 0.24% of the total available volume.

The streamlines in Figure 19 also clearly demonstrates that laminar flow into the raw water riser is achieved.

7.3.2.3. Model Results – Study 3: Wash Water Pressure Gradient

The wash water discharge plume exits the pipe at -60m with horizontal momentum and neutral buoyancy. Again the maximum plume dilution of 95% was selected as the point where sufficient mixing with ambient water had occurred and the plume was no longer distinguishable. Based on this criterion the wash water discharge plume was calculated to spread horizontally a maximum distance of 67.5m from the discharge pipe and vertically 6.4m below the pipe.

Figure 20 shows that the partial pressure of the dissolved gases is significantly lower than the saturation pressure. Therefore there is no risk of effervescence of the dissolved gases (CO_2 and H_2S) from the wash water plume suggesting that they will remain in solution as acids.

7.3.2.4. Model Results – Study 4: Wash Water Temperature and Chemical Composition

Figures 21 and 22 show water temperature and carbon dioxide on a vertical plane through the wash water discharge pipe. Hydrogen sulphide was not included in the model, because it is assumed to be oxidised to sulphurous acid in the partially aerated waters of the lower biozone. The model results show that the discharge has a minor impact on temperature and CO_2 around the immediate vicinity of the discharge pipe but that the impact cannot be detected horizontally beyond 67.5m from the pipe.

The results of these studies have provided valuable information confirming that the mitigation measures are largely sufficient to prevent major impacts and this is discussed below in relation to the major issues outlined in section 7.2. Although the fate of H_2S in the lower biozone has not been fully resolved, the model results suggest that any impact would be localised within the vicinity of the discharge pipe.

7.4. Mitigation

7.4.1. Construction Phase

In order to comply with the Mandatory Guidelines (V10) guideline G8 requires that safety precautions should be taken during the construction (and operation) to cater for the risk of rising bubbles from the sediments on the lake bottom in case of:

- Anything heavy such as an extraction pipe being dropped to the bottom.
- Placing of anchors for floating facilities.
- Underwater sediment slides or similar causes of spontaneous release of gas bubbles.

Therefore, key to minimising the risk is a greater understanding of the sea bed in the immediate vicinity of the anchor locations. It is planned to set the anchors in place as soon as possible and allow them to settle prior to the physical mooring of the GEF to avoid bottom disturbance and water withdrawing occurring at the same time. This will reduce the possibility of a localised gas release leading to a moderate local eruption. Prior to the bottom testing for ooze (as mentioned in section 7.2.3), the lake bed in the vicinity of the proposed anchor points will be surveyed to determine whether there are any sensitive areas on the seabed e.g. CO_2 vents, which could result in localised eruptions if disturbed by the anchors. Clearly these areas will be avoided and the GEF mooring points moved as necessary. Only the location of the Phase 1 gas-GEF is fixed, but the locations of the 3 other GEF GEFs have yet to be finalised.

With these measures in place the risk of disturbance of the lake bed will be reduced to negligible.

7.4.2. Operational Phase

7.4.2.1. Lake stability

Some of the potential impacts of the project on lake structure and therefore stability could be major, principally due to the large volumes of water involved. The requirements of the Mandatory Guidelines relevant to the identified impacts, together with the design features which address them, and supported by the modelling results are discussed below. It should be appreciated that the assumptions made by the Expert Committee have been incorporated into this assessment to ensure that the design of the plant conforms to the Mandatory Guidelines.

The guidelines include Mandatory Technical Requirements (MTR), Mandatory Administrative Requirements (MAR) and Guidelines (G). Those relevant to the project, i.e. those with a safety, lake stability or environmental component are discussed below:

MTR1: Water Extraction and re-injection must be done horizontally to facilitate laminar flow. The estimated depth of the lake in the vicinity of gas-GEF 1 is 365m and the raw water riser will be situated at 355m, the water will be raised using an auto-siphon method. As water rises the reduced ambient pressure within the riser causes the gas to come out of solution. The degassed water will be re-injected at 280m. These Figures will be revised for the other 3 gas GEF systems to be installed in Phase 2 and adjusted according to the actual depth of the lake bed. The extraction of the water at 355m is predicated on maintaining, as near as possible, a laminar flow within the density layer and it is taken that only water above the intake pipe will be sucked into the intake. The concept, based on the smaller scale venting system at Lake Manoun in Cameroon (Kling et al 2005) is that the water is drawn in horizontally on a siphon principle. This can be replaced by water above but the water below the intake will not be touched. The same volumes of water are to be re-injected at the new density level caused by gas extraction which is equivalent to the water at 280m. According to the first Mandatory Technical Requirement (MTR1), this must also be horizontal since a vertical re-injection may physically breakdown stratification (Expert Working Group 2006).

- The output from the model studies 1 and 2 confirm the laminar nature of the flows for both the intake and discharge water and confirm that the stability of the density layer remains intact under all operational scenarios. Furthermore the model studies show that the degassed water plume remains within a small radius of the degassed water discharge pipe and that there is no mixing of the layers. The density gradient therefore remains intact.

MTR2: Washing water must be withdrawn from the biozone, and returned to the lower part of the biozone. Washing water will be taken from a depth of 20m and discharged at 60 m which is close to the bottom of the biozone. Both of these depths conform to the mandatory requirements and provide sufficient mitigation to reduce the impact.

- The results of the modelling studies 3 and 4 show the extent of the wash water plume and the composition of the gases within the plume. The studies show that the wash water discharge has a no impact on the stability of the biozone and confirm the design adheres to the mandatory guidelines thus providing sufficient mitigation.

MTR3: Water used to dilute degassed water before re-injection must not be taken from the biozone. The degassed water is not diluted prior to discharge so the design meets the requirements of MTR3.

MTR6: If degassing water is re-injected into the main gradient layer, it must re-stratify below the lower limits 10 percent of the main density gradient (now at about 270m depth). It is intended to match the density of the re-injection water with the density of the receiving water at the return depth of 280m. During production simulations with the production separator operating at 2.1 barg, between 60 and 70% of CO_2 is returned in the degassed water. The density of the re-injected degassed water (~1001.83 kg/m^3) is slightly higher (less than 0.05%) compared to the water density of the upper resource zone, the location of our degassed water injection point (~1001.37 kg/m^3 @ -270m and 1001.41 kg/m^3 @ -300m of the upper resource zone[7]). In the design, close density control is met by using a combination of controlling the separator pressure and dispersing the degassed water by using the diffuser at the outlet. A hydraulic, or pneumatic, control valve inserted into the gas flowline between the separator and the raw gas compressor will control the operating pressure in the separator by varying the amount of gas flow through the valve. Each separator will have its own control valve.

- Modelling study 1 demonstrates the predicted behaviour of the plume under the expected degassed water constituency. The results show that the plume will descend as it mixes with ambient water and will stratify at a depth of about -310m above the Lower Resource Zone. The plume will be below the lower 10% of the main density gradient. These studies confirm that the design meets the criteria set out in MTR6.

MTR9: The design of the deep-water extraction systems must prevent any self sustaining gas lift effect should a pipe-break or rupture occur (e.g. in a riser pipe or return water line). There will be butterfly valves in the gas extraction loop to turn down or turn off the rate of flow of water and hence the rate of extraction of gas. Furthermore the riser will be constructed of a double barrier. If the inner barrier (wall) fails gas will leak into the annulus between the two barriers causing a pressure increase in the annulus. Annulus pressure will be monitored to detect any pressure increase. The technology is adopted for standard oil and gas well practice offshore and on land. These measures

[7] Densities were calculated using the density calculation worksheet developed by EAWAG and supplied to Antares by ContourGlobal

should be sufficient to respond to emergency shutdown, thus reducing the risk and the associated impact.

The design fully complies with MTR9 and reduces the impact to minor.

MTR10: Plant design must ensure zero gaseous emissions during normal operations. The plant is designed to either utilise the extracted gases (methane) or to return the unwanted gases (CO_2 and H_2S) in the wash water to the base of the biozone. The results of the wash water discharge modelling show that the concentrations of gases will be well below saturation concentrations. Therefore the dissolved gases are expected to remain in solution during normal operation. The exception is H_2S which will be oxidised to sulphate. There should be no air emissions under normal operation although there will be intermittent flaring for short periods e.g. during start up or when needed for safety reasons. This is normal practice and is not usually counted as operational emissions.

The design fully complies with MTR10 and reduces the impact to minor.

G4: The wash water will be taken from a depth of -20m and the Management Guidelines state that the wash water should be taken from less oxygenated water from a depth of around -40m. Recognising the Expert Committee's concern about the potentially explosive nature of using wash water from the oxygenated level of the biozone about -40m, the design has been developed to operate the wash tower at 100 psig, which is higher than the lake's hydrostatic head pressure at 20 metres. This means that there will not be any free oxygen in the tower. This in combination with the high levels of $C0_2$ being introduced by the raw gas stream will prevent an explosive atmosphere from forming.

Therefore the design has resolved the issue and the impact has been reduced accordingly so that there will be no residual impact.

G7: Water extraction pipes should be located and designed to minimise potential problems with the intake of sediments. The lake bed is known to consist of loose unconsolidated sediments with a significant proportion of clayey particles. Thus it might actually be quite difficult to determine the actual depth of the lake bed, particularly if the sediments are flocculants. The present design has raw water riser approximately 10 m above the lakebed and it is assumed that this is sufficient to prevent intake of sediments. However, lake bed surveys will be undertaken and these will provide more robust data upon which to base the depth of the raw water riser. In addition, the results of modelling study 2 shows that flow is laminar and supports the theory that no sediments will be brought up in the raw water.

The resultant risks will be minor.

The present project design also takes into account the guidance given in the Expert Committee April 2006 report on Lake Kivu Gas Extraction. In this document it is advised that the returning wash water should be discharged at the base of the biozone to minimise the risk of coming into contact with fish. This has been interpreted in the project design as re-injection at 60m. Since these waters are already

deprived of oxygen they would encourage H_2S gas to remain in solution for longer or at least until the wind induced mixing occurs to refresh the oxygen. However the localised nature of the plume, at least according to the modelling results, suggests that any impact would be restricted to the vicinity of the discharge pipe.

Monitoring will reinforce the design and mitigation measures. Since the model is a predictive tool the lake will be monitored to ensure that the mitigation measures put in place are working effectively and to confirm that the model predictions are correct. Monitoring will;

- Check if things are conforming to management predictions.
- Include '*research on the job*' in areas where predictions are difficult. A carefully implemented monitoring programme will be carried out with rapid feedback to management on changes in key elements of the system.

There is no doubt that the increased chance of a minor release due to project operations is offset by the reduction in the inevitable catastrophic gas release if nothing is done. Thus the extraction project is not only desirable, it is imperative in order to attenuate the greatest risks of gas releases in the future.

7.4.3. Decommissioning

The benthic inflow of warm, saline CO_2 rich water has been estimated by Tietze (1978) to be between 0.5 and 1km^3 per year. In the predicted smooth operation the lowest layers, into which this inflow is issuing is shrinking and the density gradient, if anything, becoming more marked. Thus, any gas, coming in with the warm water inflow will saturate this layer rather more quickly than at present, giving the possibility of an earlier eruption (Expert Committee 2006). To offset this, the Expert Committee recommended that venting pipes be put into the deeper part of the lake when extraction is complete to reduce this possibility. There is equally a view that venting should not be allowed in the lake (Expert Committee 2006). However, given that the predicted lifetime of the project is 25 years, that during this time there will be a great deal more data available, and that appropriate technology will have advanced, it is acceptable to consider the options for decommissioning later in the project lifetime. Clearly the issue of to vent or not to vent requires resolution before the fate of the plant can be determined. In any event, extraction of the gas will have already reduced risks of eruption.

7.4.4. Residual Impacts

The hydrodynamic model has demonstrated that the project design includes mitigation measures to reduce the risks associated with lake stability and uncontrolled gas release to low levels. Furthermore the measures fully comply with the Mandatory Guidelines. Thus everything possible has been done to minimise the probability of major impacts.

The only residual impact identified through the impact assessment is:

- Disposal of the wash water in depths of around 60m may not achieve the separation of the contaminated (H_2S and CO_2) water from the water regularly inhabited by fish. However, this the modelling suggests that the wash water plume is very restricted and localised and remains within the exclusion zone around the facility, this in itself minimises the risks. However, the fish will not recognise the exclusion zone and the sardine shoals have been recorded in these depths, so there remains a possibility that some fish could come into contact with the un-oxidised H_2S. The extent to which the H_2S may oxidise in the relatively poor oxygenated waters of the lower biozone is still unknown. However, it can be said with confidence that the wash water will not affect the density gradient in the lake. Monitoring of water quality in fisheries will be undertaken to assess the extent of any impacts that might occur and allow further mitigation measures to be developed.

7.4.5. Cumulative Impacts

The cumulative impacts of this development fall into two categories. The first is associated with Phase 2 of the KivuWatt plant and the second refers to other developments of a similar nature. The principal impacts are associated with the stability of the lake.

7.4.5.1. Kivu Watt Phase 2

Of particular importance here are the modelling results and the effect of raising large volumes of water from the deep layers on the density gradient. We must draw some conclusions from the model of the single GEF which shows us that the discharge of the degassed water remains in a very limited localised area of approximately 165 m diameter with a vertical spread of some 43m. Given that the GEFs will be many kilometres apart they can in effect be considered as 4 separate entities and the de-gases water plumes will not mix with each other but remain as discrete plumes beneath each installation. Therefore the stability of the density gradient should not be altered.

The risks associated with escaping gas and possible ruptures in the delivery pipeline have all been dealt with and even if the maximum amount of gas 171m^3 were to escape simultaneously from all 4 GEFs (an extremely unlikely occurrence) the gas clouds would be unlikely to merge because they are so small and the resultant impact would be in the same order of magnitude as a single rupture.

Similarly the effects noted in the wash water discharge are localised within the exclusion zone around each GEF and, there has been no impact demonstrated on the upper density layer from the discharge of the wash water, the stability of the lake should not be altered.

Finally the impact of the wash water discharge on the water quality of the biozone is equally limited to the immediate vicinity of the GEF inside the exclusion zone and so the impact would be localised.

7.4.5.1.1. Other Developments

We are not in possession of any details concerning other developments of a similar kind scheduled for development for either Rwanda or Congo. However, some assessment can be made with reference to the predicted volume of the resource expounded by the Expert Working Group.

The modelling tells us that the impact of the removal of water from the lower resource zone is the equivalent of 0.24% of the lake's lower resource zone volume is removed. If we assume that all 4 plants are operational for 25 years this actually represents about 24% of the resource. The Version 12c Guidelines actually provide for a 50:50 split of the resources between the Democratic People's Republic of Congo and the Republic of Rwanda. Furthermore the IFC/World Bank (2009) report states that they anticipate that within 40-60 years most of the gas in the lake will have been harvested and so this suggests that the effect of the development on the resources is reasonable and that there will be sufficient additional resources available for exploitation by others.

Projects developed from any future concessions awarded will be required to assess cumulative impacts including the ContourGlobal KivuWatt Ltd development.

8. Human Environment

The human environment is assessed in respect of socio-economics, land use and cultural heritage.

8.1. Context & baseline

Kibuye is the ninth largest town in Rwanda and its population has grown rapidly to its current level of 45,000. The existing spatial structure is defined by topography, land tenure and man-made features. The principal points to note of relevance to the EIA are:

- The ribbon development around the Kigali-Kibuye road.
- The topography and drainage of surface run-off to Lake Kivu.
- The predominance of agriculture and subsistence farming with consequent effects of land degradation due to clearance of woodland and forest.
- The importance of the Lake for fishing and transportation.
- The site is located on land designated as an industrial zone in a sparsely populated area. The nearest Imidugudu[8] settlements are 2km south east and 1km east of the site respectively and the nearest area of large settlement is Niyabihanga, at the junction of the site road and the main Cyangugu to Gisenyi road some 2km from the site itself. There are some scattered dwellings closer to the site near Top Ridge, the nearest being 450m south east of the Power Plant site and on the other side of the ridge. There are no dwellings within the boundaries of either the Power Plant site or the MLS.
- The Kivu Watt site is located in the Ruganda cell which had a population of 450 people in 92 households in 2006. It appears that there was some resettlement associated with the development of the road and the transmission station as part of the establishment of the industrial area. This resettlement pre-dates and is separate from the power generation site proposals. The population in Niyabihanga was 817 (163 households) in 2006. More recent data is unavailable.

8.1.1. Demographics

Demographic data provided in the Kibuye Master Plan indicates the following:

- A young population with 44% below the age of 15.
- High illiteracy levels (61%), with only 23% of people completing primary education. This compares unfavourably with national levels where 45% complete primary education.
- High rates of HIV/AIDS and mortality.
- An immigrant population of 30%.

[8] Imidugudu is a post-genocide system of settlement pattern in a grouped village system imposed by the government to resettle the surviving population and returnees.

- High poverty levels with 66% of the population living below the poverty line on an income of <10,000 RWF per month (US $18). This compares with national Figures of 57% below the poverty line and 37% in extreme poverty. Reportedly 20% of Rwandan children are chronically malnourished, Figures for Kibuye are not available.
- 40% of household headed by women.
- The level of education achieved has a marked influence on occupation; almost 90% of those who have not completed any education work in the agriculture sector. In rural areas 93% of women work in agriculture and fisheries compared with 80% of men.

As regards the local economy, 82% of households derive their income from agriculture. 51% are self-employed in small-scale, informal businesses principally trading.

As regards national health data, 75% of the population has access to healthcare and 85% has access to clean water. Average life expectancy is 46 years.

8.1.2. Land Use & Master Plan

The approved Kibuye Master Plan (2002-2016) sets the context for land use in and around the site (Figure 11). Key features of the plan that are relevant to this study are:

- The designation of the project site as an industrial zone with the specific intention of using part of the zone for power generation utilising methane from the lake.
- Designation of other strategic investment areas for the development of an airport, harbour, modern market and military zone.
- Determination of environmentally vulnerable areas such as wetlands, water catchment areas, shoreline etc and the establishment of conservation and protection measures.
- Proposals for:
  - Improvement to roads and other infrastructure.
  - Greater control by the Municipality for agricultural and urban development land.
  - Development of ecotourism on the islands of Lake Kivu and the lake shoreline at Nyabindahe and Nyagahinga.
  - Sewage treatment and waste management facilities

8.2. Archaeology and Historical / Cultural Resources

There is little information available on archaeological or cultural heritage at the site. As the site has been heavily disturbed either for site preparation works or for agriculture at the MLS it is assumed that there is no remaining significant archaeological resource.

8.3. Local economy

Rwanda is among the ten least developed nations of the world and is categorised as a very low income country. In rural areas such as Kibuye, agriculture, fishing and forestry are the mainstays of the economy. However deforestation means that there is little dependence on forestry for local communities in the Kibuye area. 2005/6 data from the National Institute of Statistics show 81% of men and 86% of women in the western province as economically active.

National data from the same sources (as shown in Table 12) show the dependence of the country on the informal sector and on subsistence farming, i.e. more than 3 million people and almost 90% of the total population.

Table 12 Employment by formal and informal sectors

	Non-Farm		Farm		All	
Formal sector	**Workers**	**%**	**Workers**	**%**	**Workers**	**%**
Waged	199	22.2	32	0.9	231	5.2
Independent	40	4.5			40	0.9
Total formal ('000s)	239	26.6	32	0.9	271	6.2
Informal sector					279	6.4
Waged	279	31.1	328	9.4	607	6.9
Independent	308	34.3			308	7.0
Family	72	8.0			72	1.6
Subsistence			3,119	89.7	3,119	71.3
Total informal ('000s)	659	73.4	3,447	99.1	4,106	93.8
Total employment ('000s)	**898**	**100**	**3,479**	**100**	**4,377**	**100**

Table 13 shows gender and economic activity for Rwanda as a whole. No statistics are available specifically for Kibuye. This demonstrates the heavy reliance on the agri-fish sector and also illustrates the problem of finding skilled workforce for the plant operation. This will present difficulties for ContourGlobal KivuWatt Ltd in the immediate timeframe especially given the high local expectations regarding the project as demonstrated in the public workshop – see section 8.6 and Appendix F.

Table 13 Gender and economic activity

	Rural Areas		All Rwanda	
Occupation	**Male**	**Female**	**Male**	**Female**
Professionals	1.8	0.8	2.6	1.4
Senior Officials & Managers	0.0	0.0	0.1	0.0
Office clerks	0.3	0.1	0.6	0.5
Commercial & Sales	5.0	3.4	6.4	5.4
Skilled Services Sector	4.3	1.0	7.3	4.3
Agriculture & Fishery Workers	79.9	93.0	71.4	86.2
Semi-skilled Operatives	6.4	1.4	8.4	1.9
Drivers & Machine Operators	0.4	0.0	1.2	0.0
Unskilled Labourers	1.8	0.2	2.0	0.2
All	**100**	**100**	**100**	**100**

There are few regional statistics but the average per capita income in Rwanda is equivalent to US $370 per annum. GDP per capita has been gradually increasing over recent years from US $212 in 2001 to $370 in 2007 and may currently be higher than this.

Rwanda has a small tourism industry which is planned to be further developed particularly in and around the national parks and Lake Kivu. Tourism collapsed during the period of genocide (1994) and only achieved pre-genocide numbers of 24000 international visitors in 2003. The lake is very popular with Rwandan tourists and several hotel developments have been constructed in order to service this demand.

Agriculture is an important component of the economy of Rwanda and 70% of the country is under permanent cultivation.

There are twelve separate classifications of agricultural land in the country (Figure 23) with productivity determined by soil properties, climate, altitude, slope gradient, vegetation and man-made factors such as management practices and soil erosion.

In the region around Kibuye, the Kivu Lake borders, and the proposed site the soil is shallow clay loam and of good to excellent agricultural value. However, current agricultural practice is said to be poor with low yield crop and has led to land degradation high unemployment. This is further exacerbated by uncontrolled urban expansion into prime agricultural areas.

Statistical data are sparse. The most recent data compiled by the National Institute of Statistics for Rwanda are for 2006 and 2007.

Crops are mainly grown for domestic consumption the main crops being bananas, beans, sweet potatoes, cassava, sorghum, millet, green peas, arrowroot, maize, groundnuts and sugar cane. Irish potatoes, green peas and tomatoes are grown commercially. Despite this intensive cultivation Kibuye

is reportedly poor in food security and is a food deficit area that imports maize and rice from Kenya and Uganda, bananas, sugarcane and timber from DRC.

Beef cattle, goats and sheep are main livestock production although the region produces a very small percentage (just over 5%) of the total Rwandan livestock production.

All land belongs to the Government of Rwanda. In rural areas the occupiers of land have customary rights of cultivation, building, transfer, inheritance and leasing. The area around Kibuye and also part of the MLS is under intensive cultivation for subsistence farming and for cash crops. Where land is expropriated the Rwandan Land Law (2005) allows for the harvesting of crops before the land is taken.

8.4. Lake transportation

The lake offers a highway for trade and communal mobility and consequently is also a provider of employment. Trade may also be international since a lake crossing offers easy access to the Democratic Republic of Congo. Many lakeside communities may be dependent upon this transport link.

Presently there are two large cargo vessels transporting goods and people around the lake. The boats are equipped to transport 120 people plus 20 or 30 tons of goods, depending on the boat. A fully loaded boat plus 120 people is worth around US $5,000 to its owner. There are two boats and each boat travels to and from Cyngugu – Gisenyi via Kibuye twice a week therefore both can potentially generate a turnover of approximately US $160,000 per month or around US $1.9 million p.a. Maintenance of the cargo boats is carried out in Kibuye yet major repairs are generally carried out in Gisenyi where there is greater availability of spare parts.

The main cargo transported along this route comprises local produce such as bananas, beans, sweet potatoes, cassava, sorghum, millet, green peas, maize, sugar cane, livestock and fish. Building materials like cement, tiles, wood, etc. are also transported by these cargo ships. The trip from Cyangugu to Gisenyi takes approximately fifteen hours, including all the stops for loading and unloading the cargo. Each boat employs five people full-time and another two occasionally when needed.

The gas transport pipelines will extend from the shore towards the centre of the lake where the extraction GEFs will be located (approx. 13 km offshore to the west). The pipelines will cross the main shipping route from Cyngugu to Gisenyi yet the pipes will be submerged at a depth of 20 m to facilitate navigation over them.

This means of transportation is an effective way of transporting the local produce from Kibuye to other areas around the lake. Equally, cargo boats are crucial to bring goods from other areas into Kibuye, as transport by road would be more expensive and not very efficient given that road access is generally poor, in particular in coastal areas around the lake.

The transportation sector has also been organised in cooperatives, and in Kibuye there is only one boat transport cooperative called COTRALAKI which has ten registered transport boats. COTRALAKI represents the interests not only of the owners of the large cargo vessels but also the interests of the "transporteurs" who use the same sort of boats as the fishermen to transport goods short distances around Kibuye. It was not, however, possible to obtain the exact number of transport canoes currently operating in Kibuye. Equally it was not possible to define the turnover generated by this sub-sector; it is nonetheless important to emphasise its relevance given that much of the commercial activity in Kibuye and surrounding areas greatly depends on this means of transportation.

8.5. Potential Impacts

Both positive and negative impacts are assessed.

8.5.1. Positive impacts

Positive impacts are anticipated to arise as a result of the development in the form of provision of local employment, training and beneficial effects on the local economy.

8.5.1.1. During construction

The principal benefits occurring during site construction activities will arise from the awarding of contracts for goods and services locally and the generation of employment opportunities.

The contract for early site works has been awarded to Fair Construction, a Rwandan company.

Other services that will be supplied locally will include materials and labour, transport, car hire, accommodation and restaurant, telephone, internet and travel services. Whilst the exact value of these services is not yet determined there is the potential for a significant boost to the local economy. There will also be increased demand for local produce and the project may be a catalyst to improve the local products especially if tourism is to increase as a result of the electricity provision.

It is anticipated that approximately 250 jobs will be generated during construction of which approximately 200 will be local jobs. A proportion of these will be unskilled labour and may be more easily sourced from the local workforce.

The development will attract a number of immigrants seeking work and such an influx can bring its own problems including possible increased HIV/AIDS risks, pressure on local public services and inflation pressures on local goods and services.

8.5.1.2. During operation

Contracts for Phase I that will be awarded are anticipated to be valued at US $5-10M and these will include local contractor and local employment opportunities.

During Phase I, initially, initially seventeen local staff (out of a total of 61) will be employed in the following roles:

- HSE Manager.
- Administrative assistants.
- Supervisor.
- Vessel Master.
- Vessel crew.

Job opportunities will increase over time and ContourGlobal KivuWatt Ltd intends to gradually replace the expatriate staff over time. ContourGlobal KivuWatt Ltd proposes an extensive training programme to be instituted by the local university for engineers and other roles for the operation of the plant and production facilities. After six years of operation and the implementation of Phase II, local staff numbers will be 103 out of a total of 116. Local staff will be employed in the following additional roles:

- Mechanical engineers and technicians.
- Control and instrumentation engineers and technicians.
- Operations supervisors and technicians.
- GEF operations supervisors and technicians.

Of these 103 local jobs, eleven will be in management or administration, 34 in engineering, 14 in Power Plant operations and 44 on GEF's and boat crew.

Given the poor educational levels of the local community the training programmes will be extremely important and it is possible that some senior staff will have to be brought in from elsewhere, e.g. Kigali or other regional centres.

In addition to job provision, indirect economic benefits will accrue through the provision of a secure, low cost energy supply. During public consultation, the project team was advised that local businesses are affected by frequent power outages that impact on their working hours and a secure supply is considered to provide an important boost to local business. Energy supply will also be critical to the development of the burgeoning tourism industry that is developing around the lake.

8.5.1.3. During decommissioning

The project will be handed to the GoR after 25 years although the lifetime of the plant will be longer than that.

The MLS will be handed to the GoR on completion of the GEF construction. However the site will continue in use to provide maintenance services to ContourGlobal KivuWatt Ltd. Moreover the jetty

that will be constructed will be available for public use and will benefit local communities and the boatmen.

Table 14 summarises significant positive impacts.

Table 14 Significance of positive human impacts

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Job creation & training	Minor/Major	Major	Not assessed	X
Local economic development	Minor/Major	Major	Not assessed	X
National economic development	Minor	Major	Not assessed	X

Impacts associated with decommissioning were not assessed due to the timescale of the project. Human impacts associated with e.g. employment loss on decommissioning will be assessed as part of a decommissioning plan prepared in advance of project closure.

8.5.2. Potential negative impacts

Negative impacts will mainly occur during the construction Phase of the project arising from economic displacement of farmers from the MLS, possible health impacts due to potential increases in the level of HIV/AIDS within the local population as a result of a rapid influx of workers and possible effects on the nearby market.

8.5.2.1. Economic displacement

Impacts on subsistence agriculture in the MLS include the destruction of 1 ha of agricultural land and the economic displacement of 27 squatter farmers. The MLS land was also used by the Gasura Primary School for growing cattle fodder for the school cow and this practice has also ceased due to the land expropriation. Data provided by MININFRA (Recensement des biens pour appropriation – see Appendix G) lists the farmers affected, fourteen of whom were female. We understand that the farmers have fragmented land holdings and that the MLS only comprised a part of their farms.

The total compensation paid was 23,954,252 RWF. The cut off date for the census of the farmers was early May 2009 and the compensation payments were made on 29 May 2009.

Compensation paid by MININFRA in line with Rwandan Law varied from individual payments of 3500 RWF to 100,000 RWF except for the school which received 200,000 RWF. The average daily rate for an agricultural labourer is 500RWF and in the case of eleven farmers the compensation equates to a month's wages; in the case of six farmers for half a month's wages.

This compensation was purely for the value of the crops.

Although the farmers were compensated by the government, ContourGlobal KivuWatt Ltd wanted to determine the true impacts of the displacement. Consequently a preliminary survey was undertaken that collated information on farmers' gender, size of plots, nature of farming (subsistence or sale) and crops grown. Information of the amount of compensation paid to each was provided by MININFRA.

The main points arising from the survey were:

- 27 farmers were affected and also the local primary school that used part of the site.
- 14 of the 27 farmers displaced were women.
- The number of dependents was not determined, however we understand that the average household is of five to six persons therefore there are potentially 162 people that could be affected by the resultant decrease in income or household food supply.
- Crops grown were principally sweet potatoes for the community and cattle fodder for the school cow. The primary school was compensated for the loss of fodder and as a consequence have money for more cows but it will take time to apply for tenure of replacement pasture.
- Crops were for family use and/or for sale and average production was 400kg pa on a 10 x 10m plot. 1 kg of potatoes could be sold for 150 RWF.
- The farmers from the MLS were all from Gafurugoto village.
- One affected farmer did not have a plot at the MLS but did farm at the transmission site (a relocation made for a separate project on behalf of the GoR). This was actually for legally owned land and accounts for the larger payment of 22,386,595 RWF.
- Cultivated land at the MLS varied in plot size between 12 x 8m and 16 x 12m.
- Most of the farmers have other plots elsewhere.
- The average income generated from the sale of crops based on 400kg pa is 60,000 RWF and sale of crops is the farmers' only source of income.
- Where necessary farmers try to improve the productivity of their land through the use of fertilisers, which are considered expensive, or manure.

