

# PERSEUS MINING (GHANA) LIMITED

## SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT – EASTERN PITS PROJECT

Rev. No.	Prepared By	Reviewed	Approved	Date	Description/Change effected

**May 2015**



## EXECUTIVE SUMMARY

### 1 INTRODUCTION

The Perseus Mining (Ghana) Limited (PMGL) Eastern Pits Project (the Project) comprises the development of an open pit mining operation and related infrastructure to mine and process ore from defined reserves from a number of associated gold deposits. The Project is located 16 km west of Dunkwa-on-Ofin, in and around the Ayanfuri community in the Central Region of Ghana. Ayanfuri lies along the sealed highway from Ghana’s second largest city, Kumasi, located 107km by road to the north and the port of Takoradi, located 186 km by road to the south.

In order to carry out active mining activities in the Eastern Pits area, the Company has to submit a Supplementary Environmental Impact Statement (SEIS) for approval to expand its mining operations at Fetish, Esuajah North, Chirawewa and Bokitiso pits (Eastern Pits). The application is in compliance with the Ghana EIA Procedures, the Environmental Protection Agency (EPA) Act, 1994 (Act 490) and the Environmental Assessment Regulation, 1999 (LI 1652) which makes Environmental Impact Assessment (EIA) mandatory for the proposed project. An application to the EPA to commence the Eastern Pits operation and a response received from the EPA (dated 15<sup>th</sup> January 2014, Reference CM 42/5) following review of the application requested PMGL to submit to the Agency a Supplementary Environmental Impact Statement (SEIS) incorporating a review of the existing environmental conditions of the Project area.

### 2 DESCRIPTION OF THE PROJECT

The Eastern Pits Project will consist of construction of access roads, haul roads, operation, and decommissioning (including reclamation) phases for a conventional open pit. The mining operation will cover the Fetish, Esuajah North, Chirawewa and Bokitiso pits. Ore from the Eastern Pits will be treated at the existing Gravity Flotation Intensive Leach (GFIL) process plant.

Edikan Gold Mine (EGM) is surrounded by five catchment Communities: Ayanfuri, Nkonya, Abenabena, Gyaman and Fobinso. The main land use within these communities is farming and has been the mainstay for the people of the aforementioned Communities. However, significant portions of these lands have been disturbed by historical mining and illegal small mining activities which make it a brown field operation. The Company holds two Mining Leases–Ayanfuri and Nanankaw Mining Leases (ML). The two Leases are 42.9 km<sup>2</sup> and 43.93

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km<sup>2</sup> respectively. The PMGL Mining Leases are located in the Central and Western Regions of Southern Ghana and are located on the eastern flank of the highly prospective Ashanti Belt. They are located 6.3km west to 30.7 km south west of Dunkwa-on-Offin and 30km to 57km south west of Obuasi.

The Eastern Pits are located in the North Eastern section of the Ayanfuri concession. Current exploration activities have increased the resource base of the operation and the process plant is undergoing a progressive upgrade in order to attain a steady production rate of 8.0 Mtpa. Current End-of-Mine life is estimated at 2020.

Mining operations will be limited to open pit mining using conventional excavator/truck mining methods. Mining of the pits will be carried out by a contractor and will be managed by PMGL's Mining department. The contractor will be responsible for site preparation, cleaning of existing pits, haul-road construction and maintenance, drill and blast, load and haul of ore and waste material to the ROM pad and waste rock dump respectively. The technical services comprising of mine planning, production scheduling, grade control, surveying and the monitoring of the contract mining operations will be undertaken by PMGL personnel.

A second ROM pad will be constructed in the Eastern Pits area, approximately 1.5 km southeast of the Fetish pit. The base will be constructed with low grade ore from the first pit to be mined (Fetish) as per the mining schedule. Ore will be stockpiled and blended from the pits using dump trucks which will be determined or dependent on the pit shells at the time of mining. The ore will then be hauled to the primary ROM pad where it will be crushed at the process plant site. Alternatively, a primary crusher will be mounted at the secondary ROM pad to crush ore prior to haulage to the primary ROM pad. Waste mined will be constructed on the natural topography after available topsoil within the footprint area has been stripped. The Mining Contractor is responsible for establishing all of the facilities required to support his operation. PMGL will provide access to an area located South West of the Fetish pit.

The Eastern Pits will not have a separate process plant but ore will be hauled to the existing and operational crusher and processing plant located at the Western pits area and treatment process is as detailed in the comprehensive Environmental Impact Statement (EIS) submitted in May 2010 and as outlined in the Environmental Management Plan submitted in December 2012.

Ore from the Eastern Pits operation will be stockpiled at a temporary ROM pad near the Fetish pit area which will then be hauled to the existing process plant for blending and treatment.

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Emergency generators will be provided on site in the event of mains power failure. Electricity will be extended from the Gridco substation located at the plant site to the Eastern Pits area. Fuel and hydrocarbon will be supplied by a sub-contractor and this will involve the installation of a double skin 500,000 litre tank at the contractor lay down area, the facility will be placed in a bunded area (110%) and fitted with an oil/water separation system. The contract for supply will include the waste oil management system. The supplier will store, remove and recycle the spent oils. Communication for the Eastern Pits operation will be mainly through radio communication and mobile phone network system. Radio communications will be via separate channels for mining, process plant and an emergency channel. A communication booster station will be mounted to interface between the Western and Eastern Pits.

### 3 Baseline Information

Ten (10) years climatic data was obtained from Dunkwa-on-Offin, where the nearest national climatological station operated by the Ghana Meteorological Agency (GMA) is located. In addition, four (4) months data was provided to allow for comparison. Four (4) months total rainfall data obtained from PMGL in 2013 at Fetish, Esuajah South, Mine Community and Esuajah North are put into perspective with the data obtained from Dunkwa-on-Offin. The highest rainfall (483.8 mm) was recorded at Esuajah North whereas the lowest rainfall (426.3 mm) was recorded at Esuajah South.

Sampling for air quality and noise levels was conducted at the project site from October to December, 2013. The weather condition was sunny with some slight showers in the day and clear skies at night during the sampling period. Three (3) sampling locations, Fetish, Esuajah South and Esuajah North were selected within the project area for baseline air quality and noise level survey. Particulate matter concentrations were monitored in terms of TSP and PM<sub>10</sub> over a 24-hour period at the three (3) selected locations and compared with their respective Ghana EPA Air Quality guideline. Generally, low concentrations of TSP were recorded at the various selected locations when compared with the Ghana EPA Air Quality guideline of 150µg/m<sup>3</sup>. The concentrations ranged from 41.3 µg/m<sup>3</sup> to 186.4 µg/m<sup>3</sup>.

The EPA zoning reference for the monitored locations is commercial areas, and therefore the applicable noise limit is considered for comparison. The daytime noise limit is set at 65 dB(A) and night-time noise limit is 60 dB(A). The equivalent noise (LAeq) level recorded over the sampling period is used as the descriptor for noise at each receptor location for both daytime and night time noise to indicate the noise levels for the existing environment (without the

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influence of the proposed project). The  $LA_{eq}$  ranged from 41.8 dB(A) – 63.3 dB(A) and 44.7 dB(A) – 60.0 dB(A) for day and night respectively.

The proposed project area is drained by streams and creeks including Danyami, Asuaa, Afuaworaa, Asanka and Aponapon which are all tributaries of River Subin. A total of 22 water sampling locations (12 surface sites and 10 groundwater site) were selected within and around the entire project area for baseline water quality studies. Water samples were collected on monthly basis for physical, chemical, nutrient and metal analysis. The pH of surface water samples taken from the project area was slightly acidic to neutral. It ranged from 4.2 (PAS19 – downstream of Asuaa) to 8.5 (PAS67 – Esuajah South pit). The samples outside the recommended range for drinking water set by the WHO (6.0 – 9.0) were all acidic. It is therefore noted that non-conforming surface water samples in the project area are skewing toward acidity. The highest conductivity value was 468 $\mu$ S/cm recorded at PAS37 (downstream of Danyami) and the lowest record was 25.8 $\mu$ S/cm, at PAS 23 (Chirawewa pond below waste dump). The levels recorded for all the locations are within the EPA recommended standard of 1000 mg/L. High concentrations of Total Suspended Solids (TSS) were recorded at most of the sampling locations. The concentration recorded ranged from 1.2 – 64,379.8 mg/L with majority exceeding the recommended EPA level of 50 mg/L. The major contributory factor for the high TSS values is due to upstream galamsey activity. Significant levels of nutrient concentrations were recorded for chloride, sulphate, calcium and sodium. The levels ranged from 1.2 – 116 mg/L, 1.0 – 139.8 mg/L, 1.1 – 94.6 mg/L and 0.5 – 48.4 mg/L respectively. The levels recorded are below the recommended EPA limit of 250 mg/L. There are no available standards for comparison for the rest of the nutrient. The concentration recorded for Iron (Fe) ranged from 0.1 – 1.7 mg/L. However, the remaining heavy metals recorded levels below their respective detection limits. Generally, the ground water samples were slightly acidic to neutral in nature and had pH ranging from 4.2 – 7.5.

The results are consistent with the previous baseline monitoring data. The remaining values recorded at all the sampling points were within the EPA and WHO guideline limits. Approximately 85 percent of the returns were below the respective detection limits.

Although commercial mining has been a major destructive force of the forest vegetation, agriculture, particularly food and cash crop farming, has and continues to be another major land use system in the area. Food crops such as plantain and cassava, and cash crops, mainly cocoa and oil palm are prevalent in the area. At present, there is no evidence of commercial logging activities within the proposed area. However, logging with chainsaws by the local people is still evident in the area. The vegetation, on the whole, is heavily modified as a result of a decade of open cast mining and agricultural activities. Relic patches of indigenous

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vegetation are very disturbed, scrubby and isolated. The high preponderance of pioneer species (more than half of the floristic composition) and climbers are indicative of the vegetation's response to the massive degradation of the study area. Tree species recorded are mostly at seedling and sapling stage with very few measuring  $\geq 30$  cm dbh.

Species of global conservation concern recorded are of a minor conservation merit or threat category. The conservation status of the vegetation of the study area (as a whole or any part thereof) is therefore not a biodiversity hotspot.

The radioactive activity concentrations of gross- $\alpha$  and gross- $\beta$  in water samples from the pits, surface water and underground water (bore holes) used in the surrounding communities of the study area and their corresponding committed effective dose were observed. All the water sources had gross- $\alpha$  and gross- $\beta$  values below the recommended levels. The guideline values ensure an exposure lower than 0.1 mSv/year assuming a water consumption rate of 2 litre /day. Comparing these results with the WHO guideline values, it can be observed that all the values of the gross- $\alpha$  and gross- $\beta$  are lower than the guideline values. This indicates that all the water sources in the study area which are designated for drinking and domestic purposes do not have significant natural radioactivity.

#### 4 Assessment of Impacts

All mining activity effects some changes in the natural environment. The extent and nature of the impact can vary widely depending upon the method of mining, the characteristics of the mine site and its surroundings and the control and management of the mine operation. The total disturbance of approximately 998ha represents 10.7 % of the of the two Mining Lease areas (93.1 km<sup>2</sup>). The nearest facility to Nkonya is the haul road (Year 5 development) from the Fetish pit to the Plant site, a distance of 1.12 km. The impact of construction and operational activities from the Pits will be solely on the Ayanfuri communities. Impacts on Gyaman and Nkonya communities will virtually be minimal. Social impacts on the Community arising from mine development are discussed in section 4.11 as are those for the other Communities. Gyaman Community is also distant from mine facilities. The nearest facility is the FTSF (boundary at full development) at 1.8 km distant. The Plant site is 3 km distant. Consequently, the impact of construction and operational activities will be virtually none.

There are positive socioeconomic impacts that would occur from the development of the Project. There is, however, a potential for negative environmental and social impacts associated with the construction and operation of the Project.

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## 4.1 Visual Impact

The potential sources of undesirable visual intrusion associated with the development and operation of the Project were identified as the Esuajah North waste rock dumps. The development and implementation of the Project facilities will result in modification of the site configuration through the creation of artificial lines (the pits, dumps of 25m to 70m (Fetish) height for the waste rock dumps, etc.). Because of the natural topography of the area and the proposed location of the various mine facilities, the Project will have very limited visual impact on communities around the Project area. Ayanfuri has been identified as potential critical viewpoints. The footprint base of the final waste dump will be approximately 250 m from the Community boundary which will result in the resettlement of households within the 500 meters radius buffer zone. The Fetish Waste Rock Dump will have a maximum height of 50 m. This waste rock dump has been specifically designed to provide a degree of noise and light attenuation between the Community and mining activity. The southern edges of the waste rock dump east of Esuajah North pit will be visible from the northern limit of Ayanfuri. The dump height will be 35m high. This impact category can be classified as very localised and will require implementation of specific mitigation measures.

## 4.2 Impact on the Atmospheric Environment

Dust from blasting is the source which so far appears to defy total control. Traditionally, the only practical control was to blast when climatic conditions preclude the spread of dust to particularly sensitive locations. Fly rock arising from blasting can have a major impact on stakeholders, flora and fauna unless careful blasting measures are in place. On haul roads, dust could arise from spillage from trucks and abrasion by their wheels. The entire major mine haul roads and access roads will be located well away from human settlements. Minor nuisance dust generation may be expected where haul roads cross public roads – the haul road from Esuajah North pit and that from the Fetish pit as per existing level crossing around Ayanfuri used during previous mining activities. Based on observations made within several mining operations in West Africa and Ghana, this impact can be classified as locally significant, intermittent and reversible which will require mitigation measures.

The ore of the Project is not refractory and, therefore, will not require any oxidation step such as roasting which can produce toxic fumes containing sulphur dioxide and/or arsenic when present in the mineralisation. Potential sources of gaseous emissions will be from diesel engine fumes from vehicles and stand-by generators when used during power supply failures. It must be noted that, blasting fumes (containing low quantities of nitrous oxide and carbon monoxide) will be generated in quantities, which are generally neither detectable nor measurable at the pit limits. Besides carbon dioxide (CO<sub>2</sub>), the main gaseous substances resulting from diesel engine combustion will be sulphur oxides (SO<sub>x</sub>), nitrous oxides (NO<sub>x</sub>) and carbon monoxide (CO).

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### 4.3 Noise and Vibrations

Project operations will increase the general and ambient level of noise and vibration within the vicinity of its operations or the catchment Communities. The recipient media will be mainly the Project workers, hamlets and nearby communities (Ayanfuri, Gyaman and Nkona). The majority of the ore will require drilling and blasting is a point source for noise generation. Noise and vibration will be generated mainly from hauling equipment, movement of heavy machinery and blasting. Although straight line distances between Ayanfuri Community and the perimeter of Fetish pit respectively will be less than 500 meters. Noise arising from blasting operations will impact on psychological condition of community members and fauna even if such nuisance occurs once a day or on irregular basis. It is relatively common to have people confusing air over pressure with level of vibration. It will therefore be the responsibility of the mine to deal with the local population by providing continuous information and education. Impact from blasting activities can be classified as significant, intermittent and irreversible.

### 4.4 Impact on the Aquatic Environment

The majority of streams in the Eastern Pits area eventually drain into the Offin River via the Subin River. The Chirawewa pit complex area is drained by the Kyriawewa and Meretwe streams that form part of the Mansi River catchment of the Ankobra River. The main tributaries of the Subin River are the Aponapon, Bowodinanwu, Asuaa, Danyami and the Nsanka streams. The streams and rivers draining the Eastern Pits area receive flow contributions, which originate from an area where the deposits are located. Therefore, the main mining area is classified as headwaters for these tributaries. The physico-chemical parameters of these streams will be impacted by the project. Impact on surface water regime would include modification of stream hydrology through alteration, erosion and siltation giving rise to the more frequent occurrence of extreme events within the catchment area; and possible deterioration in surface water quality with particular respect to pH, suspended solids, cyanide, heavy metals, oil and grease. Leachates from Acid Rock Drainages (ARD) will also result in elevation pH, sediments and dissolve metals in both surface and ground water. Run-off from cleared areas and waste dumps will also increase the silt loads of surface waters.

### 4.5 Impact on the Ecological Environment

Development of mining and associated operational facilities will not result in the destruction of any ecologically important areas of vegetation or sensitive habitat. The vegetation generally, is very disturbed and modified as a result of previous mining operations. Indigenous vegetation is scrappy characterised by relic patches of degraded secondary forest, thicket re-growths and fallow farm bush with high preponderance of pioneer species.

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There are only a few isolated timber species of marketable size worth salvaging. Clearing of vegetation will result in the destruction of in matured timber species and seed banks in the project area. The terrestrial fauna survey of the Eastern Pits area as a whole indicate that habitat disturbance resulting from earlier commercial and illegal mining activity, subsistence farming, logging and hunting pressures has all but destroyed good faunistic diversity, especially for the larger mammals. Rare species found in the area will result in extinction. Overall, development in the Project area will impact significantly on the existing and terrestrial fauna of the area.

#### **4.6 Impact on Soils and Land use**

Land preparation associated with infrastructure development (mine offices and mine workshops) and operation of mining projects will remove vegetation and topsoil. These operations will induce soil erosion, including subsoil erosion, and lead to degradation of soil structure, decreasing soil fertility and in the long term, agricultural production or the establishment of a vegetation cover. Another consequence of land clearing and erosion is the transport of soil during heavy rains into water bodies, resulting in siltation and increase of suspended solids. In the absence of specific erosion control and management procedures Project development and operations will have a significant impact on loss of soils and soil-forming materials.

The development of the PMGL Eastern Pits will have a high impact on agricultural land use and the hamlets, houses of farmers and individuals working in the areas that will include mostly the Ayanfuri communities.

## **5 MITIGATION MEASURES**

Under normal circumstances, most of the impacts assessed can be mitigated by good planning and environmental management practices during the life of the mining operation.

### **5.1 Visual Impact**

The design of the Fetish and Esuajah North waste rock dump will take into consideration visual impact of the dump to communities and other stakeholders and the design with minimum impact will be adopted. Waste dump heights will not exceed landform patterns in the area. Accelerated re-vegetation program will be undertaken at the site and a screening barrier comprised of fast growing tree species (Acacia and Leuceania species) will be planted along the section of the current access roads, elevated ridges and other locations that will be deemed necessary after assessments. The intent of this planting is to establish a “green zone” to

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assist in screening these mining areas from Ayanfuri, Akyiase, Wampem and Gyaman Communities. As the dump is developed, the dump slopes will be planted with herbaceous plants (medicinal) and a mixture of native and exotic tree species of commercial importance which are found in the region.

## 5.2 Atmospheric Environment

During access construction, fugitive dust will be generated from site clearance, vehicle movements and haulage of materials, blasting and crushing. To mitigate these impacts:

- Dust suppression will be carried out by water bowsers in such a manner and frequency that will ensure minimum dust generation. This measure should be sufficient to prevent the formation of high quantities of dust considered to be a nuisance to human health and vegetation.
- Specific measures will be taken to prevent over-speeding of vehicles when driving on site and through or near towns and Communities on the way to the site.
- Regular and mandatory maintenance of all equipment to reduce emissions

Mitigation measures to reduce the impact of blasting, including prevention of fly rock generation will be ensured; for instance fly rock will be managed through directional blasting, usage of controlled charge quantities of explosives, design of the stemming column, use of water proof explosives and well defined procedures. All community structures within the 500 meters radius of any pit will be relocated. Low values for wind speed and high topography of the site should all contribute to limit conditions in which dust can be dispersed.

## 5.3 Noise and Ground Vibration

Noise and ground vibration monitoring will be undertaken to ensure compliance with regulatory guidelines. Planned maintenance and repair of heavy machinery and hauling equipment will be undertaken regularly and ensure that noise generated from these equipment are reduced. PMGL will ensure that in the design and construction of access roads, the location and the noise impact will be taken into consideration as much as practical.

Ground vibration levels will be within Mineral Commission Regulatory requirements. A 500 meter exclusion zone is adopted for all blasting activities on the site and blast guards are posted at known access points to prevent inadvertent access to any blast zone. PMGL policy on drill and blast will address the number of blast holes fired per blast, time of blast and blast on special days such as public holiday.

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## 5.4 Fly Rocks

Fly rock will be managed through directional blasting, usage of controlled charge quantities of explosives, design of the stemming column, use of water proof explosives (emulsions) and well defined procedures. Public roads close to pit operations will be temporary directed during blasting events

## 5.5 The Aquatic Environment

Any settlements located downstream of the construction sites may have their main source of water impacted. For preventive purposes, the following mitigation measures will be implemented by PMGL during access construction and operations:

- Appropriate drainage control measures to minimise soil erosion will be put in place during preparation of each site. These measures will include construction of settling ponds at appropriate locations downstream of mine facilities such as the waste dumps, access and haul roads and the services area.
- Vertiver grass will be planted on the crests and slopes of waste rock dumps and on exposed surfaces to prevent sedimentation due to erosion.
- Land clearance will be progressive and will be carried out as and when required for the development of a particular area;
- Necessary earthworks will be undertaken to ensure effective drainage around the perimeter of the pits, haul roads and access roads;
- Early re-vegetation of disturbed areas will be undertaken as much as practicable using topsoil and/or subsoil segregated during the preparation phase;
- The vegetation and swamps along the various water courses (riparian flora) will be protected as much as possible.
- Undertake quarterly ARD sampling of all waste rock dumps and pits

In order to further ensure a controlled situation over water quality, additional measures will be adopted by PMGL. Management practices will be implemented to avoid or limit any occurrence of accidental spillages which may result in a deterioration of the aquatic environment. Storm water from run-off is controlled through the use of drainage control features such as settling ponds to minimize soil erosion. These are constructed at appropriate locations downstream of project facilities such as the waste rock dumps, the treatment plant and the mine services area. Other best management practices such as brush barriers, temporary sediment ponds, containments; small rock check dams and sediment fences to minimize erosion and minimizing exposure of mine process materials to storm water will be implemented. Nevertheless, PMGL will assess and locate monitoring boreholes at strategic areas that will enable the capturing of potential or possible ground water contaminants. PMGL will establish a ground water monitoring program and will

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sample on a routine basis (quarterly), including water level readings and the taking of water samples for water quality testing purposes.

## 5.6 The Ecological Environment

The development and operation of the Eastern Pits will not have any major pollution effects or cause loss of rare or endangered flora and fauna species. The baseline flora and fauna studies conducted did not find any flora and fauna species of conservation importance. Nevertheless, PMGL will endeavour to preserve, or avoid any serious impact on the ecological environment and adopt several measures promoting conservation of certain areas.

## 5.7 Soil and Land Use

Vegetation clearing, topsoil removal and land preparation for development and operation potentially induces soil erosion. PMGL will adopt measures to limit these impacts and to promote soil conservation, particularly during design and construction of the mine facilities. PMGL is committed to paying compensation for crops grown on land required for mine development. Following a series of meetings a Compensation Agreement has been negotiated with the local farmers group. This group was represented by their elected representatives from Ayanfuri, Nkonya, Wampem, Gyaaman, Akyiase, in the Upper Denkyira West and Wassa Amenfi East Districts.

## 5.8 The Socio-Economic Environment

PMGL is obligated to compensate people who, because of the proximity of their farms and/or buildings to areas needed for mine development, or because of public safety concerns, are required to be relocated or resettled.

## 5.9 Waste Management

PMGL has identified the various types and their potential mode of disposal. Any waste, such as oil filters, waste paper and wood packing will be disposed of in accordance with best practice applicable in Ghana. PMGL will ensure that all employees and contractors are made fully aware of their environmental responsibility toward waste management.

## 5.10 Health and Safety Aspects

Safety will be an integral part of the operations as it contributes to maximisation of productivity and lowered costs. Good safety practices are reflected in having a clean work environment and attention to procedures and routines: which if improperly managed can lead to environmental incidents, employee training, preparation of health and safety procedures, provision of suitable personal protective gear equipment, protection against fire

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potential and monitoring of employee health will be the very important aspects of the safety programme.

### 5.11 Health and Safety Aspects

Safety will be an integral part of the operations as it contributes to maximisation of productivity and lowered costs. Good safety practices are reflected in having a clean work environment and attention to procedures and routines: which if improperly managed can lead to environmental incidents, employee training, preparation of health and safety procedures, provision of suitable personal protective gear equipment, protection against fire potential and monitoring of employee health will be the very important aspects of the safety programme.

## 6 ENVIRONMENTAL MONITORING PROGRAMME

PMGL proposes to continue its monthly monitoring program until production starts after which the frequencies of monitoring and sampling locations will be reassessed. The proposed environmental parameters that will be included in the monitoring programme at the Eastern Pits are Meteorological Data, Surface and Ground Water Quality, Dust, Noise, Vibration and Socio-economic Environment. Ecological Environment and Sediment will also be carried out biannually.

Climatic data from the national climatological stations at Dunkwa-on-Ofin will be collected on an annual basis. Daily rainfall readings will be taken from rain gauges installed at the old Cluff Administration building, Esuajah North area and the Mine Community stations. Information acquired will be kept by the company to maintain historic data and establish a trend in the climatic data.

The Eastern Pits Project may impact significantly on the surface and ground water quality, especially where downstream water users utilize water for drinking and domestic purposes. It is proposed that surface and ground water samples will be collected and sent for laboratory analysis from all identified sites on a monthly basis until the start of the project construction phase. Once construction commences, it is proposed that the frequency of sampling may be changed between weekly and fortnightly, monthly and quarterly. Those sites with increased risk of exposure to adverse impacts from operations will be sampled more frequently than those with a low risk of exposure.

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The company will continue to monitor Total Suspended Particulate (TSP) and Particulate Pollution less than 10 micrometer (PM10) concentrations on daily basis within the catchment communities. In order to characterize background noise levels of the Project area, noise monitoring will be undertaken at receptor locations during the development and operational phases. It is proposed that noise monitoring is conducted in Ayanfuri community and other areas where deemed appropriate on daily basis. As well, ground vibration and airblast will be monitored for each blast on daily basis. However, sediment and aquatic monitoring will be conducted biannually at locations monitored during the baseline and any other area deemed appropriate.

## **7 PROVISIONAL ENVIRONMENTAL MANAGEMENT PLAN**

A provisional Environmental Management Plan (PEMP) has been prepared and will be implemented to ensure that appropriate control and monitoring measures are in place to deal with all significant potential environmental impacts of a project.

The PEMP gives consideration to the Corporate Commitment and Health, Safety and Environmental (HSE) policies, Environmental Management Structure, Financial Allocations, Existing Natural Environment, Existing Socio-Economic Environment, Environmental Impacts and Mitigation Measures, Environmental Action Plans and Monitoring Programme. However, a detailed and specific programme shall be written prior to commencement of the Project. The social aspect of the programme shall be done in conjunction the Social Development Consultative Committee to obtain input from appropriate stakeholders.

To facilitate environmental and social management practices PMGL has established a Health, Safety, Environment and Community (HSEC) Department for the western pits and the proposed Eastern Pits projects. The Department will be responsible for directing and maintaining all health and safety issues, environmental monitoring and reclamation programmes/activities in the Project area and engaging regulators and stakeholders on related issues. This ensures specific environmental management responsibilities are allocated as appropriate and commitments stated in the environmental policy are achieved.

The HSEC Manager reports to the PMGL Executive General Manager thereby ensuring that sustainability issues for the proposed project are assigned the appropriate priority and level of attention.

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## 8 REHABILITATION AND DECOMMISSIONING PLAN

PMGL will implement a concurrent progressive rehabilitation and a specific mine site reclamation plan at closure. The plan will focus on the reclamation of the process plant facilities, open pits, haul and access roads, waste rock dumps, ROM Pad, ore stockpile areas, and workshop. The main objectives of the plan will be to ensure human health and the safety of humans and property as well as minimise potential significant adverse environmental effects on adjacent natural resources, being groundwater and surface water, air quality, fauna and flora.