8.5.2.2. HIV/AIDS

HIV/AIDS is prevalent in the area and affects local communities in numerous ways; ContourGlobal KivuWatt Ltd employees residing in the area could potentially be affected through infection or some of the collateral effects of HIV/AIDS in the community or amongst the company workforce. There is also the potential for an increase in the prevalence of HIV/AIDS due to an influx of large numbers of people seeking work at the site. Experience from other industrial developments in rural Africa shows that rush economic migrations are accompanied by increases in prostitution and an increase in Sexually Transmitted Diseases (including HIV/AIDS).

8.5.2.3. The market

A weekly market is held on land adjacent to the MLS and close to the road between the MLS and the Power Plant site. Construction activities could impact on the market traders and customers by:

- Generating dust and noise.
- Safety concerns due to the presence of heavy plant and equipment on the site.
- Safety concerns due to vehicle movements between the Power Plant and the MLS. Heavily laden lorries transport excavated material from the Power Plant site to the MLS at the rate of four trips per vehicle per hour.

8.5.3. Mitigation of negative effects

8.5.3.1. Resettlement Action Plan (RAP)

27 farmers have been economically displaced from the MLS and the Gasura Primary School is also no longer able to use the land. The farmers have been compensated in accordance with Rwandan law but this is insufficient to meet the requirements of IFC and therefore of OPIC.

IFC Guidance Note 5 on Land Acquisition and Involuntary Resettlement is clear as to the requirements for economic displacement (i.e. where people are not physically displaced but have a drop in income or lose their livelihood as a result of the project as is the case of the MLS area) and includes:

- Prompt compensation for loss of asset or access to assets.
- Provision of replacement property, in this case agricultural land of equivalent value and productivity or cash compensation at full cost where appropriate to persons will legal rights or claims to the land.
- Compensation of persons (except for opportunistic squatters) without legal rights for lost assets such as crops, irrigation infrastructure and other improvements made to the land at full replacement cost.
- Provide additional targeted assistance (such as access to credit facilities, training or job opportunities) to improve or at least restore their income-earning capacity, production levels and standard of living where livelihoods or income levels are adversely affected.
- Provide transitional support as necessary based on a reasonable estimate of the time required to restore earning capacity, production levels and standards of living.
- To comply with IFC requirements, ContourGlobal KivuWatt Ltd will be expected to supplement governmental efforts in order to bring the mitigation measures in line with the IFC standards (Performance Standard 5). ContourGlobal KivuWatt Ltd will prepare a RAP, in further consultation with the farmers, to restore livelihoods and establish a grievance mechanism for receiving and resolving complaints. The plan will review what additional targeted assistance and

transitional support is needed to restore pre-displacement conditions. At the moment it is unclear how significant the loss is in terms of the scale of the impact until the scale of other landholdings is known and what proportion of livelihood has been lost.

It should be noted that there is a scarcity of available land that means that replacement land is unlikely to be an option. The options might therefore be:

- Improving productivity and added value at the farmers other land holdings. Possibly by linking in with existing agricultural improvement programmes and organisations in the area.
- Supporting alternative livelihood options (although this must be done with extreme care as it can be difficult and risky to shift subsistence farmers to equally secure livelihoods); providing job opportunities on the project might be an option. Understanding their existing livelihoods as well as a good understanding of potential alternatives will require good market analysis as well as understanding what skills they have and what opportunities are available.

To ensure compliance with IFC PS5 the following Phased tasks will be conducted to generate a RAP that is evidence based, fully participatory, legal, and which promotes sustainable development:

- Phase I – Scoping Study: The short Scoping Study will be conducted in Rwanda to identify key stakeholders, potential red flags to RAP development, and to identify and recruit local consultants. It will also involve a review of secondary literature and pertinent legislation, and collation of relevant geographical data (e.g. maps, aerial photographs).
- Phase II – Socio-Economic Research and RWG Formation: The second Phase of the RAP will undertake several concurrent tasks to specify project impacts and the affected population. This is the culmination of a number of activities and includes: mapping the local area (using official and participatory mapping resources); conducting a census of the affected people and an inventory of affected assets; carrying out a socio-economic study and Market Survey; analysing survey and study data; and consulting with affected people to discuss compensation, assistance benefits and development opportunities to determine 'feasible' preferences and manage expectations.

The second Phase will also entail the identification and examination of the legal framework (recognising both statutory and traditional laws and to ensure the RAP is legally compliant); and, the significant process of forming a Resettlement Working Group (RWG) through consultation with PAP.

- Phase III – Compensation Framework, and Grievance Redress and Monitoring Mechanisms: The third Phase focuses on generating a number of frameworks and mechanisms to ensure the data collected is brought together into a manageable structure. This entails the preparation of a Compensation Framework which is created by determining the criteria for eligibility for compensation (e.g. land holding type, length of land occupancy etc.); the preparation of an Entitlement Matrix (to record categories of people affected, all types of loss associated with each category, all types of compensation and assistance); definition of roles and responsibilities and

the implementation schedule for compensation payments (conducted in agreement with stakeholders and through the RWG); budget creation and the overall implementation schedule; and determining the organisational structures and responsibilities for implementation, monitoring and evaluation.

Phase III will attend to the design of the RAP grievance redress mechanism (which will adhere to the Compliance Advisor Ombudsmen (CAO) 'A Guide to Designing and Implementing Grievance Mechanisms for Development Projects' (2008), which is used to advise World Bank Group in policy development and project safeguard mechanisms); and the design of appropriate Monitoring and Evaluation mechanisms (taking into consideration both the need for periodic assessments against predetermined milestones, and the need for internal 'management' monitoring and external independent assessment, the latter conducted in the post-implementation period). The final task of Phase III will be Completion Audit 'checklist'.

- Phase IV – RAP Write-up and Sign-Off: The final Phase of RAP development will involve full RAP 'write up' (incorporating all relevant findings, frameworks, budgets, schedules and mechanisms), submission to client and then funding body for review, and, revision (if required), and final submission to funding body for sign-off.

- Phase V – RAP Implementation: Following sign off and agreement from ContourGlobal KivuWatt Ltd to proceed, the RAP will be implemented by the appropriate persons.

Though very much dependent on the findings of the scoping study, it is estimated that the RAP will take a period of four months to prepare. The scope of the RAP is relatively small and it is expected that the period of implementation will be relatively short. The speed of implementation will depend very much on the ability of the implementation team's capacities and the institutional structures in place to safeguard its implementation (in accordance with the M&E and Grievance Redress Mechanisms) as agreed through the RAP design process. ContourGlobal KivuWatt Ltd has recruited an international consultancy to develop the RAP and assist with its implementation. Presently, it is estimated that the RAP design will commence in the fourth quarter of 2009 and with implementation no later than the second quarter of 2010.

The consultancy recruited to undertake the RAP assignment is experienced in developing RAPs in an African context and to IFC PS5. It will undertake the RAP in a fully consultative manner with appreciation for the need to engage participatory research methodologies that are sensitive to age, gender, ethnicity and educational attainment.

It is through these sorts of mechanisms that the consultancy will discern the most appropriate form of compensation required by the Project Altered People (PAP). As the context does not allow for Land-for-Land compensation (because there is a shortage of available land), the compensation might be in the form of skills training, grants, or credit for enterprise start-up. It will be the task of the consultants

to discern the most suitable compensation package for each PAP and to ensure that they have the skills and wherewithal to manage the compensation in a manner that promotes sustainable development.

In addition, the RAP will ensure compliance with IFC PS5 by following the IFC's '*Handbook for Preparing a Resettlement Action Plan*' and by recruiting a suitably qualified and experienced organisation to develop the RAP and assist with its implementation.

8.5.4. HIV/AIDS

According to the United Nation's most recent estimates, Rwanda's HIV / AIDS prevalence rates amongst adults (aged 15 – 45) is 2.8%; this means approximately 170,000 adults are living with HIV[9]. Figures for the project site area are unavailable. It is recommended that ContourGlobal KivuWatt Ltd be proactive in the fight against HIV/AIDS by designing and implementing a 'HIV/AIDS Framework for Action' to reduce the spread of HIV/AIDS and manage its impact. The framework should be comprehensive and incorporate initiatives which address the workplace and workforce, the community-at-large, and as adjunct of the latter, a strategy to address project-induced in migration.

8.5.4.1. Workplace initiatives

Initiatives should implement comprehensive and effective workplace HIV/AIDS programmes that are collaboratively designed. They should ensure that employee rights and confidentiality are provided for within an HIV/AIDS workplace policy. This is the cornerstone of HIV/AIDS Framework for Action. Key elements of the policy should address the elimination of stigma, employee rights including non-discrimination and confidentiality, periodic workplace programmes, management responses to the epidemic, medical care and treatment, and other issues such as the inclusion of suppliers and contractors. ContourGlobal KivuWatt Ltd should consult the AIDS Management Standard Initiative to inform the design of its workplace policy and to better understand the standards by which a company's commitment to an AIDS policy in the workplace is evaluated. The following resources are also important and relevant for the formation of a workplace policy.

The International Labour Organisation (ILO) Code of Practice on HIV/AIDS and the World of Work. This code provides guidelines for the development of policies and programmes on HIV/AIDS in the workplace and is complemented by an education and training manual.

- *IFC GPN for HIV/AIDS in the Workplace*. This provides guidance on good practice in developing a programme for dealing with HIV/AIDS based on developing a policy and HIV/AIDS education and awareness as well as promoting prevention of HIV/AIDS (Table15).

Table 15 Good practice for HIV/AIDS

[9] UNAIDS – Country Responses: Rwanda. Online resource available at: http://www.unaids.org/en/CountryResponses/Countries/rwanda.asp (accessed: 08/10/09)

Activity	Information sources
Define the problem though collection baseline information on HIV/AIDS in the workforce and identify risk factors (e.g. sole male workers at construction sites).	▪ Ministry of Health statistics. ▪ Recent mortality data. ▪ Internal surveys. ▪ Calculations based on regional statistics and numbers of influx workers.
Develop HIV/AIDS policy	▪ Post policy in public places.
Develop education and awareness programmes	▪ Posters/billboards. ▪ Used trained external resources from local health centres. ▪ Participate in local initiatives. ▪ Educate beyond workforce through community awareness raising. ▪ De-stigmatise disease.
Promote prevention of the spread of HIV.	▪ Condom distribution. ▪ Review H & S procedures (e.g. for bleeding during accidents). ▪ Voluntary counselling and testing.

- *Multi-country Collaboration for Model Code of Practice*. The Southern African Development Community (SADC) developed a code of practice for its 14 member countries (Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.
- In consideration of the above, ContourGlobal KivuWatt Ltd should ensure its policy:
- Makes an explicit commitment to corporate action.
- Is consistent with appropriate Rwandan laws.
- Lays down a standard of behaviour for all employees (whether infected or not).
- Gives guidance to supervisors and managers.
- Helps employees living with HIV/AIDS to understand what support and care they will receive, so they are more likely to come forward for voluntary testing.
- Helps to stop the spread of the virus through prevention programmes.
- Assists an enterprise to plan for HIV/AIDS and manage its impact, so ultimately saving money.

A sample Workplace HIV/AIDS policy statement that may be used as the basis for an internal policy statement is included in this document (see Annex H).

While workplace policies are a key step in combating HIV/AIDS, comprehensive HIV/AIDS workplace programmes are required to put policy into practice. ContourGlobal KivuWatt Ltd should consider a '*workplace education and care programme*'. These programmes, include, for example, workplace education programmes, provision of treatment for STIs, invite peer counsellors to educate about prevention, encourage voluntary counselling and testing (VCT), provide medicinal care for HIV/AIDS related opportunistic infections, and promote a healthy lifestyle.

8.5.4.2. Community Initiatives

It is expected that the community in the vicinity of the project site will provide some labour for ContourGlobal KivuWatt Ltd operations, and it is from the local community and larger communal context that the company may derive its contractors and procure its supplies.

The second element of ContourGlobal KivuWatt Ltd's HIV/AIDS Framework for Action involves community initiatives which constitute an outreach to local inhabitants, suppliers and local government workers. The community initiatives will focus on reducing the spread and mitigating the effects of HIV/AIDS in the long-term. This is best achieved by supporting the formation of local organisations and initiatives that can provide sustainable efforts for a long-term response to HIV/AIDS within specific communities and in concert with local government and effective NGOs.

Some examples of community initiatives that ContourGlobal KivuWatt Ltd will consider are:

- *Collaborative Community-based Intervention Programme*: an initiative that brings together a number of actors from the private, public and civil society sectors. In particular it calls for ContourGlobal KivuWatt Ltd to partner with relevant GoR Health Departments and NGOs operating in the area with a HIV/AIDS mandate to ensure a uniform HIV/AIDS prevention and treatment programme is implemented. This example includes certain cost-saving elements.
- *Delivering Health Education Messages to Young People*: Typically, these initiatives are focused on developing and implementing strategies that are innovative and which resonate with the target audience. Methods of education for youth include cartoons, drama and role play, music and storytelling.
- *Supporting Youth Development, Training and Microcredit*: This initiative focuses on increasing economic opportunities for youth and women with the intention of offering women and youth options other than sex work. Examples of training include IT training, batik / tie-dying, literacy classes and handicraft. Vocational training can be supported with enterprise development training and help to access micro-credit.
- *Corporate Grants for HIV/AIDS*: This example refers to the potential ability of business to make charitable gifts for community prevention and care projects. Often these resources fund projects that provide health care, education and HIV prevention services for poor and underserved people. Company employees can form part of this initiative as outreach volunteers, visiting communities and co-workers to conduct HIV/AIDS awareness programmes.
- *Providing Pharmaceuticals to Communities*: This initiative entails collaboration with pharmaceutical companies that have philanthropic policies to distribute HIV/AIDS relevant drugs freely to communities in underdeveloped countries and organisations that have the necessary expertise to deliver the programme effectively. For example, Boehringer Ingelheim, a pharmaceutical company, announced that it would offer Neviripine to prevent mother-to-child transmission (MTCT) of HIV/AIDS free of charge for a period of five years. Projects for

distribution and delivery systems have been initiated by Doctors without Borders in South Africa and Uganda.

- *Peer education*: This initiative refers to the role a company can play in inviting a capacity building NGO or CBO to educate a select few people from the local communities in HIV/AIDS prevention and treatment awareness. These few people are then tasked (often with some remuneration from the company) to spread their knowledge amongst their peers in their local environments.

As indicated within the IFC GPN cited above, gauging the success of HIV/AIDS intervention programmes requires that a baseline of data and a better understanding of the socio-economic context (e.g. through generating a profile of economic, health, education, demographic, gendered aspects of area) be generated. These are obtainable through a collation of numerous data from sources as varied as socio-economic and health surveys, and national and local statistics. Once the context and baseline have been established, and while the programme is in effect, a programme monitoring and evaluation mechanism is required with periodic sampling of the population to assess change.

The Community Liaison Officer and Manager with responsibility for EHS issues will institute an HIV/AIDS programme for the project.

8.5.4.3. Managing Project induced in-migration

As part of its drive to mitigate some of the potential negative impacts of its presence, particularly in relation to the spread of HIV/AIDS amongst the local workforce and inhabitants, ContourGlobal KivuWatt Ltd could consider devising a strategy for managing project induced in-migration. The IFC's recently published document on project-induced in-migration suggests that project implement agencies develop an Influx Management Plan (IMP) based on a fully consultative risk assessment and management strategy[10]. However, this may be in conflict with Rwandan policy on the free movement of labour and may impose an additional impact on Rwandan nationals. Careful consideration needs to be given to this issue (which should also include the wider HIV/AIDS policy) before a final decision is made on how this sensitive issue should be addressed.

8.5.5. Other mitigation

Other mitigation measures are as follows:

- Nuisance to the Friday market in the form of dust generation will be controlled by water spraying of site roads and controls on vehicle speeds in dry and dusty areas.

[10] IFC (2009), The Migration Effect: Risk Assessment and Management Strategies for Addressing Project-Induced Migration. Online resource available at: www.ifc.org/ifcext/sustainaibility.nsf

- Community safety measures will include checking of vehicles leaving the site to ensure that tail gates are secure; restricting public access to construction site, controlling vehicle speeds on public roads and using safety stewards at crossing points on Fridays.
- Boats will be enabled to cross the submerged pipeline safely.

Table 16 summarises significant negative effects.

- **Table 16 Summary of negative socio-impacts in the absence of mitigation**

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Economic displacement	Minor/Major	Negligible	Negligible	√
Nuisance to market	Minor/Major	Negligible	Minor	√
Road safety	Minor/major	Negligible	Minor	√
Lake transportation	Minor	Negligible	Negligible	√
Site safety	Minor/Major	Negligible	Minor	√
HIV/AIDS increase	Major	Major	Minor	√

8.5.6. Residual impacts

In the event that the proposed mitigation measures are effectively implemented, residual impacts will be negligible or minor.

8.6. Community consultation & Grievance mechanisms

Community consultation for the project has been undertaken on a number of occasions as summarised below:

- By Green and Clean Solutions (GCS) during the production of the April 2009 ESIA.
- By SKM during the production of this ESIA.
- By ContourGlobal KivuWatt Ltd at a consultation workshop held on 11th and 12th August 2009.

The GoR EIA regulation of 2005 set out requirements for stakeholder consultation. In particular REMA should arrange for a public meeting to be held within 20 days of notification of receipt of an EIA. The meeting will be open to members of the public as well as governmental and other agencies all of whom may comment on the EIA and the proposed development. We understand that this process is in hand and will be undertaken in late October 2009.

Key findings from the GCS EIA consultations are outlined below:

- Residents are aware of the gas extraction as they have seen the infrastructure installed by the GoR for its venture with Dane Associates Ltd.

- Fishermen did not have details but thought there would be income generating activities associated with the development.
- Local traders anticipate an increase in business.
- The transport co-operative thought they might need to relocate across the lake.
- People had been displaced during the construction of the access road for the KP1project and complained that the compensation paid was insufficient to buy replacement land.
- Local residents did not perceive any risks of eruption of the lake although District officials commented on the potential hazard.
- The project was perceived as generating jobs although there were fears that local people would not be employed because of lack of technical skills.
- Some concern was expressed regarding potential increases in HIV/AIDs due to an influx of single male workers.

Unfortunately the GCS EIA did not address the impacts on local communities in any detail and further consultation was considered necessary.

During the SKM ESIA additional consultation was undertaken with fishermen and with the displaced farmers.

Finally, a two day public consultation for the local community and other interested parties was held in Kibuye in August 2009. The report on consultation and the workshop is appended in full and summarised here.

Day 1 was an informal event designed so as to allow informal face to face discussions in small groups using plans and maps whereas day 2 was more formal with technical presentations by the project team and speeches by national and local dignitaries including the Minister for Water Mines and Environment and the Mayor of the Province.

The outcome of the two days of discussion is presented in Table 17.

Table 17 Informal discussion topics

Discussion topic	Questions/concerns raised	Project team response
The team showed the layout of the onshore and off-shore activities and explained that there would be 500m exclusion zones around the GEFs, the re-injection areas and the Power Plant itself. Between the GEFs and the plant the gas transfer pipeline would be submerged floating at a depth of 20m. These exclusion zones were for safety reasons and also for protection of the pipeline where this was at a shallower depth, i.e. where it came ashore at the Power Plant and where it originated at the GEFs.	What restrictions would be placed on local fishermen working in proximity to the GEFs and the Power Plant? Nets were sometimes cast at depths lower than 20m, so how could the pipeline be avoided? At times of high winds on the lake it is difficult to prevent boats blowing across the pipelines as they are rowed. Could the company provide outboard motors so that the boats could move quickly How would safety of the fishermen be ensured? Could the pipeline either leak methane or blow up because of the methane?	No boats would be allowed within the exclusion zones but boats would be allowed to cross the pipeline. There would be buoys and lights along the length of the pipeline for 250m either side of the pipeline so that the fishermen would be aware of the location and could therefore avoid dropping nets over the line. It may be possible to locate the pipeline at a lower depth. This to be confirmed. There are no plans to provide outboard motors. There will be alarms and safety systems in place that will automatically shut off the gas flow in the event that a problem is detected. The gas extraction facilities also have fire protection systems.

Question	Response
Are there tangible safety measures in place in case of accidents?	There are shut down safety systems currently designed into the existing gas extraction process that in the event of a sudden change in gas mixture, the process would be shut down. There is similar monitoring instrumentation in the gas processing systems that will also assure the changes in processed gas quality are also addressed in a safe mode. There are also fire safety systems and automatic warning systems built in. Potential risks associated with gas extraction and possible effects on the lake in the event of a pipe break or rupture or gas outburst below the biozone and the need for mitigation of any effects have also been addressed. ContourGlobal KivuWatt Ltd has undertaken hazard analyses (HAZOP[11]) and is in the process of undertaking a hydrological model (and of course the HAZOP which explored such risks as the failure or leak in the riser or leak in the gas export pipeline), will also address such issues. Finally, an Emergency Response Plan (ERP) to deal with any accidents should they occur will be prepared prior to any work starting on the gas extraction.
With the implementation of the project it appears that the fishing zone will be reduced. Is there any plan to help local fishermen to face new challenges, e.g. moving their activities to other fishing ground, provision of engines for boats, nets etc?	We do not anticipate that the exclusion zones will impact on catches due to the fact that the exclusion zones are only for 500m around the GEFs, the re-injection areas and the Power Plant site. Boats will be able to cross the pipelines as these will be submerged 20m below the surface although there may be restrictions on deep nets above the pipelines. In any event we will be monitoring catches to ensure that there are no adverse effects.
Have you put in place a sound resettlement plan?	We are in the process of preparing a plan for the farmers that were economically displaced from the Marine Landing Site (MLS). The farmers have been compensated in accordance with Rwandan law but we are looking at other means of restoring any lost livelihood as a result of the project. We have recently completed a survey of the effect on the famers and will be holding further discussions to establish the best means of dealing with any effects.
What will be the environmental impact of the plant for people living 2km from the plant?	There will be no adverse impacts although there will be direct or indirect economic benefits due to job creation and boost to the local economy.
Is there any capacity building plan specifically for women?	There is no plan as such but ContouGlobal KivuWatt is an equal opportunities employer and will be recruiting both men and women. Recruitment will be based solely on skills, aptitude and irrespective of gender. The company will also provide training so that the majority of the jobs on the project will eventually be staffed by locals whether men or women
Will it be possible for boats to pass over the submerged pipelines?	Yes except for where the pipelines come into shallower water close to the GEFs and the Power Plant where there will be exclusion zones of 500m
What will be the benefit of the project to the rural population?	The project will benefit the local economy both directly and indirectly. We have not calculated the economic effects but they will clearly be significant as there will be provision of jobs and the opportunity for provision of

[11] This modelling has since been completed.

Question	Response
	contracts and services to local businesses both during the construction Phase of the project and when the plant is operational. We project that there will be approximately 200 personnel hired during the construction period and approximately 100 persons hired over the course of the operations of the plant.
Lake Kivu is owned jointly by Rwanda and DRC. How will you manage to only extract the gas from within the Rwanda Borders?	State Minister for Mines and Natural Resources, Vincent Karega, advised that Rwanda and the Democratic Republic of Congo have equal shares of the methane gas. Mr Karega said that the project would not be compromised since the lake is shared by the two countries. He said that agreements have been reached to rectify such misunderstandings should they arise. "*The lake has a known quantity of the amount of gas and 50% of it belongs to Rwanda. We shall utilize it in such a way that we do not encroach on the other country's share,*"
What is the speed of the gas in the pipeline from the GEFs to the on-shore plant?	The gas in the pipe is normally measured in pressure rather than speed which is a more accurate indication of what will be in the pipeline for safety and operation purposes. The pipeline will operate at 20.68 barg @ 65.5C (300 psig & 150F) a flow approximately 8.04 million standard cubic feet of gas per day leaving the GEF.
How will you manage the process of returning the wash water to the lake without negative impact to the biozone?	We are undertaking a modelling study that looks at the effects of the abstraction and the re-injection and will use the results of this to ensure that there are no impacts on lake stability or the biozone. We will also be undertaking water quality monitoring and will of course comply with the Mandatory Guidelines and Prescriptions that have been prepared by the Government of Rwanda and international experts for the protection of the lake.
Do you think the project will change the local culture of using wood and charcoal for energy especially in Kibuye?	We hope that by providing a reliable supply of electricity at a lower cost than currently available there will be a decrease in use of wood and charcoal.

Questionnaires were also distributed and over 200 responses were received from a total number of almost 300 attendees so the consultation workshop allowed ContourGlobal KivuWatt Ltd to provide information to and obtain information from a large number of stakeholders. Analyses of the responses received show that there is overwhelming support for the project and high expectations that the project will provide tangible benefits in the form of job provision, electricity supply and economic and community development.

There were concerns regarding the potential negative impacts of the project including effects on farmers, fishermen and lake transport and the need to ensure environmental protection. The numbers of respondents expressing these views were comparatively small if expressed as a percentage of all comments. However it may be that larger numbers hold this view but were unable to complete the questionnaires due to the generally low levels of literacy. Most of the comments came from the large fishing community and only a small number of farmers responded none of whom were from farmers from the MLS.

There are factors that will have to be monitored to ensure that the predictions made by the project team in respect of mitigation of social and environmental effects are correct and continue to be so. These will be further developed and will also form part of the Environmental Management & Mitigation Plan and future community consultations and comments made during the workshop will be factored into these and also into design development for the project.

The principal actions to be taken as a result of this exercise are as follows:

- Development of the EMMP.
- Continued consultation in respect of farmers and development of the Resettlement Action Plan (RAP).
- The establishment of a grievance mechanism in the event of complaints.
- Development of a policy and programme for dealing with HIV/AIDS.
- Input into design factors, for example the depth of and the marking systems for the pipelines.
- The establishment of training programmes for local workers.

The results of this consultation have been used to assess impacts on two groups in particular, the fishermen and the farmers, and to prepare appropriate mitigation measures. These are discussed in the relevant sections of the report.

8.6.1. Grievance mechanism

A grievance mechanism will be established as part of the project community consultation programme. Company and community stakeholders will be involved in the design of the programme which is intended to:

- Build trust with local communities.
- Provide a credible process for consultation leading to fair and lasting results.
- Identify and proactively manage emerging issues.

Specific issues to be addressed in the programme will include:

- Effects on the weekly market close to the MLS during construction works.
- Preparation and implementation of a resettlement action plan (RAP) for the economically displaced farmers.
- Updates on project development.
- Development of an HIV/AIDS policy and programme.

The programme will apply to both construction and operational activities.

8.6.2. Communications

A communications programme will be established for both local and external stakeholders.

9. Fisheries

9.1. Baseline

Of the current socio-economic uses of the lake the most prominent is fishing although it is no doubt used extensively for water and washing by the riparian population. The earliest surveys of the lake fisheries estimated a catch of around 300 Mt per year. Since then, however, a small freshwater herring, *Limnothrissa miodon*, from Lake Tanganyika was introduced around 1960. This was first noted in the fishery in 1976. Now the catch of this species is reported to be around 3,000 Mt per year with catches of all other species amounting to around an additional 300 Mt. The reason that *Limnothrissa* has made such a big contribution is because it is an open water pelagic species which feeds on phyto- and zoo- plankton and so can use the primary and secondary production of the lake directly whilst all the other species are essentially bottom or shallow water species. The products of this very important fishery are all marketed within Rwanda and constitute an extremely important source of high grade animal protein to the poorest of the country. Various donors have supported this sector and the socio-economic benefits have been surveyed in the past by FAO.

With respect to fish farming, it is still widely underdeveloped around the coastal areas of the Lake. However, the government has recently proposed a development plan for this sector but it has yet to come to fruition. Nonetheless, it is expected that this will be an important industrial sector in the coming years.

The fisheries sector in the Karongi district and in Kibuye in particular, is considerably well organized as fishermen have formed cooperatives and associations. These organisations facilitate the communication between its members and with the authorities. Indeed during the consultation process their existence greatly helped establishing contact with all the relevant stakeholders.

According to MINAGRI's records (the governmental body responsible for the management of the lake's fisheries), in the district of Karongi there are currently 104 registered fishing boats. Boat owners generally join one of the five existing fishing cooperatives (Table 18).

Table 18 Fishing Cooperatives in Karongi District.

Cooperative	Number of boats	Membership
Baraka	6 canoes and 18 dugouts	31 and 6
Twuzuzanye	12 canoes	78
Abizera	12 canoes	46
Ubumwenyarwanda	6 canoes and 44 dugouts	58 and 88
Terimbere	6 canoes	46

The role of these cooperatives is not only to unite efforts regarding the fishing activities (e.g. group fishing) but also to provide help to individual members for tasks such as house construction, helping to sell the catch, looking after young children, etc. No information as to when this data was last updated was obtained. The census was carried out under the scope of the Kibuye fisheries project and is thought to be nearly 3 years old. As such and given the possibility that some changes in the fleet might have occurred during this period of time, it is not possible to be precise about the total current number of both fishermen and members of each of the cooperatives operating in the Karongi district.

During the visit to Kibuye, it was clear that great importance was given to the role of the cooperatives. Indeed it was noted that the work carried out under the scope of these associations greatly contributed to group cohesion within the fishing communities. It is important to highlight the positive impact of these organizations in the community development and stability. Anecdotal accounts of collaboration between cooperatives were also obtained yet it was not clear if this was a common practice or a sporadic collaboration.

Joining a cooperative is a standard practice for anyone who enters the fishery, and if a group of people rather than an individual consider entering the fishery it is also common for them to form a new cooperative instead of joining an existing one. In fact, this was the case of the most recently formed cooperative in the Karongi district. It was however, not possible to ascertain how many fishermen and respective boats will take part in this cooperative, equally it was not possible to find out where the cooperative will be based.

The enforcement capabilities of the fisheries authorities are extremely limited in terms of both human and physical means. The agents not only have difficulty in reaching the more remote landing sites but also lack motivation to fulfil the tasks inherent to their jobs, mostly due to the low salaries they receive. It is also important to mention the conflict of interest between their activities as governmental agents and their active participation in the industry for their own benefit. It is not uncommon for a fisheries inspector to work for/with fishermen in order to supplement their monthly income with the salary paid by a boat owner.

Presently there are a total of 353 registered fishermen in the above mentioned cooperatives. From all the members, 94 operate small fishing boats, generally dugouts (see Figure 26), and the remainder operate the larger fishing boats (canoes Figure 27). Fishermen in the dugouts operate close to shore, use gillnets and their most valuable catch is tilapia. Fishermen on the larger boats on the other hand operate offshore, using large purse seine nets to catch isambaza or freshwater

herring (*Limnothrissa miodon*), their main and most valuable catch. Isambaza is caught at night using light to attract the fish shoals to the boats.

Fishermen using the dugouts (2 people per boat) operate from sunrise to around midday whereas the fishermen in the canoes (10 – 12 people per canoe) start the fishing operation at around 18:00 hours and return to shore early in the morning after sunrise.

The monthly average income of an individual fisherman is around $25 USD (or approximately 15,000 RWF). The majority of the landings take place in the morning so that the catch can be taken to the markets and sold on the same day (see Figure 28). Fish is generally transported in plastic bowls. No ice and/or appropriate boxes for fish transport were seen to be used, thus a certain degree of losses during handling are expected.