The rehabilitation of the Eastern Pits area will cover both historical facilities and new developments. At mine closure, the active mining or operational areas will be restored to a usable state that will be beneficial to all stakeholders with special emphasis on the catchment communities. The rehabilitation and decommissioning activities which will be undertaken will conform to Environmental Assessment Regulations, 1999 (LI 1652), Minerals and Mining Act, 2006 (Act 703) as per the reclamation schedule, the Minerals and Mining (Health, Safety and Technical) Regulations, 2012, (LI2182), international standards like World Bank Policies and IFC Guidelines.

It will be subject to ongoing review as part of the environmental management activities in the three (3) year environmental permit review. PMGL is not required to submit a formal closure and decommissioning plan (CDP) until two (2) years before the closure of the Project. In practice, the earlier development of a CDP assists both the Company and the EPA in understanding what will be required, technically and financially, and that the environmental management practices during life-of-mine are consistent with the plans for mine closure and decommissioning.

It is intended that over the life of the mine (6 years), the rehabilitation plan will be subject to regular and detailed review (every three years). The reviews will enable the plan to be improved on and to incorporate changes in design, physical conditions and change in legislation. Post-reclamation monitoring and maintenance will begin after completion of the reclamation work and will extend through the period of physical stabilization. It is expected that such monitoring will be for a minimum of three (3) years. PMGL will finance of the rehabilitation and closure aspects of the project from its annual budget and operating costs.

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## 9 STAKEHOLDER CONSULTATION

Perseus Mining (Ghana) Limited endorses the concept that communication with project stakeholders is an essential component of any project development process. The company is committed to open communication with all agencies, organizations, and individuals with an interest in the development of the Project. The Company has undertaken consultation, disclosure activities, and stakeholder engagement exercises since acquiring the concessions in 2008. Project stakeholders including individuals, groups, and organizations with an interest in the Project are engaged on regular bases in the consultation process.

A Public Consultation and Disclosure Plan (PCDP) have been developed to showcase how PMGL involves the public in the Eastern Pits Project at various stages of the operations. The purpose of the PCDP is to ensure adequate information is provided to Project Affected Persons (PAPs) and other stakeholders in a clear and timely manner, and that these groups have sufficient opportunity to voice their concerns and opinions so that they can influence project decisions. In addition, Progress Reports will be developed on a quarterly basis for disclosure to key stakeholders and communities. These Reports will contain details of specific activities undertaken and planned for the coming months.

Formal Consultation and Information Disclosure on the Project issues occur through a variety of processes and activities including community durbars/public meetings, community consultative committee, crop negotiation committee, resettlement compensation negotiation committee, consultation with government agencies, traditional authorities, among others. Notwithstanding these, informal stakeholder interaction occurs when PMGL representatives undertake their daily tasks. These consultations take place with Community Relation team, Resettlement team and also other members of the Community and Social Development Unit, such as surveyors and technical personnel.

## 10 CONCLUSION

The Eastern Pits Project like most mining projects has some potential environmental and social impacts both in the short and long term. These impacts as they pertain to open cast mining are well known and could be mitigated by adopting combinations of sound engineering and social interventions. These impacts include increase in airborne particulate (dust) and gaseous emissions, deterioration of water quality and loss of habitat and archaeological resources. Some benefits that may be associated with the project include, job creation, improvement in

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social infrastructure and taxes to government as well as socially beneficial project to the communities.

In view of the commitments from PMGL to ensure that the adverse impacts arising from implementing the Eastern Pits Project are duly mitigated and beneficial aspects are enhanced for the community, region and the nation as a whole, it is suggested that this project be considered very positive and favourable.

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## 1 INTRODUCTION

### 1.1 Background Information

Perseus Mining Ghana Limited (PMGL), formally Central Ashanti Gold Limited was permitted in June 2010 (EPA/EIA/306) to commence operation on the Ayanfuri and Nanankaw concessions. The permit which required PMGL to commence operation within eighteen (18) months could not be met. There was therefore the need to re-evaluate the baseline data captured in 2008 and this was officially communicated (CM 42/5) by the Environmental Protection Agency (EPA) to PMGL in January 2014. In order to carry out active mining activities in the Eastern Pits area, the Company has to submit a Supplementary Environmental Impact Statement (SEIS) for approval to expand its mining operations Fetish, Esuajah North, Chirawewa, Bokitiso and pits (Eastern Pits). The Eastern Pits Project will involve activities including development of cut back of existing open pits, construction of haulage roads, drill and blast, dewatering and construction of other related infrastructure.

The application is in compliance with the Ghana EIA Procedures, the Environmental Protection Agency Act, 1994 (Act 490) and the Environmental Assessment Regulation, 1999 (LI 1652) which make Environmental Impact Assessment (EIA) mandatory for the proposed project.

### 1.2 Objectives of the SEIS

The objectives of the SEIS are as follows:

- To provide a current and detailed description of the proposed PMGL Eastern Pits Project as well as the findings of the environmental and socio-economic baseline studies.
- To assess the significance of environmental and socio-economic issues associated with the development, operation and closure of the proposed project.
- To provide a description of mitigation measures to reduce potential negative impacts and enhance positive impacts of the proposed Project.
- To provide a Monitoring Programme to be implemented during the entire life of the proposed Project to monitor the impact on the environment.
- To provide an acceptable Closure and Decommissioning Plan to minimise the impact of the proposed Project on the surrounding environment once the mine is closed.
- To provide a Conceptual Rehabilitation Plan for implementation during the operation of the proposed Project.
- To meet the requirements of the EPA for the permitting of PMGL's Eastern Pits mine in Ghana.

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## 1.3 Policy, Legal and Administrative Framework

This sub section provides an overview of the institutional and legal framework guiding Environmental Impact Assessment (EIA) and preparation of Environmental Impact Statement (EIS).

### 1.3.1 Company Policies

#### Environmental Policy

Perseus Mining (Ghana) Limited regards environmental care as an integral part of its business and is committed to excellence in the management of the environment at the Edikan Gold Mine. We are committed to minimizing environmental impacts in all stages of operation from exploration, construction, planning, development, mining, processing and decommissioning.

As an international resource and mining company, we are cognizant that all company stakeholders, including employees, the local communities and others have a right to expect the company to take responsible and environmentally sustainable approach to mitigate the impact of our operations.

To attain the overall vision, the Company is committed to:

- Complying with all applicable legal requirements and with other requirements to which the company may subscribe to.
- Continual assessment and improvement of environmental performance and the prevention of pollution based on the principles and provisions in the ISO 14001 guideline.
- Develop, implement and continually improve environmental management systems to ensure that environmental processes are integrated into all business units within the organization.
- Instituting effective controls to prevent the pollution of groundwater, surface waters, soil and air and to minimize impacts on fauna and vegetation.
- Ensure responsible environmental stewardship in purchasing, transport, storage & use of chemicals, hydrocarbons or any other material that may have significant environmental impact.
- Ensure all employees and contractors understand their individual environmental management responsibilities and increase their knowledge through environmental education and training.
- Minimizing the use of consumptive resources and promoting the reduction of waste products through recycling.
- Communicate honestly and consult openly on our activities with all relevant stakeholders to ensure transparency with respect to environmental performance.

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- Monitor environmental performance through audits, workplace inspections and environmental sample analysis to identify issues and opportunities for continual improvement.

### Occupational Health and Safety (OHS) Policy

PMGL is committed to achieving continuous improvement in its health and safety performance. We believe that people are our greatest asset and accept that all employees, contractors, visitors and the communities in which we operate have a right to expect prudent and responsible occupational health and safety performance from our activities.

To achieve this PMGL will:

- Provide a workplace that is conducive to effectively managing occupational health and safety.
- Fulfil, as a minimum, compliance to Ghana legislation and other relevant requirements including employer “duty of care” obligations.
- Seek to continually improve our occupational health and safety performance by utilising available technology, knowledge and management practices.
- Report all incidents and identify health and safety hazards and implement changes if required.
- Manage risk through a site wide risk register to ultimately eliminate workplace injury/illness and incidents across the company.
- Develop, implement and continually improve health and safety management systems to ensure that safe work practices are integrated into all areas of the site and empower local contractors to manage their health and safety responsibilities to PMGL and legislative requirements.
- Ensure OHS training is provided across the business to ensure all employees and contractors have the appropriate skills and knowledge and are held accountable for their area of responsibility.
- Ensure sufficient resources, in terms of people, equipment and budgets are available to meet our health and safety objectives.
- Provide safety leadership to advise and assist on safety issues with all stakeholders.
- Ensure a high degree of emergency preparedness to effectively respond and recover from any health and safety incident.
- Implement effective systems to address the health and safety risks of transporting, storing, handling and disposal of cyanide and other hazardous chemicals.
- Require individuals proactive approach in self-regulation of their and others safety and the PMGL OHS Policy.

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### Social and Community Policy

PMGL is a gold mining company working in the Western & Central regions of Ghana and within the communities of Ayanfuri, Gyaman, Fobinso, Abenabena and Nkonya and is committed to fostering enduring relationships and partnerships with the communities in which it operates and supports community development, capacity building and social infrastructure improvement.

We acknowledge that our future is dependent on our ability to add value by sustainably developing, operating and closing operations to the satisfaction of our stakeholders.

To achieve this, PMGL will:

- Ensure all employees and contractors recognise and respect the value of cultural heritage and cultural diversity.
- Maintain continuous dialogue with local communities to ensure the early identification and mutual understanding of potential issues.
- Establish long-term, trusting relationships with communities based on honest and open communication and consultation.
- Approach and resolve community issues in a consistent manner to ensure fair and equitable resolutions are achieved.
- Provide employment and skills training to the communities in which we operate as a priority.
- Support the development and implementation of sustainable social and economic initiatives through community cooperation and participation.
- Promote local business opportunities that deliver lasting benefits to the community.
- Comply with, as a minimum, all legal and other social requirements for which we are accountable.
- Develop and implement management systems to effectively identify, assess, control and review the impact our operations have on the communities in which we operate.

### 1.3.2 General Institutional Framework

Project developments in Ghana are normally influenced by three (3) components of government namely; national, regional and local. In addition, traditional authorities possess substantial institutional relevance. The principal Government Institutions of relevance to the proposed project include:

- National – Ministries, Departments and Agencies including Ministry of Lands and Natural Resources, Ministry of Environment, Science, Technology and Innovation, Minerals Commission, Inspectorate Division of the Minerals Commission, Environmental Protection Agency, Ghana Wildlife Authority, Ghana Highways Authority and Water Resources Commission;
- Regional – Western and Central Regional Coordinating Council (RCC) and
- Local – Upper Denkyira West and Wassa Amenfi East District Assemblies.

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### 1.3.3 General Legal Framework

Environmental Impact Assessment for new developments, projects or undertakings have been a requirement since 1989. The EPA has established new procedures for Environmental Impact Assessments involving gradual phases depending on the nature, complexity and location of the undertaking (Ghana’s Environmental Impact Assessment Procedures, 1995). This procedure was subsequently reviewed, adopted and passed by Parliament as a Legislative Instrument – Environmental Assessment Regulations (LI 1652) in 1999. These procedures require that an Environmental Impact Statement (EIS) is prepared by the proponent, reviewed and approved by EPA to form the basis for the issuance of environmental permit prior to the commencement of the undertaking.

The various provisions of Acts, Regulations and Guidelines relevant or potentially relevant to the proposed project include the following:

- Environmental Protection Agency Act, 1994 (Act 490);
- Environmental Assessment Regulations, 1999 (LI 1652);
- Minerals and Mining Act, 2006 (Act 703);
- Water Resources Commission Act, 1996 (Act 522);
- Water Use Regulations, 2001 (LI 1692);
- Minerals and Mining (Health, Safety and Technical) Regulations, 2012 (LI 2182);
- Minerals and Mining (Compensation and Resettlement) Regulations, 2012 (LI 2175);
- Minerals and Mining (Explosives) Regulations, 2012 (LI 2177);
- Minerals and Mining (Support Services) Regulations, 2012 (LI 2174);
- Minerals and Mining (General) Regulations, 2012 (LI 2173);
- Mineral and Mining (Licensing) Regulations, 2012 (LI 2176);
- Wildlife Animals Preservation Act, 1961 (Act 43);
- Wildlife Conservation Regulations, 1971 (LI 685);
- Labour Act, 2003 (Act 651);
- EPA’s Sector Specific Effluent Quality Guidelines for Discharges into Natural Water Bodies;
- Mining and Environmental Guidelines, 1996;
- EPA’s Ambient Air Quality Guidelines; and
- EPA’s Ambient Noise Level Guidelines.

#### Environmental Protection Agency, 1994 (Act 490)

This Act establishes the Environmental Protection Agency (EPA) and stipulates that every undertaking or project that may have an impact on the environment must be registered with EPA. The EPA has the mandate to request an Environmental Impact Assessment (EIA) in respect of any undertaking, which it considers potentially detrimental to the environment and no licenses, permits or approvals required from other governmental departments relating to the project will be issued unless a request for an EIA is complied with. The EPA is also empowered to serve an enforcement

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notice on any person responsible for any project requesting him to prevent or cease any activity it considers harmful. The following are relevant sections of Act 490 that pertains to the project:

**Part I – Enforcement and Control Section 12 (1 and 2)**

- Section 12, subsection 1: “The Agency may by notice in writing require any person responsible for any undertaking which in the opinion of the Agency has or is likely to have adverse effects on the environment to submit to the Agency in respect of the undertaking an environmental impact assessment containing such information within such period as shall be specified in the notice”.
- Section 12, subsection 2: “Where the Agency issues a notice under sub-section (1), it shall inform any organ or department of government that has responsibility for the issue of any license, permit, approval or consent in connection with any matter affecting the environment that the notice has been issued, and the organ or department shall not grant the license, permit, approval or consent unless it has been notified by the Agency that the notice has been complied with”.

**Environmental Assessment Regulations, 1999 (LI 1652)**

The Environmental Assessment Regulations, 1999 (LI 1652) defines the procedures and requirements for obtaining an environmental permit for any undertaking in Ghana. The regulations provide details on Screening, Scoping Reports and Draft Terms of Reference, Environmental Impact Assessment procedures, Environmental Management Plans and other matters pertinent to project as well as grievance procedures among others. The following are the relevant regulations of LI 1652 that pertains to projects:

Part I - Environmental Permit Regulations 1, sub regulations (1 and 2), 2, 23, 24 sub regulations (1, 2, 3 and 4) and 25 sub regulations (1 and 2).

- Regulation 1: “No person shall commence any of the undertakings specified in Schedule 1 to these Regulations or any undertaking to which a matter in the Schedule relates, unless prior to the commencement, the undertaking has been registered by the Agency and an environmental permit has been issued by the Agency in respect of the undertaking”.
- Regulation 1, sub regulation 2: “No person shall commence activities in respect of any undertaking which in the opinion of the Agency has or is likely to have adverse effects on the environment or public health unless, prior to the commencement, the undertaking has been registered by the Agency in respect of the undertaking”.
- Regulation 23: “An undertaking in respect of which a reclamation plan is required shall be required to post reclamation bond based on approved work plan for reclamation”.
- Regulation 24 – Environmental management plan, sub regulation 1: “The person responsible for an undertaking in respect of which a preliminary environmental report or an environmental impact statement has been approved shall submit to the Agency an

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environmental management plan in respect of his operations within 18 months of commencement of operations and thereafter every 3 years”.

- Regulation 24, sub regulation 3: “The environmental management plan shall be a document in such form as shall be determined by the Agency”.
- Regulation 24, sub regulation 4: “The environmental management plan shall set out steps that are intended to be taken to manage any significant environmental impact that may result from the operation of the undertaking”;
- Regulation 25 – Submission of annual environmental report sub regulation 1: “A person granted an environmental permit under these Regulations shall submit an annual environmental report in respect of his undertaking after 12 months from the date of commencement of operations and after every 12 months thereafter to the Agency”.
- Regulation 25 sub regulation 2: “The annual environmental report shall be in such form and contain such particulars as the Agency shall direct”.

### **Minerals and Mining Act, 2006 (Act 703)**

The legislative framework for mining in Ghana is stated in this Act and the provisions of the 1992 Constitution. Within this legal framework, the State is the owner of all minerals occurring in their natural state within Ghana’s land and territorial waters, including its exclusive economic zone. All minerals in Ghana are vested in the President on behalf of and in trust for the people of Ghana. Thus, regardless of land ownership upon or under which minerals are situated, the exercise of any mineral right requires by law, a license granted by the Minister responsible for mines acting as an agent of the State; on the recommendation of the Minerals Commission; for the exercise of powers relating to minerals.

The Minerals and Mining Act, 2006 clearly distinguishes surface activities that can be undertaken by owners and lawful occupiers of land in the Mining Lease Area and the Proposed Mining Area. The Mining Lease Area is the whole land area covered by the mining lease whereas the Proposed Mining Area is a specific area (within the mining lease area) designated from time to time, with the approval of Minerals Commission. Owners and lawful occupants of land within the Mining Lease Area retain the right to use their land for livestock grazing and crop cultivation, provided these activities do not interfere with mining operations of the company. Within the Proposed Mining Lease Area however, permission of the mining company is required if any structure is to be erected. For these acts of disturbance, compensation claims by the owners or lawful occupants include compensation for depriving them of the use of the natural surface of the land, loss or damage to immovable properties such as structures and loss or damage to crops. The following are the relevant sections of Act 703 that pertains to the project:

- Section 9, subsection 1: “Despite a right or title which a person may have to land in, upon or under which minerals are situated, a person shall not conduct activities on or over land in

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Ghana for the search, reconnaissance, prospecting, exploration or mining for a mineral unless the person has been granted a mineral right in accordance with this Act”.

- Section 9, subsection 2: “Activities conducted under a mineral right shall be limited to the activities permitted by the mineral right”.
- Section 9 subsection 3: “Subsection 1 does not prevent a Government Institution or Agency from conducting geological activities in accordance with its powers under an enactment”.

### **Water Resources Commission, 1996 (Act 522)**

- Section 12: “The property in and control of all water resources is vested in the President on behalf of and in trust for the people of Ghana”. This implies that there is no private ownership of water in Ghana, but that the President, or anyone so authorized, may grant rights for water use. The Water Resources Commission is the agency authorized under the Act to regulate and control the use of water resources, through granting of water rights and water use permits.
- Section 13: “No person shall divert, dam, store, abstract or use water resources; construct or maintain any works for the use of water resources except in accordance with the provision of this Act”.
- Section 17: Subject to obtaining approvals or licenses under the Water Resources Commission Act 1996 (Act 522), a holder of a mineral right may, for purposes of or ancillary to the mineral operations, obtain, divert, impound, convey and use water from a river, stream, underground reservoir or water course within the land the subject of the mineral right.

### **Government Participation in Mining Lease**

- Section 43, Subsection 1: where a mineral right is for mining or for exploitation, the government shall acquire a ten percent free carried interest in the rights and obligations of the mineral operations in respect of which financial contribution shall not be paid by Government.

### **Rights Conferred by Mining Lease**

- Section 46: subject to this Act and Regulations made under this Act, a mining lease authorizes the holder, the holder’s agents and employees and the person authorized by the holder, in accordance with this Act, to enter upon the land the subject of the mining lease, to:
  - (b) Erect equipment, plant and buildings for the purposes of mining, transporting, dressing, treating, smelting or refining the specified minerals recovered by the holder during the mining operations.

### **Water Use Regulations, 2001 (LI 1692)**

- Regulation 1(d): Industrial water use.

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- Regulation 14, sub regulation 1 (a and b): A permit granted under these Regulations shall be for the period specified in the permit; and may be renewed.
- Regulation 14, sub regulation 2: An application for the renewal of a permit shall be made to the Commission not later than ninety days before the expiration of the permit.

### **Minerals and Mining (Health, Safety and Technical) Regulations, 2012 (LI 2182)**

The regulation provides general guidance on the safety conditions of a mine environment, duties of employers including the general administration of mines to safeguard the health and safety of miners.

### **Minerals and Mining (Explosives) Regulations 2012 (LI 2177)**

The LI 2177 sets out statutory regulations for the application and general administration, operating plans, certificates and permits, authorization and labeling, general safety precautions, transportation and storage of explosives among others for mining.

### **Minerals and Mining (Licensing) Regulations, 2012 (LI 2176)**

The LI 2176 provides regulations for the process of applying for and obtaining licenses for various mining activities, extensions or renewals of licenses, amendments or termination of leases, and granting mining leases.

### **Minerals and Mining (General) Regulations, 2012 (LI 2173)**

The LI 2173 provides general guidance on the procurement of goods and services, localization policy and management of contractors.

### **Minerals and Mining (Support Service) Regulations, 2012 (LI 2174)**

The LI 2174 sets out statutory regulations for the application and general administration, licensing and classification of support service companies to mining companies.

### **Minerals and Mining (Compensation and Resettlement) Regulations, 2012 (LI 2175)**

The LI 2175 sets out regulations for compensation, resettlement, surface rights, exercise of surface rights in a mining lease area among others.

### **Wildlife Animals Preservation Act, 1961 (Act 43)**

- Making of Trophies 6. (1) and (2).
- Surrounding Animal by Fires 7. (1) and (2).

### **Wildlife Conservation Regulations, 1971 (LI 685)**

PART V – Restriction on hunting in close seasons etc.

### **Labour Act, 2003 (Act 651)**

- Part XV – Occupational Health, Safety and Environment.

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- Section 118 sub sections 1 – 5 – General Health and Safety Conditions 118.

### EPA Guidelines

Environmental Assessment in Ghana, A Guide (1996), produced by the EPA, provides detailed guidance on the procedures to be adhered to when undertaking an EIA. This includes:

- **Environmental Impact Assessment Procedures (1995)** produced by the EPA details the procedures to be adhered to when undertaking an EIA.
- **Environmental Quality Guidelines for Ambient Air (EPA)** provides advice on maximum permissible levels of a variety of air pollutants.
- **Environmental Quality Guidelines for Ambient Noise (EPA)** provides advice on the maximum permissible noise levels.
- **Ghana's Mining and Environmental Guidelines (1994)** provides guidance on environmental factors that should be considered by mine operators. It includes guidance on EIA/ESIA content and the contents of a Reclamation and Decommissioning Plan.
- **Sector Specific Effluent Quality Guidelines for Discharges into the Natural Water Bodies (EPA)** provides maximum permissible effluent discharge concentrations for a number of parameters.
- **EPA Akoben Programme Rating Methodology (2010)** is an environmental performance rating and disclosure initiative of the Environmental Protection Agency (EPA), Ghana. Under the AKOBEN initiative, the environmental performance of mining and manufacturing companies are assessed using a five-colour rating scheme (GOLD, GREEN, BLUE, ORANGE and RED), indicating environmental performance ranging from excellent to poor. These ratings are annually disclosed to the public and the general media, and it aims to strengthen public awareness and participation.

## 1.4 International Guidelines

The design of the Project and its subsequent implementation has taken into consideration various guidelines published by the World Bank Group/International Finance Corporation. These include the Environmental, Health and Safety Guidelines for Mining (December 2007). Further, the principles contained in the "Equator Principles" have also been used as additional benchmarks for project design and implementation of environmental and social sustainability. The Communities Consultation programme that is in progress has drawn extensively on the principles and guidelines described in "The Community Development Toolkit" jointly produced by the International Council on Mining and Metals, World Bank and Energy Sector Management Assistance Program (ESMAP) and published as ESMAP Formal Report Series, Report No. 310/05, and October 2005.

## 1.5 Layout of Document

The document has been designed according to the requirements of the Ghana EPA and consists of a series of chapters describing various aspects of the SEIS:

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<b>Chapter 1:</b>	Introduction (this chapter)
<b>Chapter 2:</b>	Description of the Project
<b>Chapter 3:</b>	Baseline Information
<b>Chapter 4:</b>	Identification and Assessment of Impacts
<b>Chapter 5:</b>	Mitigation Measures
<b>Chapter 6</b>	Environmental Monitoring Programme
<b>Chapter 7</b>	Provisional Environmental Management Plan
<b>Chapter 8</b>	Rehabilitation and Decommissioning Plan
<b>Chapter 9</b>	Stakeholder Consultation
<b>Chapter 10</b>	Conclusion

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## 2 DESCRIPTION OF THE PROJECT

The Eastern Pit Project will consist of construction of access roads, haul roads, operation, and decommissioning (including reclamation) phases for an open pit mining operations. The mining operation will cover the Fetish, Esuajah North, Chirawewa and Bokitiso. Ore from the Eastern Pits will be treated at the existing Gravity Flotation Intensive Leach (GFIL) process plant. Historical facilities include; Nkonya, Besem, Besem South and Besem North pits as well as the Nkonya and Besem Waste Rock Dumps.

### 2.1 Project Ownership

Edikan Gold Mine (EGM) is being operated by PMGL, a mining company registered and incorporated under the Ghana Companies Code, 1963 (Act 179) and issued with a certificate to commence business in 2008. PMGL is 90 per cent owned by Perseus Mining Limited, which is based in Perth, Western Australia and 10 percent free holdings by Ghana Government. The Government of Ghana is a shareholder by right having full entitlement to dividends and obtains 10% of the share of PMGL in accordance with the Minerals and Mining Act 2006 (Act 703). The Company registration certificate can be found in Appendix 1. The Mine has total deposit reserves of 2.7 million ounces of gold plus 5.7 million ounces of Measured and Indicated gold resources. The Eastern Pits Project has a reserve of 1.3 million ounces. Production commenced in the 3<sup>rd</sup> quarter of 2011 with initial capacity of the mine estimated at 200,000 ounces per annum. The company presently employs approximately 160 nationals with additional 500 contractors employed as part of the contract mining, provide heavy equipment maintenance, catering, and construction and other ancillary services.