Generally, fish which is not sold is processed, i.e. frozen or sun dried. Often the least valuable dried fish species are ground and transformed into fish meal. Dried isambaza, on the other hand, is sold directly for human consumption. The fish can be processed by the fishermen themselves (sun-drying) or by the auction company (where fish is deboned, packed into 500g boxes and frozen). The majority of the frozen isambaza is taken to Kigali and sold there at a premium price. It was estimated that around 15% of the total landings of isambaza are taken to away to Gitarama and Kigali.

A large share of all isambaza caught within and around the areas where the project will be implemented is landed in Kibuye most likely because the city has good road accesses to other major cities in the country. The annual catch of isambaza around Kibuye (from the canoes only) was estimated at around 370 Mt per year. These estimates were calculated considering an average catch of 35kg per fishing trip per canoe. These estimates were based on both the data obtained locally (individual monthly sales obtained from the auction facilities) and on observed individual fishing capability (direct observation and assessment; including consultation with individual fishermen, assessment of fishing gear, number of people involved in fishing operations, number of fish boxes on board, etc.). Each canoe does 24 fishing trips per month and the whole fleet comprises 36 canoes (registered boats only). The first sale value of this catch equates to just under $800,000 USD p.a. or approximately $22,200 USD / canoe p.a. (at a market price of $2.15 USD/kg or 1,200 RWF/kg). In addition to this there is also the value of all other species caught, yet they are worth considerably less. Their total value is roughly 10 - 15% of that of the first sale of isambaza. This is firstly because the quantities caught are considerably smaller relative to the quantities of isambaza and secondly because the value of all other species is generally lower. This reinforces the

importance of isambaza not only because it is a good source of high-quality protein but also because it is the most significant source of income.

It is important to note that the management of the fisheries in Lake Kivu is still under development, and this is one reason why there is a scarcity of unreliable information concerning catches and landings at the various locations around the lake at the present time. Indeed, the current fisheries monitoring effort is not robust enough to provide accurate data to the fisheries management authorities. As a result, estimates of total annual catches have been produced based on poorly defined data sources. Problems such as the fisheries agents often being in a position of conflict of interest do not contribute to improving the situation.

Moreover, it was not possible to obtain data on historical landings in order to provide a trend in catches for the most recent years. Most of the existing information was outdated, i.e. pre-1998. After the genocide (1994) no records of catches were kept until recently. We have had access (visual) of landing estimates at MINAGRI; yet again these were of very limited use as they refer to a period (2000-2005) when the fishing fleet in the Kibuye area was significantly smaller than it is today.

Emphasis must be given to the fact that in Kibuye, fish sales are fishermen's only source of income. Even though some fishermen possess small patches of cultivated land, they tend not to sell the products they grow; agriculture is carried out for subsistence only. Moreover, fishermen do not generally take part in this activity; all agriculture related tasks are typically carried out by their wives, children and extended family. During the consultation it was possible to sample the number of members in the families of the fishermen who attended the meeting. They were asked how many people there were in their households whose livelihoods they supported. The majority of the fishermen's families constituted four or more members, and nearly half of the households had nine or more people (including extended family members).

In Kibuye there are problems regarding food security as the local agricultural production is not sufficient to cover overall consumption; this is confirmed by the amount of goods being imported into Kibuye mostly by boat (see the lake transportation section). Furthermore, the increase in agriculture production has been outpaced by the increase in population size, especially during the last decade. This factor contributes to emphasising the importance of the fisheries sector in Kibuye as it provides the population with high-grade animal protein. It is worth mentioning that fresh fish is an expensive commodity which is certainly not afforded by everyone, nonetheless, processed fish is comparatively cheaper and therefore more easily afforded by the poorer segment of the population.

Per capita fish consumption in Rwanda is amongst the lowest in the rifts region, previous studies have estimated fish consumption to be in the order of 1.5 kg/person p.a. In Kibuye fish consumption is higher as fish is more readily available, yet no accurate estimates were obtained. Fish products are sold in the market in Kibuye and by fishmongers around the village. Substantial losses in product value are believed to occur as a result of the poor handling of the fish, especially given the relatively high temperatures observed in Kibuye.

Among the fishermen who were interviewed only a small number had ever used banking credit to fund their professional activities. It seems that this mechanism is still not well publicised in this part of the country. The few people that took advantage of the credit system did it through a standard commercial bank and committed to payback the loans the traditional way, i.e. with a scheduled loan payback scheme. It is important to note that this group of people is more exposed to any risks associated to potential problems with the fisheries as not only would this impact their livelihoods but would also render them unable to pay back the loans.

The boat building industry is also connected with fishing. The results of the survey have shown that that it takes three people one and a half to two weeks to build a single canoe whereas a dugout takes one person the maximum of one week to build it. It was not possible to obtain clear information into the exact number of shipyards currently operating in Kibuye, mainly because some fishermen who are also skilled carpenters often carry out repairs and maintenance work on the boats. There is however indication that there are two main boatyards operating all year round fully dedicated to boat construction and maintenance. The maintenance of the local fishing fleet is carried out in Kibuye.

In terms of fisheries management, the government has established a series of rules and regulations as a means of contributing towards the sustainability of the lake's fisheries resources. It was observed, however, that the enforcement of some of these rules was considerably weak, mainly resulting from the lack of physical means to carrying it out. Significant weaknesses were also detected in the landings control system, i.e. the inability to collect information on the location and quantities landed. With respect to fisheries technical management measures, e.g. minimum mesh size, they are generally respected.

As part of the government's role in the fisheries management, it granted a license for the implementation of an auction facility in Kibuye. The main purpose of the auction company is to centralise fish landings in Kibuye and surrounding areas. It is known that the auction facilities currently absorb a good share of all fish landed yet it was not possible to obtain an accurate estimate of the total landings.

The existence of an auction facility in Kibuye is important as fishermen are given the possibility to sell the whole of their catch; especially taking into account that isambaza is caught in quantities that are not always absorbed solely by the local market. At these facilities there are both work force and capabilities for processing fish which was not sold to the public by drying or freezing. Easy access to these facilities at all times is therefore crucial so that fishermen can land their catches and minimize losses.

In summary, it is possible to say that Kibuye's local economy is greatly dependent on the lake's activities, namely fisheries and lake transportation. It was however not possible, from either the literature review or the data collected during site visits to obtain a wholly accurate estimate of the relative contribution of these activities into the local economy.

9.2. Impacts

9.2.1. Construction Phase

9.2.1.1. Near shore Affects

This concerns the construction of the support facilities such as the Marine Landing Site (MLS) and construction of the GEF and other equipment used for the extraction of methane.

The likely impacts during the construction of the MLS will result from the large movements of earth and the dispersion of sediments into the lake near shore waters, especially during the construction of the slipway. The construction activities will give rise to an increase in turbidity around the construction area which could ultimately have an impact on the near shore ecosystem. Due to the fact that there are no strong currents in the lake, it is believed that the suspended particulate material (SPM) will settle at a relatively fast rate hence most of it will be cleared shortly after all construction works finish. In light of this, the impact is expected to be limited both in time and extent.

In terms of potentially affecting commercially important species it is thought that tilapia could suffer the most given that it generally nests in near shore locations. There has been no modelling exercise undertaken to determine how the sediment will behave and although this is likely to be a localised impact, with minor effects in the broad context of the lake fishery, precautionary measures are recommended.

The predicted impacts associated with construction works are also significantly circumscribed to the near shore area surrounding the MLS. These impacts will consist mainly of potential spills of

products used during the assembly of the GEFs or any other structures/equipment. It will be necessary that anti-spill policy and disposal rules are implemented.

9.2.1.2. Offshore Affects

This concerns the anchoring of the GEFs in deep water and accidental damage to the lake bottom from falling debris.

The Expert Committee (2006) noted that *moderate*, *local eruption* can be triggered by accidents such as dropping an anchor or other heavy objects into the bottom sediment which could produce a localized gas release. This is turn could produce a localised fish kill if the gases were allowed to escape into the biozone. It is intended to conduct a lake bed survey in advance of placing the anchors so that particularly sensitive areas of the lake bed can be avoided e.g. CO_2 vents. In addition, the anchors will be tested prior to final placement (for further discussion see section 7.2.3). These measures are in themselves sufficient mitigation to prevent accidental release of gases to the biozone.

9.2.2. Operational Phase

It is important that no potentially hazardous products spreads throughout the biozone, namely those resulting from the extraction of the methane dissolved in the deep waters of the lake. The biozone is a thin layer relative to the total depth of Lake Kivu, with only the top 40m able to support the already limited fish biodiversity. A systematic contamination of this layer would have a devastating effect in the fisheries resources, firstly because their primary food sources (phyto and zooplankton) would be affected as they are extremely sensitive to environmental changes (e.g. changes in pH), and secondly because fish species could themselves be affected by the toxicity of these products.

One of the potential impacts resulting directly from the methane extraction operation is the decrease in the pH in the biozone which would lead to changing the solubility of the reactive silicon in the surface waters, ultimately changing its concentration thus its availability for used by the diatoms (e.g. Uroselenia sp.) which are the dominant phytoplankton species in the biozone. Diatoms are nutrient rich species and are crucially important in the diet of zooplankton which forms the basis of the diet of many of the lake's species including *L. miodon*. The impact of nutrient fluxes into the biozone would be to increase biological productivity, which may also be of benefit to the fisheries in the lake. Such increases in productivity were observed in Lakes Nyos and Manoun when nutrient rich bottom water was released at the lake surface by the degassing pipes. In the current design the nutrients from the degassed water will be released back to the resource zone 355 m below the lake surface and so should not mix with the surface waters. This situation should

be distinguished from the strong nutrient enrichment (eutrophication) that would result if large quantities of bottom water were released directly within the biozone at the lake surface but as the degassed water will be returned to the upper resources zone at -270m there will be no effect of additional nutrients in the biozone.

L. miodon, the most important commercial species, is considerably robust and adaptable to changes in environmental conditions however it is not known to occur in lakes with acidic waters (Sarmento *et al.*, 2006). It is still uncertain whether there will be acidification of the biozone due to seasonal mixing (H_2S rich water brought from the wash water discharge zone to the surface), although the modelling suggests that any effect could be extremely localised. Given that the mixing during the long dry season often extends down to 70m (10 m deeper than the depth of the re-injection of the wash water), mixing in certain periods could be sufficient to oxidise and disperse the H_2S. However this may mean that localised oxygen depletion and acidification will be a short term effect until the upper water layers can re-oxygenate (from the air) and the normal buffeting capacity of the lake (which is considerable) negates any effects of increased acidity.

Ecological impact would be greater if the stratification of the lake was broken and if large scale mixing occurred between the biozone and the adjacent layer. However the results of the modelling show that the wash water discharge does not have any impact on the density layers in the lake so this event is unlikely to occur.

A potential rupture in the gas riser pipeline system could also impact the ecosystem if the flow of deep resource water is not contained shortly after the rupture. Should this not happen, the methane rich water could contaminate the biozone. However the design mitigates this through the inclusion of a double walled pipe and detection system that will seal the delivery system in the event of a rupture in the inner pipe thus restricting discharge to the amount of gas in the pipeline at any one time and this is a very small volume of around $172m^3$. This volume would not present a major threat as defined by the Expert Committee (2006).

Should the gas riser rupture occur below -180m the gases will still be in solution and so would be isolated in the upper resource zone. Again this does not represent a risk.

A summary of the potential receivers and stressors is given in Table 19:

- **Table 19 Summary of Potential Impacts on the Aquatic Ecology in the absence of mitigation.**

Potential impacts				
Stressors	**Effect**	**Plankton**	**Commercial fish species**	**Biodiversity**
H_2S and CO_2	Contribute to acidification of waste	Medium effect Potential change in structure of planktonic community	Medium effect Reduction in abundance and shift in location of shoals	Medium effect Localised reduction of biodiversity
Ammonia, iron and phosphates	Contribute to the eutrophication of the water column and potential toxicity to the local biodiversity	No effect – deep water re-injection	No effect – deep water re-injection	No effect – deep water re-injection
Chemical products fuel and lubricants	Pollutants and contaminants	Low effect Localised effect on the planktonic community due to contamination	Low effect Potential contamination of commercial fish species. Could affect reproduction of fish in the areas surrounding the GEFs	Low effect Localised impact if contaminants remain circumscribed in the area around the GEFs

Another potential impact is that brought by the use of other chemical products and waste (e.g. degreasing agents, hydraulic fluid, detergents, fuels and additives, sewage treatment chemicals, etc.) created during the implementation and operation Phases. Extreme care has to be taken to ensure that no hazardous chemicals (used during the operation of the GEFs) come into contact with the biozone.

Another type of impact is the physical impact. It is possible that a large number of fish could gather around the extraction GEFs as most species get attracted to light. Given that there will be exclusion zones around the GEFs (i.e. no fishing will be permitted) this could potentially mean that fish would be more concentrated in these areas and the GEFs would effectively act as or Fish Attracting Devices (FADs). The overall effects of this impact have to be further investigated to know if the light will somehow affect the dynamics of the fish populations. This could also have a significant human impact as fishermen could see their catches reduced due to the lower availability of the fish in surrounding areas. Equally, the presence of light sources along the pipelines should

also be considered as potentially having an impact on the distribution of fish. Conversely, because these areas will be exclusion zones it may be that the artificial structures provide positive benefits acting as pockets of conservation.

Noise and vibration may also be considered stressors to which fish could potentially be sensitive. Similarly an artificial magnetic field may also impact the ecosystem dynamics. Further investigation should be carried out into this issue in order to quantify the potential overall effects.

9.2.3. Decommissioning

During the decommissioning Phase significant impacts are not expected. Care should be taken to ensure that there will be no leakages of accumulated waste products in the GEFs. The disassembling of the various extraction components should also be carried out in a way that potential impacts are minimised and wherever possible done on land in where contaminants can be fully contained. Table 20 summarises the significance of impacts.

Table 20 Summary of potential impacts on fisheries in the absence of mitigation

Summary of Impact	Construction	Operation	Decommissioning	Mitigation Needed
Effects on lake water quality	Minor	Major	Minor	√
Eutrophication	-	Major	Negligible	X
Access to fishing grounds	negligible	Major	Negligible	X

9.3. Mitigation

9.3.1. Construction Phase

9.3.1.1. Near shore Effects

During the construction Phases measures will be taken to ensure that there are no spills of chemicals into the lake's waters. Treatment of all residual products needs to be considered and international regulations for waste disposal applied. The potential spread of sediment from run-off from the MLS into the lake will be mitigated by using silt curtains and by ensuring that works on the shore (e.g. construction of the slipway) are carried over the shortest possible period and during the season with the lowest winds to avoid further spreading of the sediment. A small impact on the lake's bottom in the areas surrounding the MLS is expected. This impact will however be minor.

Monitoring of the level of turbidity in specific locations around the MLS will be carried out during the construction Phases.

9.3.1.2. Offshore Effects

The only predicted impact concerns the possible destabilisation of the lake floor through the placement of the anchors attaching the floating gas GEFs. In order to comply with the Mandatory Guidelines guideline G8 requires that safety precautions will be taken during the construction (and operation) to cater for the risk of rising bubbles from the sediments on the lake bottom in case of:

- Anything heavy such as an extraction pipe being dropped to the bottom;
- Placing of anchors for floating facilities;
- Underwater sediment slides or similar causes of spontaneous release of gas bubbles.
- Therefore, in order to minimise the risk of destabilisation of the lake floor a detailed lake bed survey to determine exact depths and nature of the lake bed in the proposed anchor locations prior to placement of the anchors will be undertaken. This will be done before the anchor systems are placed and this will reduce the possibility of a localised gas release leading to a moderate local eruption. Therefore, the risk will be reduced to negligible.

9.3.2. Operational Phase

Clearly the main impacts identified in the operational Phase are directly linked to the lake stability issues and the potential contamination of the biozone from escaping gases from either the raw water riser or the wash water. Should the biozone become contaminated there could be resultant impacts on the aquatic ecology.

The discussion on mitigation measures concerning the physical and chemical properties of the lake also apply in terms of the biological function because these three aspects are intimately linked. Therefore the points raised in section 7 apply equally in this context and only those issues specifically associated with the fishery are discussed further below with specific reference to the Mandatory Guidelines which have encapsulated mitigating measures. These are mandatory requirements and so must be respected in the design and operation of the plant. The assumptions made by the Expert Committee have been incorporated into this assessment; therefore the point of the assessment is to ensure that the design of the plant conforms to the Mandatory Guidelines.

- **MTR8:** Methane gas produced offshore must not be transported to the shore in a way that might affect the surface use of the lake, or risk a gas outburst below the biozone. Gas export

pipelines must be located between 10m and 40m depth. In the current design the gas is exported to the mainland via a floating pipeline weighted to remain at 20m depth. Any rupture of the pipe would release pure methane that would bubble to the surface but, given its low solubility, the effect on the aquatic system should not be great. Moreover the operation has automatic shutdown systems if a leak is detected. Operating procedures will call for an inspection of the pipeline on a weekly basis as a minimum and most likely crews coming to the GEF will actually monitoring the pipeline along its route to spot for leaks. Furthermore the supply from the barge and the receipt of gas at the other end will be compared to determine and losses. This complies with the Mandatory Guidelines, and will not affect surface use of the waters by fishermen, but some concern has been expressed by the local fishing communities that this may prevent them deploying certain types of fishing gear in the vicinity of the export pipelines. As such it may be possible to increase the depth of the export pipeline to avoid potential conflict. However, this will only be considered if a true conflict can be demonstrated and it does not affect the transportation of gas. Alternatively fishing activities could be prevented from taking place close to the pipelines, especially because some fishermen are known to use anchors during the windy season as they need to maintain their position to optimize the fishing operation. A 150m buffer zone each side of the pipe where no fishing could be carried out, as proposed in the project design, is a reasonable solution.

- In addition there is still some uncertainty concerning the oxidation of the H_2S in the wash water discharge. The low oxygen content of these waters could lead to a build up of H_2S as all the available oxygen is consumed in oxidation. The remaining H_2S may be elevated into the upper biozone during periods of wind induced mixing. This could lead to fish deaths in the local vicinity. Although this is likely to occur within the exclusion zone this still represents a loss of valuable fish stocks but the impact cannot be quantified and therefore remains a risk.

Handling of consumables used in the operation of the GEFs such oil for the hydraulics, fuel, cleaning products, degreasing agents will be subject to specific procedures, including response plans, to ensure that their use is managed in way that no contamination may possibly occur.

It is anticipated that light sources in the GEFs will have an effect on the distribution of fish in the surrounding areas, although it is not certain whether this would be a positive or negative effect. One of the ways of mitigating the potential effects of the light emitted by the GEFs would be to place them in a fashion such that little light would hit the surface of the lake. This would involve detailed planning and design of the illumination scheme for the GEFs. Similarly the light signalling along the pipelines should only emit light upwards from an angle not smaller than 3º relative to the surface of the lake.

Monitoring the behaviour of fish shoals around the GEFs would be advisable. This could be done by using high frequency echo-sounders which are readily available in the market and relatively easy to operate. It will be necessary, however, for the echo-sounding equipment to be fitted with a data recording device for subsequent analysis of the data. The monitoring should be carried out several times during the year to cover all seasons and weather conditions. Also during operation continuous monitoring of the coastal area surrounding the MLS will be carried out, including turbidity and the presence of potential pollutants and this will be included in the EMMP.

9.3.3. Decommissioning

During the decommissioning Phase, a comprehensive assessment of the all the potentially hazardous substances on board the GEFs will be carried out prior to disposal. Most of the decommissioning operations which involve dealing with chemical waste and accumulated residual substances should be dealt with in land where they could be easily contained in case of spillage.

No further impacts on the fisheries and fisheries operations are predicted.

9.3.4. Residual Impacts

Everything possible will be done during the project to minimize the probability of major impacts, but the risks cannot be entirely eliminated. However, provided that the mitigation measures are adopted there should only be a minor residual impact associated with the fisheries in relation to the potential accumulation of H_2S in the biozone. This is addressed in the EMMP.

10. Environmental Quality

Environmental quality is assessed in respect of air, noise, soil, water and waste management.

10.1. Air Quality for the Power Plant

The emissions on-shore from the Power Plant and off-shore from the GEFs are presented separately in 10.1.1 and 10.1.2 respectively.

Section 10.1.3 considers potential trans-boundary issues. These issues are included here as they are considered to be most relevant in respect of air quality.

10.1.1. Baseline

The proposed Power Plant is to be located upon a small peninsular of land on the west coast of Lake Kivu. The site is elevated above the lake – see section 5.3 for site context. Outside the immediate site boundary, and away from the lake, the site slopes steeply upwards; this is typical of the wider area, which is characterised by relatively steeply sided, moderately densely vegetated hills and valleys rising from the lake.

There are no known major industrial sources of emissions to air in the area likely to be significantly affected by the emissions from the Power Plant (the air shed). There are, however, plans to further develop the area surrounding KivuWatt into an industrial area.

There is little information available on background air quality however on site observations indicate that air quality standards are currently good.

The closest residential receptor is approximately 450 m southeast of the Power Plant. The Power Plant itself is located in an industrial zone.

10.1.2. Potential Impacts

This section presents an assessment of the impacts to air quality arising from emissions from the operation of the proposed Power Plant. Specifically these will be oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and particulate matter (PM). The predicted impacts are assessed against impact assessment criteria for the protection of human health.

Emissions of dust will also occur during the construction and decommissioning periods; however this pollutant has been screened out from detailed assessment. This is due to:

- The relatively short term nature of the construction period (relative to the operation of the Power Plant).

- The high rainfall associated with the area which will act to minimise any dust emitted and reduce the transport of that which is emitted.
- Deposition of any emitted dust being very close to the source (generally less than 200 m).
- Mitigation measures consistent with good practice for construction and decommissioning.

Incremental impact of emissions from the stacks associated with Phase I and Phase II of the development are assessed in respect of NO_x, SO_2 and particulate matter (PM). Emission concentrations for these have been provided to SKM by the proposed engine manufacturer. Consequently we have modelled all three although it is unlikely that SO_2 and PM will be emitted in more than negligible quantities from the combustion of methane/natural gas.

Other pollutants will also be released; however it is judged by SKM that the quantities of these will be insignificant, relative to any ground level impact assessment criteria for the protection of human health. The definition of significance for each pollutant is defined below.

Given the absence of any guidelines or impact assessment criteria specific to Rwanda and also the requirement in the Concession Agreement to comply with IFC standards, the following have been followed for this assessment:

- IFC Environmental, Health and Safety Guidelines for Thermal Power Plants. (2008).
- IFC Environmental, Health and Safety Guidelines. General EHS Guidelines: Environmental. Air Emissions and Ambient Air Quality (2007).
- World Health Organisation, WHO air quality guidelines global updated 2005.

No known existing ambient air quality data exists in the area and therefore defining the baseline environmental conditions in the context of air quality is not straightforward. Incremental concentrations are therefore discussed relative to concentrations likely to be experienced, as judged by SKM from the available data.

Atmospheric dispersion modelling (see Appendix I) has been performed to identify the potential impact during the operation of the Power Plant. This is consistent with the requirements of IFC guidelines which require projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, to prevent or minimise impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines or other internationally recognised sources.

- Emissions do not contribute a significant portion to the attainment of relevant air quality guidelines or standards. As a general rule, the Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.

Significant sources of air emissions are defined in IFC guidance as 50 tons per year for PM, 500 tons[12] per year for NO_x and 500 tons per year for SO_2. Based on the information provided to SKM by the engine manufacturer, during Phase II of operation the Power Plant will emit 1,418 tons per proposed year of NO_x, 500 tons per year of SO_2 and 83 tons per year of PM. These exceed the significance criteria for all three pollutants and therefore were further assessed through dispersion modelling. Modelled concentrations were then compared with IFC guidance and also with WHO Ambient Air Quality Guidelines for the protection of human health to determine impacts.

The final stage of the assessment process considers the necessity for additional mitigating measures to be adopted and the resulting residual air quality impact.

WHO Ambient Air Quality Guidelines for the pollutants assessed are replicated in Table 21. The significance of the impact is assessed relative to the 25 per cent assessment criteria.

Table 21 Applicable IFC and WHO Ambient Air Quality Guidelines (WHO 2005)

Pollutant	Averaging period	Guideline value (in µg/m^3)
Sulphur dioxide	24 hour	125
	10 mins	500
Nitrogen dioxide	1 year	40
	1 hour	200
Particulate matter PM_{10}	1 year	20
	24 hour (99th percentile)	50
$PM_{2.5}$	1 year	10
	24 hour (99th percentile)	25

[12] Note: all measurements here are as the guidance which uses imperial tons.

10.1.2.1. Construction

Construction of the proposed Power Plant has the potential to impact on local air quality through the generation and deposition of dust. As with any construction site, dust may be generated as a result of surface preparation and earthworks including earth moving and materials handling. Internal site traffic moving on un-metalled roads within the development site may cause sufficient mechanical disturbance of loose surface materials to generate dust during prolonged periods of dry weather. The proposed development includes the following main components which may generate dust:

- Preparatory earthworks to allow the construction of the development
- The construction of the main components of the Power Plant.
- Vehicle movements at the construction site.

Dust has been screened out from detailed modelling due to:

- The relatively short term nature of the construction period (relative to the operation of the Power Plant).
- The high rainfall associated with the area which will act to minimise any dust emitted and reduce the transport of that which is emitted.
- Deposition of any emitted dust being close to the source (generally less than 200 m).
- The assumption that any construction traffic travelling to the site using sealed roads, or alternatively, unsealed roads greater than 200 m from any human receptor (residential, commercial etc).

10.1.2.2. Operation

Phase I of the Power Plant will comprise three engines. Phase II will be comprised of an additional nine engines.

It is assumed that traffic associated with the operational Phase will be minimal, arising mainly from the transport of relatively low numbers of staff to the site.

Emissions to air will be from a stack associated with each engine. The pollutants emitted, and other relevant data for each of the engines, as used in the modelling, are presented in Table 22. These are as provided to SKM by the proposed engine manufacturers. Ground level concentrations, following emissions from these sources, are quantified through dispersion modelling, as detailed later in this section. The table also presents the IFC guideline limit for emissions to air for NOx (no IFC guidelines apply for CO, SO_2 or PM).

Table 22 Emission characteristics as modelled, for each engine

Parameter	Units	Value per engine
Stack diameter	M	1.81
Stack height	M	20[1]
Exit velocity	m/s	25
Normalised flow rate[2]	Nm^3/s	17.2
Exhaust temperature	Celsius	346
NO_x emission concentration (IFC guideline)	mg/Nm^3	200
NO_x emission concentration	mg/Nm^3	200
NO_x emission rate	g/s	3.4
CO emission concentration (IFC guideline)	mg/Nm^3	n/a
CO emission concentration	mg/Nm^3	379
CO emission rate	g/s	6.5
SO_2 emission concentration (IFC guideline)	mg/Nm^3	n/a
SO_2 emission concentration	mg/Nm^3	71
SO_2 emission rate	g/s	1.2
PM emission concentration (IFC guideline)	mg/Nm^3	n/a
PM emission concentration[3]	mg/Nm^3	10
PM emission rate	g/s	0.2

Notes:
1) A height of 25m may be adopted.
2) At reference conditions 101 kPa, 0ºC, dry, 15% oxygen
3) No PM_{10} or $PM_{2.5}$ emission rate was made available; as a conservative approach, the PM emission rate was modelled as the PM_{10} and $PM_{2.5}$ emission rate

IFC provide emission guidelines for new thermal Power Plant facilities. The guideline relevant to this project (reciprocating engine, spark ignition) is 200 mg/Nm^3 for NO_x. There are no emission guidelines for other pollutants. This value is identical to the emission concentration provided to SKM by the proposed engine manufacturers and will be the maximum concentration emitted from each engine. As a conservative approach, it is assumed that emissions will occur continuously at this emission limit from each stack.

Tables 23 and 24 show the modelled results for both Phases of operation.

Table 23 Atmospheric Dispersion Modelling Results (Phase I of the Power Plant)

Pollutant	Averaging period	Guideline value (in µg/m^3)	Maximum predicted incremental ground level concentration (µg/m^3)	Predicted concentration as a percentage of the WHO Ambient Air Quality Guidelines (%)	Significance with reference to the 25% IFC 2007 criterion?
Sulphur dioxide	24 hour	125	9.4	7.5	No
	10 minute	500	25.6	5.1	No
Nitrogen dioxide	1 year	40	4.6	11.5	No
	1 hour (50% NO_2 ratio applied)	200	34.9	17.5	No
Particulate matter PM_{10}	1 year	20	0.3	1.5	No
	24 hour (99th percentile)	50	1.6	3.2	No
$PM_{2.5}$	1 year	10	0.3	3.0	No
	24 hour (99th percentile)	25	1.6	6.4	No

Table 24 Atmospheric Dispersion Modelling Results (Phase II of the Power Plant)

Pollutant	Averaging period	Guideline value (in µg/m^3)	Maximum predicted incremental ground level concentration (µg/m^3)	Predicted concentration as a percentage of the WHO Ambient Air Quality Guidelines (%)	Significance with reference to the 25% IFC 2007 criterion
Sulphur dioxide	24 hour	125	26.9	21.5	No
	10 minute	500	110.3	22.1	No
Nitrogen dioxide	1 year	40	13.6	34.0	Yes
	1 hour (50% NO_2 ratio)	200	153.8	76.9	Yes
Particulate matter PM_{10}	1 year	20	0.8	4.0	No
	24 hour (99th percentile)	50	3.9	7.8	No
$PM_{2.5}$	1 year	10	0.8	8.0	No
	24 hour (99th percentile)	25	3.9	15.6	No

■ **Table 38 HAZOP risks, recommendations & solutions**

Phase I

Highest ground level concentrations, relative to the WHO Ambient Air Quality Guidelines, are for NO_2, with incremental concentrations representing 11.5% of the annual and 17.5% of the 1 hour guidelines respectively. However, none of the pollutants emitted during Phase I of the Power Plant exceed the significance criterion of 25% of the guidelines. This indicates that emissions from this Phase of the project are likely to be acceptable and not likely to represent a significant impact.

Phase II

Ground level concentrations as a result of emissions from Phase II of the Power Plant are much higher than for Phase I. This is to be expected, given that there are 12 engines operating rather than 3.

The maximum impacts, with reference to the WHO Ambient Air Quality Guidelines, are (as for Phase I), most significant for nitrogen dioxide. The maximum predicted concentrations caused by the facility are greater than 25% of both the long and short term guideline values for NO_2. However, this is not necessarily at the location of the most affected sensitive receptor.

The maximum annual concentration is predicted to occur 300 m downwind of the stacks. The maximum one hour concentration occurs 170 metres downwind of the stacks. It is noted that the nearest sensitive receptor is approximately 450 m southeast of the plant. However, according to the meteorological data provided, this is not downwind of the plant. The modelling predicts that pollutant concentrations at this location will be less than 25% of the guideline values.

Concentrations are predicted to fall below 25% of the short term guideline value within approximately 500 m of the stacks. It is unlikely that more than approximately 10% of the NO^x in the plume will have been converted to NO_2 at such a short distance from the stacks. Predicted short term NO_2 concentrations are therefore likely to be a significant overestimate.

Terrain and the influence of the adjacent lake have not been taken into account in the modelling. The meteorological data is partly deficient, (as noted in appendix I) . However, there are a number of conservative assumptions included in the modelling that partly negate this. These include all twelve engines emitting at their maximum permitted limit, and a conversion factor of 50% being applied to short term NO_x concentrations.

Background concentrations of NO_2 are likely to be low due to the predominately rural nature of the area.

However, the robustness of the modelling results is limited by the following factors:

- The absence of terrain and lake effects being considered explicitly by the model.

- The absence of any definitive background concentrations of pollutants.
- The lack of significant quantities of reliable/validated meteorological data.

It has been found that the air quality impact of the construction and decommissioning Phases will be small or negligible, assuming the implementation of a range of measures to minimise dust emissions, as defined by good practice.

For Phase I of the project, impacts were judged acceptable, given that maximum incremental ground level concentrations were below the 25% of assessment criteria significance value as defined by the IFC guidelines.

For Phase II of the project, predicted impacts on ambient NO_2 concentrations were found to exceed the 25% criterion at the point of maximum impact, in conjunction with the uncertainties acknowledged in the dispersion modelling, and the non-compliance with Good International Industry Practice for Stack Height. However, at the most affected sensitive receptor, all incremental ground level concentrations were found to be acceptable.

- All stacks were originally proposed as being 20 metres above ground level. This height is lower than the 35 metres calculated using the Good International Industry Practice (GIIP) for Stack Height methodology, as required by IFC Guidelines. However, given that the detailed dispersion modelling results, using a 20 metre stack height, predict that concentrations at the nearest sensitive receptor are less than 25% of the WHO guideline values, a 20 metre stack height is deemed acceptable. ContourGlobal KivuWatt Ltd is re-assessing the situation to determine if a 25m or a 20m stack height will be used. According to the meteorological dataset used, maximum concentrations will occur over the lake.

10.1.2.3. Decommissioning

All emissions from the stacks will cease prior to decommissioning. There may however be dust generated during the demolition of the Power Plant, emissions from plant and machinery used on the site during the decommissioning Phase and traffic using roads in the vicinity of the development. However, in comparison with the construction Phase of the development, the impact of these emissions is expected to be very small as shown in Table 25.

- **Table 25 Summary of air quality impacts**

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Dust from construction	Minor	Negligible	Minor	√
Phase I NOx	Negligible	Negligible	Negligible	X
Phase II NOx	Negligible	Minor	Negligible	√
Particulates	Negligible	Minor	Negligible	X
SO_2	Negligible	Negligible	Not assessed	X

10.1.3. Mitigation

10.1.3.1. Construction

Whilst the likelihood of a significant impact as a result of emissions of dust during the construction Phase is deemed low, generation and dispersion during construction will be minimised through good construction practice. This good practice includes:

- Construction equipment will be designed and used in a manner which minimises dust generation.
- Water spray dampening of soils and spoil will be undertaken to prevent dust blow during hot, dry weather conditions.
- Careful location, grading and management of stockpiles of soil and similar materials will be undertaken to prevent wind-blow.
- Sealing and / or re-vegetation of completed earthworks will be undertaken as soon as reasonably practicable.
- Lorries will be sheeted during transportation of friable construction materials and spoil.
- Drop heights will be minimised during material transfer activities, such as unloading of friable materials.
- Regular cleaning of surfaced roads and maintenance of un-surfaced roads will be undertaken to reduce off-site transport of soils and to avoid dust generation.
- Speed limits will be applied to vehicles using unsealed roads to minimise dust generation.
- Wheel washing facilities will be provided for vehicles entering the public road system.
- Positioning and movement of construction equipment will be undertaken in a manner which minimises dust generation.

10.1.3.2. Operation

A number of mitigation measures will be integral to the design and operation of the proposed plant to help reduce emissions and subsequent ground level concentrations. These will include:

- The use of efficient, gas engine technology to minimise the generation of NO_x emissions.
- Appropriately designed stacks to ensure an adequate flue gas velocity for dispersion of emissions to atmosphere.
- The use of effective combustion control to limit CO emissions.
- The use of a low-sulphur fuel (natural gas) which will result in low sulphur dioxide emissions.
- The use of sufficiently high stacks to ensure adequate dispersion of emissions.
- Annual, independent stack emissions testing and ambient air quality monitoring during operation as required by IFC.

As no solid fuel will be stored on site there will not be any significant fugitive emissions. No emissions will result from the delivery of fuel to site, as the natural gas will be delivered by pipeline.

10.1.3.3. Decommissioning

The good practices employed during the construction Phase will be replicated during decommissioning. This will ensure any impact from emissions to air is very small from this Phase of the project.

10.1.4. Residual impacts

10.1.4.1. During Construction

Following the implementation of good practices as detailed in the mitigation section the incremental impact to air quality and dust deposition at sensitive receptors is expected to be negligible.

10.1.4.2. During Operation

The impact assessment indicated that impact of NO_x would be negligible as the resultant plume would be dispersed away from any sensitive receivers based on the proposed stack height of 25m. Nevertheless some mitigation measures are recommended in order to ensure that the predicted levels, particularly of NO_x, are met. These follow good engineering practice. Provided that these measures are put in place, residual impacts on the sensitive receivers are expected to be negligible.

10.1.4.3. During Decommissioning

As with the construction stage, the potential for dust to be generated during the decommissioning Phase will be short-term and temporary in nature.

It is predicted that the good practices employed during the construction Phase, replicated during decommissioning will ensure that the predicted impacts of dust generation on receptors in the area will be minimised. Impacts due to dust generated from the proposed decommissioning are therefore predicted to be negligible.

10.1.5. GEF Gas Engine Emissions

Emissions from the 3MW gas engines located in each GEF have not been modelled, as the flue gases emitted from these engines will be of relatively small volumes and will disperse over the lake, with ground level concentrations becoming insignificant before reaching sensitive receptors. These engines will be subject to the following emission limits:

- **Table 26 IFC emission guidelines applicable to gas/diesel engines on GEFs**

Parameter	Units[1]	Gas firing	Diesel firing
NO_x	mg/Nm^3	200	1,850[2]
CO	mg/Nm^3	n/a	n/a
SO_2	mg/Nm^3	n/a	<3% sulphur in fuel
PM	mg/Nm^3	n/a	100

Notes:
1) All concentrations at reference conditions 101 kPa, 0ºC, dry, 15% oxygen
2) If bore size diameter >400mm. Limit is 1,460 mg/Nm^3 if bore size diameter is <400mm, or 1,600 if justifiable to maintain high energy efficiency.

10.1.5.1. Gas Flaring and Potential for Unlit Venting

In order to enable start up operations or to allow safe shut down in an emergency or for maintenance, it is necessary that a limited quantity of gas be flared to atmosphere at those times. The gas may contain potentially toxic quantities of methane, carbon dioxide and sulphur dioxide and flaring will take place from a horizontal vent approximately 25 m above the lake surface with the flare tip approximately 30 m from the edge of the GEF.

The quantities of gas involved and likely minimal occurrence of flaring during the project lifetime are such that associated emissions would quickly be dispersed to atmosphere. These emissions are considered negligible and have therefore not been assessed.

A potential risk may, however, be perceived in the event that a system malfunction results in the venting of a quantity of un-ignited gas from the flare stack, which could potentially impact upon

GEF workers and/or lake users should they come into contact with the gas. Assessing the significance of the potential effects in line with Section 7.1, the potential significance ranges from minor (respiratory problems) to major (fatality through asphyxiation), though this should be considered in context of the likelihood of occurrence which is considered to be very low.

To assist in understanding this risk an emissions dispersion modelling exercise was undertaken by Antares Offshore[1].

The results of the modelling indicate that at and above the design relief (gas flow) rates, the unlit gas is blown upward and away from the facilities where it would disperse in the atmosphere and accordingly any potential effects would be negligible.

However, at lower than design flow rates and in calm wind conditions a potential risk exists to workers and users of the lake from the dense un-ignited gas drifting down towards the GEFs. A lower than designed gas flow rate may potentially occur in the unlikely event of additional technical failure, such as blockage in the raw gas compressor discharge or similar failure during system start up.

In addition to modelling described above, the following mitigation measures have been/will be considered in the project design:

- System working pressures have been designed to avoid flaring where possible.
- A facility to provide supplementary product gas into the flare stream is included in the event that low methane levels make combustion difficult.
- Automatic system fail-safe devices including sulphur dioxide and carbon dioxide gas alarms and emergency shutdown procedures have been designed to enable rapid detection and arrest of un-planned flaring/venting. In particular, the closure of the production separator gas outlet valves will typically be expected to halt long-term continuous flaring/venting.
- Emergency air packs will be provided at clearly marked locations and safe refuge will be available within the control room.
- Emergency egress plans to evacuate workers from the GEFs.
- Exclusion zone around GEFs to prevent lake traffic coming into an area which could potentially contain a gas cloud.

[1] Antares, 2008. KivuWatt Phase 1 Gas Extraction Facility: Unlit Relief Air Dispersion Assessments. Antares Document No. B-2008-141-TN-741

Given the low likelihood of occurrence and mitigation measures described above, residual effects to GEF workers and lake users are considered to be negligible. In the unlikely event that a gas release occurs at below design flow rates and calm weather conditions, GEF workers are considered to be adequately protected. Lake users will not be able to travel within the GEF exclusion zone and any gas release is expected to be safely dispersed outside of the exclusion zone.

10.1.6. Transboundary Impacts

IFC Guidance Note 1 (Social and Environmental Assessment and Management Systems) defines transboundary effects as "*impacts that extend to multiple countries, beyond the host country of the project, but are not global in nature*" and states that assessments should "consider potential transboundary effects, such as pollution of air, or use or pollution of international waterways".

IFC Guidance Note 3 (Pollution Prevention and Abatement) states that "*the client will avoid* the release of pollutants or, *when avoidance is not feasible*, minimize or control the intensity or load of their release. This applies to the *release of pollutants* due to routine, non-routine or accidental circumstances with the potential for *local, regional*, and transboundary impacts".

The potential for transboundary impacts associated with the development exists given the location of the project close to the border with DRC, the fact that there will be environmental discharges to air (flaring) and to the lake (degassed and wash water injection) and that the methane resource is a single deposit crossing the border and as such belongs equally to both Rwanda and DRC.

Potential transboundary issues arising from project operation will be limited to the effects of gas flaring (or venting) emissions during start up, or in the event of a failure in the gas extraction system.

The potential for plume migration (both degassed water and wash water injection) is considered in Section 7. Issues arising from development of the resource are not expected as the GoR and DRC government have already agreed on the proportioning of the resource in the form of concession areas outlined in Section 2.

Due to the distance from the GEF to the DRC border (approximately 5 km from the nearest GEF) and likely limited quantities of gas involved (either flared gas or vented gas), the potential significance of this effect is considered to be negligible as any gas emissions are likely to be safely dispersed before exiting the GEF exclusion zone and prior to reaching the DRC border. Accordingly, the issue is not considered further.

10.2. Noise

The project will be developed in 2 Phases, but for the purposes of this noise assessment it is assumed that both Phases are complete in order to allow for full capacity and the associated noise levels generated.

Figure 3 shows a Project Overview including the GEF locations, the Power Plant Site and the Marine Landing Site. Figure 4 shows the nearest noise sensitive locations.

10.2.1. Baseline

The GEFs, Power Plant Site and Marine Landing Site will all generate noise as summarised below:

- **GEFs:** Noise generated during normal operation lifting and treating water and gas. They will, however be a significant distance (13 km) from the shore.
- **Power Plant:** Noise generated during construction and then normal operation of the Power plant.
- **Marine Landing Site:** Noise generated during construction of the GEFs and then reduced noise during normal operation.

The project has to comply with design guidelines provided by the IFC, and is therefore subject to the environmental noise criteria specified in the IFC guidelines, which include noise limits for industrial, commercial and residential areas that should be achieved by new developments.

The aim of this Environmental Noise Impact Assessment is to demonstrate that the IFC noise criteria can be achieved using current technology, and to describe in outline terms the noise abatement methods that are likely to be incorporated into the plant design in order to do so. This is achieved by creating an environmental noise model of the development using typical/estimated sound power level data for the major noise sources involved, and by demonstrating with the model that the project noise criteria can be met. The noise data used in this report should not be regarded as final at this stage, and a more detailed noise prediction will be undertaken as part of the detailed design, using accurate noise data for the specific equipment to be used, in order to demonstrate that the criteria will be met.

The IFC noise guidelines provide guidance on acceptable environmental noise levels for new industrial plants and require that either they limit any increase in background noise levels to +3 dB(A), or that they satisfy the fixed criteria given in Table 27:-

- **Table 27 Noise criteria (dB re 2 x 10-5 Pa)**

Location Type	Maximum allowable hourly equivalent sound pressure levels (Laeq)	
	Day (0700-2200 hours)	Night (2200-0700 hours)
Residential, institutional, Educational	55	45
Industrial, commercial	70	70

There are currently no other significant noise sources in the area, and as a result of this, background noise levels are likely to be particularly quiet and significantly below 45 dB(A) at night-time. In view of this, it is proposed that the noise limits in Table 27 above are appropriate for this project.

10.2.2. Potential impacts

10.2.2.1. During construction

Noise and vibration during construction of the Power Plant

Noise generation during the construction process is inevitable. However, with the nearest housing being approximately 450 metres South East of the site, and screened by rising land, the impact of construction activity on residents is likely to be small, particularly as the noisier activities are confined to the daytime.

To provide information on potential construction work noise levels, Table 28 gives predictions of noise levels at the nearest sensitive residential location based upon data contained in British Standard BS5228: Noise Control on Construction and Open sites. Predicted construction activity noise levels at other residential locations around the site will typically be lower than those shown due to increased distance and/or screening.

- **Table 28 Predicted noise level from Power Plant construction activities at nearest housing (dB re 2 x 10-5Pa)**

Construction Activity	Activity Laeq (10 metres)	Distance Attenuation (450 metres)	Screening Correction	Laeq at Position 1
Clearing Site, Excavation and Construction				
Tracked Loaders	80	-33	-10	37
Tracked Excavators	87	-33	-10	44
Dossiers	92	-33	-10	49
Dump Trucks	81	-33	-10	38
Concrete pump	83	-33	-10	40
Diesel Generator	74	-33	-10	31
17m^3/min compressor	90	-33	-10	47
Pre-cast concrete piling	89	-33	-10	46
Typical acceptability criteria	**Laeq(12 hour)**			**65-70**

The above calculations include a correction for acoustic screening offered by the land between the proposed site and the nearest residential locations (position 1 in Table 27). During the noisiest Phases of the construction, the noise level is likely to be no greater than a long-term $L_{eq\ (12\ hour)}$ of 42 dB(A), with a maximum short term $L_{eq(5\ mins)}$ of 52 dB(A), from all sources, at the nearest residential properties. This is considered acceptable due to the temporary nature of the activities and the noise generated.

Noise and vibration during construction of the Marine Landing Site

Noise generation during the construction process is inevitable. However, with the nearest housing being approximately 500 metres West of the MLS site, and screened by rising land, the impact of construction activity on residents is likely to be small, particularly as the noisier activities are confined to the daytime.

To provide information on potential construction work noise levels, the table below gives predictions of noise levels at the nearest sensitive residential location based upon data contained in

British Standard BS5228: Noise Control on Construction and Open sites. Predicted construction activity noise levels at other residential locations around the site will typically be lower than those shown due to increased distance and/or screening.

- **Table 29 Predicted noise levels from MLS construction activities at housing (dB re 2 x 10-5 Pa)**

Construction Activity	Activity Laeq (10 metres)	Distance Attenuation (500 metres)	Screening Correction	Laeq at Position 1
Clearing Site, Excavation and Construction				
Tracked Loaders	80	-34	0	46
Tracked Excavators	87	-34	0	53
Dossiers	92	-34	0	58
Dump Trucks	81	-34	0	47
Concrete pump	83	-34	0	49
Diesel Generator	74	-34	0	40
17m3/min compressor	90	-34	0	56
Pre-cast concrete piling	89	-34	0	55
Typical acceptability criteria	Laeq(12 hour)			65-70

The calculations include no correction for acoustic screening offered by the land between the proposed site and the nearest residential locations. During the noisiest Phases of the construction, the noise level is likely to be no greater than a long term Leq (12 hour) of 52 dB(A), with a maximum short term Leq(5 mins) of 62 dB(A), from all sources, at the nearest residential properties.

When the Marine Landing Site has been completed, it will be used to construct the gas lifting GEFs. The GEF construction process, however, would be expected to be considerably quieter than the construction of the Marine Landing Site itself.

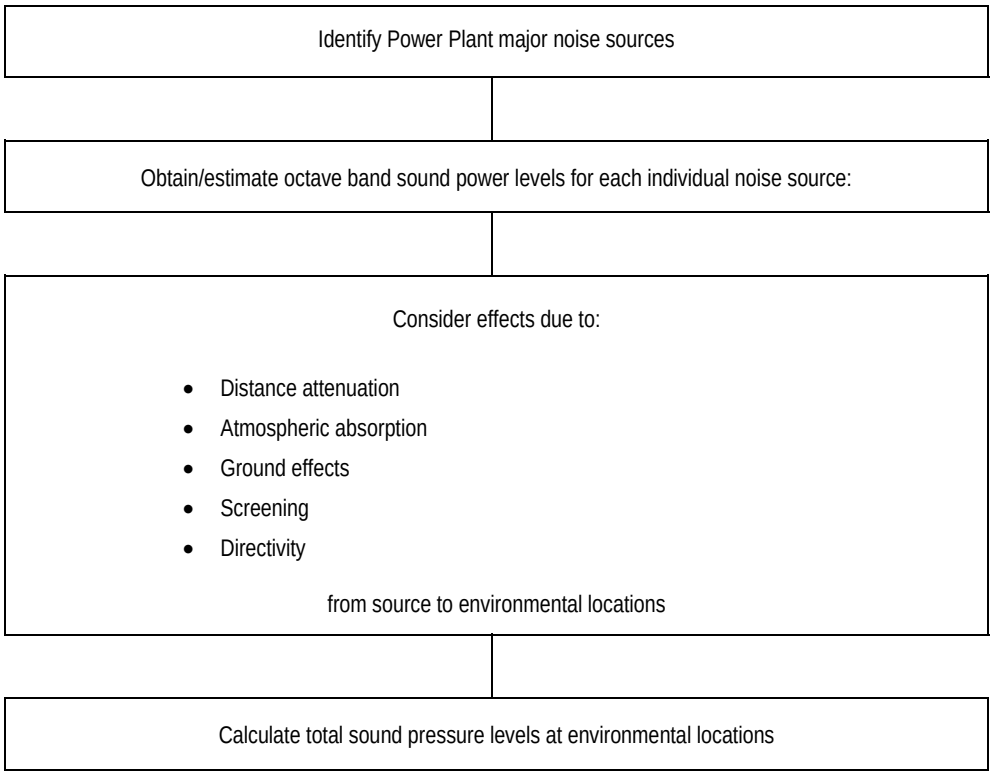
10.2.2.2. Noise and vibration during Power Plant operation

To predict environmental noise contributions from the proposed Power Plant a computer based Environmental Noise Model has been set up based on estimated octave band sound power levels of each identified major noise source and assumed building fabric transmission losses, with corrections applied to account for distance to environmental location, directivity, ground effects and atmospheric attenuation, together with any screening due to land topography or other items of on-site or adjacent plant and buildings.

The noise model calculation procedures used are in accordance with ISO 9613-2 and the software used is the Predictor noise model supplied by leading acoustic instrumentation supplier Bruel & Kjaer.

The main noise sources are identified from preliminary drawings along with estimated sound power levels used in the noise model. The process involved in creating the noise model is summarised in the following flow chart.

ACOUSTIC MODEL FLOWCHART



10.2.2.3. Computer noise model results

Predicted environmental noise contours around the proposed Power Plant are given in Figure 31, and are summarised below in Table 30 for the nearest dwellings along with the proposed criteria:

- **Table 30 Predicted LAeq noise levels from the proposed Power Plant at nearest dwellings (dB re 2 x 10-5 Pa)**

Residential Location (Ref. Figure 1)	Predicted LAeq level from the proposed Power Plant LAeq	IFC Noise Criteria
Nearest Dwellings	44	45

- **Table 31 Summary of noise impacts**

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Construction of MLS	Negligible	Negligible	Negligible	X
Construction of power plant	Negligible	Negligible	Negligible	X
Power Plant	Negligible	Minor	Negligible	√

10.2.3. Mitigation

10.2.3.1. Noise and vibration control measures during construction

The main method of mitigating the effects of temporary construction noise on the residential environment will be to limit noisy site activity to daytime periods only, if necessary.

The chosen contractor will employ the best practicable means to minimise noise and vibration on the site and will comply with any noise attenuation conditions agreed with the relevant Authorities.

10.2.3.2. Noise control measures during Power Plant operation

In order to achieve the levels of environmental noise predicted in this study, detailed consideration has been given to a number of influencing factors and noise control treatments have been incorporated into the scheme to mitigate against any adverse effects of noise on the community.

The following have been incorporated into the scheme.

- **Computer simulation**. Because the design will require detailed acoustic design work, it will be necessary for the designers to utilise a computer simulation of environmental noise to the community. This will involve each noise source being modelled and the total noise level being predicted at housing and checked to ensure it complies with the specified limits, throughout the detailed design Phase.
- **Site layout and orientation**. The final arrangements of layout and orientation will be subject to detailed designs and equipment selection. However, particularly noisy sources will be directed wherever possible away from the nearest residential properties
- **Tonal and impulsive quality**. The impact of a noise will automatically increase when tones, whines or impulses are noticed in the audible noise. Care will be taken, therefore, both to identify particular sources on the plant and to ensure that these will be adequately silenced.
- **Equipment choice**. Where options become available for selecting intrinsically quiet equipment, these will be taken up wherever practicable.

- **Noise control treatment**. In addition to the benefits of selecting intrinsically quiet equipment, a package of proprietary noise control treatments has also been considered in the proposed scheme. The package comprises treatments broadly as follows, although the final noise data on selected equipment items may mean variations in the nature and extent of such treatments.

  - Gas engine generators to be housed in building with walls, possibly of sandwich type construction, to provide appropriate level of acoustic insulation.
  - Silencers fitted to all Gas engine combustion air intake apertures, if required.
  - Silencers fitted to all Gas engine exhaust gas outlet ducts, if required.
  - Low noise or silenced Gas engine radiator fans, if required.
  - Silencers fitted to Power Building ventilation inlets and outlets, if required.
  - All other auxiliary equipment purchased so as not to cause the overall project noise criteria to be exceeded.

10.2.3.3. Commissioning noise survey

After commissioning, and with the Power Plant on base load, a further noise survey can be undertaken in order to demonstrate that the development complies with its design objectives.

This current environmental noise impact assessment has shown that the acoustic design of the proposed Power Plant near Kibuye, Rwanda, can satisfy IFC environmental noise criteria, and that its environmental noise impact will consequently be minimal. However, it should be noted that predicted noise levels for this assessment are based on preliminary or estimated noise data, and that more detailed noise predictions will be undertaken as part of the detailed design stage to ensure the environmental noise criteria will be met in practice.

10.2.4. Residual impacts

Residual impacts should be negligible provided all recommended mitigation measures are adopted.

10.3. Soil Quality

10.3.1. Baseline

Information on soil types is taken from the Kibuye Master Plan and a study prepared by the University of Ghent in Belgium based on an extensive soil survey of Rwanda undertaken between 1981 and 1994.

In general, regional soils are lateritic (intensively weathered tropical sandy soils with high proportions of sand, iron and alluvia). Heavily fractured bedrock, steep slopes and high rainfall have resulted in a high degree of soil erosion.

In the Kibuye area, there are light, easily workable and moderately fertile loamy soils on gently sloping hillsides typically underlain by shales and granites. Steeply incised gullies are eroded in places. Steeper hillside soils are shallow, rocky and often poor due to a combination of intensive cultivation and top soil erosion.

Parent material of dominant Rwandan soil units is shown in the geological map (Figure 13) which shows the soils on the peninsula of the Power Plant site area to be derived from quartzite and quartzitic schists; with soil depth of between 0.5 and 1.0m, and to be well drained.

The soils in the area of the MLS are on alluvium and are more fertile than on the peninsula and the water table is near surface. The area is flatter and until recently has been cultivated for many years.

The site and its surrounding area are undeveloped and have no history of use that might have resulted in significant site contamination.

10.3.2. Potential Impacts

There are a number of construction activities that could have potential impacts on the soils and/or geology of the site, including:

- Site enabling works (clearing and levelling of the site prior to construction) potentially including blasting of the hard rock at the gas Power Plant site.
- Construction of the Marine Landing Site and Power Plant site infrastructure.
- Construction of roads and infrastructure.
- Laying of electric cables.
- Use of site compounds.
- General site activities.

This section provides a summary of the potential risks of the proposed development, based on an assessment of activities that will occur during the construction, operation and decommissioning of the proposed Power Plant and MLS, prior to the inclusion of mitigation measures.

The actual effects (residual effects) of the development are outlined below.

Impacts during decommissioning will be similar to those for construction.

■ **Table 32 Potential impacts on soils in the absence of mitigation**

Activity	Potential impact
Site clearance and enabling works	Mobilisation of sediment laden run-off that could enter Lake Kivu.
Dewatering of excavations	Discharge of sediment laden run-off to Lake Kivu.
Construction of buildings, foundations, hard-standing and site roads.	Generation of dust. Spillage of materials such as cement. Generation of turbid run-off.
Traffic movements	Generation of dust and exhaust fumes.
Material and fuel storage	Spillage/leakage of oil and fuel

10.3.2.1. During operation

■ **Table 33 Potential operational impacts on soils in the absence of mitigation**

Activity	Potential impact
Presence of buildings hard-standing & roads within the MLS.	Changes in surface water run-off patterns which could change flood risk.
Site activities	Spillages or leakages of oil, fuel or other potentially polluting substances.

■ **Table 34 Summary of soil impacts in the absence of mitigation**

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Site clearance and enabling works and sediment run-off to the Lake	Minor	Negligible	Minor	√
Dewatering of excavations.	Minor	Negligible	Minor	√
Site activities and potential spillages or leakage of fuel and/or other materials.	Minor	Minor	Minor	√
Presence of buildings hard-standing & roads within the MLS. Changes in surface water run-off patterns which could change flood risk.	Negligible	Minor	Negligible	√
Traffic movements	Minor/Major	Negligible	Minor/Major	√
Storage of fuel and materials	Minor	Minor	Minor	√

10.3.3. Mitigation

Mitigation measures will be designed in accordance with best practice for construction works. The storage area for fuels, greases, oils and lubricants need to be considered, with empty drums and containers stored separately in isolated areas and removed when there are sufficient quantities for refilling or re-use.

- A waste oil skip will be provided.
- Bunding of chemical and lubricating oil storage tanks and use of oil interceptors.
- Adoption of best practice pollution prevention control measures, including stand-off from any ditches, cut-off drains or small bunds around potentially polluting activities, designated areas.
- For fuel storage and refuelling, and Environmental Management Method Statements for contractors working on-site.
- Appropriate design of intake and outfall structures.
- Best practice measures for the handling of soils for earthworks activities and formation of foundation excavations.
- Stockpiles of soil to be kept away from watercourses and mitigation measures to be included to minimise surface water runoff.
- Management of construction traffic to minimise creation of fugitive dust.
- Appropriate monitoring.

10.3.3.1. During construction

During the site clearance and enabling works there will need to be earthworks, soil excavation and vegetation removal. To limit potential impacts associated with sediment levels increasing within surface water runoff, the Contractors will be required to adhere to a sediment control plan throughout the construction process. This will outline the routine working and emergency procedures for the control and mitigation of erosion and dust generation during excavations and soil handling, such as stockpiling soil away from watercourses and undertaking earthworks during dry weather conditions where possible.

Soil will be excavated so as to ensure that damage to soil structure is minimised. Such measures will include:

- Use of backhoe loaders and dump trucks for soil excavations and movements.
- Soil excavations to be carried out during dry weather, where possible.

- Re-use of soil for restoring excavations where possible.
- Topsoil and subsoil to be excavated and stored separately.
- Minimal soil resources to be excavated and transported off-site.
- Excavated soil resources to be seeded and re-vegetated as quickly as possible, if not re-used, to avoid erosion potential.
- Disturbed areas to be seeded and re-vegetated as quickly as possible.

The soils from the MLS area will be carefully removed and re-used on an appropriate selected area (i.e. one where soil erosion is not a significant issue) were they can be most usefully used, e.g. in landscaping activities at the Power Plant.

The site will require an EMMP which will also include details on the management of materials and wastes. This is separate from the EMMP included in Appendix A and has already be prepared and included in contract conditions for the site contractor.

Groundwater levels at the MLS are not known but can be assumed to be near surface. It is possible that groundwater will be encountered while excavating the MLS site. If and when groundwater is encountered, water will be pumped out and passed to a settling lagoon to allow suspended sediment to settle out. Treated water will be discharged to Lake Kivu.

Site activities could result in spills and leaks of materials used in the construction process, including fuel, oil and lubricants. The EMMP includes measures for avoiding the likelihood of spills and leaks. ContourGlobal KivuWatt Ltd will implement an auditing programme which will verify environmental performance on the site during construction.

Best working practices will be adopted throughout the construction works to protect the water environment. The storage of oil, fuel and other substances will be within the designated construction area. Oil and fuel will be within impervious storage bunds with 110% capacity, so that any spillages or leaks are contained.

Construction machinery will be checked regularly to prevent oil leakages. Any maintenance required would occur over hard standing or on a suitable impermeable ground cover. Refuelling will be limited to a designated area, on an impermeable surface, away from any drainage infrastructure. Spill kits will be available on site at all times. Any spills will be cleaned up as soon as possible, according to the spill response plan in the EMMP.

The storage of oils and other potentially polluting substances will be stored within the designated construction area which will be cognisant of the need to prevent water ingress in the event of an extreme flood of the site.

10.3.3.2. During operation

This section describes the mitigation measures that will be incorporated into the development during the operational Phase to reduce effects on the water environment and soil. As the MLS will be transferred to the GoR on completion of GEF construction, mitigation beyond construction is only presented for the Power Plant. The Power Plant has the potential to affect the soil environment throughout its operation; therefore, a long term strategy for sustainable mitigation has been developed.

All areas where potentially polluting substances will be stored and used will be in areas with appropriate bunding constructed to industry standards. Bunds will provide 110% of stored volume and will be made from impervious materials. In the event of an oil spill into a bund the oil will be pumped out to a road tanker for re-use or disposed of in an environmentally acceptable manner.

Fuel (other than gas for power generation) will be delivered to the plant via road and offloaded at the Power Plant.

The site will be operated in accordance with best working practices and measures to protect the water environment.

10.3.3.3. During decommissioning

Earth Works

During decommissioning it is anticipated that earthworks will be the reversal of the construction. Soil will be replaced across the plant and MLS sites, taking care to replace subsoil and topsoil separately.

Site Activities

As with construction operations, site activities may result in a risk of spills and leaks of polluting substances used during decommissioning, including fuels and lubricants. A site EMMP will be developed in consultation with the authorities and the site contractor. This will include measures for avoiding the likelihood of spills and leaks and an auditing programme which will verify environmental performance on the site during construction. As site activities during the decommissioning will be the same as those encountered during construction, the mitigation measures will be similar.