Contact details for Perseus Mining Ghana Limited are:

**Office Address** : No. 4 Chancery Court  
 147 Giffard Road  
 East Cantonments, Accra  
 PO Box CT2576, Accra

**Telephone** : +233 (0) 302 760 530 / +233 (0) 302 767 924

**Fax:** +233 (0) 302 760 528

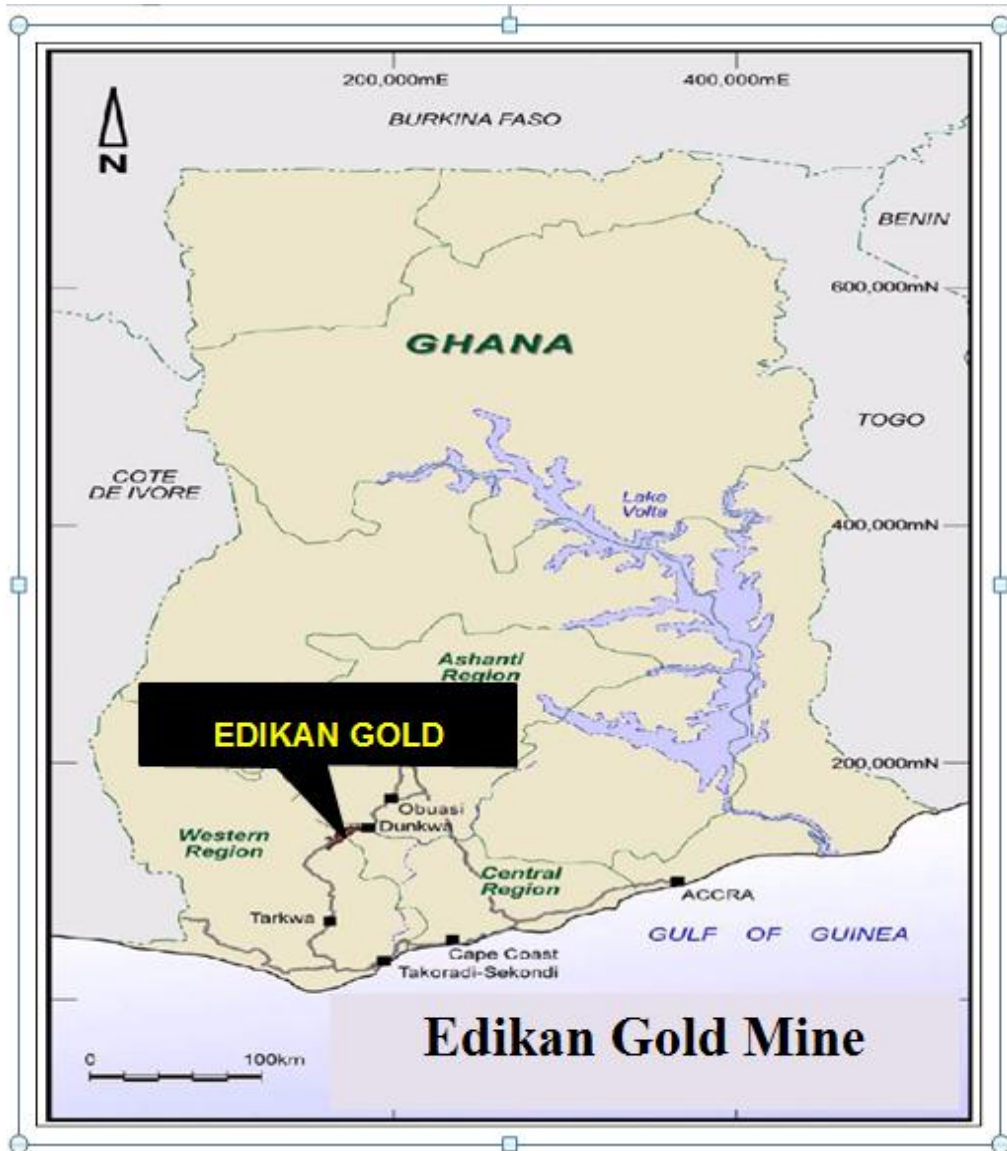
**Contact Person** : **Jeff Quartermaine (Chief Executive Officer)**

### 2.2 Project Location

The Project is located 16 km west of Dunkwa-on-Offin, near Ayanfuri Community in the Central Region of Ghana (Figure 2.1). Ayanfuri lies along the sealed highway from Ghana's second largest city, Kumasi, located 107 km by road to the north and the port of Takoradi, located 186 km by road to the south. Other cities located on the Takoradi to Kumasi highway include the major mining centres of Obuasi (46 km by road to the north) and Tarkwa (95 km by road to the south). The Project is bounded by Latitudes 5°59'49"W and 5°55'12"W and by longitudes 1°56'15N and 1°50'02"N.

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The Project is surrounded by three catchment Communities; Ayanfuri, Nkonya, and Gyaman. The proposed project falls within the Administrations of the Upper Denkyira West District of the Central Region. The principal land use within these communities is farming and has been the mainstay for the people of the aforementioned communities. However, significant portions of these lands have been disturbed by historical mining and illegal small mining activities which makes it a brown field operation.



**Figure 2.1: Location of Mine**

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## 2.3 PMGL Leases

The current PMGL Mining Leases are located in the Central and Western Regions of Southern Ghana and are located on the eastern flank of the highly prospective Ashanti Belt. They are located 6.3km west to 30.7km south west of Dunkwa-on-Offin and 30km to 57km south west of Obuasi.

Currently, the Company holds two Mining Leases, Ayanfuri and Nanankaw Mining Leases (ML). The two Leases are 49.2 km<sup>2</sup> and 43.93 km<sup>2</sup> respectively (Figure 2.2). The Eastern Pits are located in the North Eastern section of the Ayanfuri concession as illustrated in the infrastructure map (Figure 2.3)

### Mineralisation

Gold mineralisation at Ayanfuri occurs in quartz veins, stringers and stockworks and is largely hosted within two main lithologies:

- Granitic intrusive bodies (“granitoid”)
- Typical “Ashanti” style shear zones within metavolcaniclastics (“shear zone”)

There are five main deposits in the eastern corridor (Figure 2.4). These are summarised in the following sections.

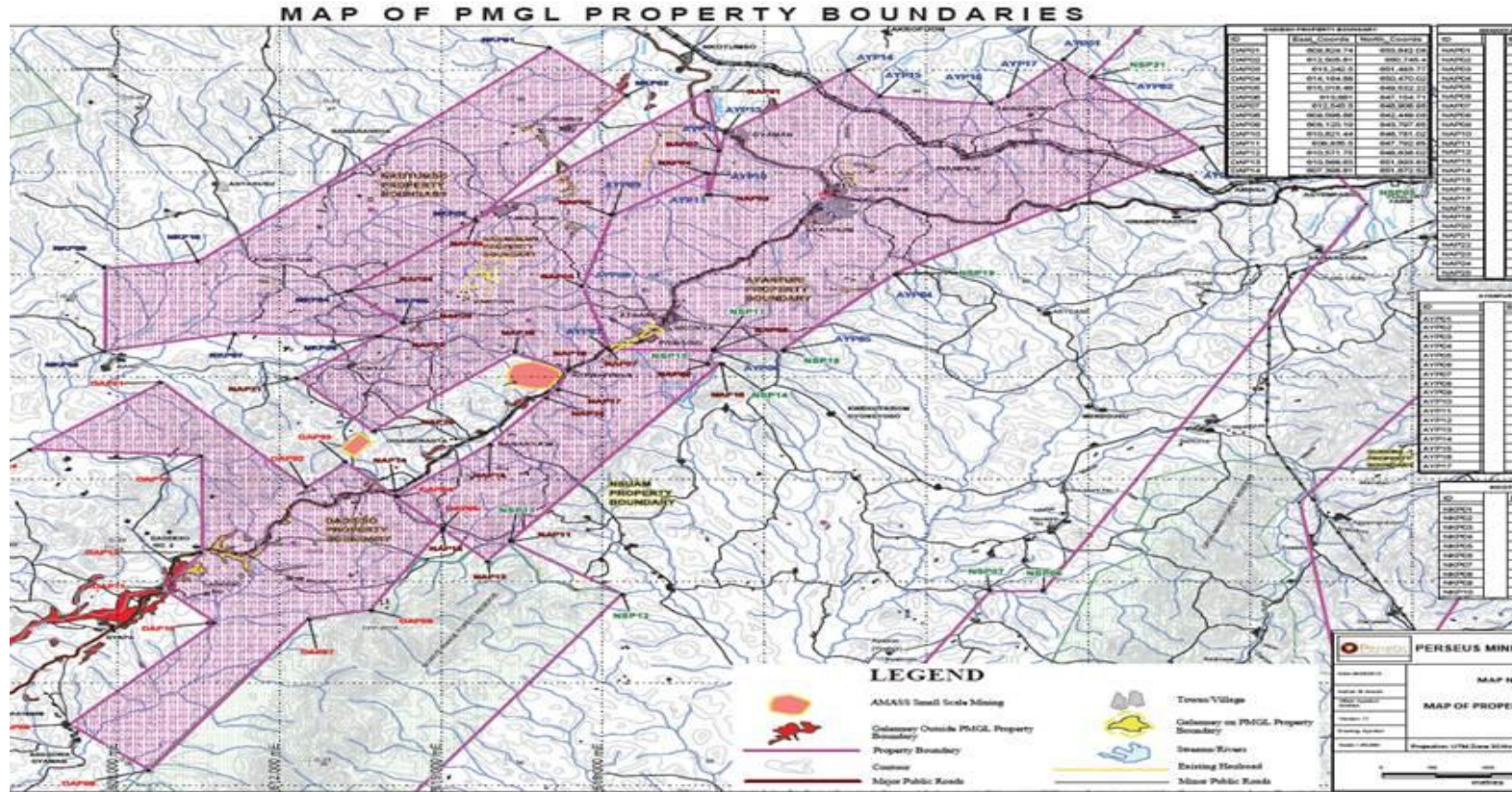
#### 2.3.1 Fetish

Fetish comprises of the two main styles of mineralization in the district. The deposit is made up of two parallel granite bodies which are steeply dipping to the east and an associated sheared hosted sediment gold mineralization within an area 650m long and 300m wide. The low grade eastern granite is up to 130m wide. The sheared hosted sediments lie to the west of the high grade granite body averaging 20 m in width. Gold mineralization in the granitoid is associated with quartz carbonate veins with disseminated or deformed arsenopyrites and pyrites. In the sediments gold mineralisation is confined within the sheared zones in the presence of boudinaged quartz carbonate veins and stringers in close association of deformed arsenopyrite and pyrites.

#### 2.3.2 Chirawewa

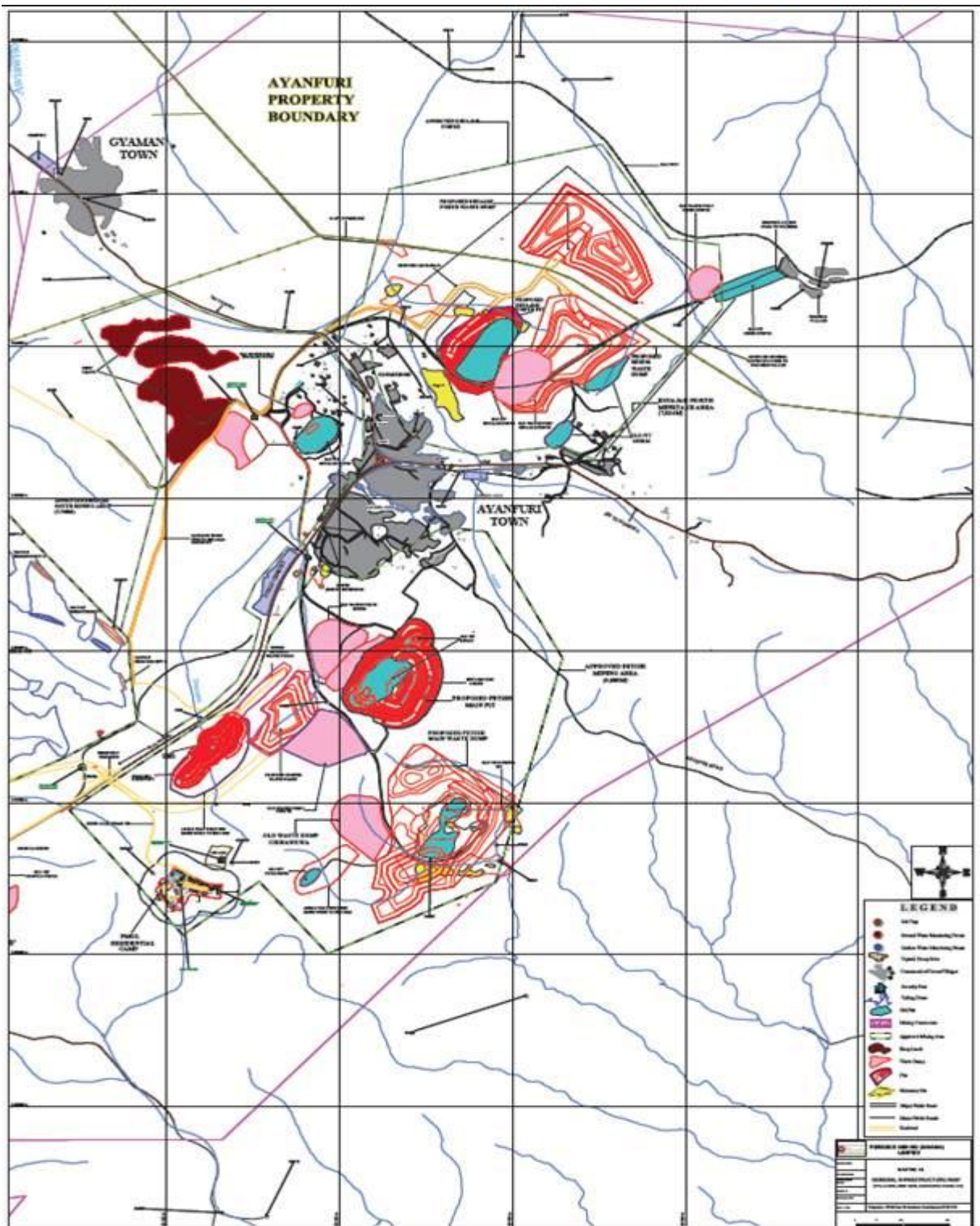
Chirawewa deposit is located approximately 1km south of Fetish. There are two granite bodies hosting gold mineralisation in the area found close to its contact with the sediments. The main Chirawewa deposit extends for 200m and ranges from 20 to 100m in width. The other deposit found to the eastern flanks of the main is relatively smaller and appears discontinues at both the both ends along strike. Structurally these intrusions are steeply dipping and mimic the structures of those of the surrounding rocks. Gold in the intrusive are mostly observed in zones with sericite, quartz carbonate veins, and stringers.

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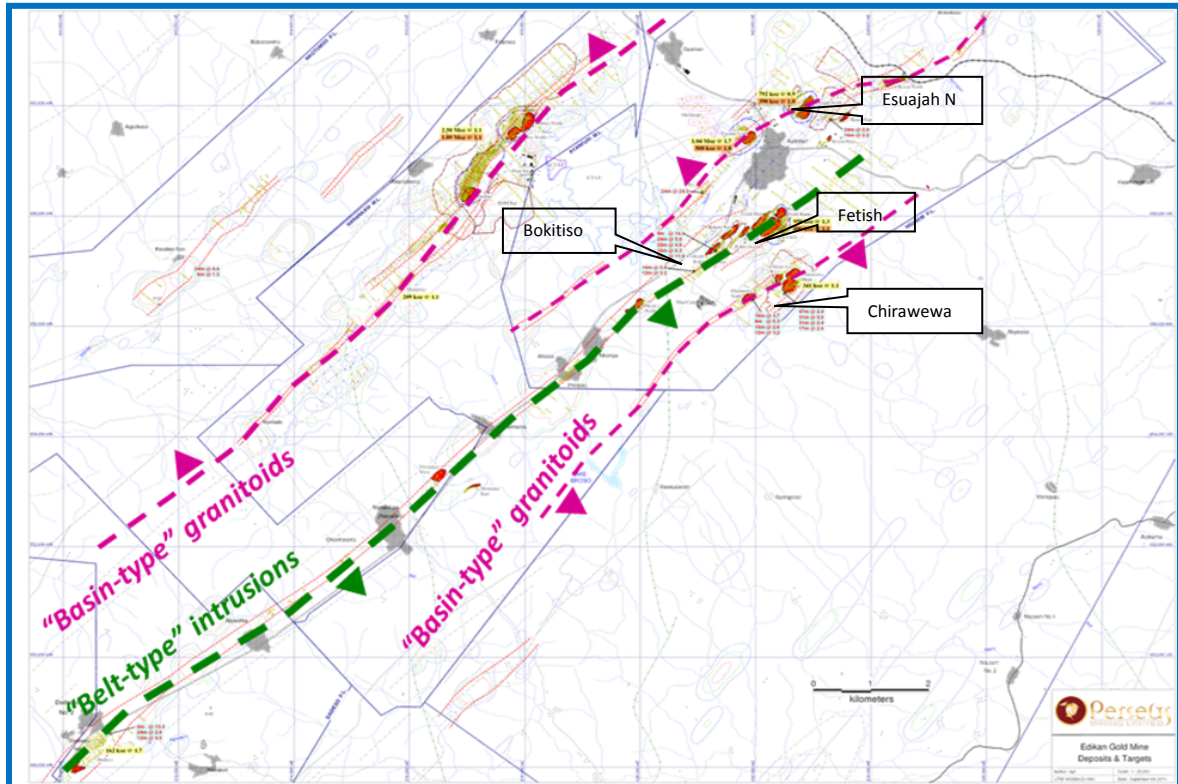
**Figure 2.1: Ayanfuri and Nanankaw Mining Leases**

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**Figure 2.2: General Infrastructural Map of Mine Area**

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**Figure 2.3: Eastern Pit Deposits**

Recent investigation has revealed some amount of gold in the sediments sandwich between the two granite bodies but this is still under investigation. Gold in sediments is hosted within the sheared zones marked by the presence of graphite, quartz carbonate veins and disseminated sulphide mineralisation consisting of arsenopyrite and pyrite. Gold in the sediment appears to show a very strong positive correlation with the sulphide percentage.

### 2.3.3 Bokitiso

Bokitiso deposit is located about 500m to the south west of the Fetish Deposit with a strike length of about 522m and an average width of 110m. Gold is hosted in a typical "Ashanti style" shear hosted mineralisation trending NE. The shears are steeply dipping to the east. Gold mineralization on the prospect is within the deformed zones in association with graphitic schist and sediments and has a positive correlation with disseminated pyrite, dolomite and ankerite alteration and stock works of quartz veins and quartz carbonate stringers. In contrast, gold mineralisation in the graphitic sediment is occasionally observed in association with arsenopyrite.

Traces of gold mineralisation have been observed in a felsic intrusive to the north-eastern portions of the prospect in association with medium grained pyrite and planar quartz veins and this needs to be investigated.

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### 2.3.4 EGM Mineral Resource Estimate

The Company's Measured and Indicated Mineral Resource base at EGM is 2,373 ounces of gold and the Inferred Mineral Resource base is 919 ounces and is tabulated below in Tables 2.1 and 2.2. The Company's Proven and Probable Mineral Reserves at EGM are as shown in Table 6. The information provided is:

- Based on December 2014 Resource estimation;
- Based on Gold cut-off grade of 0.4g/t;
- Last updated in July 2013 and allows for ore depletion to 2020.

**Table 2.1 Mineral Resources – EGM**

Deposit	MEASURED RESOURCE			INDICATED RESOURCE			MEASURED & INDICATED RESOURCE		
	Ore Tonnage	Grade	Gold	Ore Tonnage	Grade	Gold	Ore Tonnage	Grade	Gold
	(Mt)	(g/t)	Ounce	(Mt)	(g/t)	Ounce	(Mt)	(g/t)	Ounce
Fetish	12.7	0.90	367.5	18.1	1.1	640.1	30.8	1.0	1,007.6
Esujah North	16.9	0.90	489.0	18.4	0.8	473.3	35.3	0.8	962.3
Chirewewa			0.0	5.8	1.0	186.5	5.8	1.0	186.5
Bokitiso	0.7	3.70	83.3	1.6	2.6	133.7	2.3	2.9	217.0
<b>Total</b>	<b>30.3</b>	<b>0.96</b>	<b>939.8</b>	<b>43.9</b>	<b>1.02</b>	<b>1,433.6</b>	<b>74.2</b>	<b>0.99</b>	<b>2,373.4</b>

**Table 2.2- Inferred Mineral Resources – EGM**

Deposit	INFERRED RESOURCE		
	Ore Tonnage (Mt)	Grade (g/t)	Gold Ounce
Fetish	9.8	1.10	346.6
Esujah North	3.6	0.90	104.2
Chirewewa	10.4	0.90	300.9
Bokitiso	2.9	1.80	167.8
<b>Total</b>	<b>26.7</b>	<b>1.07</b>	<b>919.5</b>

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### 2.3.5 EGM Mineral Reserve Estimate

Mining consultant Runge Pincock Minarco completed an independent estimate of the Mineral Reserves for the EGM as at December 31, 2014 in accordance with the requirements of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (the JORC Code, 2004 Edition). The Mineral Reserves, which comprise material from four open pits which are Fetish, Chirawewa, Bokitiso, Esuajah North and stockpiles (refer to Table 2.3), are as follows:

- Based on June 2013 Resource estimation;
- Oxide – 0.6g/t cut-off; Transitional – 0.5g/t cut-off; Fresh – 0.4g/t cut-off, regular block;
- Inferred mineral resources considered waste; and
- Last updated in June 2014.

### 2.3.6 Project Size

The total land take required for the Eastern Pits area for mining and the various infrastructures will be approximately 209 hectares of which 90% is a brown field. This represents 2.4% of the two Mining Lease areas (93.1 km<sup>2</sup>).

Ashanti Gold Company (AGC) closed out the Ayanfuri Project in 2004 with approximately 376 hectares of disturbed area since operations began in early 1994. Utilisation of land take largely comprised 154 ha of pits, 73 ha of waste dumps and 133 ha of heap leach material within the Ayanfuri and Nanankaw Mining Leases.

**Table 2.3- Mineral Reserves – EGM**

Deposit	PROVED RESERVES			PROBABLE RESERVES			PROVE & PROBABLE RESERVES		
	Ore Tonnage	Grade	Gold	Ore Tonnage	Grade	Gold	Ore Tonnage	Grade	Gold
	(Mt)	(g/t)	Ounce	(Mt)	(g/t)	Ounce	(Mt)	(g/t)	Ounce
Fetish	8.6	1.00	268.0	8.6	1.4	381.0	17.3	1.2	649.0
Esuajah North	10.5	1.00	326.0	3.5	0.9	105.0	14.0	1.0	431.0
Chirewewa	-	-	-	2.4	1.2	95.0	2.4	1.2	95.0
Bokitiso	0.8	3.30	80.0	0.1	2.8	7.0	0.8	3.2	87.0
<b>Total</b>	<b>19.9</b>	<b>1.09</b>	<b>674.0</b>	<b>14.6</b>	<b>1.26</b>	<b>588.0</b>	<b>34.5</b>	<b>1.17</b>	<b>1,262.0</b>

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### 2.3.7 Location of Various Facilities

The location of the various facilities that constitute the Eastern Pits is as presented in Figure 2.5.

### 2.3.8 Site Preparation

#### General

The major construction phase will include the following sequential steps:

- Resettlement of structures within the active blast zone of the pits. Currently, land compensation has been completed except for disputed a fallow land which is still under negotiation stage; Resettlement Action Plan (RAP) has already been submitted to the Agency.
- Cleaning of existing pits of sludge and mud which will be followed by vegetation clearing and overburden removal; and
- Construction of haul roads and contractor auxiliary infrastructure.

Site preparation activities will involve clearing of vegetation, cutting and sale of marketable timber, use of scrap wood and branches as brush barriers for sediment control where applicable, and chipping of unsuitable or excess wood and branches for mulch. The enumeration of timber and other economic species have been completed with the assistance of the Dunkwa office of the Forestry Commission and the timber concessioner, (Messrs Western Industrial Farms). Matured timber or economic species will be disturbed as and when the area is needed for mining activities. Compensation and harvesting terms will be reached with the concessioner.

Topsoil will be stripped, stockpiled and labelled for later use during re-vegetation activities. Some stockpiled topsoil will be used during construction period for re-vegetation activities while the bulk of the topsoil will be maintained for dump closure and final reclamation use. Topsoil stockpiles will be vegetated with native grasses (e.g. *Panicum maximum*, *Cynodon nlemfuensis*, *Chloris gayana*,

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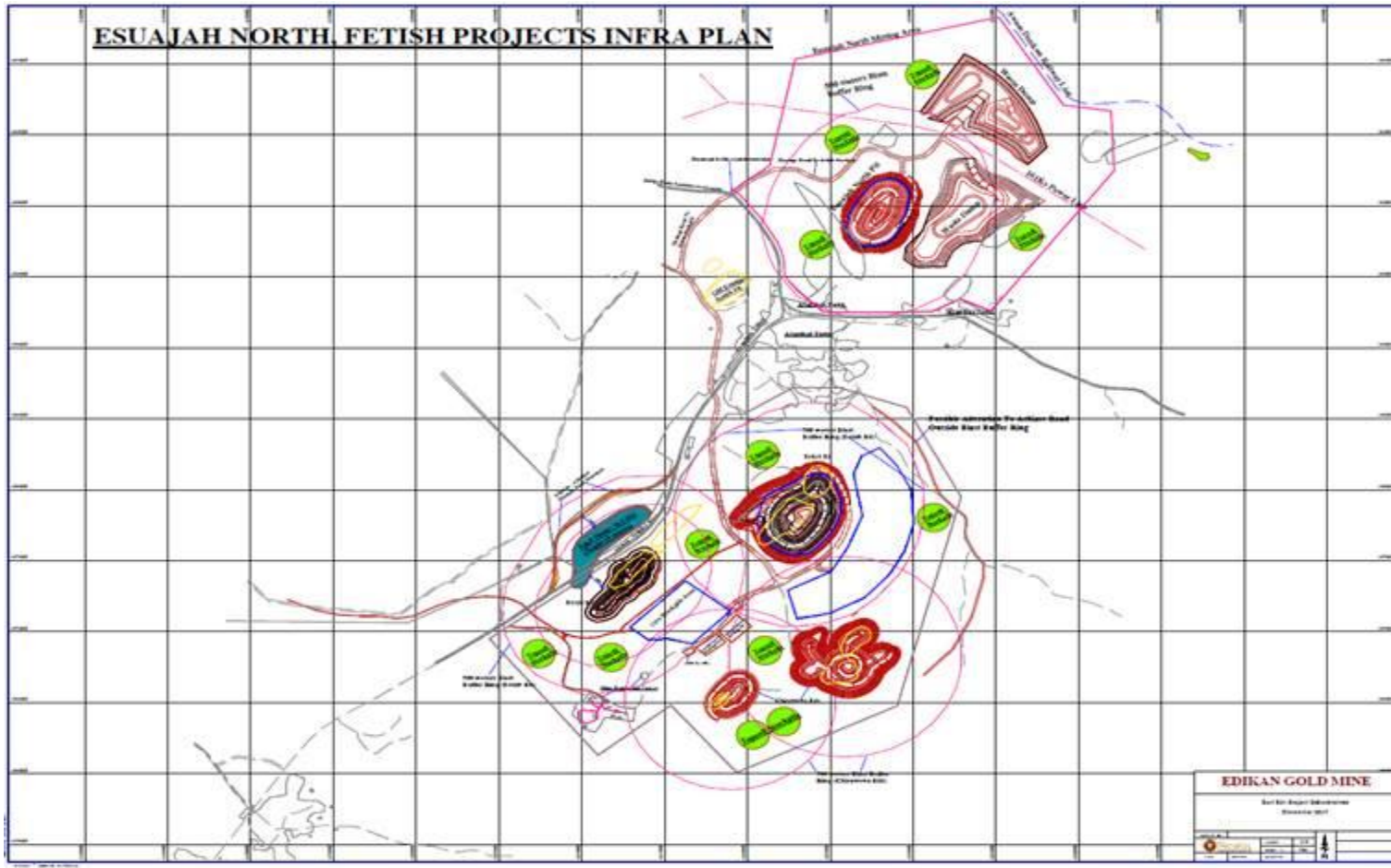


Figure 2.4: Location of Pits and Topsoil Dumps at Eastern Area

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*Andropogon gayanus*, *Bracharia ruziziensis*, *Tripsacum luxum*, *Setaria sphacelata* and *Cenchrus ciliaris*) to stabilise stockpile outcrops and to minimise erosion and soil loss.

Clearing of the various sites will be a gradual process and will not exceed the surface of the area required for each of the facilities. It will not be necessary to clear the entire surface footprint of the waste dumps in one operation, as waste rock is produced and stored progressively from the beginning to the end of the life of the Project. Site preparation activities that involve clearing, grubbing and topsoil stripping and stockpiling will be co-ordinated by the Health, Safety, Environment and Community Department (HSEC) to minimise any negative impacts on local communities and the environment in general.

### 2.3.9 Clearing Activities

Preparation of various components (access roads, haul roads, pit cleaning, clearing of waste dumps, ROM pad and contractor laydown) will involve activities such as felling of trees, clearing of vegetation, stockpiling of wood and branches, where applicable segregation and stockpiling of topsoil and where necessary surface compaction. Stockpiled topsoil will also be used for early re-vegetation purposes required to stabilise certain structures such as embankments or earth mounds. In previously highly disturbed areas activities will be on a lesser scale. The activities of clearing, grubbing and topsoil segregation will be co-ordinated by PMGL’s HSEC Department to minimise the negative impacts on the environment and local community.

Due to most of the pits being under water for over ten (10) years, it is anticipated the final pit cleaning will be slurry in nature and this will be deposited at the waste dumps as part of the ground preparation before mining commences. Depth profile sampling of pit waters has been assessed and monitoring data submitted to the Agency. EPA approval will seek prior to commencement of dewatering activities. The specific land requirements for each facility are listed in Table 2.4.