10.3.4. Residual impacts

In the event that the mitigation measures proposed are implemented and followed all residual impacts are considered to be negligible. However a monitoring programme is proposed so as to ensure adherence to the plan.

10.4. Water Environment

The potential for impact from the proposed development on the surface water and groundwater environment, within the site boundary and its surroundings are assessed. Potential impacts and significance during the construction, operation and decommissioning of the project, and outlines mitigation measures to control any identified potential effects are identified. The assessment also considers the possible effects of the proposals on soils and geology whereby changes may lead to effects on the water environment.

The assessment considers the potential impacts of the development on the following water features:

- Local terrestrial surface watercourses (permanent, seasonal, man-made and natural), wetlands (note that the impacts discussion on the lake is included in Section 7).
- Groundwater, including shallow soil water, confined and unconfined groundwater.
- Water abstraction (e.g. public and private water).
- Flooding and surface water drainage regimes (natural and artificial), including its influence on existing erosion and deposition processes.
- Soils and geology and their interrelationship with the water environment.

Water Baseline and Receptors

10.4.1.1. Climate

Climate is an important driver of hydrological conditions. Average rainfall is between 1100 mm and 1200 mm with a high degree of humidity around the Kibuye area.

Given the nature of seasonal rains and the high precipitation values experienced during these periods it is considered that there is a high potential for surface water runoff to be generated, much of which may create ephemeral water features. Climate change predictions suggest that in the future there will be more rain falling over shorter periods and hence the likelihood of ephemeral flows could increase.

10.4.1.2. Surface Water Hydrology

The site is located in an area of steep mountainous terrain on the edge of Lake Kivu. All precipitation which forms runoff will flow towards Lake Kivu as the main drainage receptor in the region.

The proposed Power Plant site is located on a ridge line peninsular of Lake Kivu and as such has a very small up gradient catchment. Therefore, there is little potential for runoff generation at the Power Plant, with the exception of rainfall over the proposed site. Consequently no surface watercourses or drainage features have been identified over the site.

The proposed Marine Landing Site is located within an area of former wetland now degraded on the margins of the Lake Kivu. The site is also located within a small valley feature which could collect runoff during heavy rainfall. Regional relief mapping also indicates the presence of a drainage channel which formerly flowed into this wetland area. However, there is no evidence of permanent or seasonal surface watercourses upstream of the site. The site visits were undertaken in the dry season and therefore overland 'flash' flows may form ephemeral channels during wet seasons. However, no evidence of former flood events or dry river beds was observed at the site or highlighted during discussions with locals.

10.4.2. Groundwater

The geology of the area, as described in Section 10.3, Soils and Geology, comprises quartzites and metaquartzites, dominated by quartzite. Groundwater bearing units are therefore likely to comprise fractured zones within the predominantly impermeable strata. Any groundwater flow will be influenced by fractured zones, direction of local dip and topography. Groundwater levels are expected to be influenced by the Lake Kivu with groundwater levels similar to the lake in the vicinity to the shoreline.

Within the valley leading to the Marine Landing Site the geological map of the region indicates deposits of Alluvium. Groundwater flow is likely to occur within this Alluvium and be responsive to levels of precipitation. Evidence of this can be seen at the northern end of the MLS where groundwater seepage can be observed from beneath the road embankment which crosses the valley up catchment of the proposed site. This seepage is most likely to represent drainage and groundwater flow collected from the upstream catchment directed into the valley floor Alluvium.

No ground investigation was undertaken prior to the start of site works at the MLS and therefore information on groundwater levels and quality are not known. However, it is clear from the geology and from on-site observations that the water table will be close to surface and in continuity with the lake.

10.4.2.1. Water Quality

During the site visit undertaken during the week commencing the 25th May potable water and surface water samples were retrieved from the MLS area by ContourGlobal KivuWatt Ltd. The samples were scheduled for a limited suite of analysis to allow comment to be made on the relative composition of the water and its suitability for use. The results of the analysis are presented in Table 35 and are compared with WHO water quality guidelines for drinking water.

- **Table 35 Results of Surface Water and Tap Sampling**

Determinant	Tap Sample	Lake Sample	World Health Organisation (WHO)
Arsenic Dissolved	<0.75	2.3	10
Barium Dissolved	5	16	700
Beryllium Dissolved	<1	<1	nv
Boron Dissolved	<20	<20	300
Cadmium Dissolved	<0.22	<0.22	3
Chromium Dissolved	<1	3	50
Copper Dissolved	<1.6	<1.6	2000
Lead Dissolved	0.5	0.5	10
Nickel Dissolved	5.0	<1.5	20
Selenium Dissolved	<1	1	10
Vanadium Dissolved	<1	3	20
Zinc Dissolved	19	9	3000
Iron Total	22	-	0.3
Mercury Dissolved (CVAF)	<0.01	<0.01	1
Total Alkalinity as CaCO3	-	660	nv
Nitrate as NO3	-	<0.3	50
Sulphate (soluble)	24	18	250

All units are in ug/l unless otherwise stated.
Nv – no screening value
World Health Organisation (WHO) Guidelines for Drinking Water Quality 1984 (updated in 2006).

The results of the analysis for the sample retrieved from the lake and nearby potable water complies with the World Health Organisation criteria. It was not possible to analyse for bacterial quality due to a delay in the delivery to the laboratory.

- **Table 35 Results of Surface Water and Tap Sampling**

Determinant	Tap Sample	Lake Sample	World Health Organisation (WHO)
Arsenic Dissolved	<0.75	2.3	10
Barium Dissolved	5	16	700
Beryllium Dissolved	<1	<1	nv
Boron Dissolved	<20	<20	300
Cadmium Dissolved	<0.22	<0.22	3
Chromium Dissolved	<1	3	50
Copper Dissolved	<1.6	<1.6	2000
Lead Dissolved	0.5	0.5	10
Nickel Dissolved	5.0	<1.5	20
Selenium Dissolved	<1	1	10
Vanadium Dissolved	<1	3	20
Zinc Dissolved	19	9	3000
Iron Total	22	-	0.3
Mercury Dissolved (CVAF)	<0.01	<0.01	1
Total Alkalinity as CaCO3	-	660	nv
Nitrate as NO3	-	<0.3	50
Sulphate (soluble)	24	18	250

All units are in ug/l unless otherwise stated.
Nv – no screening value
World Health Organisation (WHO) Guidelines for Drinking Water Quality 1984 (updated in 2006).

It should be noted that there is no incidence of bilharzia in Lake Kivu.

10.4.2.2. Local Drinking Water Source/Supply

This section draws predominantly from the Kibuye Master Plan (KMP). Water demand in Kibuye in 2006 is indicated to have been 118m³/day and is projected to rise to 151 and 185m³/day by 2011 and 2016 respectively.

An estimated 45% of potable water supply in the Kibuye municipality is provided through the municipal reticulation system, with the remaining 55% taking personal supplies from local rivers/springs or Lake Kivu. The layout of the municipal network is indicated on Figure 30.

Access to the municipal network is either through private connection or communal drinking points (water kiosks or standpipes).

The network is supplied by intakes constructed at elevated highland springs. Gravity flow is assumed to be the main delivery mechanism with a likely requirement for local pumping. The network comprises six main supply projects: Five are community administered and supply rural

villages directly from the upland springs. These springs range in yield from approximately 1.0 – 4.5 l/s and the supply is untreated, though intakes are described in the Kibuye Master Plan as '*well protected and located in hills generally devoid of human settlements and farming activities*' which may promote a reasonable standard of quality. The Kagabiro Line is shown as supplying the area west of Kibuye, though it does not appear to reach the vicinity of the MLS.

The remaining project is administered by Electrogaz and provides a treated water supply to Kibuye from five springs in the Karongi Hills. The springs produce a combined yield in the order of 10.0 l/s which is piped to a treatment plant at Kanyabusage / Nyarusozi, located approximately 4 km southeast of Kibuye. The plant utilises a simple filtration/chlorination process, delivering the treated water to storage tanks of unknown number and volume from where the town is supplied through the reticulation system.

For residents without a private supply connection, Electrogaz leases stand pipes or communal kiosks to individuals for a deposit of RWF 15,000 and fixed volume rate of RWF 200 per metre cubed. The individual can then sell on the water at no more than RWF10 per 20-litres.

Given that the municipal supply is sourced in springs many kilometres from the site, it is not expected that the project development will impact on municipal water supply. Additionally, there is no evidence of local water supplies in the vicinity of the Power Plant and the MLS which the project will affect. However it appears that the local community uses the lake water at times when the nearest standpipe is out of action, e.g. during maintenance periods so any effects on the lake could be an additional impact.

10.4.2.3. Project Water Demand

Water will be used during construction for sanitary purposes, washing equipment and to spray the site down to reduce dust emissions.

Expected water use during the construction Phase is as follows:

- 45 m^3/day during large concrete pours (for example for stack and engine foundations).
- 20 to 25 m^3day average construction consumption (2 to 3 m^3day minimum construction consumption).

During operation, connection to the public network is envisaged for on-shore activities although the Concession Agreement does confer rights of abstraction from the lake. Based on information currently available, water consumption shall not exceed 0.362 m^3/h from the Power Plant and no more than 5.68 m^3/h from the GEFs. Water discharges from the Power Plant will be 0.03 m^3/h oily water from workshops and sanitary water of 0.25 m^3/h. Sewerage from the GEFs will be 0.75m^3/h and will be treated in a package unit prior to discharge.

10.4.3. Baseline Sensitivity

The power project site has a small drainage catchment and is located above Lake Kivu. There is little evidence of groundwater beneath the Power Plant site and no rivers or water usage, except for the lake itself. This site is therefore not sensitive with respect to surface water or groundwater.

The MLS site is located within a valley and is underlain by alluvial deposits. Evidence from site visits indicates there is groundwater flow through the alluvium. It is considered that this valley feature collects runoff and rainfall infiltration from up catchment. Groundwater levels in this valley and across this site could vary seasonally. This will require careful management and design of the structures proposed in this location.

10.4.4. Impacts (groundwater and surface water)

10.4.4.1. During construction

The following impacts could occur during the construction of the Power Plant and MLS:

- Heavy rainfall leading to runoff generation and flooding

  During the rainy season the potential exists for extremely intense rainfall which can exceed the infiltration rate of surrounding soils. This can often result in the generation of flash flooding, which will be exacerbated in this location due to the steep sided valley slopes. Such events could cause an impact on the construction Phase by interfering with the construction works such as the pouring of concrete foundations. It could also create a pathway for pollutants to enter groundwater or Lake Kivu.

- Heavy rainfall leading to erosion of bare soils leading to the input of sediment into Lake Kivu

  The Power Plant site is currently being stripped and cleared ahead of development and this work is largely completed. Material excavated from the Power Plant site will be used at the MLS site for the creation of the slipway and workshops. This movement, excavation and stockpiling of material could result in the erosion of bare soils during heavy rainfall. This could be exacerbated if soils are stored close to the lake shore or any ephemeral drainage feature. Sedimentation run-off to the lake however is also likely to occur without the project i.e. because the wetland function (trapping sediments) has already been impacted by the change of land use to subsistence agriculture.

- Ephemeral flows or rising groundwater across the site of the MLS encountered during excavations and piling. As discussed above, groundwater seepage occurs beneath the road embankment to the east of the MLS, indicating the presence of groundwater beneath the MLS site. The site was also a former wetland area of Lake Kivu. Any excavation could encounter groundwater which in this location might be complicated to control due to its proximity to

Lake Kivu. Similarly, piling works will also potentially interfere with groundwater flow regimes in this location.

- Spillages of potentially contaminated materials

  At either site and during either the dry or rainy season there is the potential for contaminated materials such as oil, fuel and lubricants to be spilled or leak into surface water or groundwater. Either would result in a direct pathway to Lake Kivu.

- Increased water demand could divert supplies from elsewhere

  The construction of the Power Plant and the MLS will require the use of fresh water for the preparation of concrete.

10.4.4.2. During operation

The following impacts could occur during the operation of the Power Plant and MLS:

- Groundwater flow interference at the MLS site

  The MLS is to be raised and infilled to allow for the construction of the MLS platform and slipway. The material will be locally sourced fill most likely from the excavation of material at the Power Plant site. The infill and piling of the jetties could cause a reduced permeability to groundwater flow beneath the MLS site, which could cause an upstream increase in groundwater levels and possible surface ponding and increased groundwater pressures.

- Groundwater and surface water flooding

  It would appear that the MLS site is located in an alluvial valley where groundwater levels could rise during the rainy season. This could result in localised flooding of the proposed MLS site. Surface water flooding from flash floods and heavy rainfall could also occur at either site interfering with the operation of the plant.

- Draining vessels during maintenance

  Drainage water is likely to contain oil and grease and any discharge can impact on ground and surface water.

- Spillages of potentially contaminated materials

  As during the construction Phase, at either site and during either the dry or rainy season there is the potential for contaminated materials such as oil, fuel and lubricants to be spilled or leak into surface water or groundwater. Either would result in a direct pathway to Lake Kivu.

10.4.4.3. During decommissioning

Similar potential impacts would result during the decommissioning Phase as those highlighted during the construction Phase. These principally include:

- Flash flooding impacting operations.
- Erosion of excavated materials including bare soils and concrete dust.
- Spillages of potentially contaminated materials such as fuel, oil and other substances.

Table 36 Summary of potential impacts on water in the absence of mitigation

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Run-off and flooding during heavy rainfall and impacts on lake and groundwater	Minor/Major	Negligible	Minor	√
Contamination of groundwater	Minor	Negligible	Minor	√
Groundwater flow interference	Minor	Minor	Minor	√
Drainage from vessels		Minor	Minor	√
Demands on water resources	Minor	Negligible	Minor	√

10.4.5. Mitigation

- Control of seasonal flows and drainage

Excavation works are being undertaken outside the rainy seasons to avoid having to deal with excessive rainfall and runoff. Where excavations are being dug or foundations laid up during the rainy season, which commences in September, slope diversion channels will be constructed as appropriate to ensure that runoff is direct away from the construction area. These channels will be constructed in a manner to ensure that they do not lead to the creation of erosion pathways or indeed do more damage. This will require the use of natural vegetation within channels to provide a form of attenuation.

- Drainage design

Drainage provision may be required during the construction of both the Power Plant and the MLS site. This is likely to comprise the use of cut off drains or a diversion channel in the case of the MLS site. At this stage the detailed drainage design is not available. When this is being prepared due consideration will need to be given to appropriate design to prevent environmental impacts.

- Storage of potentially contaminative substances

All oil, fuel and other potentially contaminative substances will be stored away from Lake Kivu and will be located within bunded areas providing at least 110% of storage by volume stored. All re-fuelling of plant and equipment and maintenance will also be undertaken in designated areas which will be defined as low risk areas within the Environmental Management Plan (EMMP).

- Water supply

All water supply used during the construction Phase for the construction process, such as the formation of concrete, will be extracted from Lake Kivu. Drinking water for construction workers will be tanked into the construction site most probably purchased from the local reticulation system.

ContourGlobal KivuWatt Ltd is considering the sinking of a community well to supply the local community when standpipes are out of action for maintenance purposes. This could be located up gradient from the MLS and will avoid the necessity of using lake water as an alternative supply to the standpipe. Clearly if a well is to be sunk the necessary approvals will need to be obtained.

10.4.5.1. During operation

- Drainage design

Drainage provisions are required at both the Power Plant and the MLS site. At the Power Plant this will be to ensure that after excessive rainfall the site drains effectively and water is passed to Lake Kivu without being channelled and creating an erosion potential and so that excessive sediments do not enter the Lake. A silt and soil trap arrangement will be fitted to the end of the drainage system.

At the MLS site there is the potential for groundwater levels to rise or for ephemeral flows to occur along the valley. To a certain extent the road embankment constructed across the valley will create an attenuating control on the flow of water from up stream. That said it will be necessary for the design of the foundations and the placement of fill material within the MLS to be cognisant of groundwater level changes. This will require that the placement of fill material and piling ensures that the design will still allow groundwater flow beneath the site and the development will not result in a reduction in ground permeability. It will also be prudent for any sensitive elements of the MLS to be raised above a nominal freeboard to ensure that there is no operational risk from rising water levels. However, it is expected that all operational areas will be well above the level of Lake Kivu which is the overriding control on groundwater levels.

- Storage of potentially contaminative substances

As during the construction Phase, all oil, fuel and other potentially contaminative substances will be stored away from Lake Kivu and will be located within bunded areas providing at least 110% of storage by volume stored. All re-fuelling of plant and equipment and maintenance will also be undertaken in designated areas which will be defined as low risk areas within the Environmental

Management Plan (EMMP). Ongoing environmental management (audits and review) will also ensure that the risk of spills and leaks from the plant are monitored to ensure that risks to the water environment are minimised.

- Water Treatment

Water shall be treated before being discharged into the natural environment to ensure compliance with IFC guidelines.

- Potentially polluted water shall be treated in the oily water treatment unit before being discharged into the natural environment.
- Sanitary water (showers, toilets) will be treated in septic tanks before being sent to the biological treatment unit then discharged into the natural environment.
- Rain water will be discharged into the natural environment; the risk zones (storage of products) will be equipped with secondary containment to prevent discharge of polluted water into the natural environment.
- GEF

A Drain system will be installed to meet local regulations. At this time, a closed drain system exists for draining major vessels while performing maintenance. Rainwater will be separated from any oil or grease located on the skids and discharged locally once local requirements have been met or exceeded via an open drain system.

10.4.5.2. During Decommissioning

Much of the mitigation described during the construction Phase is applicable to the decommissioning Phase. Adjustments will be made to the mitigation provisions based on the antecedent conditions at the time which may require some adjustments to be made.

10.4.6. Residual Effects

10.4.6.1. Construction

The degree of seasonal groundwater level changes and flash flooding is currently largely unknown. However, it is expected that during intense tropical storms heavy rainfall and overland flow will interfere with the construction Phase and lead to the erosion of soils stripped from the construction. This could cause short term and very intermittent impacts of minor magnitude. Whilst the receiving environment of Lake Kivu is undoubtedly sensitive the volume of inflows and the likely elevated background suspended sediment in inflows the overall effect is not considered to be significant and this may be no worse than when the MLS was being used for agriculture.

Provided the mitigation measures outlined above are in place this is not likely to result in a significant effect on groundwater quality or movement or on Lake Kivu.

A total of 250 workers will be present on the construction site. This could place a demand of 2250 litres of potable water each day. If this demand was in addition to existing local demand this would undoubtedly result in increased pressure on local water supply. This effect would be present for the period of the construction Phase and the effect is considered to be minor.

10.4.6.2. Operation

Provided that the mitigation measures recommended are put in place there should be no residual impacts on groundwater and surface water associated with the operational Phase of the project.

10.4.6.3. Decommissioning

Similar residual effects are considered to occur during the decommissioning Phase as have been predicted for the construction Phase. However, fewer demands on the local water supply infrastructure are expected and sewage treatment facilities will also be in place to deal with the increased workforce.

In summary, if mitigation proposals are instituted as suggested, effects will be either negligible or minor and short-term.

10.5. Waste – Baseline

The local waste infrastructure in the area of the development is relatively undeveloped and at the moment it is not clear exactly how people dispose of solid waste. There does not appear to be any formal system of collection and there are no designated landfill sites. The Master Plan for the area indicates that a solid waste disposal site will be constructed to serve Kibuye, but this does not appear to be an engineered system, there is no indication of budget in the Master Plan and it is not listed as an item in the strategic investment areas. Indeed there is very little detail in the Master Plan which simply refers to site location, being either a disused quarry or a flat, dry lands with soft soils. There are no timescales for development given in the Master Plan so it is not certain when this facility might become available. The other important point is that the need (and presumably the size of) the solid waste disposal site has been based on population projections and a generation rate of 0.5kg/household per day, which is remarkably low especially by African standards. It is not clear whether the development expansion planned for Kibuye, and the construction potential that goes with this, have been taken into account in the planning process for solid waste disposal.

Therefore, disposal of waste, from the construction Phases in particular, cannot rely on there being a disposal facility close by. This is particularly true for potentially dangerous materials or contaminants that would normally be disposed of under special conditions. There is no recycling facility available although it is assumed that, in common with many poor communities, useable

materials are often informally recycled within the community and reused for essential household repairs etc.

Nevertheless, the contractor needs to minimise the wastes produced during the various Phases of the project, and to ensure that the handling, disposal and informal recycling of wastes can be undertaken with the minimum of risks to the environment and maximum benefits to the community.

The wastes generated from the Marine Landing Site (MLS), the Power Plant and the GEFs generally fall into three Phases:

- Construction Phase.
- Operation Phase.
- Decommissioning Phase.

The exception is the MLS only the Construction Phase is to be considered during this exercise as following construction the MLS will fall into the ownership of the GoR. The operation and decommissioning Phases will therefore be the responsibility of the GoR.

10.5.1. Construction Phase

It is not possible at this stage to estimate quantities of waste that will arise from the construction activities. However, the following types of wastes can generally be expected.

- Building rubble.
- General construction wastes, including cement bags.
- Waste metal (including welding rods, disc cutters, piping etc).
- Waste oils and lubricants.
- Waste paints and solvents.
- Wood.
- Plastics.
- Electrical cabling and electrical components.
- Domestic wastes, including food wastes.
- Sewage effluent.
- Paper.
- Empty oxygen and acetylene tanks (if oxy-acetylene welding and cutting required).
- Glass.

It is understood that rock from the main Power Plant site will be transported to the MLS in order to prepare the ground to a suitable condition for construction. This material is non-contaminated rock and is not considered as a waste material. However its transportation from the Power Plant site to the MLS should be undertaken in properly covered wagons to prevent loss of material from the wagons during transportation.

Wherever possible excavation materials and topsoil will be used for landscaping and levelling requirements within the construction site, and hence will not be considered as a waste.

The GEF construction will be undertaken in Mombasa and transported in section for final completion on site at Lake Kivu. The GEFs will be completed on site at the MLS. Once constructed, the GEFs will be anchored off shore to collect the gas for use within the Power Plant.

10.5.2. Operational Phase

The majority of wastes will originate from the Power Plant. Smaller quantities of wastes in the form of waste oils, oil filters and general waste will be generated on the GEFs. The quantities of these latter works is not yet known. Waste generated at the GEF's will be transferred to the Power Plant and stores and managed along with the Power Plant wastes.

- Maintenance wastes include:
  - waste oils and lubricants;
  - scrap metal;
  - waste electrical and electronic components;
  - batteries;
  - contaminated rags;
  - contaminated spill response equipment;
  - contaminated safety clothing, gloves, masks, and equipment;
  - waste wood;
  - waste paints and solvents; and
  - contaminated plant and machinery, including filters;
- Domestic and food wastes.
- Sewage wastes.
- Sludges.
- Oily water and run-off.

Filters are installed before certain critical components and equipment to protect them from impurities. Filters are used e.g. in:

- The lubricating oil system (filter cartridges from lubricating oil units).
- The charge air system (charge air filters).
- The engine hall ventilation system (ventilation unit suction filters).
- The generator ventilation system (ventilation air filters).

Some of these filters are washable, but disposable filters are replaced after a certain period of operation. The washing is usually done with oil. The used washing oil can be disposed of together with sludge and used lube oil.

10.5.3. Decommissioning Phase

- Demolition rubble.
- Top soils and excavation wastes.
- General demolition wastes.
- Waste metal (including, disc cutters etc, piping etc).
- Waste oils and lubricants.
- Waste paints and solvents.
- Wood.
- Plastics.
- Electrical cabling and electrical components.
- Domestic wastes, including food wastes.
- Sewage effluent.
- Paper.
- Empty oxygen and acetylene tanks (if oxy-acetylene welding and cutting required).
- Glass.

10.5.4. Impacts

The impact of the wastes generated is dependent upon the nature of the wastes and the medium into which they are disposed of. This is also true of accidental release of the wastes. The potential impacts, with respect to scale of impact, considered below cannot currently be quantified due to lack of information about the quantities of wastes arising. However, the impacts determined below consider the potential harm that may arise. The scale of the harm will be dependent upon the release of material. IFC guidance (General EHS Guidelines) specify priorities for waste management including waste prevention, recycling, storage, transportation, treatment and disposal. This guidance has been used in determining impacts and designing mitigation for the project.

Many of the wastes generated will, if accidentally released into the environment, essentially be considered as a litter nuisance. However, the following wastes are considered as having a potential to cause considerable harm to the environment.

The loss of containment of the materials identified will have an effect whether during construction, operation or decommissioning. However during the construction and decommissioning Phases it can be assumed that the levels of all the wastes will be higher, albeit for a shorter period of time, due to the nature of the activities being undertaken. In this case the impact of loss of containment of the wastes identified will potentially have a larger deleterious effect during the construction and decommissioning Phases than during the operational Phases, due to the potential of material that can be released to the environment.

- Construction Waste

By far the largest component of solid waste will be construction wastes which can be as great as 15% of the total construction materials on site and generally find their way into landfill. This can represent a considerable volume of material and, given that there are no formal waste disposal facilities can impact on local communities unless recycled in which case there can be a benefit rather than an impact.

- Waste oils and lubricants

Waste oils and lubricants will have a considerable detrimental effect on the environment if released in quantity. Small releases will also have a detrimental effect, in proportion to the amount released.

If released into water or groundwater, these materials will have a detrimental effect on the potability of the water. They will have a negative effect with regards to increased Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Sufficiently large releases can have a serious deleterious effect on fish and birds, as well as the wider ecosystem in general. However, the releases from the plant are expected to be minor because the volumes of oils used will be small. Perhaps the largest risk will be from oil storage areas.

Used mineral oils are also carcinogenic and thus the health and safety of workers, and other people should be considered.

If lost to the land the main concern is leaching to the water environment of both the oils and lubricants themselves and of the breakdown products of oils and lubricants. If these materials get into a potable supply of water this may have serious consequences on water quality.

However, there is a market for waste oils that are recycled for use as timber treatment or burned as industrial fuel.

- Waste paints and solvents

Paints generally contain solvents and heavy metals. The release of paints to the water environment can have a significant deleterious effect on the aquatic ecosystem to which it is released. The paints and coatings will have a high BOD and COD. The heavy metals within the paints can have a bioaccumulation effect. Solvents within the paints can have a duel effect, in raising short term Volatile Organic Carbon (VOC) concentrations in the air and the generation of low level ozone on decomposition. In the water environment they will add to the BOD and COD loading on the receiving waters.

The release of waste solvent will have a deleterious effect on receiving waters, increasing both BOD and COD. Dependent upon the nature of the solvent released the solvent will either be miscible with the receiving water or immiscible. In addition, any release of solvent may have a short term negative effect on local air quality with respect to VOC and low level ozone creation.

The main risk associated with a release of solvent to the ground will be of contamination of groundwater and, depending on the volatility of the solvent, a short term negative effect on the local air quality.

Certain solvents are also carcinogenic and care should be given to their disposal on health and safety grounds.

- Sewage effluents

Untreated sewage effluents will have a deleterious effect upon any receiving waters if released. This will arise from an elevated BOD and COD as well as from any microbiological organisms that may be released with the sewage. During the construction and decommissioning Phases this impact will be greater than during the operational Phases due to the numbers of individuals working on the site at any one time.

10.5.5. Mitigation

The local waste infrastructure within the region of the development has not been extensively determined, although the Master Plan indicates that the area around Kibuye will be developed. This development indicates that suitable disposal facilities for solid waste disposal will be developed. The local recycling infrastructure is unknown but it is expected that most construction wastes at least can be recycled in the community on an informal basis.

The disposal of contaminated materials poses a different problem as these will need to be disposed of in different facilities and not in general landfill or disposal sites. It will be the responsibility of the contractor to identify suitable treatment and disposal facilities capable of meeting appropriate environmental standards, when creating, and then implementing the Waste

Management Plan for the construction, operation and decommissioning Phases. The Waste Management Plan so created and implemented shall identify the environmental standards to which the waste recycling, treatment or disposal facility shall operate, when handling, transporting and treating the wastes.

All wastes will require suitable storage on site prior to disposal to prevent loss of materials capable of causing pollution to the environment. Wastes generated during construction, operation, and decommissioning Phases will require transportation to the final reclamation or disposal facilities in vehicles capable of preventing loss of containment during transportation.

Wherever possible, the final site for reclamation or disposal of all wastes generated will be required to be suitably licensed facilities operating to appropriate international or local standards, and capable of treating, and recycling or disposing of the wastes without causing pollution to the environment. It is the responsibility of the contractor to establish the most suitable disposal, treatment or recycling facility to ensure correct treatment and disposal of all wastes is achieved without causing harm to the environment or to human health.

Any solid or liquid waste that cannot be recycled or composted in Kibuye will be transported to the nearest waste management site in Gitarama or Kigali. Waste transport and disposal will be sub-contracted to a government approved waste handling company such as Coped Sarl or a similar organisation. In awarding the tender for waste management ContourGlobal KivuWatt Ltd will ensure that the company has the legal manner by checking their waste management license records and ensuring that appropriate records and paperwork for waste are held. ContourGlobal KivuWatt Ltd will also undertake periodic checks of waste contractors and of their disposal facilities.

All waste disposal and carrier contractors will require auditing by an independent body to ensure that they are capable of meeting the relevant international or local standards. A waste management plan will be prepared identifying:

- The wastes that will be generated.
- Approximate quantities.
- Waste minimisation methods.
- On-site storage arrangements.
- Accidental release mitigation measures.
- Waste carrier details, and methods of off-site transportation.
- Final waste treatment, recycling or disposal destination.
- Relevant international or local standards to be applied.

The plan shall be generated, adhered to and shall be audited and confirmed by an independent body.

10.5.5.1. Construction Waste

Clearly the first mitigation measure will be to reduce the amount of construction waste. Efforts to do this can not only benefit the environment but also provide the Contractor with economic benefits through reduced costs of materials, especially since a good deal of the construction materials will need to be brought in from elsewhere. The best way to achieve reduction is through a construction waste management plan which will identify areas where waste minimisation measures can be employed.

However good the Contractor's management plan is there will inevitably be construction waste through over-ordering, cut off and general wastage. An innovative approach to disposal could be to grade and sort waste on site into different categories and make this available at no cost to the local community to take away and reuse. The alternative would be to truck construction waste offsite to the nearest disposal facility and this would incur considerable additional cost for the contractor as well as possible landfill fees. This again could be encompassed in a contractor's waste management plan.

- Waste metals:

All waste metals generated on site during the construction Phase of the MLS should be collected separately and stored in a suitable, secure location prior to disposal. Contaminated waste metals will require recovery by a suitable waste contractor for decontamination. "Clean" waste metals can be recycled within the community.

- Building rubble:

Wherever possible, uncontaminated building rubble will be utilised within the site for hardcore or other land reclamation purposes. Contaminated building rubble will be sent off site to a suitable disposal facility capable of treating or disposing of the material without the loss of contamination at the disposal site, either by leaching or other mechanism.

Mitigation must be taken to prevent run-off from the stockpiles of building rubble on site.

- Top soils and excavation wastes:

Wherever possible these materials will be utilised for land reclamation purposes within the site. There is no history of any previous contamination of the site and therefore the top soils and excavation wastes can be re-used for landscaping, screening and filling purposes without prior treatment. Mitigation must be taken to prevent run-off from the stockpiles of top-soil and excavation materials on site.

- Waste oils, lubricants, paints and solvents:

Waste oils and lubricants will be temporarily stored in oil drums placed in a sealed container which has a bund wall built into it. The container itself will be located in a bunded area of hard standing, to prevent leaks and spillages from entering the ground and the groundwater.

The waste oil, lubricants and containers will be taken from site and disposed of at the nearest suitable recycling facility.

- Waste wood:

Wherever possible, waste wood can be recycled in the community. However, where disposal is required, waste wood that is not contaminated by, or has not been treated with, halogenated organic compounds or heavy metals can be recovered for use as fuel.

- Electrical cabling and electrical components including batteries:

Electrical cabling and components could be recycled informally in the community. Spent batteries will need to be stored in a suitable storage facility on site prior to transport to a suitable disposal facility.

- Plastics, paper and glass:

Wherever possible these materials will be separated at source and recycled in the community. If recycling is not possible then the materials will be disposed of to a suitable disposal facility.

- Sewage effluent:

During the construction Phase, until suitable facilities are constructed, portaloos and portable showers should be used. The portaloos should be emptied by suitably licensed operators who will dispose of the effluent to a suitable treatment facility. Alternatively temporary facilities with a septic tank shall be constructed. Shower and wash facilities should drain to a septic tank until suitable treatment facilities are provided on site.

Once available permanent washing and toilet facilities shall be utilised and shall drain to a septic tank and thence to a package treatment facility capable of meeting IFC standards prior to discharge to the Lake, preferable via a tertiary reed bed type treatment system.

Within the GEFs, effluents from toilet and washing facilities shall be treated by an onboard package treatment facility to suitable standards, with respect to BOD, COD, ammoniacal nitrogen, and microbiological organisms, prior to discharge to the lake.

- Biodegradable food wastes:

Wherever possible these shall be composted on site.

- Oxygen and acetylene tanks (or other such tanks for welding and cutting gases):

Gas cylinders used for welding and cutting gases shall be returned to the provider of the gases for reuse.

10.5.6. Residual impacts

It is assumed at this stage that there will be no formal solid waste disposal facility available to the Contractor. It is further assumed that the majority of materials that can be re-used (construction waste, glass, metals etc.) can be recycled using an informal system in the local community and this will need to be established.

Given the above, there remains the problem of waste materials that are in some way contaminated (e.g. oily wastes, paints and solvents, containers for the same) and which will need to be removed from site and disposed of safely at a disposal site specifically designated for the purpose.

Wastes that cannot be recycled or composted will be transferred to Kigali by a licensed waste contractor for disposal at an appropriate landfill site.

- Table 38 HAZOP risks, recommendations & solutions

11. Occupational health and safety

This section principally considers occupational health and safety. However reference is also made to community safety where appropriate. Unlike other aspects of the report there is no baseline to refer to so only impacts and mitigation are considered.

11.1. Potential impacts

11.1.1. During construction

Potential occupational health and safety issues during construction activities include:

- Falls and slips.
- Failures of support systems and/or platforms.
- Noise and vibration.
- Collision with mobile plant or vehicles.
- Exposure to dust and to hazardous materials.
- Burns.
- Exposure to gas releases or asphyxiation.
- Crushing by heavy plant or collapse of structures.
- Falling debris.
- Adverse weather conditions.
- Falls into voids during piling.
- Contact with concrete.

Potential community health and safety issues include:

- Possible accidents if access to construction sites is not restricted.
- Road safety where heavy vehicles travel between the Power Plant and the MLS. This will be a particular issue during busy times and when the lake side market is operating each Friday.
- Exposure to dust if dust generation is not controlled.

This list is not exhaustive and ContourGlobal KivuWatt Ltd will be required to address these impacts through:

- Worker safety training prior to beginning works.
- Provision of PPE where appropriate.
- Signage and information on safety.

Development of a safety management system to be planned, implemented and monitored. The safety management system will also incorporate measures to protect local communities for example by restricting access to site and controlling vehicle speeds.

11.1.2. During operation

Potential impacts arising during operation include:

- Fire and burns.
- Explosion.
- Exposure to gas release and asphyxiation.
- Exposure to hazardous materials.
- Exposure to occupational noise.

11.1.3. During decommissioning

Impacts during decommissioning will be broadly similar to those during construction and will be managed in the same way through the production of a Demolition Plan.

11.2. Potential for major safety and health hazards beyond the workplace

Lake destabilisation is the principal major hazard and this is addressed in section 7. In addition there is the potential for fire and explosion effects on communities outside of the workplace. These will be addressed through the ERP that will be developed and are discussed in section 11.4.

- **Table 37 Summary of potential health and safety impacts in the absence of mitigation**

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Falls and slips	Minor	Negligible	Minor	√
Crushing	Minor/Major	Negligible	Minor/Major	√
Exposure to fire	Minor/Major	Minor/Major	Minor	√
Exposure to gas releases	Minor	Major	Minor	√
Exposure to hazardous materials	Minor/Major	Minor	Negligible	√
Exposure to occupational noise	Minor	Negligible	Minor	√

Impact	Construction	Operation	Decommissioning	Mitigation Needed
Road safety	Minor/Major	Negligible	Minor/Major	√

11.3. Occupational safety and health mitigation measures

11.3.1. During construction

- In the construction of the project, the enclosed Health and Safety Plan (see Appendix J) will be included in all major construction contracts as a requirement and the respective contractors will be required to have full compliance including a full time representative that will monitor the day to day activities for both safety and environmental issues affecting the employees and the work site.
- Additionally, the ContourGlobal KivuWatt Ltd Team will have a full staff to monitor the ongoing works which will consist of the General Construction Manager, the Marine Construction Manager, the Power Plant Operations Manager and various engineers that will monitor daily contractor work performance including safety orientation which will include emergency evacuation plans. The plan will be updated and revised as project work requirements dictate. Emergency evacuation plans will be developed for both the MLS and power generation sites.
- Figure 33 illustrates the MLS safety site plan (where works have already commenced). Similar safety plans will be developed for the Power Plant site and for the outfitting of the GEFs prior to work commencing on these.

11.3.2. During operation

For facility operations, once the operations team is in place, work will start immediately on development of specific operations procedures (SOP) which cover the installation contractor's and equipment supplier's recommendations for proper and safe operations including provisions for upset and emergency shutdown provisions. These will be prepared as one of the first activities of the operations team which will be expected to be in place within approximately 6-8 months prior to the commercial operation date anticipated for the 4th quarter of 2010. As part of the development of these procedures, which will cover the facilities both on-shore and off-shore, emergency response plans will include all of the necessary information for employee safety evacuations, public notices and announcements, and notifications to local safety and law enforcement groups. The development of the ERP will be based on coordinating with local public officials as to how notifications processes should proceed and the types of notifications that will be in place to alert those that might be affected by an emergency event including the local community whilst on-shore or on the lake.

Occupational safety will be addressed during operation through five mechanisms:

- Standard operating procedures (SOP).
- HAZOP analyses of significant risk areas such as gas extraction operations.
- Fire safety plans.
- Emergency Preparedness and Response Plans (ERP) for both the gas extraction facilities and the Power Plants.
- An Occupational Health & Safety System (OHSS) for routine activities.

11.3.2.1. Standard Operation Procedures

For any ContourGlobal KivuWatt Ltd operating facility, there are site specific operating procedures that address the safe and efficient operation of the facility, including emergency notifications, involving releases of hazardous vapours and liquids that may imperil plant employees or nearby residents. These procedures address all aspects of permits and monitoring requirements in accordance with the operating permit and various local and regional regulations that the authorities issue. In addition, these procedures will address corporate and social responsibility issues as they relate to plant operations and include the HAZOP recommendations. These procedures are instructional as to how the plant will be operated in all aspects including starting up, shutting down, operating under normal and abnormal conditions, and emergencies. These will be developed in the project shortly after the operations team is in place which is normally within 6-8 months prior to the commercial operations date, tentatively the 4th quarter of 2010 for ContourGlobal KivuWatt Ltd, and when most if not all of the equipment supplier's information has been submitted, the contractor's installation details are completed and start-up and commissioning activities are underway.

The operations personnel prepare both the specific procedures and will incorporate existing corporate standard operating procedures with required modifications to address local conditions as may be required. The ContourGlobal KivuWatt Ltd procedures will be prepared for both the off-shore and on-shore facilities, but will share common standards as they may apply to health and safety and emergency notifications. These procedures will assure a coordinated effort on the part of the gas extraction and power generation facilities which will be in constant communication. While specific site procedures are not available for KivuWatt due to the early stages of development, examples of standard operating and safety procedures are included for review (Appendix J). These represent corporate standards and plant specific standards as may be applicable.

11.3.2.2. Hazard & Operability Study (HAZOP)

A process hazard analysis and HAZOP was prepared for the gas extraction facilities and operations.

The purpose of the HAZOP is to identify possible safety, operational or events of concern and the means to reduce the risks from these. The HAZOP applied risk ranking to determine if risks needed mitigation (risk levels 1-3) or if risks were acceptable (risk levels 4 or more). The HAZOP made 80 recommendations aimed at reducing safety, asset, environmental or public image risk or promoting reliable operations. Recommendation risk levels in order of priority were as follows:

- 12 level 1.
- 19 level 2.
- 8 level 3.

The remainder were all for acceptable levels of risk.

The HAZOP report is provided as a supplement to this report.

The HAZOP considered potential deviations from the operational norm in respect of:

- Flow (e.g. no flow, reverse flow, misdirected flow etc) of extraction and reinjection waters.
- Temperature.
- Pressure.
- Composition/contamination.
- Service failures.
- Equipment.
- Maintenance.
- Commissioning.
- Safety.

Each process was examined to identify possible causes of deviation, the consequences of deviation, safeguards and the severity of the consequence on receptors, e.g. personnel, environment, facilities. A risk rating was then defined and recommendations for mitigation prepared.

For the purpose of this report we include the recommendations in categories 1-3 that require mitigation and where there are EHS implications. Those recommendations that purely relate to operational effects are not considered

Table 38 lists the recommendations and the proposed engineering solutions. Note that for ease of reference the recommendation numbers are those provided in the Riskology HAZOP report which is appended in full.

Table 38 HAZOP risks, recommendations & solutions

R No	Scenario	Recommendation	Risk rating	Proposed solution
9 &10	Reverse flow case in production separators by damage to riser or hydraulic instability leading to potential for uncontrolled upwelling of water from the upper resources zone resulting in degassing of the lake in an uncontrollable manner and release of toxic gas to the environment and exposure of the local population.	Concern is uncontrolled upwelling of water from the upper resource zone and consequences to people in the environment.	2	Autosiphon pump discharge is routed to the top of the degassed, water riser, below Shut Down Valve (SDV) 1703. Injection nozzles are orientated to discharge in a downward flow to prevent any upward blow of water in the degassed water riser. Operation manual will stipulate that SDV 1703 should remain closed when separator is not operating.
11	Leak in raw water riser below gas break out point resulting in release to the environment and exposure of personnel	Consider QA & QC of construction materials.		Use of appropriate materials and visual detection of gas at surface.
12	Reduced flow caused by leak in raw water riser above gas breakout point leading to gas release to the environment at lake surface and exposure of personnel.	Consider location of gas detectors at water surface intended to detect external leakage from risers at the surface.	1	Surface gas detection and design will include gas detectors along the perimeter of the GEF. Reduced gas production rates in the event of a leak and also shut down systems.
14	Increased flow caused by parting of degas riser leading to discharges of great volumes of gas and water at the wrong depth and mismatched density with potential for lake instability and exposure of personnel.	Ensure as part of the density monitoring programme an ROV (Remote Operated Vehicle) is available at location.	1	Mechanical integrity programme. Riser inspections. Ability.

15	Increased flow in production separators caused by bypass valve being left open or leaking leading to release of sour gas at GEF production area and exposure of personnel.	Consider subjecting all vent valves to car seal programme.	2	Plant shutdown on positive gas detection. PPE and emergency response procedures.
19	Misdirected flow in raw gas compressor caused by tube leak in HBG–1210 resulting in leakage of gas into cooling medium, potential corrosion of the cooling system loop by and release to the environment.	Consider periodic testing of water in the cooling media system. Concern is detecting gas leaking into cooling media.	3	Maintenance and inspection programmes.
24 25	Loss of water level in wash tower and gas blow to discharge riser resulting in release to environment and exposure of personnel.	Consider redundancy in level detection and safety interlocks (could be covered by SIL study). Ensure LSL-IS00A to alarm in low levels.	1-2	SIL will be performed after detail design is completed if client desires. P&ID's will indicate level alarms for all applicable level instrumentation.
21 22	Liquid condensing downstream of cooler leads to potentially high rates of corrosion by highly acidic liquids resulting in danger of exposed personnel and environment.	Consider implementing corrosion monitoring process, specifically in this area of the plant.	1	Use of corrosion resultant materials and implementation. Corrosion monitoring programme.
25 40	No flow caused by SDV – 1121 or LSH 1141being closed when it should be open leading to high liquid level in raw gas suction scrubber; potential liquids carry over causing damage to compressor and potential release and exposure of personnel	Consider redundancy in level detection and safety interlocks (could be covered by SIL study). Ensure LSH-1141is included properly on P&IDs.	1	SIL will be performed after detail design is completed if client desires. P&ID's will indicate high level alarms for all applicable level instrumentation.

16, 21, 22,23	Misdirected flow in sweet gas compressors caused by tube leaks or open valves leading to potential leakage of gas, release of sour gas or excess flaring with environmental and safety impacts.	Consider directing all vents to safe location, equipping cooling water system with gas detection and local relief valves.	1-3	HFGE will indicate double block valves with a bleed vent between them on the P&ID's for all applicable maintenance venting scenarios. All vent valves will be indicated as car seal closed (CSC). Closed venting would be via field routed tubing to the flare header. All heat exchangers will be equipped with Pressure safety valves (PSV's) per API 14C. Piping and instrumentation diagrams (P&ID's) will reflect instrument nomenclature on all P&IDs. The compressor manufacturer will be required to provide limit switches. Note that Engineers confirmed that cooling water system is a closed system with a PSV relieving to flare header. And considered that gas detection in cooling water system doesn't improve safety or operability
28 29	Corrosion of equipment caused by condensation of liquids downstream of cooler leading to highly acidic liquids. Potential corrosion can cause leaks, releases to the environment and exposure of personnel.	Consider implementing corrosion monitoring programme and ensure proper materials selection.	2	Coatings and cathode protection. Inspection programme. Proper materials selection.
32	Misdirected flow in wash water towers caused by trap failure on MAJ-1640 with potential for gas blow into closed drain header and possible gas releases at tie in points.	Eliminate trap in drain line to closed drain header from raw gas lube oil filter.	1	
35 36	Loss of water level in wash tower and gas blow to discharge riser leading to release to the environment and personnel exposure.	LSL-1500 to alarm when low levels reached. Consider redundancy in level control safety instrumentation on wash towers (include SIL analysis).	1-2	Low level alarms will be indicated on the P&ID's for all applicable level instrumentation. SIL will be performed after detail design is completed if client desires.

28	No flow in flare scrubber and pump due to FCV (feed control valves) or SPV being closed when should be open leading to inability to provide supplemental fuel gas, potential inability to meet lower flammability limit at flare tip and possible release of toxic gas.	Ensure system accounts for timing issues and potential release of flammable/toxic gas in flare header system.	1-2	Gas detection systems. Determine if all H_2S will be consumed when burning in the relief header with no supplemental gas.
45 50	Difficulty of maintaining sub-sea valves on separators leading to possible over exposure to gaseous water.	Protection and monitoring system.	2	Consider a means to maintain separator and associated sub-sea valves including installation of appropriate block valves, provision of a source of dead water and effective lock-out-tag-out of either one or half of the separators. Consider including dual barrier riser on raw water side including annual gas monitoring system.
53	Use of higher than design oxygen content. Water in cooling media system with potential flammable mixture in water wash tower, possible ignition and explosion.	Verify concentrations, do not reach flammable limits in wash water tower under any conditions.	2	PSL-1500A isolates inflow of gas water to water wash tower which occurs above flammable limit (SDV-1500A and 1501A).
57	No flow in flare scrubber and pump caused by PCV-2041 being closed when it should be open leading to inability to provide flare purge gas to flame system. Potential inability to maintain desired flammability concentrations and pressures inside flame system.	Consider revising control of FCV-2042 to open on loss of flow to PCV-2041 falling closed.	2	None identified.
58 59	Increased level in flare scrubber caused by LCV-2040 being closed when should be open leading to increased level in flare scrubber, possible liquid carry over to flare and exposure of personnel and environment.	Design of LSH-2-40	1	Design of SIS shutdown on flare scrubber.
60	Inability to safely maintain flare scrubber and pump control valves leading to exposure of personnel and possible release to environment.	Consider reviewing double block and bleed for LCV-2040.	2	None identified.

61	Inability to maintain ZZZ-2082 in flare scrubber and pump leading to exposure of personnel and possible release to the environment.	Consider adding local shut-off valve to flame front generator ZZZ-2082.	2	None identified.
65	Inability to safely maintain PBE-1980 A/B in closed drain system.	Consider adding local block valves on suction side of PBE-1980 A/B.	2	None identified.

It is clear that the majority of risk emanate from changes in flow or pressure. Other potential risks could arise from loss of liquid levels or corrosion effects.

The principal safety risks are associated with worker exposure to toxic and inflammable gases and fire risks. The principal environmental and community concern is in relation to possible impacts on lake stability due to reverse flow in production separators or discharges of gas and water at the wrong depth caused by parting of the degas riser.

Other risk issues will be addressed through re-design or through additional safety systems – SIL.

11.3.2.3. Fire Safety Plans

The protection of personnel and equipment is of paramount importance. The current designs for both the gas extraction facility and power generation plan will incorporate provisions for fire prevention (developed procedures), fire detection (sensors and alarms), and fire suppression (water and foam and portable extinguishers). Both facilities will have equipment installed including gas detection, heat sensors and manual pull stations in the event of a fire and an audible alarm system. Both systems will include public address systems to notify operating personnel of an event and both facilities will regularly train in fire fighting techniques and have a fire brigade on duty at all times.

The HAZOP plan provides for recommendations for not only design changes to assure facility safety, but also includes operator requirements that will be implemented into the fire safety plan as preventative measures to minimise the risk and potential for fires and explosions. The dangers of the facilities are well understood as part of the HAZOP discussions and the implementation of these in the operating instructions will be done as a matter of record. The major events as identified included gas releases and the potential to self ignite. Because methane very quickly dissipates in the atmosphere, the potential for vapours to accumulate in pockets will be minimal. The use of hazardous chemicals or the release of hazardous chemicals is also minimal in both facilities as there is virtually none other than storage on number 2 fuel oil for the standby generators and limited quantities of lubricating oil for the equipment which is also in limited quantities for either location.

The Fire Safety Plan will address these specific areas of concern and methods for extinguishing fires and minimising the risks associated with handling and spillage.

11.3.2.4. Emergency Response Plans (ERP)

ERP will be prepared for both the power plant and the gas extraction facilities prior to commissioning. The ERP will include, but not be limited to:

- Identification and location of potential risks and emergency scenarios.
- Risk mitigation strategies.
- Alarms and warning systems including warning lights, sirens, load speaker system and wind socks to indicate direction of prevailing winds (and therefore potential gas cloud migration).
- Procedures to identify and account for all workers and visitors.
- Establish escape routes and evacuation systems including regular drill practice for all staff for evacuations and different emergency scenarios.
- 24 hour contact information for all relevant internal/external persons, including local government representatives and emergency services. This will include at a minimum, names, addresses, phone numbers (alternative numbers if applicable) and email. In the case of emergency services, this will state the type of care available and location. It will also include the details for emergency air evacuation.
- Establishment of the onshore Emergency Response Team including Emergency Response Director/Co-ordinator and medical support. Each person will have a specific document (forming part of the ERP) defining roles and responsibilities and a checklist of actions to be undertaken in the event of an incident. The documents will also define equipment required for the role and location thereof.
- Establishment of onshore emergency organisation and control centre (and backup alternative) and essential equipment requirements (communications, safety, etc). On the gas extraction facility this will be the control room.
- A search and rescue plan for gas extraction facility workers or lake users.
- Clear communications protocols including corporate contact and initiation of contact with local authorities, local communities, government and media (e.g. radio and television if public warning broadcast is required) and procedure for establishment of an emergency toll free phone number for public information.
- A glossary detailing the location, description and purpose of all emergency response equipment.
- Procedure and equipment specification and location for establishment of air monitoring. Associated reporting protocol.
- Process and relevant format for reporting to and notification of regulatory bodies (e.g. MININFRA) and other internal (e.g. unaffected staff) / external (e.g. lake users) stakeholders.
- Worker training and awareness exercises. This will include training of a safety manager who will be responsible for maintenance of safety systems and review/iterations of ERP.
- Training and awareness programmes for fishermen and lake users. For example, fishermen/vessel captains would be trained to observe wind direction directly or by using

windsocks located on the extraction facilities (and/or on specially designed buoys around the exclusion zones) to ensure they stay upwind of the facility if they hear the emergency alarm.

- Requirement for regular ERP reviews which should include full debriefing discussions in the event of an incident. The ERP will be living documents, and will be accessible to all staff.

11.3.2.5. Safety Plans

A safety system similar to that developed for construction activities will be developed for routine activities. The operational system will be based on the requirements of ISO18001 for Occupational Safety and Health Management Systems (OSHMS).

11.3.2.6. Compliance with IFC requirements

IFC General Guidelines contain requirements for occupational health and safety (OHS) and also for community safety. The Guidelines for OHS require the following aspects to be addressed:

- Design and operation of facilities.
- Communications and training.
- Hazards (physical, chemical, biological and radiological).
- PPE.
- Special hazardous environments.
- Monitoring.

Community safety requirements include the following aspects to be addressed:

- Water.
- Structural safety.
- Life and fire safety.
- Traffic.
- Transport of hazardous materials.
- Disease prevention.
- Emergency preparedness and response.

Once the various systems are properly implemented including the SOPs, HAZOP, ERP and OSHMS, the IFC requirements will be met.

12. Summary of potential EHS impacts, mitigation & residual effects

Section 4 showed how significance criteria based on geographical context and magnitude criteria would be applied to EHS aspects and Table 8 from that section is repeated here for reference.

Table 8 Significance of impacts

Sensitivity of Impact	Magnitude of Impact		
	Low	Medium	High
International	Minor / Major	Major	Major
National	Minor / Major	Major	Major
Regional	Minor / Major	Minor / Major	Major
District	Negligible / Minor	Minor / Major	Minor / Major
Local	Negligible	Minor	Minor / Major

Table 39 summarises the significance of the environmental, social and safety issues after the application of the suggested mitigation measures. Any potential impact identified in the impact assessment will be included in the Environmental Management & Monitoring Plan (EMMP) given in Appendix A in order to confirm that the mitigation measures are being implemented and are effective.

Table 39 Summary of residual impacts

Aspect	Significance of impact (+ = positive impact)			Mitigation or monitoring needed
	Construction	Operation	Decommissioning	
Climate change	Negligible	Negligible	Negligible	No
Soil and land use	Minor	Minor	Minor	Yes. EMMP actions
Lake stability	Negligible	Major	Minor	Yes. Compliance with Mandatory Guidelines
Water quality due to discharges	Minor	Negligible	Minor	Mitigation and monitoring.
Effects on biozone	Minor	Minor	Minor	Mitigation and monitoring.
Access for fishermen	Negligible	Minor	Negligible	Monitoring only.
Socioeconomic benefits (national)	NA	Major+		No.
Socioeconomic benefits (local)	Major+	Major+		No.
Influx of workers.	Minor	Minor	Minor	Yes. HIV/AIDS programme.
Economic displacement	Minor	Negligible	Negligible	Yes. RAP needed and monitoring.
Air quality	Minor	Minor	Minor	Monitoring only.
Noise	Minor	Negligible	Minor	Mitigation and monitoring.
Health & Safety	Minor	Minor	Minor	Mitigation and monitoring.
Major incidents	Minor	Minor	Minor	Mitigation and monitoring.

13. Figures

The following Figures are provided (please see separate attachment):

Figure 1	Location map of Rwanda (source UNEP)
Figure 2	Bathymetry and gas Concession Areas
Figure 3	Project Overview
Figure 4	Project Detail
Figure 5	Lake Stratification
Figure 6	Autosiphon Method
Figure 7a	Master Layout Plan of Power Plant
Figure 7b	Master Layout Section of Power Plant
Figure 8	Administrative boundaries (Kibuye Master Plan)
Figure 9	Strategic investment areas (Kibuye Master Plan)
Figure 10	Temperature & precipitation changes projected for Africa (IPCC)
Figure 11	Temperature anomalies for Africa (IPCC)
Figure 12	Precipitation intensity on dry days (IPCC)
Figure 13	Soils and Geology
Figure 14	Relative density gradients
Figure 15	Vertical profiles of temperature, salinity and dissolved gas
Figure 16	Development of key worker variables
Figure 17	Detail of modified water diffuser
Figure 18	Plume of degassed water
Figure 19	Streamlines of degassed water
Figure 20	Partial pressure of dissolved gases
Figure 21	Temperature on vertical plan
Figure 22	$C0_2$ on vertical plan
Figure 23	Protected areas and agricultural zones
Figure 24	Crops at the MLS
Figure 25	Consultation with fishermen
Figure 26	Fishermen in dugouts
Figure 27	Newly built canoes
Figure 28	Fish at auction facilities
Figure 29	Relief and drainage model
Figure 30	Water supply network
Figure 31	Predicted noise contours
Figure 32	3D noise model for Power Plant
Figure 33	Fire and safety systems for MLS

(All Figures are provided as a separate attachment)

Appendix A
Environmental Mitigation & Monitoring Plan

1.0 INTRODUCTION

This **Environmental Management & Monitoring Plan (EMMP)** for the ContourGlobal KivuWatt Ltd 100 MW Power Plant in Kibuye, Rwanda provides the management framework needed for planning and implementation of activities during both the construction and operational Phases of the project. It is prepared in accordance with environmental commitments, in compliance with legal and regulatory requirements of Rwanda and the IFC Environmental, Health and Safety Guidelines.

The EMMP applies to both Phases of the project. It is possible that knowledge gained during the operation of Phase I will mean that the EMMP will need to be updated. The EMMP is a live document that will last the lifetime of the project and will be updated as appropriate as the project proceeds.

The EMMP is supplementary to the ESIA prepared by SKM for the project. Issues addressed in the ESIA include:

- Air emissions and noise.
- Waste management.
- Lake stability and protection.
- Land use.
- Socioeconomic impacts.
- Community and worker safety.

The objective of the EMMP is to describe the measures and actions to be implemented during the design, construction and operational Phases of the project to eliminate or reduce key identified biophysical, socioeconomic and health issues and impacts to acceptable levels. ContourGlobal KivuWatt Ltd commits to the implementation of the EMMP and will require similar commitment from its contractors and their staff and will enforce the EMMP through conditions in contracts awarded.

The EMMP concerns both general environmental requirements that are common to most construction projects, and specific environmental initiatives unique to this specific project and includes:

- Investments in equipment and other infrastructure.
- Development of required procedures.

- Capacity strengthening.

The EMMP forms part of the overall Project Management for this development and as such activities described are required to be integrated with other Quality, Sustainability and Health & Safety (H&S) management processes.

1.2 ROLES AND RESPONSIBILITIES

Roles and responsibilities for monitoring of the Project will be shared by the Bilateral Regulatory Authority, Rwandan governmental authorities and by the Project team. Comparative responsibilities are presented below:

1.2.1 Bilateral Regulatory Authority

The Management Prescriptions contain requirements for the Bilateral Regulatory Authority (BRA) that will have oversight of extraction of methane from Lake Kivu. In particular the BRA is expected to:

- Be financed from sale proceeds and production royalties.
- Co-operate with the governments of Rwanda and DRC to formalise the resource allocation in concessions.
- Provide a monitoring role for methane extraction activities.
- Develop gas harvesting plans for the lake.
- Ensure that the public is fully informed about the gas resource, the scope and results of the monitoring programme and the location and gas production of the concessions.
- Review and approve facility design drawings prior to construction.
- Inspect gas extraction facilities.

1.2.2 Rwandan Government

The Rwandan Environment Management Authority (REMA) is mandated by law to organise and approve EIA and for monitoring implementation of environmental protection measures recommended by EIA studies. Both REMA and ContourGlobal KivuWatt Ltd are responsible for environmental monitoring and auditing. It is expected that ContourGlobal KivuWatt Ltd will undertake self-monitoring, record keeping and reporting and submit this information to REMA annually. REMA will be responsible for review and on occasion verification of, reports and data submitted and for periodic inspections as needed.

In the event that ContourGlobal KivuWatt Ltd is found to be non-compliant REMA has the right to penalise ContourGlobal KivuWatt Ltd or even withdraw the Certificate of Authorisation issued in respect of the EIA.

1.2.3 ContourGlobal KivuWatt Ltd Project Team

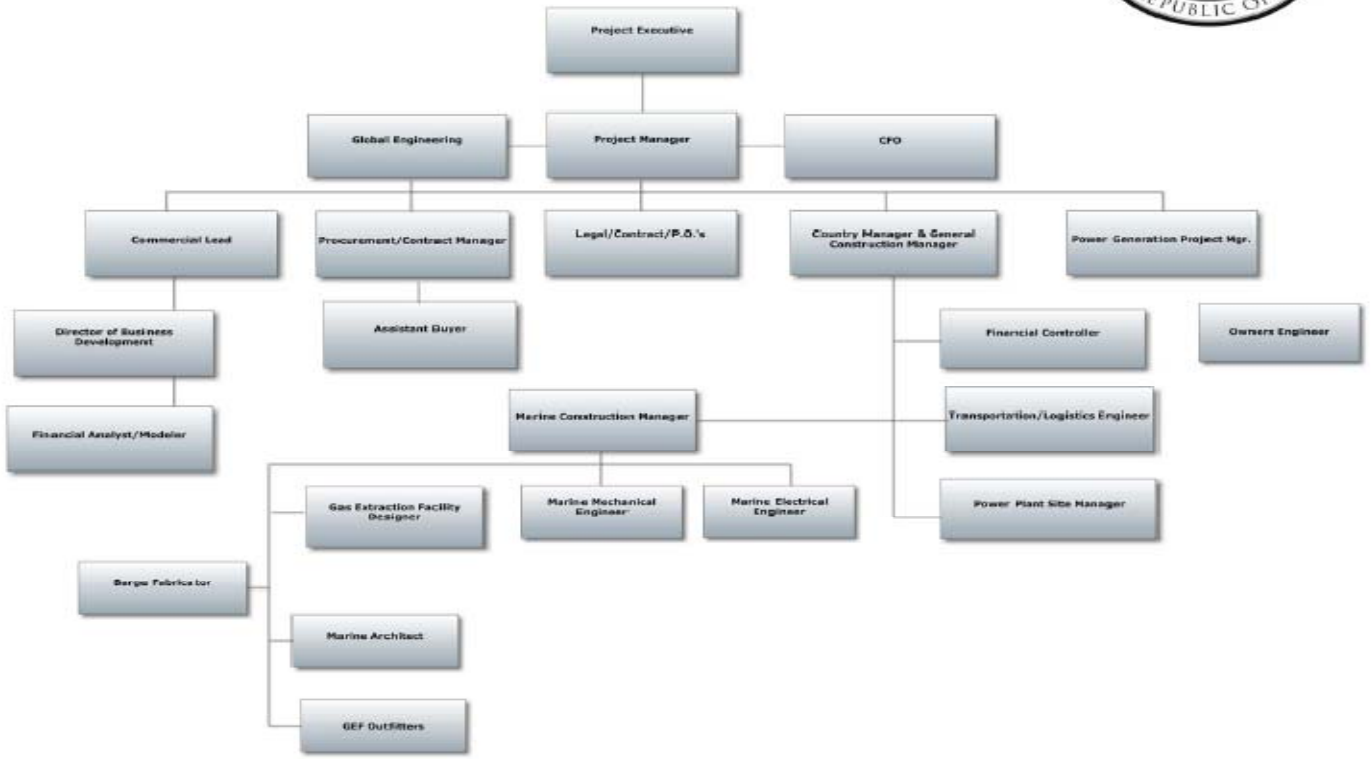
Members of the Project Team will be assigned specific roles as shown as below and will be responsible for the correct application of the EMMP during the construction and operational Phases of the project.