## 2.4 Mining and Waste Rock Disposal

### 2.4.1 Mining Method and Equipment

Mining of the pits will be carried out by a contractor and will be managed by PMGL’s Mining department. The contractor will be responsible for site preparation, cleaning of existing pits, haul-road construction and maintenance, drill and blast, load and haul of ore and waste material to the ROM pad and waste dump respectively. The technical services comprising of mine planning, production scheduling, grade control, surveying and the monitoring of the contract mining operations will be undertaken by PMGL personnel.

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**Table 2.4 – Land Requirements**

Facility	AGC Area (Ha)	Not in Project	PMGL Eastern Pits Area (Ha)	Increase Brownfield	Decrease Brownfield	Greenfield
<b>PITS</b>						
Besem North	15	15				
Besem Gap (part of Esuajah North Dump)	5					
Besem Main (part of Esuajah North Dump)	5					
South Bokitiso West (Backfilled)	4				4	
South Bokitiso W. Extension (Backfilled)	4				4	
South Bokitiso East (Backfilled)	3				3	
South Bokitsi East Ext (Backfilled)	1				1	
Chirawewa Main (Backfilled)	25				25	
Chirawewa South	1	1				
Chirawa West (Backfilled)	10				10	
Chirawewa East (Backfilled)	2				2	
Esuajah North	15		22.3	3		
Fetish Main (Backfilled & rehabilitated)	15	15				
Fetish	17.5		32.4	5.5		
Nkonya	5	5				
<b>Total Pit</b>	<b>128</b>	<b>36</b>	<b>55</b>	<b>8.5</b>	<b>49</b>	
<b>HAUL ROADS</b>	16	16	12			12
<b>WASTE DUMPS</b>						
Besem North	5	5				
Chirawewa	11	11				
North Esuajah (Rehabilitated)	18		97.3			48
Fetish	6				25	
Fetish	15		102		45	74
Nkonya	5	5				
<b>Total Waste Dumps</b>	<b>60</b>	<b>21</b>	<b>199.3</b>		<b>70</b>	<b>122</b>
<b>Leach Pads</b>	133	133				
<b>PMGL FACILITIES (New)</b>						
Eastern Mine Ore Piles			12			12
Miscellaneous			10			10
<b>Total New Facilities</b>			<b>22</b>			<b>22</b>
<b>Grand Total</b>	<b>337</b>	<b>185</b>	<b>288</b>	<b>9</b>	<b>119</b>	<b>156</b>

Open pit mining method using excavator and trucks will be employed. Mining of the ore and waste will utilise 120 to 200t size hydraulic excavators in a backhoe configuration. The different ore material types and waste rock boundaries would be delineated on each bench based on the RC grade control sampling results and the resultant geological modelling and interpretation. Bench and face mapping, for grade control as well as for geotechnical reasons, will be a routine task in finalising the ore and waste rock boundaries to be marked out for excavation. The mining operation will excavate and load the ore and

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waste rock in accordance with the marked ore and waste rock boundaries in order to minimise ore dilution. The scheduling of the excavation of different parts of a particular pit is dependent on the need for blending of ore to meet the ore grade and throughput targets of the process plant and other constraints such as space availability on the ROM pad and rehandling stockpiles. Haul roads, nominally 25m wide will be constructed during the development of the operations.

The following is the scheduling of activities for the commencement of mining:

- The Contractor shall clear the site for the mine area and the waste rock dumps in accordance with approved designs. Clearing shall consist of cutting trees, stumps and brush to approximately ground level and disposal of the cleared material by removal to locations as will be directed by the Mining Manager;
- Grubbing shall be carried out over selected portions of the mine and waste rock dump areas as per plan. All stumps, roots, scrub and similar organic matter shall be grubbed out to a depth of 100 to 300mm below the natural surface level by suitable means and removed to designated locations;
- The Eastern Pits area is a brown field with patches of secondary growth vegetation as a result of previous mining activities in the area. Where practical, topsoil will be stripped from the footprint areas of the pits and waste rock dumps, prior to mining. The topsoil will either be stockpiled for later use, or hauled directly onto profiled waste areas for rehabilitation. Stockpiles will consist of vegetation and topsoil in order to increase soil microbial degradation. Waste stripping will then commence. The shortfall in topsoil due to the absence from the previous operators for disturbed areas will be catered for by stripping subsoils for blending. Waste rock will be dumped at the designated waste rock dumps; and
- Ore from the various pits will be hauled to a ROM pad which will be built south west of the Fetish pit which will be re-handled to the main ROM pad at the plant site. Trucks will be used for the ore haulage from the Eastern Pits to the plant site which is at the western side. Up to 100 tonnes trucks will be used depending on mode of crossing (temporal level crossings with an upgrade to underpass on the IR6 Highway) in which the EPA will be notified of modifications to the medium of haulage.

#### **2.4.2 Grade Control and Ore Blending**

Grade Control drilling will be undertaken using Reverse Circulation (RC) drills owned and operated by the mining contractor. Based on the expected variability of the deposit, the pattern dimensions are expected to be 10 x 10m, and 20m deep. The application of grade control drilling will vary depending on the cut-off grade strategy applying at the time and on which part of the ore body.

Blending will be undertaken on a smaller ROM pad to be constructed at the Eastern Pits section. Ore will be stockpiled and hauled to the existing process plant.

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### 2.4.3 Drill and Blast

The mining contractor shall be responsible for the marking out of blast patterns as approved through relevant Blast Approval Notices. The Contractor shall be responsible for protecting all drilling areas including the erection and maintenance of barricades, signs, lights or any other warning devices.

The Contractor shall provide efficient dust suppression units on all of its drill rigs used for production and miscellaneous drilling. Dust suppression units shall be installed, adjusted and maintained in accordance with the manufacturer’s specifications and shall be used at all times that a drill rig is being used. Care shall be taken to ensure that dust extraction operate effectively when drilling angled holes.

- The Contractor shall schedule its drilling and blasting operations to meet PMGL’s overall production targets and objectives and shall allow for any underutilisation of its drilling equipment due to mismatch in its drilling and loading and hauling capacities.
- PMGL may require the sampling of drill cuttings from blast holes in the laterite material for the purpose of grade control. The Contractor will allow for the fitting of a suitable sample collection system approved by the Mining Manager. The provision of sampling consumables and the collection of the samples will be the responsibility of the Company.
- The Contractor shall be responsible for ensuring that the Blast Exclusion Zone is clear of all personnel, visitors and members of the public during the blasting operations and that all necessary precautions for the proper protection of all persons, the Works and all property have been taken.

In the event that the contractor has to “sleep”, whether under his own volition or under the direction of the Mining Manager, the Contractor shall:

- provide and install suitable barricades and protect the charged area in daylight hours until it is fired; or provide guards for the blast during the hours of darkness until fired

Rock fragmentation will be undertaken by free digging or drilling and blasting as required. To minimise the effect of the blasting on the slopes, control blasting will be used. The use of a particular blasting technique will vary throughout pit life depending upon rock conditions in the particular pit. Small in-the-hole hammer (ITH) or hydraulic top hammer drill rigs will be used for the waste material drilling operations.

Selection of explosive type will depend on the presence of any ground water and the success with which recommended dewatering operations are carried out. Given that the water table at the Project will be encountered at nominally 30m below the surface, use of ammonium nitrate fuel oil (ANFO) has been assumed to be limited to the material above the water table with a waterproof emulsion product required for the remainder of the ore body. Based upon the hole diameter, bench height and powder factor parameters will be provided by PMGL for blast designs.

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The Contractor shall make prevention of fly rock its priority when charging blast holes. In addition, the Contractor shall incorporate the following into its procedures, methods and standards as a minimum:

- A documented process for confirming and if necessary, correcting blast hole depths prior to charging;
- A documented process for confirming adequate burden on all holes and if necessary, either reducing charge weight or stacking imported burden;
- A documented process to ensure that adequate stemming is provided for all holes;
- A documented process to ensure that secondary breaking is performed by mechanical means wherever possible; and
- A procedure to limit toe blasting unless absolutely essential.

Environmental measures to be instituted during blasting will include:

- Demarcation of blast area, including an appropriate buffer area;
- Use of controlled blasting techniques to minimize noise and vibration;
- Blast notices with date and time of blasting will be placed at appropriate locations;
- Establishment of blast guards prior to blast initiation;
- Siren warnings prior to blast initiation; and
- Blast monitoring and control.

#### **2.4.4 General Pit Design**

Final and staged pits for each deposit have been designed on the basis of various pit shell optimisation factors. The selection of the pit shells were made by taking into account various factors including the relative relationship between stripping ratios, recovered ounces and incremental value or cost per recovered ounce. Another important consideration on shell selection was the physical shells and their interaction with the already mined out areas.

Pits are designed to allow the use of 100t-class off-highway dump trucks. These trucks have a physical width of 6.1m. Road widths are based on a safety factor of 1.6 times the truck width plus an additional 5m for safety bunds and drains. So a dual lane road will be  $(6.1m \times 1.6) + 5m$ . In pit roads are design for life-of-pit only. Mining in the Eastern Pits is proposed to commence in June 2015. The eastern pit development schedule is shown in Figure 2.7. The general pits plan for the project is as shown in Figure 2.8. The final pit dimensions are shown in Tables 2.5 to 2.7.

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### Edikan Eastern Pits Development

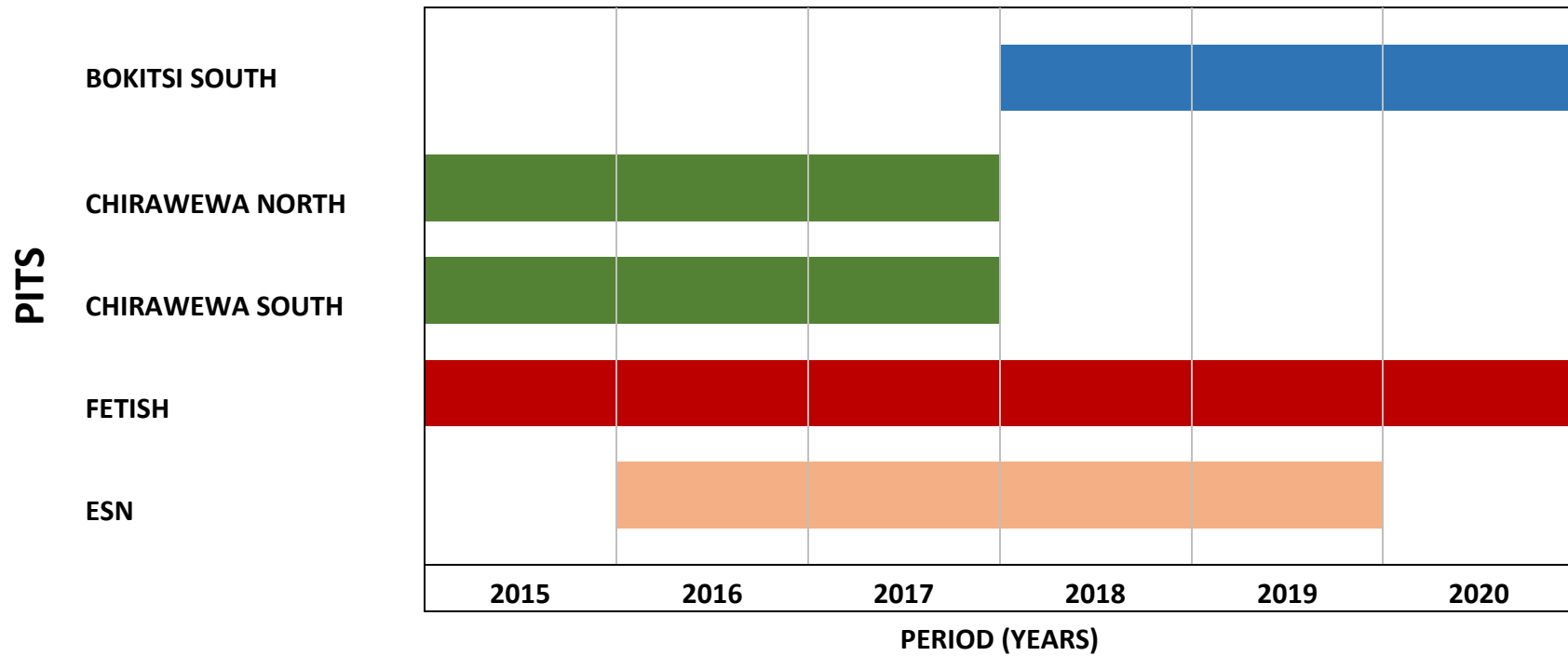
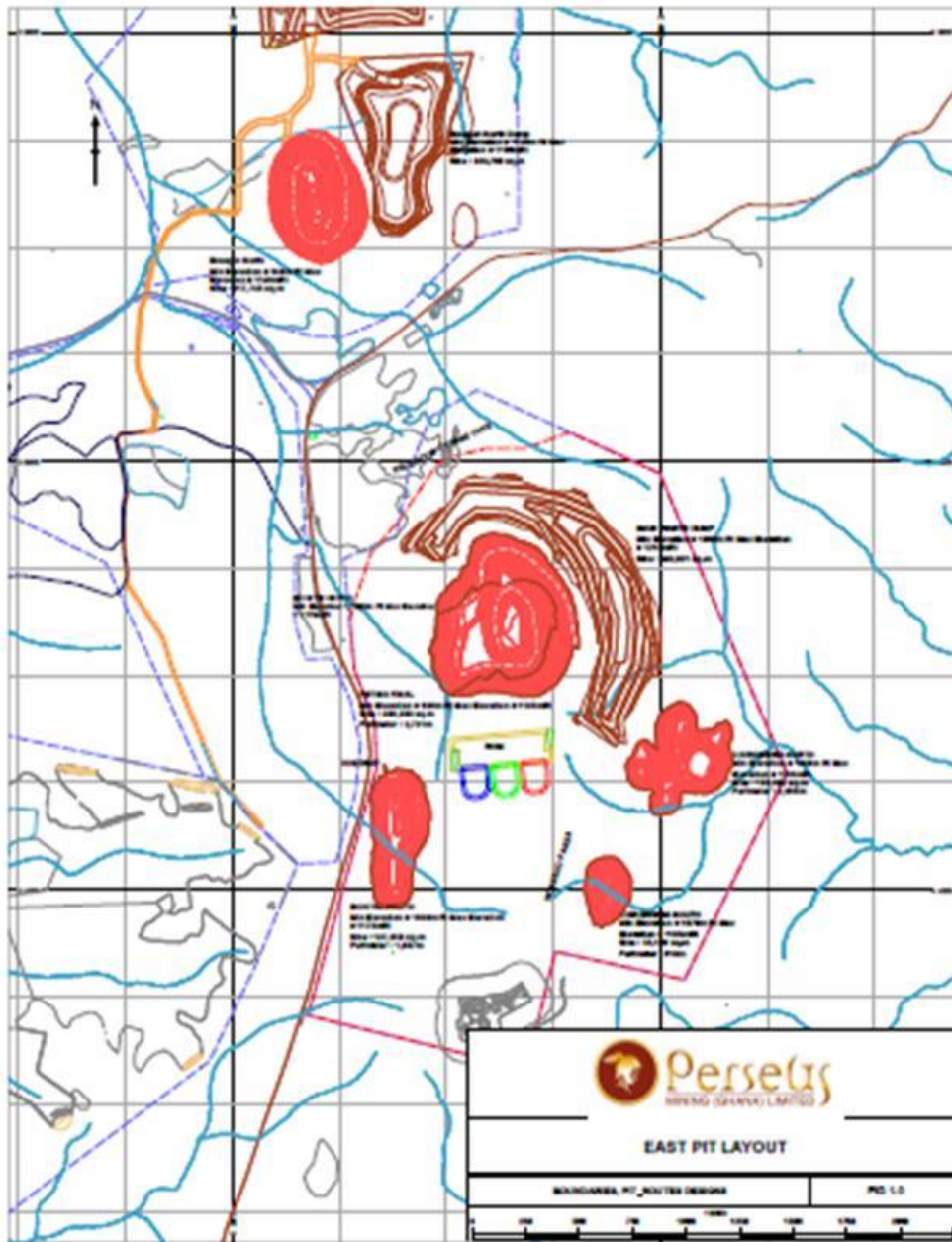


Figure 2.5: Eastern Pits Development

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**Figure 2.6: Eastern Pits Layout**

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**Table 2.5- Summary of Final Dimensions**

Pit	PMGL Final (ha) <sup>1</sup>	PMGL Final +20m (ha) <sup>2</sup>	PMGL Perimeter (m)	PMGLMax Depth (m)
Esujah North	21.70	21.70	1786	200
Fetish	35.26	35.26	2308	256
Chirawewa South	6.43	6.43	996	86
Chirawewa North	15.86	15.86	2211	136
Bokitiso South	9.61	9.61	1515	124
Bokitiso North	9.96	9.96	1315	137

**Table 2.6- Eastern Pits Dimensions**

DEPOSIT	STATE OF PIT	Base Area (Ha)	Maximum Depth (m)	Bench Height (m)	Battered Slope (deg)	Berm width (m)	Overall slope (deg)
Fetish	2015	5.85	65	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Chirewewa		1.88	45	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Fetish	2016	11.10	65	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Esujah North		5.04	45	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Chirewewa		5.29	75	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45

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**Table 2.6- Eastern Pits Dimensions - Continuation**

Base Area	Maximum Depth	Bench Height	Battered Slope	Berm width	Overall slope	Base Area	Maximum Depth
Fetish	2017	36.18	25	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Esujah North		8.51	95	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Chirewewa		1.12	20	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Fetish	2018	12.59	60	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Esujah North		5.90	60	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Bokitiso		3.95	25	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Fetish	2019	7.39	55	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Esujah North		1.71	60	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Bokitiso		4.55	65	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Fetish	2020	2.42	50	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45
Bokitiso		0.75	20	5 Oxide / 20 Fresh	80	5 Oxide / 10 Fresh	37/45

**Table 2.7- Waste Rock Dumps and Designed Parameters**

Pits	Name of Waste Dump	Base Area(Ha)	Bench Height(m)	Battered Slope(0)	Berm width(m)	Overall slope(0)
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<b>Fetish</b>	<b>Fetish Waste Rock Dump</b>					
<b>Bokitiso North</b>		46.29	15	20/25	10	18/22
<b>Chirawewa North</b>	<b>Chirawewa North Waste Rock Dump</b>		15	20/25	10	18/22
		28.83				
<b>Chirawewa South</b>	<b>Chirawewa South Waste Rock Dump</b>		15	20/25	10	18/22
		32.43				
<b>Bokitiso South</b>	<b>Bokitiso South Waste Rock Dump</b>		15	20/25	10	18/22
		11.16				
<b>Esujah North</b>	<b>Esujah North Waste Rock Dump</b>		15	20/25	10	18/22
		32.4				

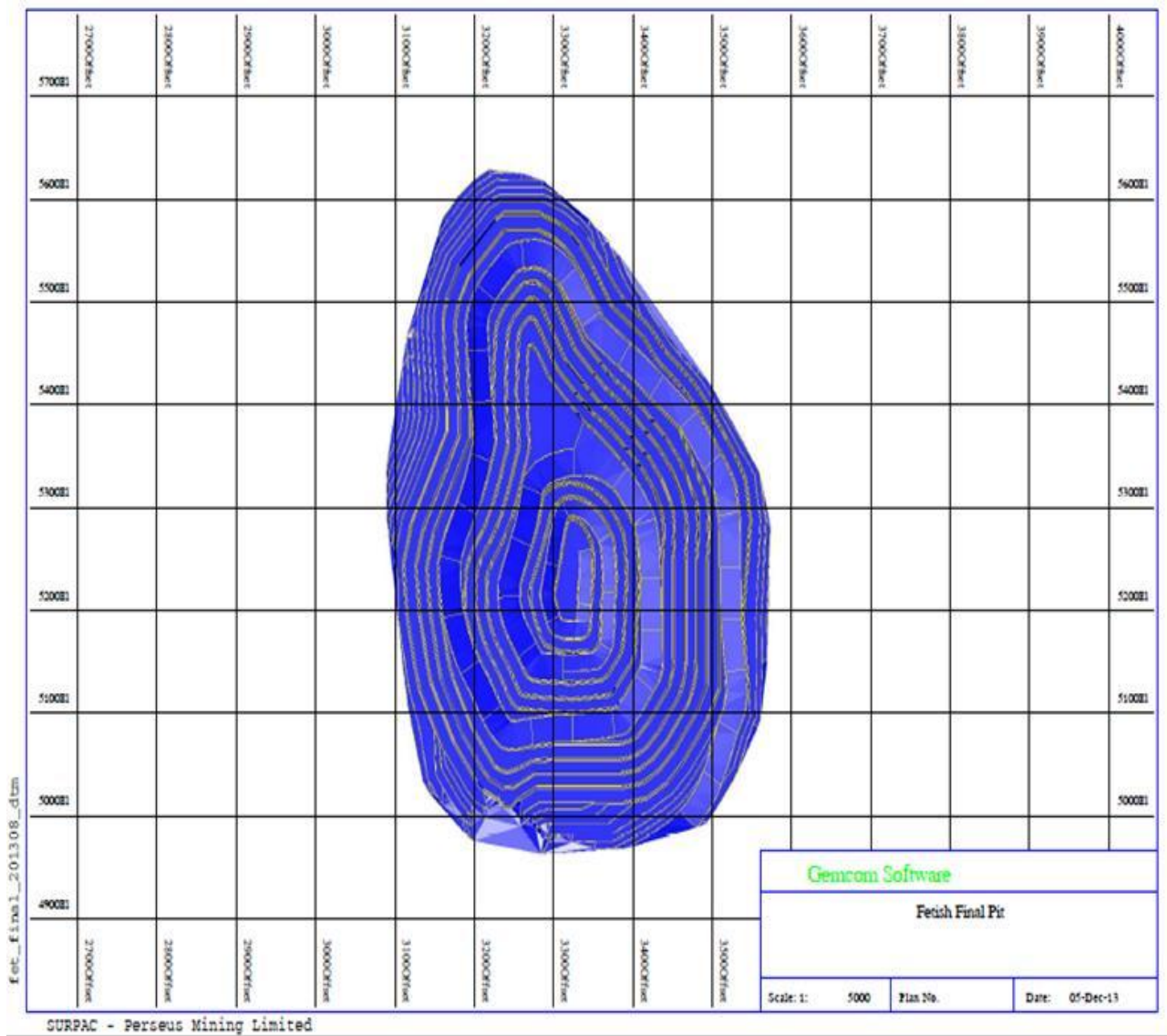
#### 2.4.5 Fetish Pit

The Fetish deposit will be mined in two stages. Stage 1, will not strictly follow the optimal pit shell in the south western corner between surfaces to 160.5 mRL due to previous mining activity. This has the advantage of greater wall stability. Stage 2 is the final stage pit and incorporates the smaller existing excavation to the north.

The Fetish Stage 2 pit will share a section of wall with Stage 1 in the south western corner of the final pit design until 150mRL is reached. Stage 2 incorporates the smaller existing excavation to the north. The pit ramp is also to the south as this allows for direct haulage to the waste dumps and ore stockpiles. Ore will then be transported to the ROM pad. The final pit design is provided in Figure 2.8 and sectional design in Figure 2.9.

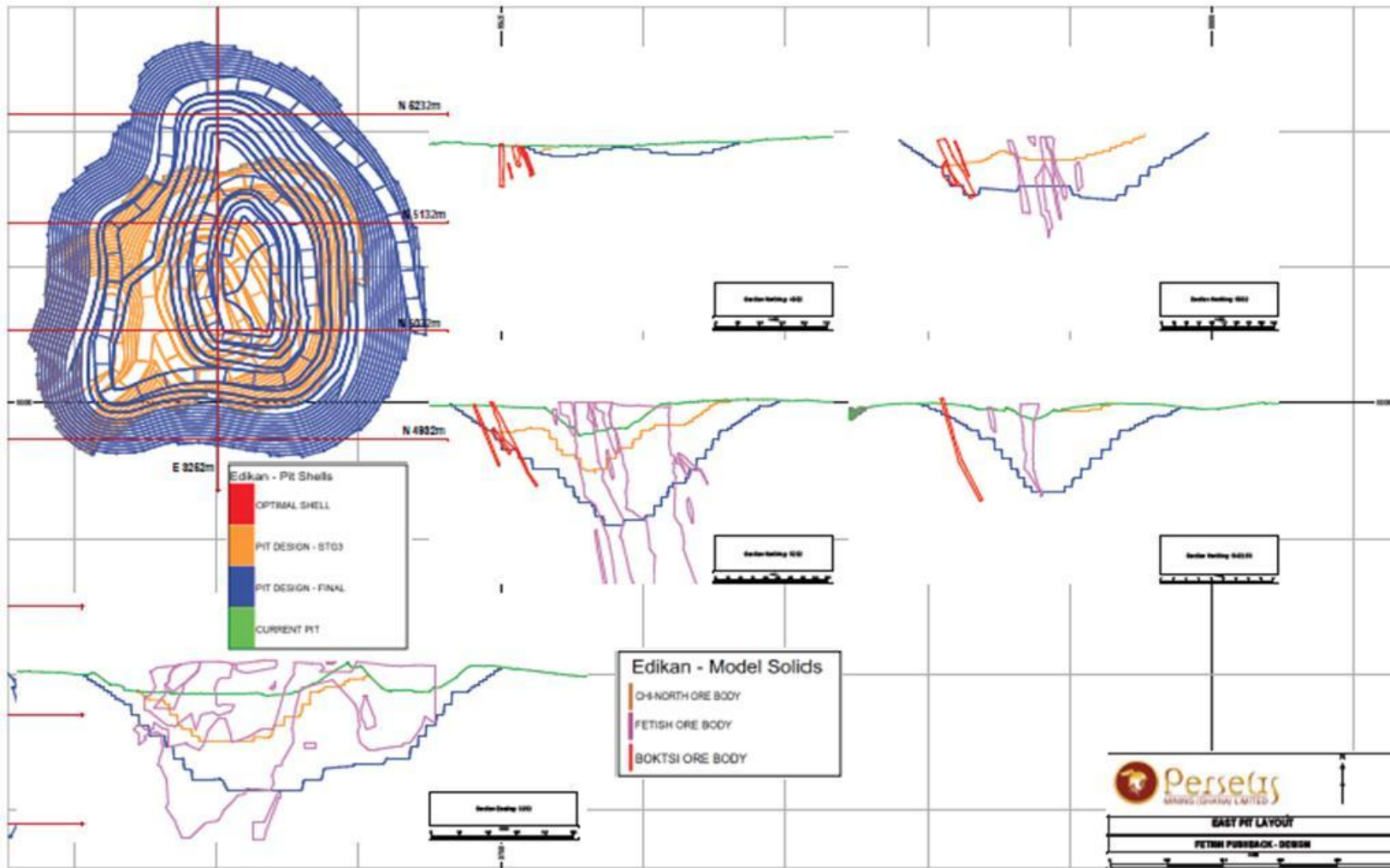
The pit will be mined to a depth of 256 m (Table 2.4). The final surface area has been estimated at 35.26 hectares with a pit perimeter of 2308 m.