ContourGlobal KivuWatt Ltd will also be responsible for ensuring that all contractor comply with EHS requirements and will do so via the following mechanisms:

- The inclusion of EHS requirements in line with this EMMP in contracts awarded.
- Review of EHS reports provided by contractors.
- Weekly inspections by the on-site management team.
- Periodic audits during construction and operational activities.

KivuWatt Project Organizational Chart

CONTOURGLOBAL



ContourGlobal KivuWatt Ltd Construction Manager

The ContourGlobal KivuWatt Ltd General **Construction Manager** will have the overall responsibility for managing the project throughout the construction period and will ensure that appropriate resources are made available for application of the EMMP, and that environmental controls and any agreed appropriate protection measures are implemented. Reporting to the General Construction Manager will be the Marine Construction Manager responsible for all marine related construction works and the Construction Manager overseeing the installation of the Power Plant.

1.2.3.1 Environmental, Health & Safety Responsibilities

The **Environmental, Health & Safety responsibilities** during Construction will be managed on behalf of ContourGlobal KivuWatt Ltd's General Construction Manager and during operation period by the appointed Environmental, Health & Safety Engineer for coordinating and managing all environmental activities during the construction and operation Phases. The Environmental/Health & Safety responsibilities include:

- Ensure that the Contractor develops, and then reviews, the EMMP and specialist procedures and method statements.
- Ensure delivery of environmental training to personnel within the project team.
- Review method statements for environmental aspects and advise of any suggested improvements prior to work starting.
- Monitor construction activities and performance to ensure that appropriate environmental control measures are being implemented and are effective and ensure compliance with the EMMP.
- Liaison with Contractor's environment coordinator to ensure coordination of environmental mitigation and monitoring procedures.
- Dissemination of instruction to all relevant personnel on site to ensure low impacts.
- Compliance with the instructions relative to the environment and the life space that the companies shall respect.
- Verification of the implementation of mitigating measures during the work site in collaboration with the public work contractors and bringing any issues arising to the attention of the management.

- The organization and implementation of monitoring during the site works and the subsequent operation of the structures.

ContourGlobal KivuWatt Ltd Community Liaison Officer

The ContourGlobal KivuWatt Ltd assigned **Community Liaison Officer** shall be responsible for:

- Overseeing development and implementation of RAP and the grievance mechanism.
- Liaising with ContourGlobal KivuWatt Ltd site staff regarding implementation of any measures arising from the grievance mechanism.
- Ensuring that the public is regularly informed with respect to site activities, including any events with possible negative impacts.

Contractor's Environmental, Health & Safety Officer

The **Power Plant and Marine Construction Contractors' Environmental, Health & Safety Officers** are responsible for coordinating and managing all the environmental activities during the construction Phase, reporting to the ContourGlobal KivuWatt Ltd's General Construction Manager. The Contractor's Environmental Officer will provide a full time presence on site throughout the construction period. His/her responsibilities shall minimally include:

- Liaison with the respective owner's Construction Manager.
- Follow the development of the EMMP.
- Monitor construction activities and performance to ensure that appropriate environmental control measures are being implemented and are effective and ensure compliance with the EMMP.
- Assistance in the development and delivery of environmental training for personnel of the Contractor and Sub-contractors.
- Management of the environmental monitoring programme, including noise, vibration and dust and review the routine reports.
- Dissemination of instructions to all relevant personnel on site..
- Implementation, operation and monitoring of the project Site Waste Management Plan.
- Environmental audit of Sub-contractors and suppliers.

This role will also be managed by the site manager at Civicon for civil works being carried out.

2.0 MITIGATION AND OFFSETTING MEASURES DURING THE CONSTRUCTION PHASE

2.1 Site development

The IFC EHS General Guidelines (2007), under Section 4 (Construction and Decommissioning), sub-section 4.1 (Environment) state: "Soil erosion may be caused by exposure of soil surfaces to rain and wind during site clearing, earth moving, and excavation activities. The mobilisation and transport of soil particles may, in turn, result in sedimentation of surface drainage networks, which may result in impacts to the quality of natural water systems and ultimately the biological systems that use these waters." Various measures are cited for preventing soil erosion and dealing with the consequences of runoff:

- Reducing or preventing erosion through scheduling to avoid heavy rainfall periods (that is, during the dry season) to the extent practical, contouring and minimising length and steepness of slopes.
- Reducing or preventing off-site sediment transport through use of settlement ponds, silt curtains, and water treatment, and modifying or suspending activities during extreme rainfall and high winds to the extent practical.
- Segregating or diverting clean water runoff.
- Limiting access road gradients to reduce runoff-induced erosion and providing adequate road drainage based on road width, surface material, compaction, and maintenance.
- Limiting disturbance to water bodies.
- Providing effective short term measures for slope stabilisation, sediment control and subsidence control until long term measures for the operational Phase can be implemented, as well as adequate drainage systems to minimise and control infiltration.

The MLS project site (covering approximately 1 ha) is at lake level and is immediately adjacent to the lake. Currently rainwater drains naturally from east to west. February to May constitutes the period of heaviest rainfall and the civil works which started in June will be completed in the dry season which continues into September. Erosion and sediment contaminated runoff are therefore expected to be minimal.

Nonetheless, the following measures are proposed (in line with IFC EHS guidelines) if works continues into the rainy season or heavy rainfall occurs:

- Limit excavation during the dry season to shallow soil removal.
- Replace soil as quickly as possible.
- Halt soil excavation activities during heavy rain.
- Maintain a low profile of removed soil with respect to rainfall.
- Identify any problematic parts of the site with respect to possible erosion that would be expedited by construction activities.
- Incorporate required measures into the construction contractor EMMP, and inform relevant works of requirements including e.g. the use of silt curtains.

2.2 Air Quality

This section presents the offsetting measures to be implemented to minimize the impacts of the construction on ambient air quality and potentially on local communities.

Good construction site practices shall be implemented to diminish these impacts:

- Tarpaulin trucks transporting loose/friable materials on and offsite site.
- Minimise the amount of materials lost during transportation.
- Limit speed to 30 kilometres per hour on unpaved roads.
- Maintain and store piles of loose/friable materials and soil in a manner that minimises dust dispersion.
- Spray water on the site to allow suspended solid particles to settle. During periods of high winds, limit construction activities that generate a great deal of dust in areas where sensitive receptors are located.
- Regular cleaning of surfaced roads.

  Positioning and movement of construction equipment will be undertaken in a matter which minimises dust generation.

2.3 Protection of water resources

Water will be used during construction for concrete mixing, sanitary purposes, washing equipment and to spray the site down to reduce dust emissions.

Water shall be treated before being discharged into the natural environment:

- Potentially polluted water shall be treated in the oily water treatment unit before being discharged into the natural environment.
- Sanitary water (showers, toilets) will be treated in septic tanks.
- Rain water will be discharged into the natural environment; the risk zones (storage of products) will be equipped with secondary containment to prevent discharge of polluted water into the natural environment.

Chemical substances storage and the generators shall be equipped with secondary containment to avoid any risk of accidental spills. Waste, in particular waste oils, shall be disposed of by specialised companies. Any leaks of oils or fuels shall be cleaned (absorbents) and recovered.

During all stages of this project and as required by the gas Concession Agreement, ContourGlobal KivuWatt Ltd shall ensure that all liquid effluents, including process wastewater, domestic sewage, and contaminated storm water and runoff, shall meet the World Bank maximum limits before being discharged (see monitoring section).

Monitoring of wastewater streams shall comply with Section 1.3 of the IFC General EHS Guidelines of 30 April 2007. The General EHS Guidelines do not specify frequency, but require that wastewater monitoring "*take into consideration the discharge characteristics from the process over time*". As the discharges involved (other than storm water) are not expected to vary considerably over time, we expect that occasional grab samples will be adequate. Composite samples would be more appropriate for storm water and runoff, which are not expected to contain short-lived polluting parameters. Quarterly samples of process wastewater treatment unit discharge (including process wastewater and domestic sewage) should be adequate. Composite storm water and runoff samples would normally only be required during the rainy season, on a quarterly basis, depending on the level of precipitation.

In accordance with the IFC General EHS Guidelines, process discharge cannot be diluted prior to or after treatment. Sampling and analysis will be implemented by trained persons. Laboratories shall have international-level certification. Sampling and Analysis Quality Assurance/Quality Control (QA/QC) will be established and implemented.

In the event that such laboratories are not available in Rwanda samples will either have to be transferred to the nearest suitable laboratory or a laboratory will need to be established on site.

Section 1.4 of the IFC General EHS Guidelines calls for implementation of water conservation programmes '*commensurate with the magnitude and cost of water use*". Water conservation measures may include:

- Water monitoring/management techniques.
- Process and cooling/heating water recycling, reuse and other techniques.
- Sanitary water conservation techniques.

During the construction Phase, ContourGlobal KivuWatt Ltd will ensure that water is used sparingly in accordance with international standards. This task will be coordinated with the soil erosion and runoff management described earlier.

2.4 Reduction of noise pollution

Preliminary noise modelling indicates that IFC noise limits at the nearest residential location will be met. Noise levels from the construction site shall be verified at the property boundaries.

Noise associated with construction can be reduced by placing effective silencers on the exhaust pipes of construction machinery, by ensuring that equipment is maintained in good condition, by using the quietest equipment possible, by placing equipment as far as possible from the most sensitive receptors and by using the buildings onsite as screens.

Work will be carried out during daylight hours, six days a week, excluding public holidays. To limit noise levels, daylight hours will also be prioritised for vehicle movements.

2.5 Waste management

During the works, the subcontractor will be responsible for the following tasks:

- A site visit will be carried out by the subcontractor prior to commencing works.
- The subcontractor shall ensure that all (construction) wastes are recovered and treated in conformity with requirements of the World Bank and the waste management plan.
- It is the responsibility of the contractor to establish the most suitable disposal, treatment or recycling facilities to ensure correct treatment or disposal of all wastes does not cause harm to human health or the environment.
- Burning of waste is forbidden.

- Furthermore, the recycling and the re-use of waste will be favoured, only inert waste (excavated soil) will be stored on site.

2.6 Economic displacement of farmers from the MLS

A Resettlement Action Plan (RAP) will be prepared to address the economic displacement of farmers from the MLS. The RAP will address additional targeted assistance and transitional support that will be offered to the farmers to supplement the compensation paid by the GoR. The RAP will comply with the requirements of IFC Performance Standard 5 for Land Acquisition and Involuntary resettlement (2005). The key features of the RAP are:

- A household asset survey.
- Consultation.
- Formation of a Resettlement working Group.
- Reaching key agreement on entitlement, income restoration, grievance redress and responsibilities for implementation.

2.7 Relations with the local population

A grievance mechanism, tied in with a public information process, is essential for the success of this project. A well-functioning grievance mechanism:

- Provides a predictable, transparent and credible process to all parties resulting in outcomes that are seen as fair, and lasting.
- Builds trust as an integral component of broader community relations activities.
- Enables more systematic identification of emerging issues and trends facilitating corrective action and pre-emptive engagement.

As recommended by the IFC, the grievance mechanism will benefit the company, in that it:

- Serves as an early warning system for wider problems.
- Yields insights from individual grievances that spotlight changes that might be needed with respect to company operations and management systems.
- Indicates possible systematic changes that might be needed to ensure that particular grievances do not recur.

The IFC view is that stakeholders from the community and company shall be involved in the grievance mechanism design is supported.

The key features of the grievance programme will be as follows:

- Central point for coordination.
- Well known multiple access points.
- Mechanism for reporting back to the community.
- Grievance log to monitor cases and improve organisation.
- Mechanism for evaluating and improving the system.

As noted earlier in section 1.2.3 earlier, ContourGlobal KivuWatt Ltd will assign a member of the team that will serve as the **Community Liaison Officer** to oversee public consultation, including dissemination of project information and handling grievances (as required by IFC Performance Standards).

The public will be advised of the Community Liaison Officer and contact information (primarily by telephone, letter and e-mail). Monthly meetings are to be held in the nearest residential area to the project site to discuss project progress, and hear any particular grievances that local residents may have. Grievances shall also be accepted from workers at the site.

The mechanism could include:

- Provision for communication of grievances to ContourGlobal KivuWatt Ltd via letters, internet, a logbook to be left at the site entrance, and/or periodic meetings where grievances can be raised.
- Provision for communicating to the public and update of project activities and actions taken in response to grievances, for example via the meetings cited above, as well as advertisements in local newspapers.

Specific measures to mitigate the negative socioeconomic impacts during the construction Phase are set out in the monitoring table at the end of this plan**.** ContourGlobal KivuWatt Ltd shall take preventive measures to ensure that the installation does not:

- Create disturbances for the nearby market: dust emissions and noise from the construction site will be reduced to minimise disturbing market traders and their customers. The site will be sprayed down if necessary and noise measurements taken in the event of complaints.

- Cause traffic jams or accidents: Traffic flow will be controlled to avoid creating traffic jams. Road safety will be taken into consideration (speed limits, choice of carriers, training of drivers, etc.).

This plan shall apply to both the construction and operational Phases.

2.8 Influx of construction workers

ContourGlobal KivuWatt Ltd will have numbers of Expatriates and other professional staff at the site during different periods of this project. ContourGlobal KivuWatt Ltd plans to eventually recruit about 103 operating local personnel at the site, at various skill levels.

The construction crew will result in the largest influx of workers to the site. Peak construction activities will introduce 200- 250 (or more) manual labourers at the site. Accommodation will be provided for expatriate workers in an on-site accommodation camp. Other manual labourers are likely to live locally.

2.9 HIV/AIDS

An HIV/AIDS programme will be developed in line with IFC Good Practice Note for HIV/AIDS (2002). This will apply to both the construction and operational Phases of the project and will include:

- An HIV/AIDS policy.
- Defining the extent of the problem and also risk factors.
- Developing education and awareness programmes.
- Promoting prevention of the spread of HIV.

3.0 MITIGATION & OFFSETTING MEASURES DURING POWER PLANT OPERATION

3.1 Air quality

3.1.2 Operation

During the combustion of methane the emissions from the future electricity plant will conform to limits provided by the IFC, both for concentrations at the stack discharge and concentrations at surface.

The assessment identified that the impacts arising during the operation of the electricity generation plant are unlikely to result in any air quality objectives being exceeded. The air dispersion modelling undertaken indicated that there could be some exceedance of NO_2 during Phase II of the project (if the proposed stack height

of 25m is used). However the approach taken was conservative due to a paucity of reliable meteorological and ambient air quality data and the inability to accurately model the terrain (due to a lack of detailed topographical data) and lake effects. The conclusions of the air quality impact assessment were that the actual concentrations at the nearest receptor will be acceptable since, for the most part, the plume will disperse over the lake. Monitoring will be used to confirm or otherwise the modelling results.

3.1.3 Management and verification plan

The air quality impact assessment will be updated based on the definitive engineering plans.

During operation, samples of gas emissions will be collected in order to precisely study emission levels, exit velocity and temperature. This should provide indications regarding the validity of the assumptions made for this assessment and will indicate the site's ongoing compliance. Once a year, ContourGlobal KivuWatt Ltd shall measure the following emissions at the stack exit: NOx and PM. Measurements of NO_2 and dust in the ambient air beyond the limits of development site will also be carried out monthly. These measurements will have to be carried out during periods of low wind speed and at the nearest sensitive receptors Note that SO_2 is considered negligible and does not need to be measured. Meteorological data will also be collected; as a minimum hourly sequential wind speed and wind direction.

The annual verifications of NOx and PM emissions will be sent to the Rwandan Environment Management Agency (REMA).

The ambient air quality management plan will be undertaken based upon World Bank guidelines which broadly specify the following, in line with which the following methodology has been developed:

- Monitoring techniques shall be internationally recognized, and be compliant with ISO, European or United States Environmental Protection Agency (USEPA) standards; and
- Monitoring may be undertaken at the facility fence line and at off-site locations. Precise locations will be based upon the results of the dispersion modelling.

The monitoring will be undertaken using the methodology in the following sections.

3.1.3.1 Analysis of NO_2 by diffusion tube

The monitoring programme will determine ambient levels of NO_2 (the monitoring will focus on NO_2 rather than total NOx, as the air quality standards refer to NO_2) and PM_{10}, as these are the main pollutants of interest associated with the operation of the plant. Of these, NO_2 is the priority as this is the only pollutant that will be emitted in significant quantities when the plant is operating.

Ambient levels of NO_2 will be monitored at six locations in the vicinity of the plant on a monthly schedule, using diffusion tubes. The monitoring of NO_2 by diffusion tube is specified in the European Standard EN 13528 Parts 1-3 : 2002/3; typically the limit of detection achievable with NO_2 diffusion tubes is $<1 \mu g/m^3$.

Diffusion tubes will miss short term peaks but will capture long term average concentrations. This is considered acceptable as they are low technology and do not require any specialist technical expertise which is potentially not available locally in Rwanda. The diffusion tubes would be changed on a monthly basis, following a schedule of four and five week periods. Supply and analysis of the tubes would be undertaken by a suitably accredited laboratory, either in Rwanda or abroad depending on the availability of local services.

3.1.3.2 Monitoring of PM_{10} and $PM_{2.5}$

IFC guidelines specify that monitoring shall be capable of monitoring PM_{10} and $PM_{2.5}$. This methodology satisfies that requirement. PM_{10} and $PM_{2.5}$ would be monitoring on a continuous basis using a Topas optical device. The monitoring of $PM_{10}$and $PM_{2.5}$ by optical methods is not directly specified in a European, USEPA or British Standard. However, the technology has been independently verified to be equivalent to the TEOM (Tapered Element Oscillating Microbalance), which complies with BS EN 12341:1999.

The monitoring of PM_{10} and $PM_{2.5}$ would be undertaken on a continuous basis, with the monitoring being set up to allow comparison with both the annual and 24 hour air quality standards. Three-monthly servicing would be undertaken by site personnel, and annual calibration of the equipment would be undertaken by the equipment suppliers.

3.1.3.3 CO_2 emissions

When the installation is functioning using gas, CO_2 emissions per unit of energy produced will be much lower than for other fossil fuels. Therefore, proportionately the facility will make a much lower contribution to the greenhouse effect.

- **Table A1** ***CO_2 emissions factors for the burning of various types of fuel (based on net calorific value)***

Type of fuel	Emissions factor (kg CO_2/GJ)
Wood peat	105.89
Brown coal	101.12
Anthracite	98.30
Sub-bituminous coal	96.00
Bituminous coal	94.53
Heavy fuel oil	77.30
Domestic fuel oil	74.01
Diesel fuel	74.01
Gasoline	69.25
Natural gas	56.06

The CO_2 emissions from the plant will be calculated on an annual basis, based upon the recorded use of each fuel type throughout the year, and using the factors provided. Where required, the fuel use in kilogrammes can be translated into Giga-Joules for use with Table A1 above.

3.2 Protection of water resources

3.2.1 Operation

Connection to the public water supply network is envisaged for on-shore activities although the Concession Agreement does confer rights of abstraction from the lake. Based on information currently available, water consumption shall not exceed 0.362 m^3/h from the Power Plant and no more than 5.68 m^3/h from the GEFs. Water discharges from the Power Plant will be 0.03 m^3/h oily water from workshops and sanitary water of 0.25 m^3/h. Sewage from the GEFs will be 0.75m^3/h and will be treated in a package unit prior to discharge.

To maintain the quality of surface water and groundwater, all water shall be appropriately treated before any discharge into the natural environment.

Rain water will be discharged into the natural environment. Surface runoff within the risk zones (storage of products, engines) will be captured in order to prevent discharge of polluted water into the natural environment.

3.2.2. Management and verification plan

To verify the compliance of discharges from the site into the natural environment, water analyses will be carried out on commencement of operation of the Power Plant

and then annually. Table A2 below outlines the discharge limits imposed by the IFC in the document General EHS Guidelines, 30 April (2007).

- **Table A2 IFC limits for water discharges from natural gas plants**

Pollutant	Discharge limits
pH	6-9
Suspended solids	50 mg/1
Hydrocarbons	10 mg/1
Biological Oxygen demand (BOD)	30 mg/1
Chemical Oxygen demand (COD)	125 mg/1
Total Ammonia	10 mg/1
Total Phosphorus	2 mg/1
Total Coliforms	400 mpn*/100 m1

**most probable number*

Quarterly samples for process wastewater, wastewater treatment unit discharge (including process wastewater and domestic sewage) will be adequate. Composite storm water and runoff samples would normally only be required during the rainy season, on a quarterly basis, depending on the level of precipitation.

In the event of persistent non-conformity (not due to an accident), a remedial solution will be implemented and new verification measurements collected after this solution has been put in place in order to verify that quality objectives have been met.

Section 1.4 of the IFC General EHS Guidelines requires implementation of water conservation.

Measures potentially applicable to this project include:

- Stormwater collection and use.
- Process water pressure management.
- Adequate spill and leakage control.

ContourGlobal KivuWatt Ltd is committed to developing a water conservation programme that will apply conservation measures, as appropriate, to the various water uses at this plant. These include the following:

- Leakage monitoring and control will be systematically implemented by the maintenance department.
- Equipment washing will be limited.
- Use of sanitary facilities will be equipped with water saving devices, and users will be required to follow water-saving practices.
- Fitting a water efficient showerhead, and limitations on the length of showers (showers can use between 6 - 45 litres per minute), cistern displacement devices (usually more effective on larger cisterns, between 9 and 12 litres), toilet variable flush systems (with possible water use reduction of up to 50%).

3.3 Waste management

3.3.1 Construction Waste

The largest volume of solid waste material will be generated from the construction works themselves. There is no waste disposal site in Kibuye at the present time. Much of the waste material can be re-used within the community and the waste management plan will identify means for local re-distribution. This will be carried out by the main contractors involved in the construction of the Power Plant and gas extraction facility.

3.3.2 Operation

The following waste streams will be generated during site operations:

- Waste oils, recovery from secondary containment and oil contaminated materials such as cleaning rags.
- Sludge from the oily water treatment unit.
- Used engine filters.
- Used batteries.
- Maintenance waste.
- Containers and drums contaminated with oil or chemical substances.
- Septic tank sludge.
- Office waste.

- Waste paints and solvents.

Liquid waste shall be stored in secondary containment systems to prevent risk of any accidental spills and pollution of the natural environment.

Waste oil, filters and hazardous waste shall be transferred to a company that specializes in the recycling, regeneration or disposal of such materials (assuming that such a company exists in Kibuye, otherwise alternative means of disposal must be found) including if necessary, transfer to facilities in Kigali.

A Waste Management Plan (WMP) will be developed that will identify:

- Waste quantities and nature.
- Waste minimisation strategies.
- On-site storage requirements.
- Accidental release mitigation measures.
- Waste carrier and transport.
- Final waste treatment.
- Standards to be met.

3.3.3 Management and verification plan

Liquid waste, together with contaminated drums and containers, will be stored in areas equipped with secondary containment in order to prevent any risk of contamination of the ground.

The contractor shall keep a record of all solid and liquid wastes generated on the site, where they are located, means of storage, disposal methods etc. These records should be kept in a form that can be easily audited on a quarterly basis. The records must clearly show the volumes and types of materials that are re-used (either within the site or in the local community) or redistributed and do not end up in final disposal. A clear record of the final location of the re-usable materials must be kept and the end user needs to sign for any materials taken off-site. Records can be audited on a quarterly basis during the construction period and thereafter annually. Records can be appended to the annual report to REMA.

These requirements assume that local waste disposal facilities will be available and it is not clear that this is the case. In the event that these facilities are not available, the WMP will be modified to devise the most acceptable methods of waste management and disposal in discussion with REMA.

3.4 Noise

3.4.1 Operation

The following noise reduction measures should be taken into account in the design of the Power Plant project:

- Avoid placing the buildings' doors and other openings on the side facing the nearest sensitive receptors.
- Use specific materials rated for their sonic insulation qualities in the construction of the offices facing the engines.
- Use the existing buildings on the site as screens and barriers to protect the nearest receptors from sources of noise.

The modelling provided shows that noise levels are expected to comply with IFC standards.

During operations, the noise generated by the Power Plant shall be verified using equipment that complies with international standards and is properly calibrated. Measurements will be made during both day and night at property boundaries and in areas with regulated noise levels to ensure that the noise generated by the Power Plant complies with World Bank standards. These measurements shall be taken at least every three years and at the time of each significant modification to the site (modifications made to equipment, new equipment, new installations, etc.).

In the event of excessive noise levels, attenuation measures shall be implemented, such as an anti-noise wall, and further verification measurements carried out after the implementation of attenuation measures.

The IFC General EHS Guidelines require that noise monitoring be implemented *"for the purposes of establishing the existing ambient noise levels in the area of the proposed or existing facility, or for verifying operational Phase noise levels."* Monitoring periods of 48 hours are suggested, on an annual basis.

3.5 Monitoring of the Lake Stability

Monitoring of lake stability is required at the commissioning stage and during operations.

3.5.1 On Commissioning

MAR6 of the Prescriptions states:

At start-up of a new or modified gas extraction facility, a concessionaire must engage a qualified third party to carry out monitoring in the lake (e.g. salinity and temperature profile measurements) around the point of re-injection. This monitoring will, with sufficient reliability and precision, demonstrate the shape of the plumes of any re-injected water (degassed and washing water). The purpose is to measure and report, from start-up until sufficient results have been reached, that there are no deviations from re-stratification levels as defined in this document. If necessary, adjustment of density control must take place followed by renewed monitoring until a satisfactory result has been obtained. The third party report will be submitted to the Bilateral Regulatory Authority.

3.5.2 During Operations

A monitoring programme has been formulated by the Expert Committee (2006). This, however, only deals with vertical monitoring whilst some horizontal monitoring will also be needed. The programme would be needed to assess the impact of gas extraction in the lake in real time and to provide ongoing, more accurate, forecast or warning of impacts given the uncertainties involved. There must be rapid feedback to the management so that they can adjust or shut down operations at short notice. The principal methods will be to measure profiles of conductivity temperature and density (CTD) with a CTD probe of the sort described in Tietze 1978 and 2000, which can also measure oxygen and pH. Schmid et al (2005) used a Sea –Bird SBE-19 CTD device equipped with a Sea-Bird SBE -22B combined pH and oxygen sensor. For more detailed temperature work they used a free-falling Sea-Bird SBE 11 equipped with two Thermometric FP07 microstructure thermistors. These basic profiles can be amplified by measuring other key chemical parameters such as phosphate and iron for samples at different depths taken with a Niskin bottle. The following vertical profiles should be carried out:

1. Conductivity, temperature and density profiles should be taken regularly at around 230m to the lake bed under the GEF sites and also in the first 100m of water.
2. Depth profiles of total gas pressure, and ideally, methane and CO_2 separately. CO_2 is determined from pH and alkalinity (see below) and CH_4 can be measured with a Capsum Mets methane sensor.
3. Install a meteorological station on the GEF with particular reference to wind speed and direction.

4. Take water samples down through the water column at the same depth as 1 above and analyze for alkalinity, phosphate, nitrate ammonia, iron and from time to time, organic carbon.
5. In the top 100m measure light penetration with a secchi disc and turbidity plus every 10m, cholorophyll; samples should be analysed for composition of phytoplankton in the top 40m.

Horizontal Measurements

6. Repeat 1 above at progressive distances for the intake and waste pipes to measure any changes and plot their scale.
7. Repeat 5 above in top 100m at progressive distances for the wash water release pipe to plot the three dimensional spread of the plume.

All measurements should be started before production (1-5) with some horizontal measurements to establish a baseline of natural variation. Seasonal variation should be established by these baseline measurements. After start up this programme should be followed once a week for 6 months and then monthly thereafter. Analysis of the plankton should initially be done every three months.

ContourGlobal KivuWatt Ltd will submit monitoring programmes to BRA as required including automatic online reporting if required. Sample points for all major streams will be installed with suitable valve arrangements for taking the necessary samples and for the BRA appointed third parties to take samples. Facilities shall be designed to allow carrying out tests with injection of tracers.

MAR7 of the Prescriptions requires reporting of monitoring data as follows:

Operators of gas extraction facilities must report certain operation and monitoring data electronically to, and in a manner and frequency defined by, the Bilateral Regulatory Authority. Operators must be prepared to carry out automatic, online reporting if required by the Bilateral Regulatory Authority. This data will be made public and used together with other data to develop better scientific understanding of the lake and guidance of extraction concession design, safety and operations. Operator shall ensure that sample points for all major streams are installed, with suitable valve arrangements, for taking the necessary samples and for the Regulator's appointed third party to take samples on request. Facilities shall be designed to allow carrying out tests with injection of tracers (through sample points).

Data to be reported include the following parameters:

a) Hourly averages of flow rates for all water extracted from and re-injected to the lake, plus the rates of produced gas or electrical power (MW) and cumulative production. Flow meters shall be calibrated once a year and copies of the calibration reports submitted to the Bilateral Regulatory Authority;

b) Monthly average values of flow rates for all gas streams produced by the extraction process, including mass balances showing the methane extraction efficiency and the relative carbon dioxide removal rate; and

c) Monthly average values of water temperature, conductivity and salinity, as well as concentrations of methane and carbon dioxide, hydrogen sulphide and nitrogen in said water and gas streams, as well as calculated and/or measured densities of the re-injection water.

Other data may be added if concerns for the lake so require.

Once a month, a full set of water parameter analysis shall be made in an agreed laboratory on samples of extracted and re-injected water.

3.6 Monitoring of the lake fisheries

Monitoring schemes are based on surveys and the results of these surveys are used to produce biomass estimates for specific fish species. For the calculation of these estimates two components are necessary, a) fisheries surveys carried out by scientifically trained personnel (which are generally limited in terms of time and spatial distribution), and b) fisheries surveys which are basically catch and landings records usually collected by the local fisheries authorities directly from fishermen. The latter component is nevertheless weak as little information is presently collected by the authorities in Kibuye, as a result there are no time series landings data. Therefore, even though scientific surveys may be carried out, there will always be a lack of historical data against which to compose ongoing results.

Taking into account the limitations mentioned above, the monitoring programme guidelines will only consider component a), as component b) should be systematically carried out by the governmental authorities. Furthermore, the suggested survey will be implemented at a local level and will focus mainly on the impact of the methane extraction operation in Kibuye.