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**Figure 2.7: Fetish Final Pit Plan**

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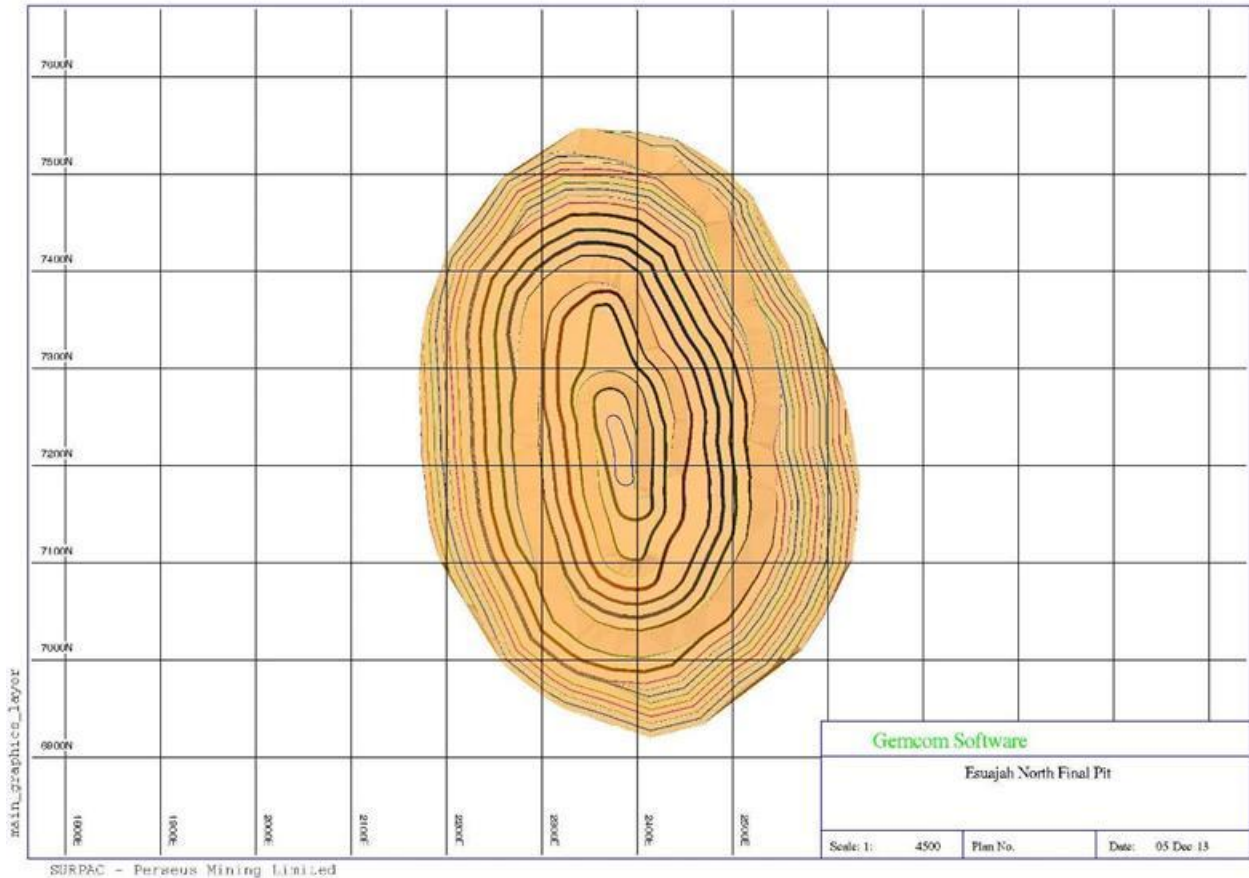


**Figure 2.9: Fetish Final Pit Plan**

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### 2.4.6 Esujah North Pit

The Esujah North Pit is situated northwest of Ayanfuri Community as illustrated in the General Infrastructural map (Figure 2.3). The pit was previously backfilled by AGC and re-vegetated which currently serves as a woodlot for the Ayanfuri Community. It will be mined in one stage as illustrated in Figure 2.10 and sectional drawing in Figure 2.11.



**Figure 2.10: Esujah North Final Pit Plan**

Detailed diamond and reverse circulation drilling have delineated ore reserve of economic values at the backfilled Esujah North pit that was backfilled and re-vegetated by the erstwhile AGC operation. The ore extends to greater part of the Esujah North waste rock dump as well. The Esujah North waste rock dump has been split into two areas, one to the north of the pit, the other to the east of the pit to avoid the infilling of a wetland tributary of the Asuaa stream. The eastern waste rock dump construction will involve the incorporation of the existing Besem waste rock dumps and the existing Esujah North waste rock dump constructed during the previous mining operation into one dump.

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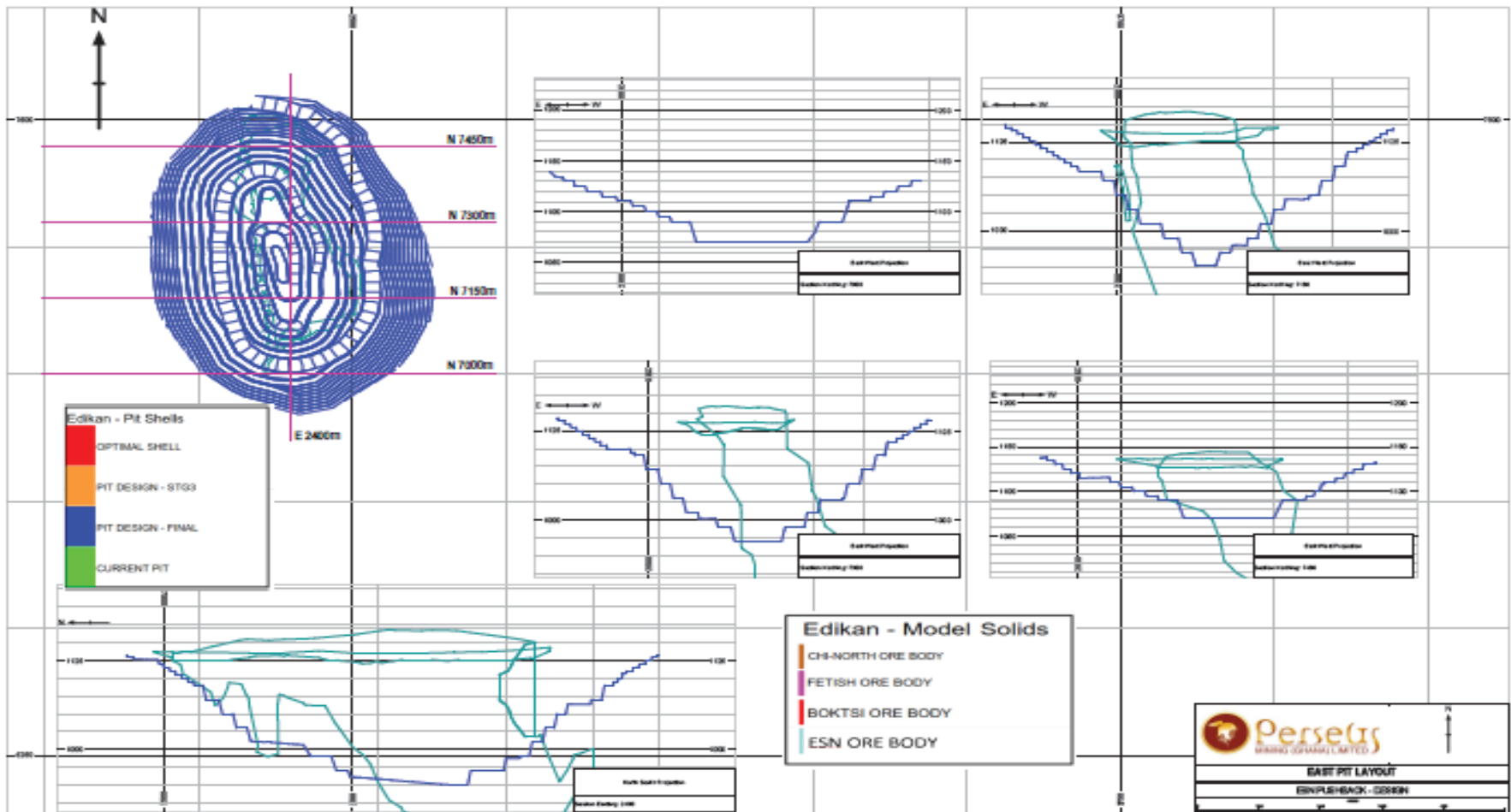


Figure 2.11: Esuajah North Section

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The east dump (main dump) will have an average height of 35m above the surrounding area (21m in the SW, 45m in the NW, 35m in the NE and SE).

The Esujah North pit is planned to be mined in Year 3 through to Year 8. The southern edge of the pit and the eastern waste dump do cut off existing Ayanfuri-Besem community access road. Farmers from Odumkrom currently use this road to access their farms. A pedestrian access will be provided from west of the Esujah North pit and along the northern edge of the north waste dump to connect the existing access. In addition, a bypass road will be constructed along the eastern edge of the main waste dump (east of the Esujah North pit) to link up the Besem Community access to the Ayanfuri-Dunkwa highway.

### 2.4.7 Chirawewa North Pit

The Chirawewa North pit will have a perimeter of 2211 m and a final surface area of 15.86 hectares. The pit will be mined to a depth of 136 m. The pit will have a battered slope of 80 and overall slope of 37/45, with bench height and berm width of 5/20 m and 5/10 m respectively. Ore will be transported by 10 wheel semi-trailer trucks to the ROM pad. The final pit design is provided in Figure 2.12 and sectional drawing in Figure 2.13.

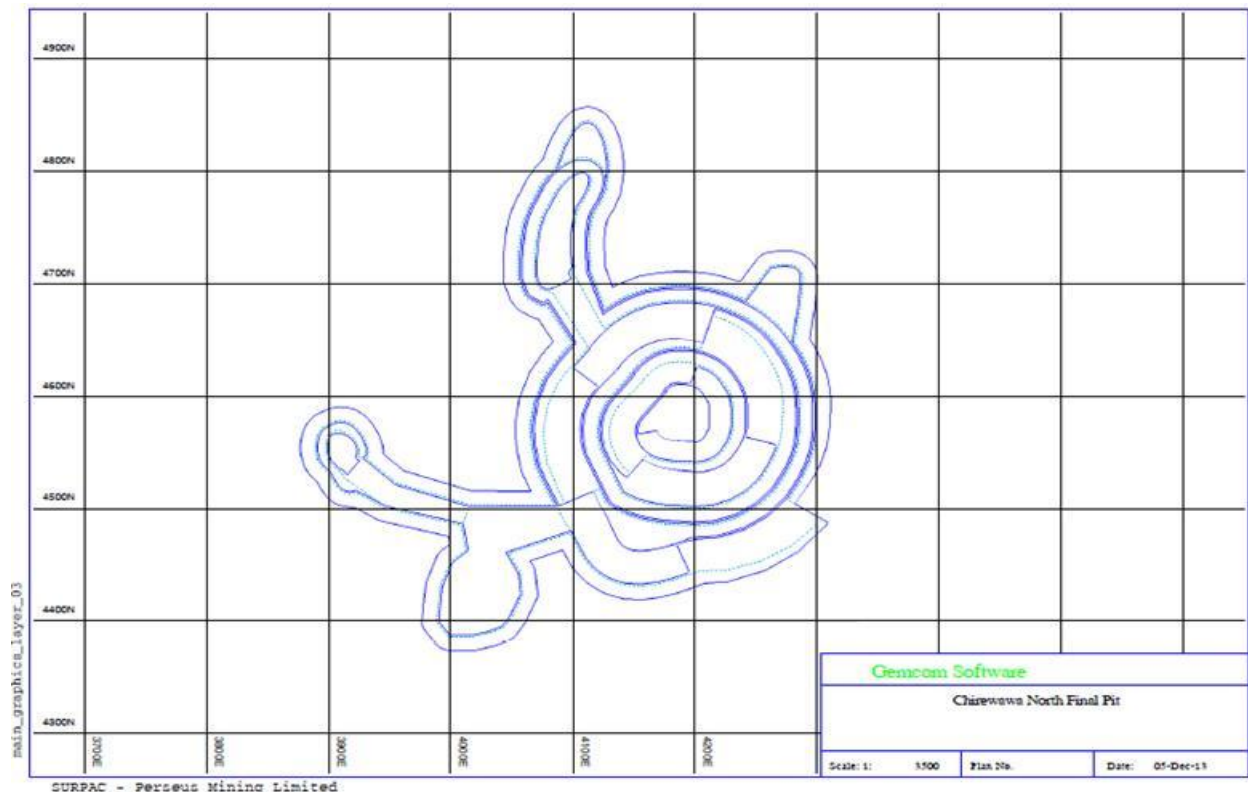
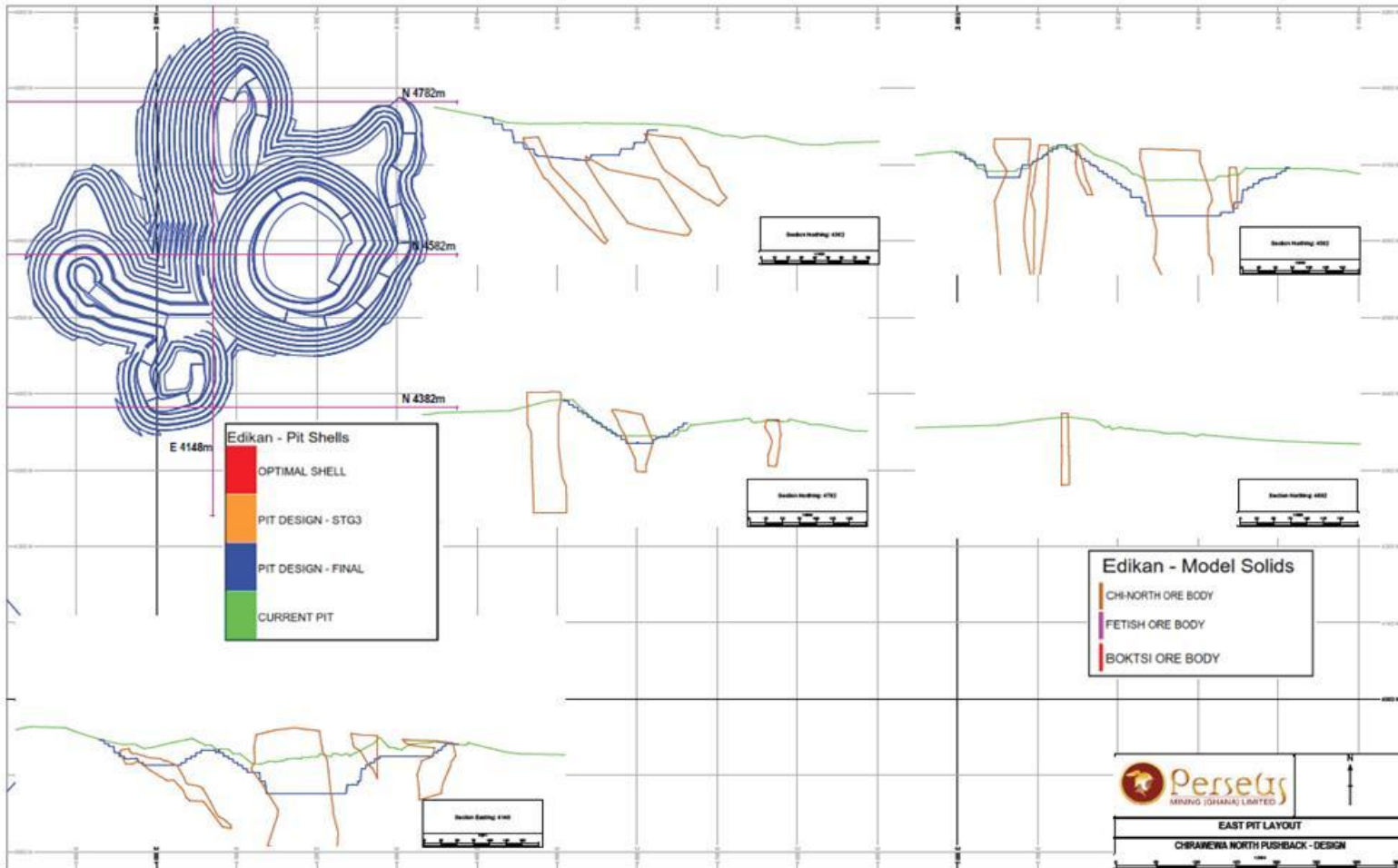


Figure 2.12: Chirawewa North Final Pit Plan

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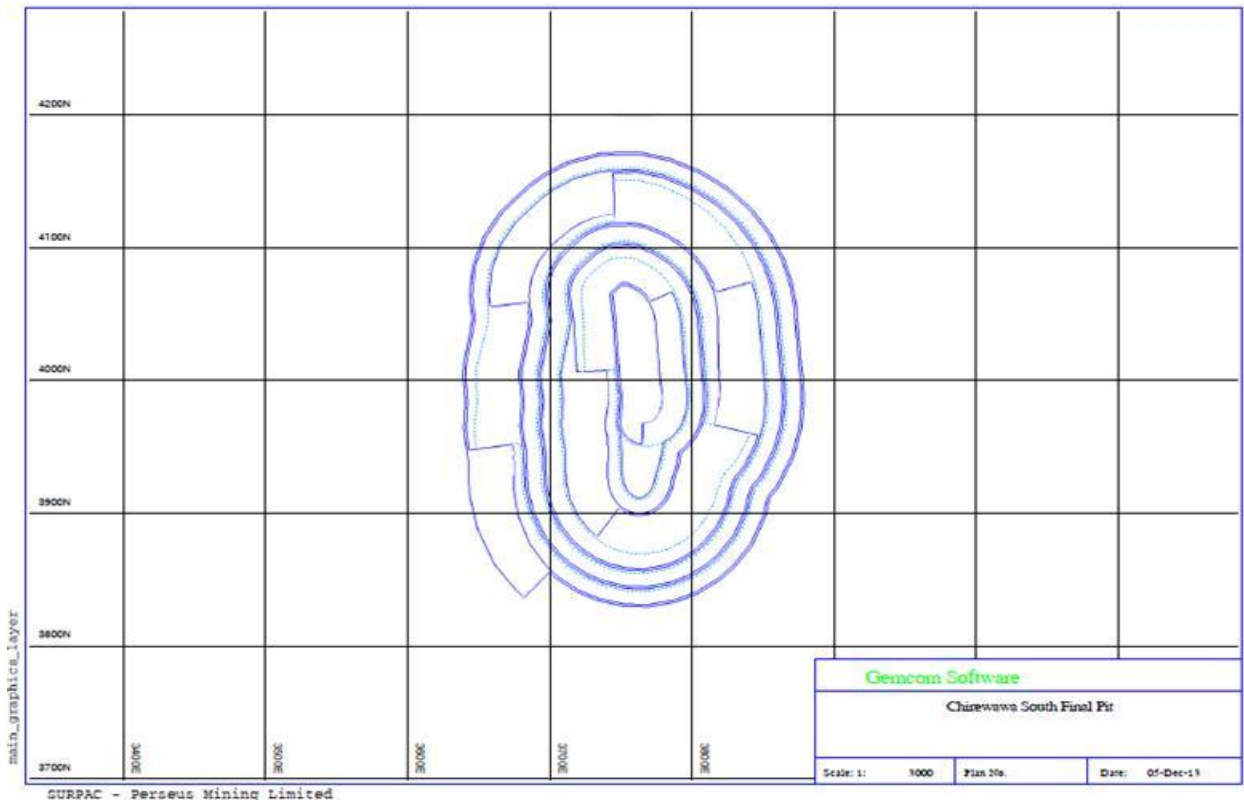
**Figure 2.13: Chirawewa North Final Pit Section**

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### 2.4.8 Chirawewa South Pit

The Chirawewa South pit deposit will be mined to a depth of 86 m. The pit will have a perimeter of 996 m, with bench height and berm width of 5/20 m and 5/10 m respectively. The pit will have a battered slope of 80 and overall slope of 37/45. The final surface area has been estimated at 6.43 hectares. The pit ramp will be to the North to allow for direct haulage to the waste dumps and ore stockpiles. 10 wheel semi-trailer trucks will be used to transport ore to the ROM pad. The final pit design is provided in Figure 2.14 and sectional drawing in Figure 2.15.

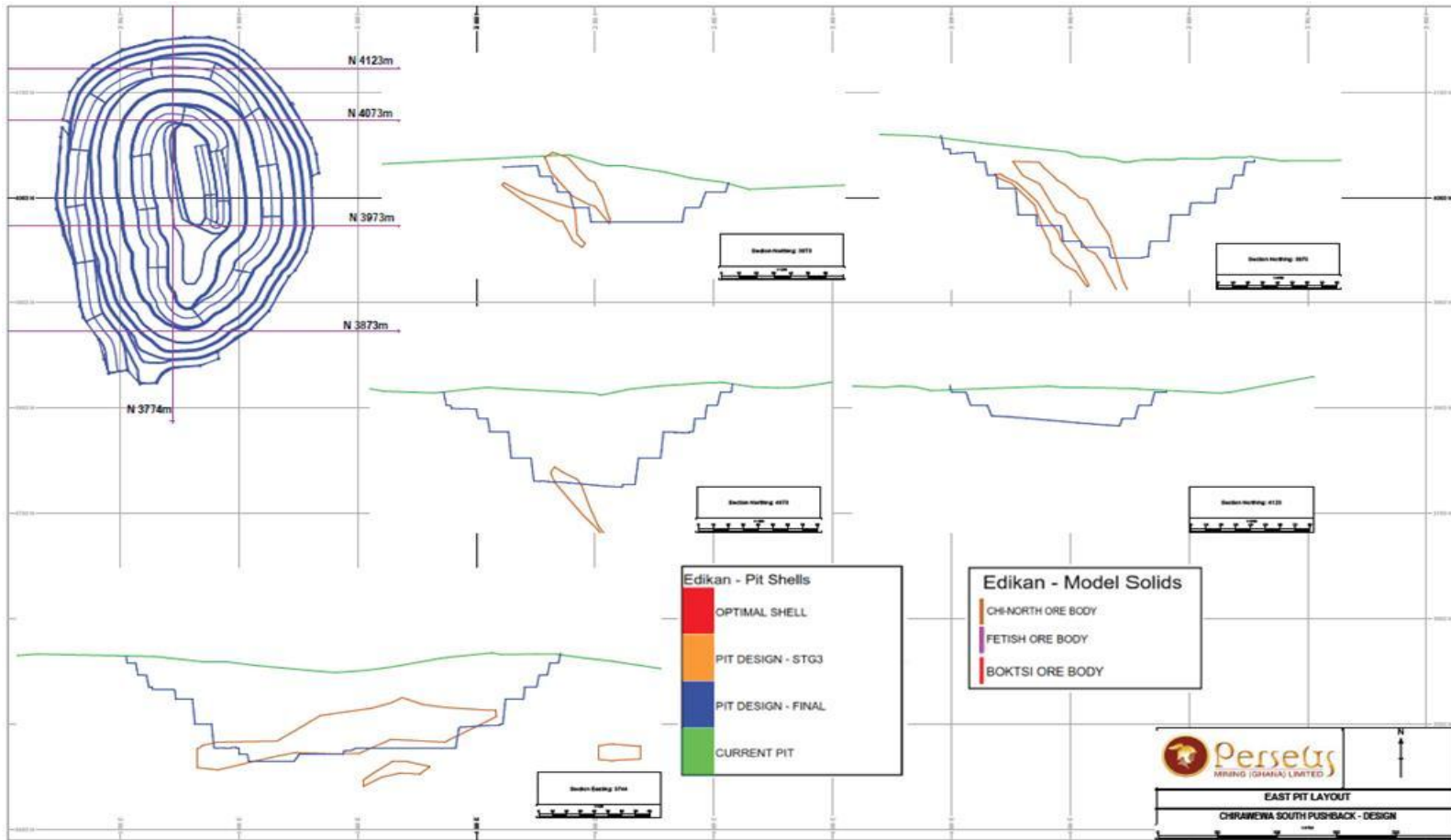


**Figure 2.14: Chirawewa South Final Pit Plan**

### 2.4.9 Bokitiso North Pit

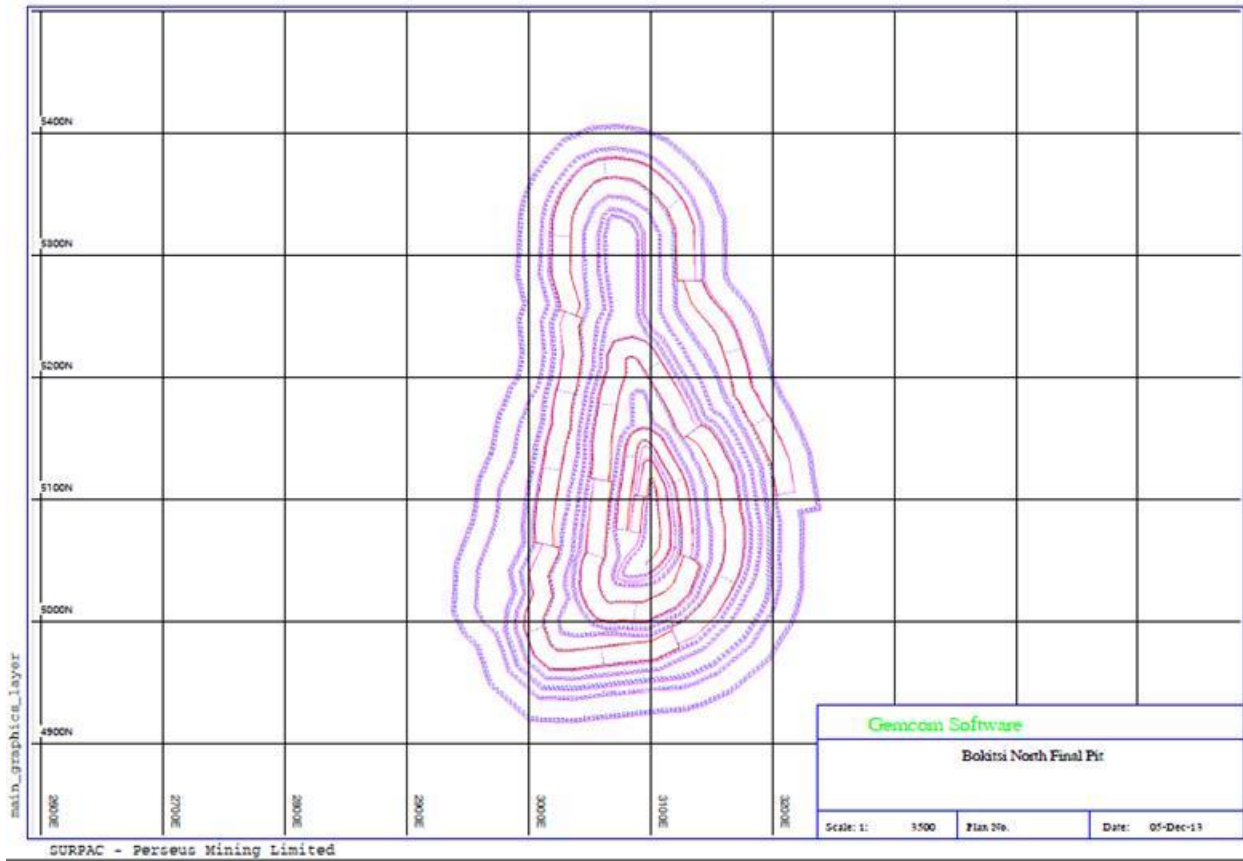
The Bokitiso North pit deposit will have an estimated perimeter of 1315 m with overall slope of 37/45 and a surface area of 9.96 hectares. The final depth of the pit will be 137m with bench height of 5/20 m and berm with of 5/10 m. Ore will be transported to the ROM pad by 10 wheel semi-trailer trucks. The final pit design is provided in Figure 2.16. The Bokitiso North pit will be part of the final Fetish pit design which implies that there will be no final pit section.

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**Figure 2.15: Chirawewa South Final Pit Section**

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**Figure 2.16: Bokitiso North Final Pit Design**

#### **2.4.10 Bokitiso South Pit**

The final surface area of Bokitiso South pit has been estimated at 9.61 hectares with a pit perimeter of 1515 m. The pit will be mined to a depth of 124 m, with bench height of 5/20 m, berm width of 5/10 m and overall slope of 37/45 m as shown in Table 2.5. The final pit design is provided in Figure 2.17 and final pit section in Figure 2.18.

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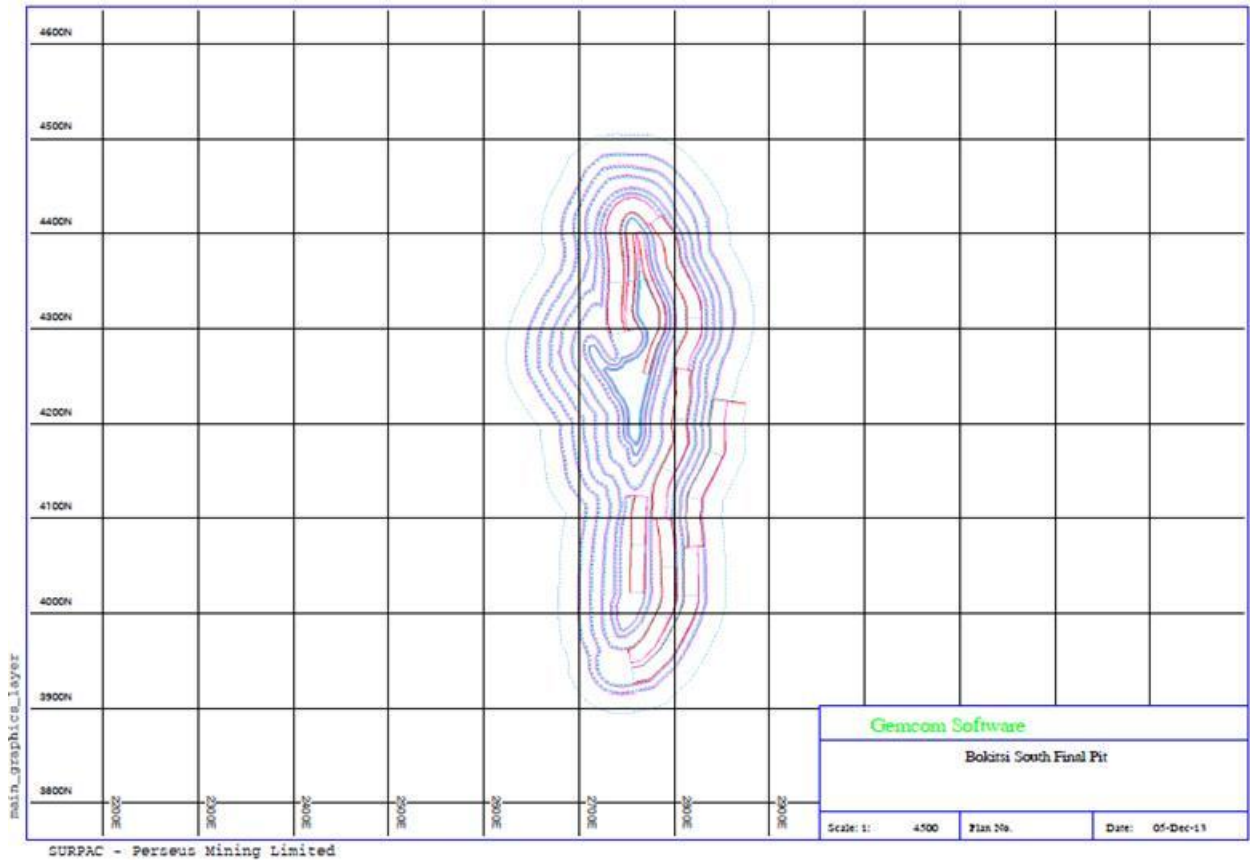


Figure 2.17: Final Pit Design of Bokitiso South

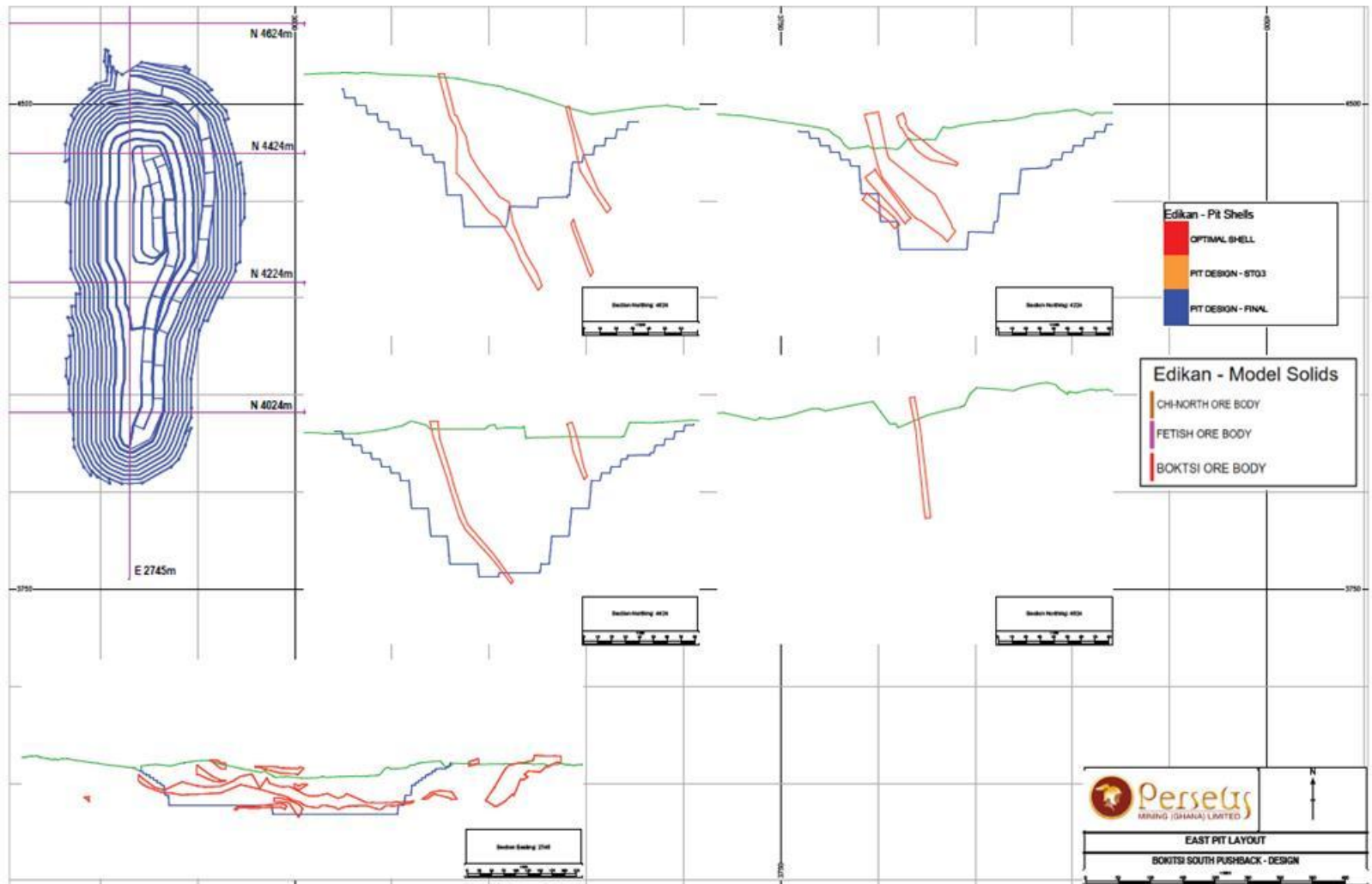
## 2.5 Mining Rate and Production Schedule

### 2.5.1 ROM Pad

A second ROM pad will be constructed in the Eastern Pits area, approximately 1.5 km southeast of the Fetish pit. The base will be constructed with low grade ore from the first pit to be mined (Fetish) as per the mining schedule. Ore will be stockpiled and blended from the pits using dump trucks which will be determined or dependent on the pit shells at the time of mining.

The ore will then be hauled to the primary ROM pad where it will be crushed at the process plant site. Alternatively, a primary crusher will be mounted at the secondary ROM pad to crush ore prior to haulage to the primary ROM pad.

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**Figure 2.18: Bokitsi South Pushback Section**

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### **2.5.2 Pit Dewatering and Drainage**

The Hydrogeological assessment which was undertaken by Coffey Geotechnics indicates that the expected groundwater inflows to the pits will be less than 10% of the total dewatering requirements.

The main source of dewatering requirements will be direct precipitation. The pumping requirement has been determined to meet the daily groundwater requirements and to pump out the water from a 100 year return interval 24 hour maximum rainfall event in 33 hours.

Water quality results of samples collected from the Bokitiso Pit indicate a pH range of 6.4 – 7.1 which is in line with EPA guideline. Other physico-chemical parameters and metal levels meet the EPA guideline limits (refer to Appendix 2.1).

## **2.6 Waste Rock Dumps**

### **2.6.1 General**

Waste rock mined will be constructed on the natural topography after available topsoil within the footprint area has been stripped. Waste rock dumps height for, Fetish, Bokitiso and Chirawewa will be 25m, 15m and 20m respectively and are designed not to significantly exceed the general height of surrounding landforms. The locations of the various waste rock dumps are shown in Figure 2.19.

## **2.7 Acid Generation Potential**

### **2.7.1 General**

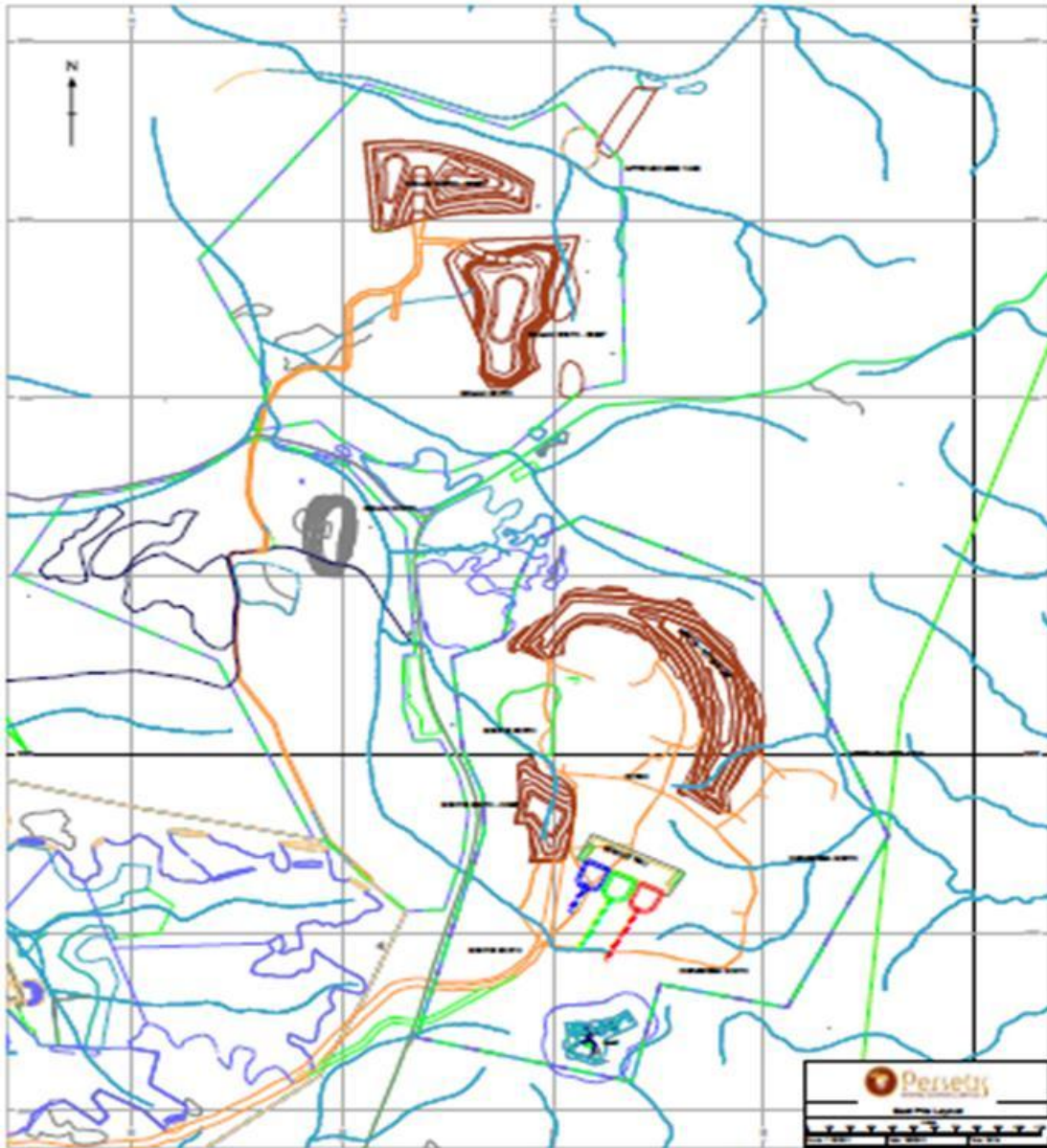
Whether or not acid mine drainage will be generated is largely a function of the mineralogy, the availability of each acid generating and neutralising mineral present, the physical characteristics of the material and the environmental setting.

### **2.7.2 Sample Selection**

The net neutralising potential (NP-AP) is usually used as a general indicator of the potential for acid generation. Selection of sample type and number of samples from PMGL exploration drill cores was based on a several factors including:

- A matrix based on the presence of granite hosted ore and waste and sediment hosted ore and hosted waste, and NP/AP < 10 or NP/AP > 30 for each of the proposed pits was constructed and evaluated.
- Non-occurring combinations were eliminated and samples selected from drill cores representing the known geological combinations.

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**Figure 2.19: Waste Rock Dump Plan**

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### 2.7.3 Results of Analysis

The results of the AGP analysis and location map are provided in Appendix 2.2. The locations of the samples that exhibited high (1), medium (5) and low (5) AGP are shown in Table 2.8. Based on the results, ore and waste rock management techniques are as follows:

- Most ore will be processed immediately and hence will pose no risk in terms of mining acid runoff. Any potential issues with the residual tailings are adequately dealt with in the tailings impoundment design;
- Any high-grade ore that require stockpiling, will be stockpiled for a relatively short period, and hence pose low risk of acid generation. Low grade ore stockpiles will be constructed in such a way to allow runoff to be collected, contained and tested prior to release to the surrounding environment (if clean), or pumped into the tailings impoundment (if acidic);
- During pre-production the geologists will work closely with the environmental staff to identify waste materials with the potential to provide ARD. These waste rocks will be tested to determine the potential for ARD. The geologists will develop expertise in selecting waste that may have ARD potential. Any waste that the geologists suspect might possess acid generation potential will be encapsulated. A secondary aim of this programme is to calibrate in-situ Sulphur assays with potential AP. This can then use blast hole samples for Sulphur to predict potential acid potential;
- Any waste with acid generating potential will be encapsulated internally within the waste dump itself hence surrounded by low permeability material, with specific seepage water management.

Waste rock that has not been specifically identified with acid potential will be evenly blended throughout the dumps, thus relying on the overall net neutralisation potential to neutralise any isolated areas of potential acid generation.

## 2.8 Waste Rock Dump Design Parameters

The design parameters that were used for the waste rock dumps are as follows:

### 2.8.1 Construction Method

The waste rock dumps will then be progressively rehabilitated by pushing down or re-shaping the batters of completed waste rock dump lifts to the design angle of 20° (as soon as each dump lift becomes inactive), covering with topsoil and planting of vegetation. Where practical, rock bunds (to serve as “velocity reducer”) or sediment ponds will be constructed at the toe of the waste rock dump (downstream) to prevent the potential release of any contaminants or sediments by surface runoff from the waste rock dumps into the nearby stream catchment.

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**Table 2.8- Sample Locations for Strong, Medium and Low AGP Samples**

Acid Generating Potential	Sample ID	Description
High	ABRC-001	RC drill (82m) sample at the Exploration camp
Low	ABRC-007	RC drill (150m) sample at Exploration camp
Medium	ABRC-026	RC drill (27m) sample at Exploration camp
Low	BGRC-01940	RC drill (40m) sample at Esuajah North Waste Dump
Medium	BGRC-01963	RC drill (63m) sample at Esuajah North Waste Dump
Medium	BKRC-02438	RC drill (38m) at the Bokitsi Pit
Medium	BKRC-02451	RC drill (51m) at the Bokitsi Pit
Low	CHDD-018	Diamond drill core from Chirawewa waste dump
Low	ENWD-001	Rock sample from the rehabilitated Esuajah North Waste Dump
Low	ENWD-002	Rock sample from the rehabilitated Esuajah North Waste Dump
Medium	ENWD-003	Rock sample from the rehabilitated Esuajah North Waste Dump

### 2.8.2 Waste Rock Dump Areas

The Fetish Main Waste Rock Dump backfills the existing Chirawewa pit then a small valley before abutting up to an existing rehabilitated waste rock dump. It will have a final height of 70m in the NE corner, 40m in the NW and 50m in the SE and SW corners and a footprint of 102 ha.

The Fetish Backfilled Waste Rock Dumps are designed to rehabilitate the area affected by the previous mining. The two South Bokitiso pits adjacent to the highway will be filled to 5m above natural surface to control drainage in the area. The second waste rock dump will fill in a small pit to the south of an existing waste rock dump before marrying into this dump.

The Esuajah North Rock Waste Dump is to be built in two sections, one to the north of the pit, the other to the east. The combined footprint of the two sections will be 97.3 ha and the height of each will not exceed 35m. Both Fetish and Esuajah North will have an ore stockpile close to the pit from where ore will be transported to the plant by 40 tonnes highway trucks. The base of these stockpiles will be built with mine waste rocks and sheeted with low grade ore to minimise dilution. Table 2.9 highlights waste rock heights as well as historical data.

### 2.8.3 Waste Rock Dump Volumes Drainages

Surface runoff from the waste rock dump tops and the batters will be collected and directed off the waste rock dumps via rock fill drains. These drains will flow to diversion channels located at the base of

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**Table 2.9- Waste Rock Dumps Parameters**

Pit	Name of Waste Rock Dump	Base Area(Ha)	Battered Slope(0)	Berm width(m)	Overall slope(0)	Waste Quantity(m <sup>3</sup> )	AGC Dump height	PMGL Height (m)
Fetish	Fetish Dump	46.29	20/25	10	18/22	12,176,287	15	25
Bokitiso North							15	15
Chirawewa North	Chirawewa North Dump	28.83	20/25	10	18/22	6,066,541	22	20
Chirawewa South	Chirawewa South Dump	32.43	20/25	10	18/22	6,824,122	22	20
Bokitiso South	Bokitiso South Dump	11.16	20/25	10	18/22	1,761,371	23	15

the waste rock dumps and will report to sediment ponds prior to discharge to local watercourses. Water retaining berms will be constructed on the crests of the waste rock dumps and on each bench.

## 2.9 Haul Roads

Mine haul roads are generally designed for the exclusive use of Rear Dump Trucks (RDT). Light vehicle traffic associated with the mine operations will also use the haul roads. All mine roads will be private roads with restricted access and policed. Ghana mining legislation and regulations (L.I 2182) requires a mining company to police public safety around the mine thus, for safety reasons, no public traffic of any sort will be permitted on these roads. Haul roads within the mining area will be 30m wide which includes drainage which gives a running width of 25m. These are dual lane roads to allow for safe passing of haul trucks and overtaking.

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These roads are constructed to a life-of-mine standard and suitable for use after mine closure with appropriate periodic maintenance (see section 8.9.10 for after closure use or reclamation). All mine roads will be maintained regularly with a grader. Standard mine site road rules will apply on all mine roads.

**2.9.1 Road Maintenance, Dust, Noise and Vibration Control**

The mining contractor will be responsible for regular maintenance of the private roads, the in-pit roads and pit floors. This includes the suppression of dust using water bowsers. A provision for an adequate number of water trucks for the purpose of water spraying will be included in the contractors’ scope of work.

The Contractor shall carry out its operations in such a way that no valid complaints about nuisance from dust are received by PMGL from the local community. The Contractor shall carry out its operations in such a manner as to ensure that noise from its mining activities does not result in valid public complaints regarding noise.

The Contractor shall select its equipment and carry out and maintain sound dampening and exhaust muffling modifications to its Equipment so as to ensure that its operations shall conform to any Statutory Regulations for noise abatement.

In the event of a complaint being received regarding excessive noise, blast vibrations or dust the Contractor shall investigate the complaint. The Contractor shall provide the PMGL Mining Manager with a detailed report within twenty-four (24) hours of the complaint. This report shall include, but not necessarily be limited to, the following information:

- full details of the nature of the complaint;
- an assessment of the validity of the complaint;
- a full description of the relevant operations and prevailing weather conditions at the time;
- details of suppression or abatement measures in place at the time; and
- details of corrective action being taken or to be taken to eliminate future complaints.

**2.10 Mining Contractors Infrastructure**

The Mining Contractor is responsible for establishing all of the facilities required to support his operation. PMGL will provide access to an area located South West of the Fetish pit.

**2.10.1 Mining Contractor Facilities**

Facilities for the mining contractor will comprise the following:

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- An office;
- The mining workshop
- Vehicle wash down area incorporating a silt and oil trap and an oil separator to remove any contaminant oil;
- Waste oil management facility;
- A fuel farm and lube facilities; and
- Ablutions block.

**2.10.2 Magazine and Explosives Plant**

The mining Contractor for the Eastern Pits operation will utilise an existing explosive magazine operated by a sub-contractor, African Explosive Limited (AEL). The mining contractor will be responsible for drilling and blasting and will have control over the explosives magazine and emulsion plant. The magazines and the explosive plant to prepare emulsion when and where required will be sub-contracted by the mine contractor to a reputable explosives manufacturer and supplier.

The current AEL magazine is located at the Western pits area near the Abenabena waste dump. The current storage capacity was designed to cater for the entire operation. The magazine is built and operated in accordance with the Minerals and Mining (Explosives) Regulations, 2012 (L.I 2177).

**2.10.3 Ammonium Nitrate Storage**

The AEL facility comprises an Ammonium Nitrate shed with an estimated capacity of 270m<sup>2</sup> which is also located at the explosive magazine. Access to this shed is restricted by a locked perimeter fence within the yard as per L.I 2177.

**2.11 Process Plant Operation**

The Eastern Pits will not have a separate process plant. Ore will be hauled to the existing and operational crusher and processing plant located at the Western pits area and treatment process is as detailed in the comprehensive Environmental Impact Statement (EIS) submitted in May 2010 and as outlined in the Environmental Management Plan submitted in December 2012.

Ore from the Eastern Pits operation will be stockpiled at a temporary ROM pad near the Fetish pit area which will be hauled to the existing process plant for blending and treatment. The components of the existing plant are as follows:

- Single stage crushing;
- Semi Autogenous Grinding (SAG);

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- Gravity recovery of free gold from a portion of the cyclone underflow;
- Intensive leaching of the gravity concentrate;
  - a) Rougher flotation with 7 cells, pre-thickening and then one concentrate regrind mill, and
  - b) A 7 stage concentrate CIL circuit.

The stripping plant includes a 3 tonne Anglo-American elution circuit with elution column, 4 electro-winning cells, removal of the gold deposition from the stainless cathodes with high pressure water sprays, smelting of the product and a carbon regeneration kiln. Figure 2.20 is the operating process plan while Figure 2.21 is a pictorial view of the process plant.

## **2.12 Water Supply, Project Drainage and Sewage**

### **2.12.1 Rainfall Catchment of the Project Area**

The project is located in the sub-tropical inter-convergence zone with two distinct wet seasons. The rainfall exceeds the evaporation pan for most of the seasons thus surface water is prevalent except during the end of the dry season. The local topography is typical of the rolling hills of the lowlands of Ghana deeply cut with creeks and rivers supporting the intensive peak rainfall intensities in excess of 160mm within 24 hours. The run-offs from the Fetish and Bokitiso Pts area flow into Afuaworaa and Danyami respectively before joining the Subin on the Ayanfuri – Gyaman Road. Run-offs from the Chirawewa pit areas flow into the Chirawewa stream which later joins the Mansi River. The runoffs from The Esuajah North pit areas will join the Asuaa stream which subsequently joins the Subin.

### **2.12.2 Raw Water Supply - Groundwater**

The raw water supply for the eastern project for the mining contractor facilities will be obtained from producing boreholes at the Mine Community areas. Other groundwater sources include pit dewatering bores and bores placed downstream of the dam walls, beside and within the swamp areas.

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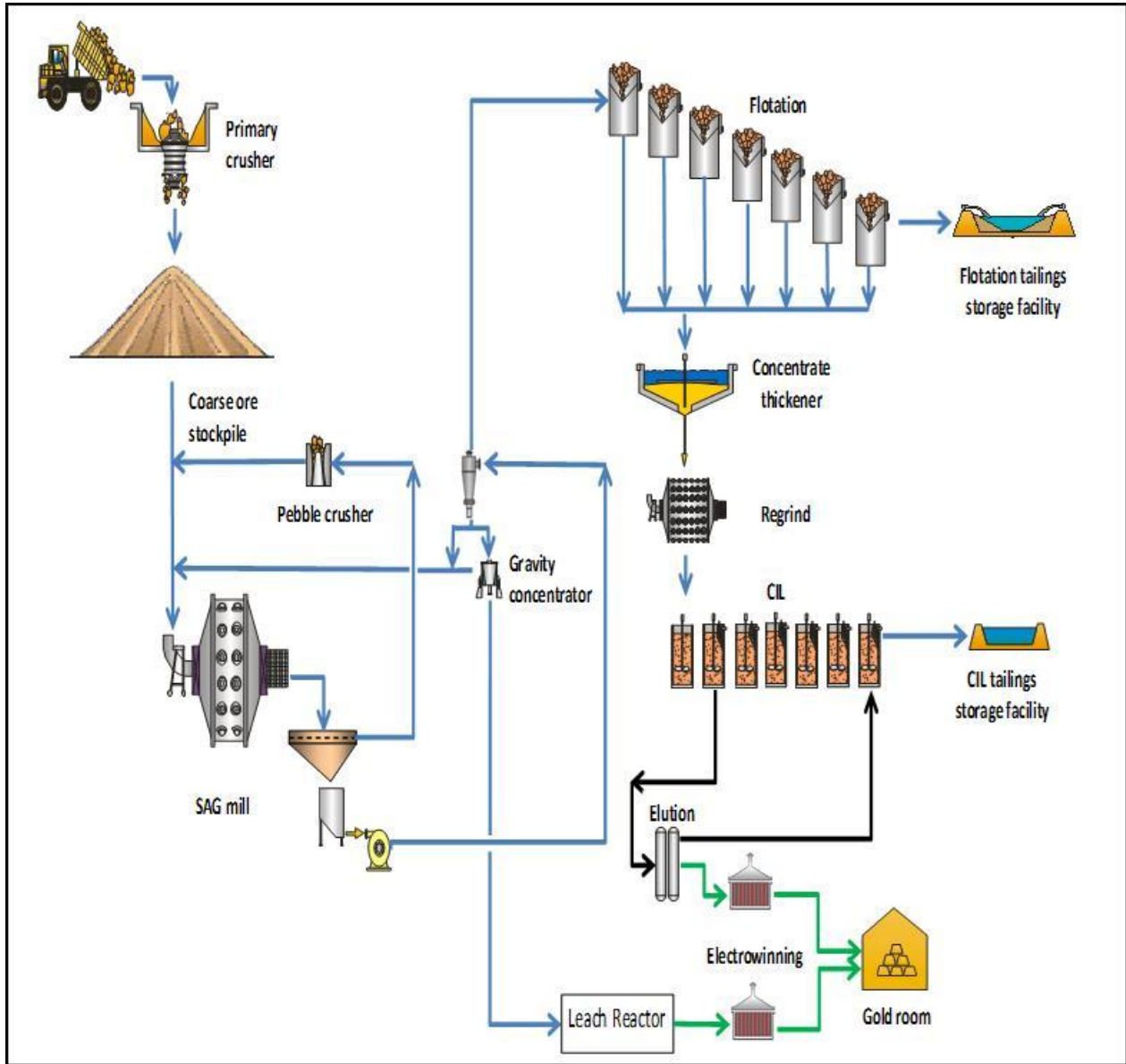


Figure 2.20: Operating Process Plan

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**Figure 2.21: Pictorial View of Process Plant**

### 2.12.3 Site Drainage

The drainage management for the Project has been designed such that clean runoff water from areas upslope of the project infrastructure is diverted, where possible, around the site via diversion drains. Where drainage diversion is not possible (i.e. some areas upstream of the pits), runoff is collected in pump sumps and either used for dust suppression, as process water or disposed of downstream if water quality guidelines are met. PMGL will prepare a water management plan which will incorporate all major drainage systems.