The objectives of the monitoring programme will be to:

- Meet the assumed requirements of the GoR for monitoring lake fisheries and fit in with their proposed (but as yet unpublished) monitoring plan.

- In the absence of any historical data, collect baseline data specific to the project area.
- Monitor the impact of the Phase I GEF and pipelines.
- Monitor the impact of the whole project.
- Combine with fisheries catch and landing data collected by the government.

The monitoring will provide a one year baseline prior to the Phase I operation commencing. While this is not ideal because of the absence of historical data, it will at least provide some information against which change can be measured. In order to increase confidence in the baseline data the surveys should be carried out at all four of the proposed GEF areas and proposed pipeline routes from the very beginning of the survey. This will then reveal any year on year natural fluctuations in the area in the absence of the Phase II GEFs. The data from the Phase II GEF area can also be applied as a 'control' to the Phase I GEF results thus allowing a useful comparison between possible natural fluctuations and changes occurring as a direct result of the GEF placement and pipelines.

The fisheries monitoring programme is shown in Table A3 .

Table A3 Fisheries monitoring

Actions	Equipment need	Personnel	Results
Acoustic surveys along the pipelines (or proposed pipeline routes) at two different time periods, (day and night) Survey carried out 4 times a year in the middle of each season (rainy/dry season)	Fine resolution high frequency echo sounder with data recording facility Boat with outboard engine and cover from rain	1 marine scientist 1 underwater acoustics specialist 1 technician	Estimation of the fish biomass along the pipelines Seasonality of the fish biomass in the areas surrounding the pipelines Assess differences of fish behaviour between day and night Assess differences of fish behaviour between seasons Understand the impact light sources may potentially have on fish behaviour along the pipelines
Acoustic surveys around the GEFs (or proposed GEF locations) at two different time periods, (day and night) Survey carried out 4 times a year in the middle of each season (rainy/dry season)	Fine resolution high frequency echo sounder with data recording facility Boat with outboard engine	1 marine scientist 1 underwater acoustics specialist 1 technician	Estimation of the fish biomass around the GEFs Seasonality of the fish biomass in the areas around the GEFs Assess differences of fish behaviour between day and night Assess differences of fish behaviour between seasons Understand the impact light sources, the noise generated by the GEFs and the GEFs themselves may potentially have on fish behaviour
Fisheries survey in the area surrounding the GEFs (or proposed areas) Two surveys per year	Local fishing boat	1 marine scientist 1 acoustics specialist 1 technician	Groundtruthing the acoustic readings Assess fish biomass Carry out a full biological sampling of the main commercial species *Limnothissa miodon*

Actions	Equipment need	Personnel	Results
		Normal fishing boat crew (8-10 people)	
Data base to store and centralise all the findings of the surveys.	1 pc and internet access	1 IT expert	Centralised DB system containing all data from surveys. Additional landings data collected onshore may also be recorded on this DB.

3.7 Relations with the local population

ContourGlobal KivuWatt Ltd shall implement preventative measures to ensure that the facility:

- Regularly communicates with local communities.
- Implements a complaints procedure.
- Does not create fears concerning possible pollution risks (emissions of pollutants, hazardous substances, risks of explosion).
- Minimises noise nuisance and emissions of pollutants.

ContourGlobal KivuWatt Ltd will respond to any complaints or concerns raised through the grievance mechanism within a week at most.

4.0 Dismantling of the facility

The concession has been signed for 25 years till the end of Phase II and the lifespan of a typical facility such as this is of more than 30 years if suitably maintained. A suspension of the activities on site is currently not envisaged. However, in the eventuality of a cessation of activities, ContourGlobal KivuWatt Ltd is committed, with the aim of ensuring the repairing of the site, to take the following actions:

- Elimination of all wastes and chemical products and associated containers.
- Dismantling of all production units and associated technical installations under conditions ensuring the prevention of pollution linked to the presence of fluids in the supply circuits.
- Cleaning of zones where necessary, emptying and rendering inert tanks, cleaning chemical product networks.

In general, the measures proposed during construction will be applied during dismantling, notably concerning:

- Noise limitation.
- Limiting dust emission.
- Waste management.
- Management of health and safety issues on site.

A decommissioning plan will be submitted to REMA for approval prior to any works commencing. This is as required by the Rwandan law on EIA.

5.0 HEALTH AND SAFETY RECOMMENDATIONS

5.1 Health and safety committee

A Health and Safety Committee will be created for the new site. These committees are normally made up of staff members in charge of operations. The members of the Committee shall be replaced and rotated regularly. The Committee shall be responsible for inspecting the facilities, making recommendations for improvements with regard to health and safety, analysing the causes of accidents and making recommendations concerning necessary changes.

5.2 HAZOP & ERP

The HAZOP prepared by Riskology made several recommendations to mitigate potential hazards; these recommendations have been addressed by ContourGlobal KivuWatt Ltd and Antares Offshore and are to be implemented as part of the design of the gas extraction facilities. These include automatic gas detection, warning and shut-off systems to operate in the event of a release or equipment mis-function. Further studies are in progress and will also be incorporated into design.

The principal safety risks are associated with worker exposure to toxic and inflammable gases and fire risks. The principal environmental and community concern is in relation to possible impacts on lake stability.

Exclusion zones will be established around the Power Plant site, the extraction GEFs and the re-injection areas.

Emergency Response Plans (ERP) will be developed for both the GEFs and the Power Plant that will include:

- Identification and location of risks.
- Risk mitigation strategies.
- Alarms and warning systems.
- Emergency organisation and control centre.
- Roles and responsibilities (internal and external).
- Escape routes and evacuation systems.
- Internal and external (e.g. Government organisation and emergency services) communications and reporting routes.
- Worker training, awareness and ERP testing.
- Location of emergency response equipment.

- Activation of ERP team.

5.3 Prevention of industrial accidents

General prevention principals

In general, ContourGlobal KivuWatt Ltd will adopt the following principles:

- Avoid risks in the workplace.
- Assess risks that are unavoidable.
- Implement protective measures, placing the emphasis on collective measure if possible.
- Train employees.
- Establish a first aid station.

Whenever necessary, appropriate personal protective equipment shall be made available to workers. Such equipment shall be verified regularly.

Training

Workers will receive training as necessary, notably:

- Training in the use of fire fighting equipment, renewable annually.
- General safety training (dangerous areas onsite, evacuation procedures, actions to take in the event of an emergency, etc), renewable every 2 years.
- Training in workplace safety, renewable every 2 years.
- First aid training, renewable every 2 years.
- Certification to work on electrical installations, renewable every 3 years.
- Training regarding chemical hazards renewable every 3 years.
- Training regarding manual handling of heavy loads, if applicable, renewable every 3 years.

This training shall be provided on commencement of employment and repeated periodically (respecting the frequencies outlined above), in particular whenever there is a change in position, a change in working methods or a change in equipment.

Subcontractors and external companies

Work by subcontractors or external companies shall be coordinated by ContourGlobal KivuWatt Ltd, which shall coordinate all outside companies performing work on the site and their subcontractors, both before and during the performance of the work, by specifically monitoring compliance with procedures fixed during preliminary coordination meetings or procedures rendered necessary by the progression of work.

The future construction site will be visited jointly by representatives of ContourGlobal KivuWatt Ltd and the subcontractor and will be periodically inspected.

Regulatory provisions for occupational health

The following provisions for ventilation, lighting and noise will be implemented.

- Workshops shall be installed in well ventilated buildings.
- Workshops and offices shall be appropriately illuminated. Emergency lighting to indicate emergency exits shall be powered by an emergency generator or by autonomous battery packs.
- At night, suitable lighting will be provided in areas requiring illumination.
- All workshops, offices and company premises shall be regularly cleaned by site personnel.
- A number of restrooms appropriate for the size of the workforce shall be provided. The rest rooms shall be located near the work areas.
- Equipment that generates the highest levels of noise shall be clearly indicated. When such equipment is installed, noise measurements shall be taken in the working areas. If the values exceed the regulatory threshold (85 dBA) appropriate signs will be provided identifying high noise areas. employees shall be provided with hearing protection for use in such areas.

Note that all signage will be in Kinyarwandan as well as English.

5.4 Relevant health and safety documents

ContourGlobal KivuWatt Ltd will develop an overall site Health and Safety document in accordance with IFC guidelines. Additionally, Power Plant EPC

Contractor will develop their own health and safety documents for their activities in accordance with IFC guidelines.

ContourGlobal KivuWatt Ltd will maintain the following records onsite:

- The register of industrial accidents.
- Health and safety verification and control reports (work equipment, electrical installations, high-pressure equipment, etc).
- Inspection reports on the quality of work environments (lighting, exposure to noise, exposure to chemical substances, etc).
- The list of subcontractors and external companies performing work and safety instructions provided to them.
- The register documenting periodic fire fighting exercises and tests of fire fighting equipment.
- The occupational health register.
- The employee register.

6.0 CONTRIBUTION TO SOCIOECONOMIC DEVELOPMENT

The project will enable Rwanda to reduce its energy dependency. It will provide the country with the power it requires to develop productive activities necessary for the country's economic development. The project will generate few negative socioeconomic impacts since it is located in an industrial area.

6.1 FRAMEWORK FOR A SOCIAL MANAGEMENT PLAN

6.1.2 Process of Development

In line with international best practice, ContourGlobal KivuWatt Ltd will develop a Social Management Plan (SMP). The SMP will recommend feasible and cost-effective measures to prevent or reduce significant negative social impacts to acceptable levels, a mechanism for monitoring the success of these mitigation measures and a Public Consultation and Disclosure Programme (PCDP). The process explained in the following text is considered necessary for the development of a Social Management Plan (SMP).

In order to successfully attend to the various tasks and responsibilities contained in a SMP, including the Public Consultation and Disclosure Programme, a Community Relations / Liaison Officer will need to be employed by ContourGlobal KivuWatt Ltd. This person needs to be chosen in terms of his/her qualifications, experience, skills and familiarity with the area. An appointment needs to be made as early as

possible in the project development cycle in order to ensure continuity in the public participation process. Public consultation was started during the ESIA process but this needs to be continued to avoid issues related to a lack of communication between ContourGlobal KivuWatt Ltd and other stakeholders.

The Community Liaison Officer will need the support and assistance of a Community Liaison Working Group (CLWG) which will be formed (in cooperation with government and with popular support) in order that various stakeholders within the affected area are represented and have a an organised forum to communicate with ContourGlobal KivuWatt Ltd. The CLWG will ensure that the needs and perspectives of all local stakeholders are taken into account. This group is also a key component for any social investment initiatives and will assist the Community Liaison Officer with such activities as Development Needs Assessments, decision making, implementation of actions and their evaluation. The group will also play an important role in facilitating the Public Consultation and Disclosure Process and will also act in collaboration with the Resettlement Working Group (RWG) which will be formed for the purposes of developing and implementing the Resettlement Action Plan. It is possible, and perhaps advisable, that members of the RWG will also be members of the CLWG. The formation of the CLWG will be formed as soon as is practicably possible, and will be a key priority for ContourGlobal KivuWatt Ltd once a Community Liaison Officer has been appointed. The roles, responsibilities and mechanisms of the CLWG will need to be defined in consultation with stakeholders.

A detailed social database for the area, including indicators of population, standard of living, housing, household income, access to natural and socio-cultural resources, health (including infection rates for HIV/AIDS), education, and social pathologies will be compiled in order to provide a baseline for the development of a monitoring programme and to identify the major potential community problems. Social service providers (Non-Government Organisations, Community Based Organisations, local government) in the area and the country will need to be identified and contacted to develop assistance programmes for identified social problems or risks. The development of the social database is a key priority for the company and its creation will be initiated once the Community Liaison Officer is in post.

A social monitoring strategy, which measures changes in livelihoods and the social environment, will be developed in order to identify the occurrence of negative and positive social impacts. This strategy will require the development of suitable indicators and tools to measure change, and an implementation schedule for the

strategy. The monitoring strategy will be developed in concert with the social database.

As already outlined, a Public Consultation and Disclosure Programme (PCDP) will be developed in line with the IFC's Good Practice Manual. The PCDP will build on the public consultation and participation process already initiated during the ESIA. ContourGlobal KivuWatt Ltd recognises that disclosure of information throughout the project (composed of construction, operation and decommissioning Phases) will help to ensure accountability and transparency. The act of public consultation will help to identify potential points of disagreements between stakeholders, ethnic / gender / religious / political based tensions, raised expectations by the project and emerging social problems that require attention and with which ContourGlobal KivuWatt Ltd may be able to assist. In the formation of the PCDP, local, regional and national stakeholders will need to be identified with a view to establishing who will require participation in pertinent areas of information disclosure or consultation. The Community Liaison Officer, with assistance of the CLWG, will execute the PCDP. Development of the PCDP will commence once the Community Liaison Officer is in post and the CLWG has been formed.

In order to enhance transparency and avoid conflict an employment Protocol will need to be developed, outlining criteria and mechanisms for employment as well as policies with regards to gender, religion, local and non-local labour and skills development. This Protocol will be developed before recruitment starts and will be made public (nationally, regionally and locally) through appropriate media. A skills audit will be conducted in the local community and a skills training programme developed to enhance recruitment potential of community members.

6.1.3 The Community Development Plan

In order to inform a Community Development Plan, a local development needs and local and regional capacity assessment will need to be conducted. This Needs Assessment will be informed by a Social Baseline Study, existing local government reports and through additional data collection (e.g. community workshops and focus group discussions). The Needs Assessment report needs to be compiled once the project becomes operational.

Based on the needs and capacities analysis, the policies of the client and the development plans (and budget) of local / regional government, a Community Development Programme (CDP) will need to be generated. This will include the areas / sectors of proposed assistance (e.g. health, agriculture etc), the description of various projects in these areas (aims, objectives and strategies), and the

identification of agencies responsible for their implementation, as well as an evaluation procedure for each project. The programme should be integrated such that each sector targeted complements rather than conflicts with other initiatives to create development synergies.

The CDP should also facilitate government development agendas and not be in conflict with or contradict them. The proposed CDP would need to be discussed with the local communities before its implementation to ensure it is compliant with their needs and expectations. The Community Liaison Officer would need to be responsible for the public consultation, monitoring and evaluation of these projects.

7.0 TIMETABLE FOR REPORT ISSUE

The deadlines and timetable for transmission of reports to the Environmental authorities (REMA) are summarised in Table A4 below:

Table A4 Timetable for reporting & submission to REMA

Theme	Report	Transmission timetable
Air	Atmosphere emissions measurements (N0x, NO_2, CO_2 metals, dust) – stack effluent and ambient air	Annual
Water	Analysis of aqueous discharges (pH, TSS, Hydrocarbons, BOD, COD, Nitrogen, Phosphorus, Coliform)	Annual
Lake stability	Lake stability	On commissioning. Plus continuous on-line monitoring and annual reports.
Fisheries	Fisheries	Annual
Waste	Summary of waste management (quantity, transport, disposal)	Annual
Noise	Noise measurements at property limit	3 Years

Table A5 lists the activities that comprise the EMMP and assigns responsibilities for implementing and verifying each activity within a specified time period.

Table A5 EMMP

Environmental monitoring and management plan

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction Phase									
Construction	Construction work	Health and Safety	Working conditions to follow best construction site practice. These will be detailed in an Occupational Health & Safety Plan that fully complies with the IFC General Guidelines, including but not limited to training, standard operating procedures to ensure safety, testing of fire alarms, the use of personal protective equipment and emergency response measures. Reference to the following documents: ▪ IFC General EHS Guidelines. ▪ The ContourGlobal KivuWatt Ltd Health & Safety Policy.	During construction	ContourGlobal KivuWatt Ltd and all contractors	ContourGlobal KivuWatt Ltd to have overall responsibility for ensuring compliance	ContourGlobal KivuWatt Ltd and contractor reports	Sub-contractors terms of reference Sub-Contractor weekly reports	Management time

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	Construction activities	General emergency procedures	Increase awareness and training of staff on the consequences of an explosion; an emergency plan document shall be prepared and will describe all measures to be implemented in the event of detection of a gas leak.	During construction	Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Periodic safety awareness tests	Test scores	Management time
Construction	Negative ESH impacts on residents	Any perceived impacts due to construction activities Economic displacement of farmers	A grievance mechanism will be established, and information on construction activities will be periodically disseminated to the concerned public. Rapid development and implementation (+ IFC PSS)	During construction During construction (2009-2010)	ContourGlobal KivuWatt Ltd ContourGlobal KivuWatt Ltd	Local citizens organisations, Competent Authority OPIC	Quick and adequate response to perceived negative impacts Internal and external monitoring	Grievance reports (monthly) Monitoring reports	To be confirmed 200,000 €

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	*Remediation, transport of materials, construction, traffic*	Dust emissions	Implementation of best construction site practices: • Cover trucks transporting loose/friable materials on and off site. Minimize the amount of materials lost during transportation. • Limit speed to 30 km per hour on roads. • Maintain and store piles of loose/friable materials and soil in a suitable manner in order to minimise dust dispersion (for example: balance cutting and filling operations). • Spray water on the site to allow suspended solid particles to settle.	Construction Phase	Civicon/Fair Construction	ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd inspections	Subcontractor inspections Periodic meetings with subcontractors	Management time

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	Use and discharge of water	Soil, surface water and groundwater contamination	• Water will be used during construction for sanitary purposes, washing equipment and to spray the site down to reduce dust emissions. All possible conservation measures will be taken, including recycling, reuse and the use of water conservation devices (for example flow restriction devices). • Potentially polluted water to be treated before being discharged into the natural environment: Implementation as soon as possible of treatment unit (oily water treatment, septic tanks).	During construction	Civicon/Fair Construction/ Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Implementation of treatment measures	Inspection of works	Included in construction costs

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	Construction work	Soil, surface water and groundwater contamination	Other attenuation measures will be implemented as follows: • Chemical substances, liquid waste storage shall be equipped with secondary containment to avoid any risk of accidental spills. • Any leaks of oils or fuels will be cleaned (absorbents) and recovered.	During construction	Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Wastes properly stored	Regular inspections by ContourGlobal KivuWatt Ltd and contractor	Included in construction costs
Construction	Excavation and other ground preparation	Soil erosion and surface runoff	Limit excavation during the dry season to shallow soil removal. Replace soil as quickly as possible. Halt soil excavation activities during heavy rain. Maintain a low profile of removed soil with respect to rainfall. Identify any problematic parts of the site with respect to possible erosion that would be expedited by construction activities. Incorporate required measures into the construction contractor HS&E plan requirements.	During construction	Civicon/Fair Construction	ContourGlobal KivuWatt Ltd	No erosion or runoff due to excavation activities	Visual inspection	Standard operating procedures

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	*Construction work*	Waste and the waste management plan.	Prioritise recycling and return to supplier. Disposal of municipal and construction waste by specialist companies. Provision of sanitary facilities and removal of waste. Liquid waste storage equipped with secondary containment.	During construction	Civicon/FairConstruction Power Plant EPC Contractor / ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd	Maximise waste recycling	Regular inspections by ContourGlobal KivuWatt Ltd and contractor	Management time
Construction	*Construction work*	Noise	Prohibit night-time work during construction. Implement measurements at property limits to verify conformity of noise emissions. PPE will be worn by all Employees and visitors to site, also sub contractors will be required to wear PPE (this will include appropriate ear protection devices).	During construction	Civicon/Fair Construction/ Power Plant EPC Contractor ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd	Working hours Noise emissions < 70 dBA Proper equipment to be worn at appropriate places	Periodic inspection of subcontractors Noise measurements at property limits Shift supervisors Confirmed by site management	Management time Measurements 3 000 € Management time Management time

			Signs will be placed at appropriate locations at site to remind staff of possible dangers and safety measures to be taken.				Appropriate signs placed at appropriate places		
Construction	*Traffic circulation*	Noise and traffic	Strictly limit speed and hours of traffic movements.	During construction	Civicon/Fair Construction/ Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Traffic circulation hours	Periodic meetings with subcontractors	Management time
Construction	*Vehicle movements*	Dangers associated with vehicle movements	• Implementation of a traffic plan (identify traffic, parking and pedestrian zones). • Limit traffic speed. Heavy lifts (onsite and offsite) will be coordinated between the construction manager and public relations officer, who will also assist with coordination with local authorities.	During construction	Civicon/Fair Construction/ Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Implementation of a traffic plan. Number of accidents linked to traffic	Visits and meetings with subcontractors	Management time

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	*Construction work*	Influx of workers into the industrial zone	• Identify an authority responsible for external relations • Ensure availability of potable water and proper sanitary facilities. HIV/AIDS programme.	During construction	ContourGlobal KivuWatt	Ministry	Authority identified	Management of potential problems during works	Management time
Construction	*Construction work*	Socioeconomic impacts: Creation of employment opportunities and small commercial activities surrounding construction site	Priority shall be given to hiring Rwandan workers.	During construction	ContourGlobal KivuWatt Ltd	Rwandan authorities	Number of Rwandan employees /Total n° of employees	Work contracts and site labour statistics	Management time
Construction	*Construction work*	Site clearance	Economic displacement of farmers.	During construction	ContourGlobal KivuWatt Ltd appointed consultants	ContourGlobal KivuWat Ltd	Livelihoods restored to pre-displacement levels	Consultation with farmers	

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Construction	*Construction work*	Health and safety of workers (including protection against workplace accidents)	Ensure that subcontractors have passed H&S training of their staff.	During construction	Power Plant EPC Contractor/ Civicon/ Fair Construction	ContourGlobal KivuWatt Ltd	Respect H&S rules during work. Number of accidents.	Include this clause in subcontractors contracts	Management time
Construction	*Construction activities*	Health, safety and minimal impact on livelihood and daily activities of residents	Install a grievance mechanism: Appoint Community Relations Officer (CRO).Appoint stakeholder counterparts. Implement grievance mechanism system (including periodic meetings with selected stakeholders).	During construction, operational and decommissioning periods	ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd	Grievance mechanism Periodic reports from CRO	Written grievance mechanism, periodic reports and minutes of stakeholder meetings.	Management time
Commissioning	Commission of extraction facilities	Preservation of lake stability	Monitoring to ensure no deviation from re-stratification levels	Start up of extraction facilities until sufficient results obtained and submitted to BRA.	Qualified independent consultants hired by ContourGlobal KivuWatt Ltd	Bilateral Regulatory Authority (BRA)	Monitoring Report	Approval report by BRA	Costs of hiring third party qualified personnel

Operation									
Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation (see also Construction)	*Negative ESH impacts on residents*	Any perceived impacts due to construction activities	A public consultation process and grievance mechanism will be established. The public consultation process will include periodic dissemination of information regarding plant operations and procedures to the concerned public.	During construction, adapted to operational period	ContourGlobal KivuWatt Ltd	Local citizens organisations, Competent Authority	Quick and adequate response to perceived negative impacts	Grievance reports	To be confirmed
Operation (see also Construction)	Plant operations	General emergency procedures	Implement 500m exclusion zone around GEFs, re-injection areas and Power Plant. Implement findings of the HAZOP. Increase awareness and training of staff on the consequences of an explosion; an emergency plan document shall be prepared and will describe all measures to be implemented in the event of detection of a gas leak. Development of an Emergency Response Plan for the site.	During operations	ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd	Periodic safety awareness tests	Test scores	Incorporated into plant management costs

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Operation of the plant*	Atmospheric pollution	Monitoring of slack emissions	Construction Phase Operation Phase	ContourGlobal KivuWatt Ltd	Rwandan authorities	Compliance with IFC limits for stack emissions for NOx, CO, and dust. Verification of parameters of smoke plume (T°, emission speed, Oxygen and humidity) NB: REMA may also require analysis of SO_2. As SO_2 is unlikely to be emitted this should be agreed with REMA. Compliance with WB limits for NOx, and dust in ambient air outside property limits	Monthly atmospheric emission measurements (stack) Use of yield parameters (combustion parameters) to guarantee permanent site conformity Annual atmospheric emission measurements (property limits	Atmospheric emission measurements : 3-4000 Euros

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Air quality monitoring*	Non-compliance with IFC air quality standards	Monthly Analysis of NO_2 and by diffusion tube at six locations around the site. Continuous monitoring of PM10 and PM2.5 by Topas. Calculation of CO_2 emissions from the plant on an annual basis, based upon the recorded use of each fuel type throughout the year.	Operation	ContourGlobal KivuWatt Ltd	REMA	Analytical results	Review of analytical results by REMA	6 175 € for Topas equipment (including shipping and service) 1 600 € annual cost for diffusion tubes
Operation	*Lake Stability Monitoring*	Lake stability	Continuous monitoring in line with requirement MAR7 of the Prescriptions	Hourly and monthly reporting	ContourGlobal KivuWatt Ltd	RBA	Monitoring results and periodic reports		To be confirmed

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Operational water consumption*	Water resources	ContourGlobal KivuWatt Ltd will develop a site water conservation plan. This will include the following elements: • Regular monitoring of water consumption (locate zones of highest consumption and possible leaks). • Installation of meters at water supply points and at locations identified as of highest consumption. • Connection with network equipped with non-return system. • Equipment washing will be limited. • Use of sanitary facilities will be equipped with water saving devices, and users will be required to follow water-saving practices.	Installation of equipment Operation Phase Construction Phase	Power Plant EPC Contractor ContourGlobal KivuWatt Ltd Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd ContourGlobal KivuWatt Ltd ContourGlobal KivuWatt Ltd	Consumption conforms to consumption presented in study Equipment installed	Monitoring of consumption	Management time for monitoring 2 to 6 000 Euros per meter Non-return system : 5 000 Euros

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Water discharge*	Soil, surface water and groundwater contamination	Appropriate treatment will be implemented prior to any discharge into the natural environment: Sanitary water will be treated in septic tanks before being sent to the biological treatment unit then discharged into the natural environment. • Potentially polluted water shall be treated in the oily water treatment unit before being discharged into the natural environment.	Treatment to be implemented during construction Phase and to be maintained in good condition throughout operation	Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Compliance of discharges with WB limits for the following parameters: pH, TSS, Hydrocarbons, BOD, COD, Nitrogen, Phosphorus, Coliform	Verification of the condition of the water recovery equipment and operation of treatment units Implement sampling and analysis of discharges at minimum annually following commencement of operations	Operational costs 1 to 2 000 Euros per analysis

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Wastewater discharge*	Non-compliance with WB wastewater discharge standards	• Quarterly grab samples of process wastewater, wastewater treatment unit discharge (including process wastewater and domestic sewage) quality (pH, TSS, BOD, COD, hydrocarbons, total ammonia, total phosphorus, coliform). • Quarterly composite samples of stormwater and runoff (normally only be required during the rainy season).	Operation	ContourGlobal KivuWatt Ltd	Competent Authority	Waste water treatment plant discharge quality	Review by Competent Authority	Internal costs
Operation	*Pipeline operation and exclusion zones*	Effects on fisheries	Acoustic and fisheries surveys	Annual for 5 years	ContourGlobal KivuWatt Ltd	MINAGRI	Catches	Comparison with baseline	Euro 25,000 per year for 5 years
Pre-operation and Operation	*Extraction and re-injection*	Effects on lake stability	Vertical and horizontal profile monitoring as required by the Mandatory Guidelines.	6 months initially then monthly throughout operation.	ContourGlobal KivuWatt Ltd	Competent Authority	Density matching and chemical and biological indicators	Review by Competent Authority	

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Infiltration of pollutants*	Soil, surface water and groundwater contamination	Fire-fighting water to be collected and treated if necessary (water can be recovered in areas of secondary containment if of sufficient capacity). Chemical products to be stored in areas with secondary containment.	During the construction Phase and to be maintained during operation	Power Plant EPC Contractor	ContourGlobal KivuWatt Ltd	Size of areas of secondary containment for recovery of fire-fighting water Installation of secondary containment		Cost to be included in construction costs Cost to be included in construction costs 300 to 1 000 € per area of secondary containment
Operation	*Waste generation - storage*	Good waste management	Liquid waste will be stored with secondary containment to prevent risk of accidental spillage of pollution of the natural environment.	Operation	ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd	Liquid waste with secondary containment	Regular inspections	300 to 1 000 € per area of secondary containment

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Waste generation - treatment*	Good waste management	• Waste will be sorted and recycled or reused as far as possible. This assumes employee training. • Waste oils, will be passed to a company specialized in recycling, regeneration or disposal of these materials.	Operation	ContourGlobal KivuWatt Ltd ContourGlobal KivuWatt Ltd		Recycling rate Shipment to specialist companies. Recycling rate N° of waste elimination documents received	Implementation of audits of the principal dangerous waste disposal contractors Issue of a waste transfer note of all dangerous waste and recovery of notes after treatment	Management time Management time Management time

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Noise emissions from equipment*	Worker exposure to high levels of noise	• PPE will be worn by all Employees and visitors to site and other sub contractors will be required to wear PPE (this will include appropriate ear protection devices) to be used in the areas of the site (close to the engines) with high noise levels. • Signs will be placed at appropriate locations at site to remind staff of possible dangers and safety measures to be taken.	Operation	ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd	Compliance with WB limit (85 dBA)	Verification of noise emissions at work station every 3 years. Results of annual hearing exam for exposed personnel	Measurements: 3 000 €
Operation	*Storage and use of fuels*	Management of fire and explosion risks and gas releases	Implementation of HAZOP	Operation	ContourGlobal KivuWatt Ltd	ContourGlobal KivuWatt Ltd		Report issue	Based on results

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	*Operation*	Workplace accidents, health and safety of personnel	Implementation of a system for the management of on site health and safety issues: • creation of an H&S committee. • safety training for employees. • management of external companies using H&S plans. • identification of explosion risk zones.	Operation	ContourGlobal KivuWatt Ltd	H&S committee + Rwandan authorities	Existence of H&S committee N° of safety trainings N° of H&S plans	Verification of H&S knowledge of employees Review of H&S plans	Management time

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Operation	Use of chemical products	Chemical risks	Hazardous substances shall be stored with secondary containment. Near and outside areas where acid is stored and handled, safety equipment shall be provided, e.g., autonomous breathing protection equipment, extinguishers, a water station with abundant flow, safety showers and eye-wash fountains. employees shall be trained regarding chemical hazards.	Operation	ContourGlobal KivuWatt Ltd	H&S committee H&S committee	Equipment available	Regular verification of systems by staff Regular training	Operational costs Management time
Dismantling Phase									

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Dismantling	*Dismantling work*	Returning site to initial condition	The following measures will be implemented in the event of site dismantling: • Elimination of wastes and chemical products. • Dismantling of all production units and associated technical installations. • Cleaning of zones where necessary, emptying and rendering inert tanks, cleaning chemical product networks.	Dismantling period	Dismantling company	ContourGlobal KivuWatt Ltd & REMA	Verification during and after works	Meeting with subcontractors Inspections	

Project Phase	Activity	Problems – Impacts	Attenuation / mitigation measures	Implementation period	Implementation authority	Verification authority	Measurable	Verification measures	Implementation cost
Dismantling	*Dismantling work*	Nuisances due to works	Implementation of necessary measures described for the construction Phase to: • Noise limitation. • Limiting dust emission. • Waste management. • Management of health and safety issues in site.	Dismantling period	Dismantling company	ContourGlobal KivuWatt Ltd	Good site operational practices	Site visits To be included in subcontractor contracts	Management time