#### Water Management in Pits

The pits will require earth bunds in upstream areas in order that runoff from extended catchments upstream does not flow over the pit rim. The earth bunds will be compacted and have adequate foundation preparation including a seepage cut-off. Pump sumps may be established upstream of these bunds. Water collected in the sumps will either be used in dust suppression, as process water or disposed of downstream if water quality guidelines are met. Where sumps are required, allowance for a

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design capacity to store a 1 in 100 year average recurrence interval storm event of 24 hours duration, and adopting a volumetric runoff coefficient of 0.8.

Diversion bunds and haul roads etc. will be used to divert runoff to the sumps and where possible runoff will be diverted around the ends of the pits. It is proposed to infill low areas with mine waste and provide lined drains to divert runoff around the pits in lieu of drainage collection and pumping.

**Erosion and Sediment Control**

The following miscellaneous erosion and sediment control measures are included as part of the drainage plans:

- Provision of silt traps downstream of main drainage lines and waste dump drop structures in order to reduce sediment load to the downstream environment.
- It is recommended that silt traps for small catchment areas (i.e. not main diversion) are initially sized on the basis of nominally of 1.3m<sup>3</sup> of silt/ha of catchment area. The sizing criteria should be checked during the first year of project development;

**2.13 Power Supply**

Emergency electric power generators of 6 megawatts will be provided on site in the event of mains power failure. Electricity will be extended from the Gridco substation located at the plant site to the Eastern Pits area.

**2.14 Fuel Storage and Fuelling Stations**

Fuel and hydrocarbon will be supplied by a sub-contractor and this will involve the installation of a double skin 500,000 litre tank at the contractor lay down area, the facility will be placed in a bunded area (110%) and fitted with an oil/water separation system. A bulk fuel storage facility permit will be obtained by Total Ghana Limited from the EPA.

The contract for supply will include the waste oil management system. The supplier will store, remove and recycle the spent oils.

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## 2.15 Communications

Communication for the Eastern Pits operation will be mainly through radio communication and mobile phone network system. Radio communications will be via separate channels for mining, process plant and an emergency channel. A communication booster station will be mounted to interface between the Western and Eastern Pits.

### 2.15.1 Employment Philosophy and Training

Given the remote location of the Project, it is intended that the operations will be self-sufficient in as many areas as possible. To ease the transition into operations, PMGL will recruit senior personnel who are already familiar with gold mining operations. To the maximum degree possible personnel will be sourced from within Ghana. There is an existing agreement between PMGL and catchment communities for recruitment of local personnel. Employment committees have been set up in all communities to recruit both skilled and unskilled labour. However, a small group of expatriates (approximately 4) will be required for both training and selected management roles in order to develop a competent operations and maintenance team which will be able to service the operation with minimal external support. A total of 160 personnel will be employed for the direct operations at the Eastern Pits whilst an estimate of 60 employees will be utilised for support services.

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### **3 BASELINE INFORMATION**

A detailed baseline survey was conducted within the proposed project site to characterize the existing environmental and socio-economic conditions of the area. The baseline survey included the following environmental parameters:

- Climate
- Air Quality
- Noise
- Hydrology
- Flora and Fauna
- Aquatic
- Geology
- Traffic
- Archaeology

The baseline information obtained will serve as a benchmark to which future deviations may be compared with and form an integral component of the final EIS. Consultants responsible for the baseline studies are listed in Table 3.1.

#### **General Climatic Conditions**

The project area falls within the wet semi-equatorial climatic region of Ghana characterised by high rainfall, medium to high temperatures and high humidity. The climate of the Project Area is determined by the movement of air masses which differ in air moisture and relative humidity rather than temperature.

Like most parts of the country, two main physical phenomena, the equatorial trough and the associated Inter Tropical Boundary (ITB) influence the climatic conditions of the area. The ITB influences the attraction of alternate air masses from the north and the south called the North-East Trade Winds and the South-West Monsoon Winds respectively. The North-East Trade Winds are associated with a dry cool wind known as the harmattan, which affects this part of Ghana during the months of December to February.

#### **Sources of Climatological Information**

Ten (10) years climatic data was obtained from Dunkwa-on-Offin, where the nearest national climatological station operated by the Ghana Meteorological Agency (GMA) is located. The description of the weather pattern within the project area is based on data obtained from Dunkwa-on-Offin, which has current and consistent 10 years duration rainfall records from 2004 to 2013.

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**Table 3.1- Consultants for Baseline Studies**

No	Task Description	Company	Lead Consultant	Scope of Work	Period
1	Baseline Monitoring - Aquatic	Consultant	J.S. Amakye	To review existing baseline and assess the conservation status of the aquatic organism and mitigate possible impact of project on aquatic environment	5/Oct/13 - 20/Oct/13
2	Baseline Monitoring - Flora	Target Consult	Gifty William	To assess the status of the flora and ascertain its ecological and conservation significance in the mine.	15/Oct/13 - 30/Oct/13
3	Baseline Monitoring - Fauna	Target Consult	Justus P Deikumah	Establish trends in fauna population and establish any factors which may preclude or affect mine operations and design	15/Oct/13 - 30/Oct/14
4	Baseline Monitoring - ground water	PMGL	In-house	Evaluate the water quality of ground water aquifers at the project site	1/Sep/13 - 30/Dec/13
5	Structural Survey	Geosystems	Dr. C Akayuli	To provide information and assess the status of structures that falls within the zone of influence around the project site	1/Sep/13 - 30/Oct/13
6	Archaeological Studies		Prof. Okoro	To provide information, assess and evaluate potential impact on the archaeological and cultural heritage of the project area and catchment communities	25/Sep/13 - 12/Dec/13
7	Baseline Monitoring- Soil	Ecology and Environment (E&E)	Ecology and Environment (E&E)	To provide important information for the characterisation of the forest, the assessment of the potential impact of reclamation and rehabilitation programmes.	02/Oct/13 - 16/Oct/13
8	Baseline for Air Quality	PMGL	In-house	To evaluate the air quality in terms of total suspended particulate and particulate matter 10 at the project site	1/Sep/13 - 30/Dec/13

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**Table 3.1 - Consultants for Baseline Studies - Continuation**

No	Task Description	Company	Lead Consultant	Scope of Work	Period
9	Baseline Monitoring- Noise	PMGL	In-house	To provide information and assess the status on noise at the project site and catchments	1/Sep/13 - 30/Dec/14
11	Weather Baseline Monitoring	PMGL	In-house	To establish trends in weather information at the project site and catchment areas	1/Sep/13 - 30/Dec/13
12	Radioactive Baseline Survey	Ghana Atomic Energy	Dr. Augustine Afaanu	To measure the naturally occurring radionuclides of U/Th decay series and <sup>40</sup> K in soil, water, waste rock, undisturbed surface soil, farm lands and historical open pits	20/Oct/13 - 16/Nov/13
13	Traffic and Transport Survey	Delin Consult	Ing Magnus Lincoln Quarshie	To provide important information, assess and evaluate potential impact on traffic (both vehicular & pedestrian)	16/Nov/13 - 30/Dec/13
13	Baseline Sediment survey	African Environment Research Consultant	AERC	Provide metal concentration and physio- chemical conditions of the streams draining the areas so as to develop mitigation measures against impacts of mine activities	25/Sep/13 - 10/Oct/13
14	Baseline Hydrogeology Survey	Umat	Prof. J. S Kuma	characterise the streams and tributaries as perennial or continuous flow by assessing its source and run off volume and peak flow	19/Nov/13 - 28/Nov/13

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### Rainfall

The rainfall distribution of the project area is bimodal. The main season is from March to July and the minor season is from September to November. A short dry spell occurs in August and the major dry season is from December to February.

The statistical summary of the total monthly rainfall is presented in Table 3.2. The analyses of the monthly rainfall data suggest that of the two rainfall seasons, the first period, March – July accounts for about 55.2% while the second period, September – November accounts for 31.1% making a total of 86.3%.

*Table 3.2 Monthly Total Rainfall Values from Dunkwa-on-Offin (in mm)*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	10.7	124.0	101.8	81.8	219.6	43.4	121.1	75.7	367.1	159.5	115.1	29.7	1449.5
2005	8.1	25.5	160.6	156.2	159.5	169.0	55.3	26.4	99.4	186.7	76.7	0.8	1124.2
2006	73.7	66.5	179.3	172.7	257.8	189.1	111.8	32.7	232.8	228.1	41.7	121.4	1707.6
2007	8.3	14.5	89.4	246.0	181.2	179.1	135.9	112.0	234.4	277.1	105.3	14.1	1597.3
2008	0.0	51.2	158.0	59.3	255.8	274.3	140.6	148.3	126.9	234.0	57.6	71.4	1577.4
2009	10.9	72.5	118.2	164.4	194.5	366.1	266.1	15.0	29.2	79.7	130.2	6.7	1453.5
2010	15.6	51.9	104.0	116.0	145.5	175.5	77.0	89.7	191.9	191.4	91.7	111.2	1361.4
2011	22.5	126.6	98.3	111.9	246.0	307.4	78.4	116.2	233.9	247.8	13.7	4.8	1607.5
2012	42	44.1	103.1	281	121.4	288.7	58.1	28.8	49.1	180.9	73.1	144.6	1414.9
2013	8.3	16.4	207	68.3	108.2	150.2	101.8	12.7	118.2	234.9	75.6	27.4	1129.0
<b>Mean</b>	<b>17.5</b>	<b>49.0</b>	<b>129.3</b>	<b>169.4</b>	<b>188.1</b>	<b>215.8</b>	<b>139.9</b>	<b>98.1</b>	<b>163.6</b>	<b>181.6</b>	<b>79.3</b>	<b>39.8</b>	<b>1491.2</b>
<b>Min</b>	<b>0.0</b>	<b>0.0</b>	<b>9.7</b>	<b>59.3</b>	<b>54.5</b>	<b>43.4</b>	<b>32.1</b>	<b>11.7</b>	<b>4.7</b>	<b>51.8</b>	<b>29.6</b>	<b>0.0</b>	<b>951.2</b>
<b>Max</b>	<b>73.7</b>	<b>148.3</b>	<b>245.9</b>	<b>362.0</b>	<b>285.5</b>	<b>415.8</b>	<b>358.4</b>	<b>224.1</b>	<b>416.2</b>	<b>365.9</b>	<b>200.0</b>	<b>140.1</b>	<b>1829.0</b>

In addition, four (4) months total rainfall data obtained from PMGL in 2013 at Fetish, Esuajah South and Esuajah North were put into perspective with the data obtained from Dunkwa-on-Offin. The highest rainfall (483.8 mm) was recorded at Esuajah North whereas the lowest rainfall (426.3 mm) was recorded at Esuajah South. Table 3.3 provide the rainfall data obtained from PMGL.

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**Table 3.3 10-year Annual Rainfall Values for Dunkwa-on-Offin (in mm)**

Month	Climatic Station			
	Dunkwa-on-Offin	Fetish	Esujah South	Esujah North
Sep-13	118.2	89.5	70.3	71.6
Oct-13	234.9	184.9	233.2	284.2
Nov-13	75.6	145.8	92.6	110.7
Dec-13	27.4	20.9	30.2	17.3
<b>Total</b>	<b>456.1</b>	<b>441.1</b>	<b>426.3</b>	<b>483.8</b>

### Temperature

The monthly average temperature values for Dunkwa-on-Offin covering the period 2004 – 2013 were assessed. The statistical summary is given in Table 3.4. The monthly average temperature ranged from 17.7°C (January) to 35.1°C (March), while the mean of the monthly average temperature varied from 25.4°C in August to 28.6°C in March/April.

**Table 3.4- Mean Monthly Temperature °C at Dunkwa-on-Offin (2004 – 2013)**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean	26.8	28.4	28.6	28.6	27.2	26.4	26.1	25.4	26.7	27.3	27.7	27.6	<b>27.2</b>
Max	34.0	35.1	35.0	34.2	31.9	30.2	30.5	31.3	31.3	32.0	33.4	33.2	<b>32.7</b>
Min	17.7	21.9	22.4	22.7	22.7	22.1	21.8	21.3	21.6	21.4	21.2	21.5	<b>21.5</b>

Compared with the three (3) month baseline data from PMGL, the mean monthly temperature for Dunkwa-on-Offin is marginally higher. The mean temperature for PMGL ranged from 24.8 – 27.2 °C while the values for Dunkwa-on-Offin ranged from 27.3 – 27.7 °C. Statistical summary of the data is provided in Table 3.5.

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**Table 3.5 - Statistical Summary of the Temperature Data (°C) from PMGL and Dunkwa-on-Offin**

Month	Statistical Function	Location			
		Fetish	Esujah South	Esujah North	Dunkwa-on-Offin
October, 2013	Mean	24.8	25.7	26.8	27.3
	Max	31.4	32.5	33.3	32.0
	Min	20.9	20.3	20.7	21.4
November, 2013	Mean	25.7	25.8	27.1	27.7
	Max	34.1	32.8	33.9	33.4
	Min	20.9	20.0	21.2	21.2
December, 2013	Mean	25.3	25.7	27.2	27.6
	Max	33.6	33.5	34.6	33.2
	Min	18.4	18.0	21.6	21.5

### Relative Humidity

The mean monthly relative humidity at Dunkwa-on-Offin for the period 2004 to 2013 ranged from 73.1 % in January to 83.0 % in July (refer Table 3.6). The mean monthly relative humidity increases from a minimum value of 44.0% to a maximum of 97.0%.

**Table 3.6-Monthly Mean Relative Humidity (%) at Dunkwa-on-Offin (2004 – 2013)**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean	73.1	73.4	75.6	77.3	79.4	81.6	83.0	81.7	80.6	79.3	77.6	77.6	<b>78.4</b>
Max	96	96	96	96	97	96	96	96	96	97	96	97	<b>96.3</b>
Min	44	52	51	59	61	68	70	67	66	64	60	57	<b>61.4</b>

In general, the mean relative humidity data recorded for Dunkwa-on-Offin is slightly lower than that recorded by PMGL. The mean relative humidity for PMGL data ranged from 66.2 – 88.2 % while the data for Dunkwa-on-Offin ranged from 77.6 – 79.3 %. Statistical summary of the values is provided in Table 3.7.

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**Table 3.7- Statistical Summary of Relative Humidity (%) from PMGL and Dunkwa-on-Offin**

Month	Statistical Function	Location			
		Fetish	Esujah South	Esujah North	Dunkwa-on-Offin
October, 2013	Mean	88.2	82.2	73.6	79.3
	Max	99.6	97.8	93	97.0
	Min	55.4	37.0	32	64.0
November, 2013	Mean	86.3	82.7	66.2	77.6
	Max	99.8	98.8	89.0	96.0
	Min	40.4	46.3	32.0	60.0
December, 2013	Mean	86.5	79.5	70.9	77.6
	Max	100	98.0	89.0	97.0
	Min	29.6	26.9	34.0	57.0

### 3.1 Air Quality and Noise Level Survey

Sampling for air quality and noise levels was conducted at the project site from October to December, 2013. The weather condition was sunny with some slight showers in the day and clear skies at night during the sampling period.

#### Objectives

The objectives of the survey were:

- To establish the current dust levels for Total Suspended Particulate (TSP) at three representative locations; and
- To determine noise levels at three representative locations for both day and night.

These objectives are a part of broader objective of the Project which is to ensure that all aspects of its operations are duly accounted for and potential adverse impacts are mitigated to ensure sustainable development.

#### Sample Locations

Three (3) sampling locations, Fetish, Esujah South and Esujah North were selected within the project area for baseline air quality and noise level survey. The geographical co-ordinates of the sampling locations as well as the location description are provided Table 3.8.

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**Table 3.8- Location and GPS Co-ordinates (UTM) of Noise and Dust Sampling Sites**

Name	Location Description	GPS Co-ordinates	
		Eastern	Northern
Fetish	Sampling was done close to the nearest residential building to the Fetish pit. The sampling site is about 100 m away from the main Ayanfuri-Tarkwa road and 50 m from the Ayanfuri clinic.	0621896	0658367
Esujah South	Sampling was conducted at the old AGC Administration building located about 40 m north of the Esujah South pit. It is also about 130 m away from the main Ayanfuri-Tarkwa road.	0621749	0659685
Esujah North	Sampling was carried out at the old Sungold residential block in Ayanfuri.	0623403	0659482

### Methodology

Air quality and noise level surveys were carried out at the selected locations over a period of 24 hours including day and night. Air quality at the proposed project site was monitored in terms of TSP and PM<sub>10</sub> using the Minivol Tactical Air Sampler while the noise levels were also assessed using Casella CEL 633C. Details of the methodology including photographs of the equipment setup are provided in Appendix 3.1.

### Dust and Noise Results

The results obtained from the survey of ambient air quality and noise levels at each receptor location of the project site are provided in Table 3.9 and Table 3.10. The results reflect the existing levels of ambient air quality and noise at the time of the survey. The Ghana EPA guidelines are also provided to compare the current environment relative to the Ghanaian regulatory requirement.

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**Table 3.9- Dust Concentration of the Proposed Project Site**

Date	Esujah South	Esujah North	Fetish	EPA PM10 STD	Esujah South	Esujah North	Fetish	EPA TSP STD
	PM10			(µg/m <sup>3</sup> )	Total Suspended Particles			(µg/m <sup>3</sup> )
	(µg/m <sup>3</sup> )	(µg/m <sup>3</sup> )	(µg/m <sup>3</sup> )		(µg/m <sup>3</sup> )	(µg/m <sup>3</sup> )	(µg/m <sup>3</sup> )	
May-13	95.40	NM	NM	70	137.38	NM	NM	150
Jun-13	69.57	NM	NM	70	161.17	NM	NM	150
Jul-13	51.02	NM	NM	70	54.32	NM	NM	150
Aug-13	69.34	NM	NM	70	75.15	NM	NM	150
Sep-13	41.22	NM	NM	70	66.06	NM	NM	150
Oct-13	40.32	39.13	52.68	70	41.34	47.93	78.75	150
Nov-13	57.69	39.11	60.51	70	112.73	48.56	89.99	150
Dec-13	103.06	82.36	128.65	70	110.68	100.76	186.43	150

NM: No Monitoring

**Table 3.10- Noise Levels of the Proposed Project Site (in dBA)**

Date	DAY (Leq)			NIGHT(Led)			EPA DAYTIME STD	EPA NIGHT TIME STD
	Esujah South	Esujah North	Fetish	Esujah South	Esujah North	Fetish		
May-13	53.7	NM	NM	44.8	NM	NM	65	60
Jun-13	20.2	NM	NM	19.8	NM	NM	65	60
Jul-13	52.6	NM	NM	48.8	NM	NM	65	60
Aug-13	47.7	NM	NM	43.3	NM	NM	65	60
Sep-13	44.9	NM	NM	39.2	NM	NM	65	60
Oct-13	46.4	54.9	57.2	55.1	53.4	53.2	65	60
Nov-13	49.4	52.1	53.8	46.1	52.1	65.6	65	60
Dec-13	50.3	41.8	63.3	47.7	44.7	51.1	65	60

### Dust Discussion

Particulate matter concentrations were monitored in terms of TSP and PM<sub>10</sub> over a 24-hour period at the three (3) selected locations and compared with their respective Ghana EPA Air Quality guideline.

Generally, low concentrations of TSP were recorded at the various selected locations when compared with the Ghana EPA Air Quality guideline of 150µg/m<sup>3</sup>. The concentrations ranged from 41.3 µg/m<sup>3</sup> to 186.4 µg/m<sup>3</sup>. The highest concentration was recorded in December, 2013 at Fetish whilst the lowest was recorded at Esujah South in October, 2013 (refer to Table 3.9). For PM<sub>10</sub>, the concentration recorded in

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October and November, 2013 were below the Ghana EPA Air Quality guideline of 70 µg/m<sup>3</sup>. However, in December, 2013, the concentrations recorded were higher. The prime source of particulate matter emissions observed during the monitoring period included the construction of main Ayanfuri-Tarkwa road and the frequent movement of vehicles and trucks on the unsealed access. Airborne and fugitive dust blown by wind especially in December, 2013 due to the hamarttan also contributed to the high levels of particulate matter values. Appendix 3.2 provides graphical representation of TSP and PM<sub>10</sub> concentration recorded and how these compared with the Ghana EPA guideline.

**Noise Discussion**

The noise levels recorded at all the three (3) sampling locations (Fetish, Esuajah South and Esuajah North) are provided in Table 3.10 and graphically represented in Appendix 3.2. The equivalent noise (LAeq) level recorded over the sampling period is used as the descriptor for noise at each receptor location for both daytime and night time noise to indicate the noise levels for the existing environment (without the influence of the proposed project).

The LA<sub>eq</sub> ranged from 41.8 dB(A) – 63.3 dB(A) and 44.7 dB(A) – 60.0 dB(A) for day and night respectively.

The Ghana EPA zoning reference for the monitored locations is commercial areas, and therefore the applicable noise limit is considered for comparison. The daytime noise limit is set at 65 dB(A) and night-time noise limit is 60 dB(A).

**3.1.1 Surface and Groundwater Quality**

**General Introduction**

The proposed project area is drained by streams and creeks including Danyami, Asuaa, Afuaworaa, Asanka and Aponapon which are all tributaries of River Subin. Cognizant of the potential impact of the proposed Eastern Pits project on the water resources, PMGL has established a baseline monthly sampling programme for surface and groundwater within and around the proposed project area. The sampling programme was initiated in January 2013 to assess the water quality of the proposed project area prior to the commencement of the Eastern Pits Project.

A total of 22 sampling locations (12 surface sites and 10 groundwater site) were selected within and around the entire project area. The various sampling locations were selected to obtain baseline information on water quality. The GPS coordinates and location description of the sampling points are provided in Appendix 3.3.

**3.1.2 Surface and Ground Water Sampling**

Water samples were collected on monthly basis for physical, chemical, nutrient and metal analysis. The samples were collected into clean sterilized 1L polypropylene bottles and 500 ml cyanide bottle and kept in an ice chest under ice packs at a temperature of 4 °C to prevent temperature influence on some of the parameters.

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## Results and Discussion

### Surface Water

The pH of surface water samples taken from the project area was slightly acidic to neutral. It ranged from 4.2 (PAS19 – downstream of Asuaa) to 8.5 (PAS67 – Esuajah South pit). The samples outside the recommended range for drinking water set by the WHO (6.0 – 9.0) were all acidic. It is therefore noted that non-conforming surface water samples in the project area are skewing toward acidity. The highest conductivity value was 468µS/cm recorded at PAS37 (downstream of Danyami) and the lowest record was 25.8µS/cm, at PAS 23 (Chirawewa pond below waste dump). The levels recorded for all the locations are within the EPA recommended standard of 1500 mg/L.

High concentrations of Total Suspended Solids (TSS) were recorded at most of the sampling locations including PAS7, PAS18, PAS19, PAS22 and PAS37. The concentration recorded ranged from 1.2 – 64,379.8 mg/L and exceeded the recommended EPA level of 50 mg/L. The major contributory factor for the high TSS values is due to the fact that most of these sampling locations are downstream active galamsey areas.

Significant levels of nutrient concentrations were recorded for chloride, sulphate, calcium and sodium. The levels ranged from 1.2 – 116 mg/L, 1.0 – 139.8 mg/L, 1.1 – 94.6 mg/L and 0.5 – 48.4 mg/L respectively. The levels recorded are below the recommended EPA limit of 250 mg/L. there are no available standards for comparison for the rest of the nutrient. The concentration recorded for Iron (Fe) ranged from 0.1 – 1.7 mg/L. However, the remaining heavy metals recorded levels below their respective detection limits.

### Groundwater

Generally, the ground water samples were slightly acidic to neutral in nature and had pH ranging from 4.2 – 7.5 the groundwater sampling locations. The results are consistent with the previous baseline monitoring data. The remaining values recorded at all the sampling points were within the EPA and WHO guideline limits. Approximately 85 percent of the returns were below the respective detection limits.

## 3.2 The Aquatic Ecology of the Project Area

### 3.2.1 Introduction

This section presents baseline information on the aquatic ecology of selected rivers within the concession of the proposed Eastern Pits Projects for PMGL. The survey focused on Algae (Periphyton and Phytoplankton), benthic macro invertebrates and Fish fauna of four rivers namely River Akeso, River Danyami on the Eastern Haulage Road, River Subin at Ayanfuri and River Asanka near Wampem. Three rivers – River Danyami on the Eastern Haulage Road, River Subin at Ayanfuri and River Asanka near Wampem were included in the monitoring exercise in October 2013.

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The following findings/observations were made during the survey:

- The monitoring station on the Gyaman Road had not recovered from the damage caused to it by the illegal miners.
- Basic physico-chemical parameters were within the limits of the WHO guideline values for drinking water except turbidity which was high and exceeded the 5NTU limit at all the stations.
- Algal populations at all monitoring stations were dominated by the Cyanophyta. The Cyanophyta constituted 45.8%, 13.1%, 85.9%, 75.7%, 93.1% and 85.0% (by number) of total algae sampled from AKII, SBI, SBII, SBIII, SBIV and ASII respectively. Thus, the highest number of Cyanophyta occurred in River Asanka at Wampem (SBIV) and the lowest in River Akesoa at Nkutumso (AKII). All the monitoring stations stood the risk of eutrophication; however the greatest risk was at SBIV.
- Palmer's Pollution Score for waters at the monitoring stations was 9, 16, 11, 22, 7 and 12 at AKII, SBI, SBII, ASII, SBIII and SBIV respectively. Thus, the trend of anthropogenic impact (pollution) at the stations was SBIII<AKII<SBII<SBIV<SBI<ASII. Therefore, all the rivers were impacted; but, the severest impacted was ASII near the Abenabena Waste Rock Dump and the least was SBIII near the Fetish Shrine.
- Seventy-two (72) macroinvertebrate taxa (species) were collected from rivers in Edikan Mine during the survey. 25, 29, 27, 34, 22 and 19 of the taxa occurred at AKII, SBI, SBII, SBIII, SBIV and ASII respectively. Only three (3) of the macroinvertebrate taxa, namely *Nais sp.*, Ostracoda and *Stenochironomus* were common to all monitoring stations.
- Eight species of fish -*Aethiomastacembelus praensis*, *Barbus ablabes*, *Brienomyrus brachyistius*, *Brycinus nurse*, *Hemichromis fasciatus*, *Heterobranchus bidorsalis*, *Hydrocynus forskalii*, *Petrocephalus bovei* and *Schilbe mystus* were captured from the rivers during the exercise. None of the species is of conservation importance.
- Fish productivity in the rivers was 0.43kg, 0.53kg and 0.01kg/100m<sup>2</sup>/night at AKII, SBII and SBIV respectively and it was considered to be low. However, the highest productivity (by weight) occurred at Akrofuom and the least at Wampem (SBIV).
- The Coefficient of condition of most of the fish species captured was above K=1.0 and indicated that the fishes were in good condition. Coefficient of condition of *Brienomyrus brachyistius* and *Aethiomastacembelus praensis* which was lower than 1.0.

Human impacts on the rivers ranged from slight to severe and it was concluded that there was need to mount a sanitation and hygiene programme within the riparian communities to reduce if not curtail the inputs of nutrients to the rivers. Details of the aquatic baseline report including sampling point description and results are provided in Appendix 3.4.

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### 3.3 The Flora of the Project Area

This report outlines a review of previous flora survey and the results of a new survey. The study aimed to review previous baseline flora survey (Tagit Consult, 2008) and to undertake a new localized survey of the Eastern Pits area. The general objective is to assess the status of the flora and ascertain its ecological or conservation significance and other relevant information to assist in the review of the project risk, mining schedule and long term environmental and social management programmes.

Specific objective include:

- Determination of frequency of occurrence and richness of species in the project area
- Determine frequency of left-over tree species
- Assessment of the conservation significance of the area
- Identification and documentation of any endangered species using the star rating system (Hawthorne and Abu-Juam, 1995).

The geographical position of the study area falls within Moist Evergreen forest vegetation type (Hall and Swaine, 1976, 1981). No significant forest vegetation reminiscent of this forest type exists in the area due to a decade of previous surface mining activities. Assessment of relic patches of degraded forest vegetation sampled by finding the mean species ordination confirms their identification as Moist Evergreen forest type.

The vegetation generally, is very disturbed and modified. Indigenous vegetation is scrappy characterised by relic patches of degraded secondary forest, thicket re-growths and fallow farm bush with high preponderance of pioneer species. Weedy growth of ubiquitous herbs and grasses such as *Mimosa pudica*, *Sporobolus pyramidalis*, *Sida acuta*, *Imperata cylindrical*, *Stachytapheta cayenensis* and *Chromolaena odorata* are common feature of drill pads, borrowed soil excavations, haul roads and truck verges where the soil is stripped of its substrate.

Perennial *Raphia hookeri* swamps and Bamboo groves are characteristic vegetation cover types noted in lowland areas. The dominant vegetation cover type is *Acacia mangium* woodlots established as part of re-vegetation schemes aimed at meeting regulatory requirements of reclamation following mine closure.

The floristic diversity of the eighteen samples enumerated comprises 50 families, 160 genera and 203 vascular plant species. Although 57% of the floristic composition are trees they are mostly seedlings, saplings and coppice shoots with very few medium sized trees  $\geq 30\text{cm}$  diameter at breast height (dbh).

Thirteen (13) species, out of a total of 203, recorded in the study area are listed at various categories of threat globally by International Union for the Conservation of Nature (IUCN Red List Ghana Plantae, 2010) and 'star rating' (Hawthorne, 1995) Seven (7) of these are listed by both criteria as either "vulnerable" or "scarlet". These species (*Guarea cedrata*, *Khaya ivorensis*, *Milicia excelsa*, *Nauclea diderrichii*, *Terminalia ivorensis*, *Triplochiton scleroxylon*, *Entandrophragma angolense*, *Pterygota*

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*macrocarpa*) are threatened by over exploitation in international trade but not “Endangered” or “Critically Endangered”. *Pentadesma butyracea*, *Uapaca heudelotii* and *Baissea zygodioides* are of a minor conservation concern and rated “Blue” by star rating.

On account of floristic assessment, the Eastern Pits area is not a biodiversity hotspot. However, protection of remnant patches of indigenous vegetation (no matter how small) with adult trees within the operational footprints of the mine could make a significant contribution to the process of natural regeneration and biodiversity conservation at the local scale. Details of the flora baseline report are provided in Appendix 3.5.

### **3.4 The Fauna of the Project Area**

#### **Introduction**

As part of the environmental baseline studies, a field survey was undertaken to characterise the terrestrial fauna of the proposed PMGL project area. The survey was undertaken in December, 2013 and covered the following taxa of animals: Avifauna (birds), large mammals, small mammals (including bats), and herpetofauna (amphibian and reptiles).

#### **3.4.1 Description of Survey Sites**

The proposed area was divided into 6 study sites and included Chirawewa, Fetish 1, Fetish 2, Bokitiso and Esuajah North.

#### **3.4.2 Results of the Surveys**

##### **Larger mammals**

A total of twenty-eight (28) large mammals were recorded in the study area during the six surveys. Only 43% (12 species) were sighted (7); their spoors scene (2) or carcasses (3) seen with hunters or chop bar operators. The presence of the remaining 16 species was based mainly on interviews with hunters and other local inhabitants. Three of the mammals recorded in the study area listed in the IUCN list of threaten species. These are Diana monkey which is listed as ‘vulnerable’ bay duiker and Royal duiker which as ‘insufficiently known’. in addition, six species (sport nosed monkey, black and white colobus, bush baby, Bossman’s potto, white bellied pangolin, Pel’s flying squirrels are listed in Convention on international trade in endangered species (CITES) appendices. Seventeen (17) of the species enjoyed full protection (**Schedule 1**) and eleven (11) enjoyed partial protection (**Schedule 2**) in Ghana (Ghana wildlife conservation regulations, 1995). Relative abundance ranged from quite common to rare depending on the particular species. The various categories of abundance were determined as follows:

- **Quite common (++)**: reported to be present by > 25% but <50% of interviewees and/or comprising <25% of animals seen dead or alive.
- **Fairly Common (+)**: reported to have been seen by >10% but <25% of interviewees within the past one year.

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- **Rare:** reported to have been seen by <10% of interviewees within the past one year.

**Small terrestrial mammals**

The catch was very poor for small terrestrial mammals. Only 5 species (total of seven (7 individual) were caught during the six nights trapping at the 6 study sites. Most of the catch was recorded at site 1. The effort thus produced an average catch rate of  $5 \times 10^{-2}$  mammals per trap night. In Ghana terrestrial mammals are known to thrive better in disturbed habitats (Yeboah, 2004) but this seems to be true when the area is cultivated with crops that could be useful to the animals. Apparently with mining fully in progress within the concession this should be expected as farming activities are mostly restricted.

**Bats**

For uniformity and need for standardization all numbers of bats caught in each study site were converted to numbers per mist net nights (no. /mnn) which is defined as a number caught per 100m mist net per night. The presence of bats in the area was generally poor with only two species of Ghana’s megachiropteran bats caught. These were *Epomops (Epomops franqueti)* and *Epomorphorus (Epomorphorus gambianus)*. They were caught at a rate of 1.4 mnn for *Epomops franqueti* and 1.6 mnn for *Epomorphorus gambianus*.

**Herpetofauna**

The number of species recorded in the six surveys stands at seven (7) reptiles and three (3) amphibia. While all the amphibian were seen in the field two species of reptiles (Gaboon viper and Chameleon) were not seen but reported to be present by local inhabitants. One of the reptilian species (Chameleon) is listed in CITES. The commonest venomous snake sighted in the area was the green mamba.

**Avifauna**

A total of 67 species of birds belonging to 27 families were caught during the surveys. Out of this number, 12 species were caught in mist nets. One seasonal migrant (*Merops albicollis*) and one Guinea-Congolian Forest Biome Restricted bird species (*Tockus fasciatus semifasciatus*) were recorded during the survey and are therefore of global conservation concern.

**3.4.3 Conclusion**

The fauna of the concession is generally very poor due to the disturbance in the immediate past and is still going on by miners and chain saw operators. As at now no animal of special conservation concern has been found in the concession that may preclude mining activities in the study area. Concurrent reclamation will allow for earlier re-establishment of fauna in the area. That is they should work in a pit at a time, finish, fill, and start re-vegetation with poly-culture of native flora before they are allowed to move to the next pit. Secondly sites V and VI (Esujah North and South) are secondary tropical forest remnants that can support large bird population if retained. It is therefore suggested that management should carefully consider the significance of these sites for the survival of biodiversity before any major disturbance commences in those sites. Detailed report is provided in Appendix 3.6.

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### **3.5 Soil Survey**

The soil baseline report focuses on describing the existing baseline conditions that may be affected by the project’s activities. The overall goal is to determine and evaluate the soil resources of the proposed area for rain fed agricultural production and for future suitability reclamation and rehabilitation. It is also intended to evaluate the physical and chemical soil fertility for the common crops grown in the area.

A combined approach was used during the survey and these include desktop review of available literature, field sampling and observation to gather additional data through soil sampling as well as further soil examination at soil series level. Samples were collected from the Chirawewa, Fetish, Bokitiso and Esuajah North areas.

Major soils of the surveyed area are developed over phyllites and greywackes; biotite granites and schists; quartzites and sandstones; and superficial pineplain drifts. The soils are however, too severely and deeply leached of any nutrient elements present. Much of the area has a long history of intensive cultivation resulting in accelerated soil erosion, and reduced fallow periods. For this reason the soils are generally exhausted of nutrients which were normally stored in the topsoil organic matter.

The nutrient status of the soils of the area is on the whole low, thus heavy application of fertilizers will be required in the cropping systems within the area. The topography of the terrain renders it unsuitable for ploughing with tractors.

The lands in the area are generally considered moderately well for cropping; this is because the soils are medium textured, highly or moderately gravelly (Bekwai series) or deep and non-gravelly (Kokofu). They may be well, moderately well or imperfectly drained and occur on gently undulating topography (1-3% slopes) where susceptibility to erosion is relatively slight to moderate if mechanically tilled and carefully managed. Narrow bands of very deep non-gravelly soils (Oda) occupy lower slopes (0-2%) and drainage grooves. Water holding capacity is moderate although surface layers are liable to dry out in dry seasons.

The upland and slope soils are recommended for a wide variety of tree and arable crops such as cocoa, oil palm, coffee, avocado pear, citrus, mangoes, guava, cola, cassava, maize, cocoyam, plantain, bananas, pineapple, pawpaw, groundnut, ginger, legumes, etc. The lowland soils (Temeng and Oda) are recommended for rice, sugarcane and vegetables. The detailed report is provided in Appendix 3.7.

### **3.6 Sediments Survey**

As part of the baseline study for the Eastern Pits Projects, sediment samples were collected from the bottom of all the sampled water bodies within and around the proposed project site to ascertain the physicochemical and heavy metal concentrations of the sediment prior to operations. As well, water quality analysis was also conducted for samples collected from the same water bodies.

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A total of eleven (11) sampling locations were covered in the study. The reason for selecting these sites was based on drainage flow pattern in relation to the site of the project. Other consideration was categorization of the locations into Upstream, Midstream and Downstream of the Eastern Fetish Main Pit.

From the analysis of the samples collected, it is evident that some surface water quality physiochemical parameters measured especially total suspended solids, turbidity and colour exceeded the various permissible limits. The BOD of all the surface water samples was low.

In all the surface water samples, the concentration of iron was above the Ghana Water Company Limited (GWCL) Maximum Contamination Limit (0.1 mg/L) but below the EPA Maximum Permissible Level (10 mg/L). Arsenic concentrations at PAS 1, PAS 2 PAS 3, PAS 8 and PAS 35 were above the GWCL Maximum Contamination Limit (0.01 mg/L). The concentrations of all the other Akoben toxic metals (Hg, Cd and Cu), cyanides were below their respective GWCL Maximum Contamination Limits.

The pH of all the sediment samples was slightly acidic. Iron concentration of all the sediments was very high. Copper concentration in all the sediment samples was low except in PAS 2 which was above the ISQG low trigger value. The arsenic, cadmium and mercury concentrations levels in all the sediment samples were lower than the ISQG low trigger value. The detailed report is provided in Appendix 3.8.

### **3.7 Radioactivity Survey**

#### **3.7.1 Introduction**

Radioactive studies have been carried out within and around the proposed Eastern Pits Project of Perseus Mining (Ghana) Limited to ascertain the baseline radioactivity levels of naturally occurring radioactive materials (NORM) prior to processing of gold ore at the area. The study was carried out based on in situ measurements of external gamma dose rate at 1 meter above ground level as well as laboratory analysis by direct gamma spectrometry to quantify the radionuclides of interest namely; <sup>238</sup>U, <sup>232</sup>Th and <sup>40</sup>K in soil, rock, ore and water. In addition, gross alpha/beta analysis was carried on the water samples. Three (3) exposure pathways; namely direct external gamma ray exposure from natural radioactivity concentrations in soil/rock-ore pads radioactivity due to <sup>238</sup>U, <sup>232</sup>Th and <sup>40</sup>K and internal exposure due to natural radioactivity were considered.

#### **3.7.2 Objective and Scope of the Study**

The primary objective of this study was to measure and assess the baseline radioactivity levels of the Eastern Pits Project as well as the immediate surroundings so that reference data could be established before mining commences. The study focused on the determination of the activity concentration and distribution of the naturally occurring radionuclides of the U/Th decay series and <sup>40</sup>K in soil, rock, ore samples by gamma spectrometry and gross alpha and gross beta activities in water samples. Airborne

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absorbed gamma dose rates were also measured at 1 meter above the ground at all samplings points with a radiation survey meter.

### 3.7.3 Methodology

A total of thirty (30) samples were randomly collected within selected areas of the mine concession and the surrounding communities. They included fourteen (14) soil, rock and ore samples and sixteen (16) water samples.

In the laboratory, each of the soil, rock and ore samples were air dried on trays for 7 days and then oven dried at a temperature of 105 °C for between 3-4 hours until all moisture was completely lost. The samples were grinded into fine powder using a stainless steel ball mill and sieved through a 2 mm mesh size and poured into one (1) litre Marinelli beakers and hermetically sealed. The Marinelli beakers with the samples were completely sealed and stored for 4 weeks, to allow the short-lived daughters of <sup>238</sup>U and <sup>232</sup>Th decay series to attain equilibrium with their long-lived parent radionuclides (ASTM, 1983; 1986). The soil samples were each counted using a sodium iodide detector for a period of 36,000 seconds (10 hours).

### 3.7.4 Results and Discussion

Results of study carried out indicate measured absorbed dose rates varied in a range of 0.02-0.17 µGyh<sup>-1</sup> (20-170 nGyh<sup>-1</sup>) with an average value of 0.08±0.02 µGyh<sup>-1</sup> (80±20 nGyh<sup>-1</sup>) The corresponding average annual effective dose was calculated to be 0.093±0.028 mSv (93±28 µSv) in a range of 0.047-0.142 mSv (49-142 µSv).

According to United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) report, the worldwide average absorbed dose rate measured in air outdoor from terrestrial gamma radiation is 60 nGyh<sup>-1</sup> (0.059 µGyh<sup>-1</sup>) (UNSCEAR, 2000). Comparing the results of the gamma absorbed dose rates in this study with the data in UNSCEAR report, the results of the absorbed dose rates is within acceptable range of dose rates values reported for other countries (UNSCEAR, 2000). However, the highest absorbed dose rate value of 170 nGyh<sup>-1</sup> was measured at locations around the Bokiti Pit. In general, the results of the study in this mine compared well with similar studies carried out in other mines in Ghana (Darko, et al, 2010; Faanu et al, 2013) although the average absorbed dose rate of 80±20 nGyh<sup>-1</sup> measured in air from the area is above the worldwide average. The reasons for the higher values of the doses for external gamma could be due to difference in geological formations as well as contribution from cosmogenic radionuclides in addition to terrestrial radionuclides.

The results of this study also compare with the previous study that was carried in Perseus Mining (Ghana) Ltd in 2011. The worldwide average activity concentration of <sup>238</sup>U, <sup>232</sup>Th and <sup>40</sup>K in soil samples from similar studies carried out around the world are 35, 30 and 400 Bqkg<sup>-1</sup> respectively (UNSCEAR, 2000). By comparison, it shows that the average values of the activity concentrations of <sup>238</sup>U and <sup>232</sup>Th in

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this study are about two times higher than the world average whilst that of  $^{40}\text{K}$  is about three times higher than values in normal continental soils (UNSCEAR, 2000). The very high activity concentration of  $^{40}\text{K}$  is because the rock ore of the mine is associated feldspar which belongs to a group of hard crystalline minerals that consist of aluminium silicates of potassium, sodium, calcium or barium. Even though the average values in this study are higher than the worldwide average values, activity concentrations are still far below the exemption values of  $1 \text{ Bqg}^{-1}$  for  $^{238}\text{U}$  and  $^{232}\text{Th}$  and  $100 \text{ Bqg}^{-1}$  for  $^{40}\text{K}$  in materials that will warrant regulatory control [IAEA, 1996].

The average gamma dose rate and annual effective dose from terrestrial gamma rays calculated from soil/rock-ore pad activity concentrations are shown in Appendix 3.9 The average absorbed dose rate was calculated to be  $741.6 \pm 260.1 \text{ nGyh}^{-1}$  in a range of  $333.9\text{-}1121.5 \text{ nGyh}^{-1}$  which is by a factor of six to sixteen higher than the dose rate measured in air at 1 metre above the ground. The average absorbed dose rate due to the soil concentrations is also about twelve times higher than the worldwide average value of  $60 \text{ nGyh}^{-1}$  (UNSCEAR, 1993; 2000). This difference could be attributed to vast differences in geology and geochemical state of the sampling sites. The corresponding average annual effective dose estimated from the soil concentrations is  $0.91 \pm 0.32 \text{ mSv}$  in the range of  $0.41\text{-}1.38 \text{ mSv}$ . It is observed that the annual effective dose from the soil concentration is about ten times higher than that from the external gamma dose rate measured in air at 1 metre above the ground.

The natural radioactivity in building materials is usually determined from the activity concentrations of  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$ . Also because 98.5 % of the radiological hazard of uranium-series is due to radium and its decay products  $^{238}\text{U}$  is replaced with concentrations of  $^{226}\text{Ra}$  in hazard assessment. In order to assess if soil/rock-ore pad which could be used for building purposes could pose any radiation hazard, the three hazard indices namely; radium equivalent ( $\text{Ra}_{\text{eq}}$ ) activity in  $\text{Bqkg}^{-1}$ , external hazard ( $\text{H}_{\text{ex}}$ ) and the internal hazard ( $\text{H}_{\text{in}}$ ) indices were calculated. The radium equivalent activity is related to the external gamma dose from the terrestrial radionuclides and the internal dose due to radon and its decay products of  $^{210}\text{Pb}$  and  $^{210}\text{Po}$ . The maximum value of  $\text{Ra}_{\text{eq}}$  in building materials must be less than  $370 \text{ Bqkg}^{-1}$  for the material to be considered safe for use. The external and internal hazard indices must also be less than unity in order to keep the radiation hazard insignificant. This implies that, the average external radiation exposure due to the radioactivity from these radionuclides in materials to be used for constructions must be limited to  $1.5 \text{ mSv/year}$  (OECD/NEA, 1979). In general however, the annual effective doses calculated from the various samples are considered insignificant in respect to the annual construction limit of  $1.5 \text{ mSv/year}$ .

The average value of the radium equivalent activity in this study is  $257.8 \pm 61.1 \text{ Bqkg}^{-1}$  in a range of  $136.6\text{-}340.3$  which is below the recommended limit of  $370 \text{ Bqkg}^{-1}$ . The calculated  $\text{H}_{\text{ex}}$  in the soil/rock-ore pad samples ranged from 0.4 (Big Fetish Pit Ore pad) to 0.9 (soil sample from Chirawewa Pit and Esujah North and South Pit) and an average value of  $0.7 \pm 0.2$  for the study area. Similarly for the  $\text{H}_{\text{in}}$ , the values ranged from 0.4 (Big Fetish Pit Ore pad) to 1.2 (Chirawewa Pit soil) with an average of  $0.9 \pm 0.2$ . For the internal hazard 21.4 % of the samples had values exceeding the recommended limit of 1.0 which implies that these materials if used for building purposes could be a source of internal hazard due radon and to its progeny. Meanwhile, 14.3% of the samples have values exactly at the recommended limit of 1.0 while the rest were below the recommended limit.

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The activity concentrations of gross- $\alpha$  and gross- $\beta$  in water samples from the pits, surface water and underground water (bore holes) used in the surrounding communities of the study area and their corresponding committed effective dose are shown in Table 4. Radionuclide concentrations in groundwater depend on the dissolution of minerals from rock aquifers. The activity concentrations of gross- $\alpha$  in the water samples varied in a range of 0.0004 Bq/l in surface water at Wampem to 0.0075 Bq/l in surface water in Nkonya borehole with a corresponding average annual committed effective dose of  $0.0007 \pm 0.0005$  mSv. For the gross- $\beta$ , the activity concentrations varied in a range of 0.0104 Bq/l for water taken from a stream in Odumkrom to 0.0452 Bq/l for water from the raw underground water at the camp site with a correspond average annual committed effective dose of  $0.0170 \pm 0.0042$  mSv. The average committed annual effective dose due to both gross alpha and beta was estimated to be  $0.0089 \pm 0.0023$  mSv. The WHO screening levels for drinking water below which, no further action is required are 0.5 Bq/l for gross- $\alpha$  and 1.0 Bq/l for gross- $\beta$  (WHO, 2004). All the water sources had gross- $\alpha$  and gross- $\beta$  values below the recommended levels. The guideline values ensure an exposure lower than 0.1 mSv/year assuming a water consumption rate of 2 litre /day. Comparing these results with the WHO guideline values, it can be observed that all the values of the gross- $\alpha$  and gross- $\beta$  are lower than the guideline values. This indicates that all the water sources in the study area which are designated for drinking and domestic purposes do not have significant natural radioactivity.

The study considered public exposure in the mining environment due to three (3) exposure pathways; namely direct external gamma ray exposure from natural radioactivity concentrations in soil/rock-ore pads radioactivity due to  $^{238}\text{U}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  and internal exposure due to natural radioactivity by accessing the activity concentrations of gross- $\alpha$  and gross- $\beta$  in water samples from the pits, surface water and underground water (bore holes) used in the surrounding communities of the study area.

The average activity concentrations of  $^{238}\text{U}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  in the soil and rock-ore pad samples were calculated to be  $65.1 \pm 2.2$  Bqkg $^{-1}$ ,  $71.8 \pm 2.2$  Bqkg $^{-1}$  and  $1168.3 \pm 15.8$  Bqkg $^{-1}$  respectively. The results in this study compared well with studies carried out in Ghana and other countries and with the worldwide average activity concentrations (UNSCEAR, 2000). The average annual effective doses estimated from direct external gamma-ray exposure from natural radioactivity at 1 metre above sampling area and that due to activity concentrations of  $^{238}\text{U}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  in the soil and rock-ore pad samples were  $0.093 \pm 0.028$  mSv and  $0.91 \pm 0.32$  mSv respectively.

In order to assess whether the soil/rock-ore pad in the study area could be a source of public radiation exposure if used for building purposes, the following hazard indices were determined; radium equivalent ( $R_{\text{eq}}$ ) activity in Bq/kg, external ( $H_{\text{ex}}$ ) and the internal hazard ( $H_{\text{in}}$ ). The radium equivalent activity is related to the external gamma dose from the terrestrial radionuclides and the internal dose due to radon and its decay products of  $^{210}\text{Pb}$  and  $^{210}\text{Po}$ . The maximum value of  $R_{\text{eq}}$  in building materials must be less than 370 Bq/kg for the material to be considered safe for use.

The average radium equivalent activity in the samples was  $257.8 \pm 61.1$  Bq/kg in a range of 136.6-340.3 Bq/kg. The mean external and internal indices were  $0.7 \pm 0.2$  and  $0.9 \pm 0.2$  respectively. The average values of the  $R_{\text{eq}}$ ,  $H_{\text{ex}}$  and  $H_{\text{in}}$  are below the acceptable values. This indicates that soil from the study area that might be used for building purposes for shelter may not pose any significant radiological

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radiation hazard and thus regarded as safe for use as building materials. However, the results of the calculated absorbed dose rate in the soil/rock-ore pad samples varied in a range of 333.9-1121.5 nGy/h with an average value of 741.6±260.1 nGy/h. The average absorbed dose rate in this study is about twelve times higher than the worldwide average value of 60 nGy/h estimated from soil concentrations (UNSCEAR, 2000).

In view of these findings it is recommended that the PMGL establishes a periodic (every three years) monitoring programme for environmental radioactivity as the operations may alter the geochemical and radiological state of the mine. In general the results in this study are comparable to similar studies carried out in other mines in Ghana (Darko et al, 2010; Faanu et al, 2010) and in other countries (UNSCEAR, 2000). It also indicates insignificant levels of the natural radionuclides in the study area and this data could serve as a reference material in future studies. It also implies that previous mining activities had not imparted negatively in terms of radiological hazard to the communities in this area. The detail baseline report is provided in Appendix 3.9.

### **3.8 Baseline Socio-Economic Environment**

The demographic health and socio-economic survey covered the following communities: Abenabena, Ayanfuri, Fobinso, Gyaman and Nkonya. The other three (3) communities located outside a 10km radius of the project site were considered to be outside the influence of the project and were included as control communities. These are Agyempaboa, Dompouse and Wassa Saa. These communities are located in three (3) Districts namely, Wassa Amenfi East, Upper Denkyira East and Upper Denkyira West Districts.

The 2010 Population and Housing Census put the population of the district at 62,496. It is presently estimated at 84,808 (UDEMA, 2010). Females constitute 50.4% and males 49.6% of the population. The current growth rate of 3.1% is higher than the national growth rate of 2.7% per annum. The Municipality is as largely rural with as much as 58.32% of the population living in rural areas (settlements with less than 5000 inhabitants). There are other ethnic groups such as Fantes, Akans, Ewes, Nzemas. Most of these are peasant farmers. Most of them practice the extended family system with only a few practicing the nuclear family system as well as maternal inheritance. The study was divided into two zone; zone 1 (ZOI) and 2 (ZOII).

The predominant religion in the district is Christianity. Other groups include Islam and traditional religion. A survey conducted in 1996 revealed that the Christian group constitutes about 93% of the entire Municipality population followed by Islam 4%, traditional 1.7% and others 1.6% (UDEMA, 2010). As at 2009, total enrolment in primary schools in the District was 26,025 pupils comprising 22699 in public and 3508 in private schools. The Economy of the municipality can be classified as mainly agrarian. Between 60% and 65% of the working population engages in vibrant farming while 15% engage in small scale mining and 10% could be found in trading and other varied economic activities. Small-scale mining contributes significantly to the socio-economic development of the District.

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The manufacturing and processing sectors employs about 6% of the active labour force. These include indigenous small-scale wood processing plants, oil palm processing, cassava processing, local gin distilling, soap making, carpentry and activities of other artisans. The District has 16 health facilities consisting of 1 District Hospital, 7 Health Centres, 2 private clinics and 6 CHPS compounds. The top-three reported health cases at health facilities (OPD attendance and admissions) are malaria, acute respiratory infection and pregnancy related Complications.

Agriculture is the mainstay of the Project area employing about 80% of the active labour-force. Cash crops grown are mostly cocoa, coffee, oil palm, plantain, and cassava. Major food crops include plantain, cassava, cocoyam, maize, rice, garden eggs, tomatoes, and pepper. About 70% of farmers use family hands for farming, the rest using hired labour and the „Noboa“ system. The Wassa Amenfi East District directorate of education has seven circuits which can be classified as one with very low level of education. The Wassa Amenfi East District has 124 pre-schools, 127 primary schools, 61 JHS, 1 SHS and 1 Vocational school. At the pre-school and primary school level, the total enrolment stands at 26,284 pupils of which 52% are boys while 48% are girls. At the JHS level 57% of the student population of 5,110 are male while 43% are females, and at the SHS 53% of the total school enrolment of 742 are males as against 47% females. All the 15 vocational school students are girls. It is also worth of note that only 22% of the teacher population of 667 are trained.

**The Traditional Structure**

Within the traditional structure, the paramount chief (*Omanhene*) is head. Below the Paramount Chief are the divisional and sub divisional chiefs (*Ahene*) whose areas are synonymous with traditional towns and Communities. Farmsteads and communities settled by strangers usually fall under jurisdiction of the sub divisional chiefs and are headed by Community heads (*Adikro*). The chief is not only a political leader but also the symbol of cultural and identity of the lineage forming the community. The chief is therefore responsible for evoking the goodwill of ancestors for the living subjects. The Paramount Chief at Wassa Akropong is Nana Sekyi Amoah Tetrete II who exerts control over the sub- chiefs. In the rural areas the contribution of chiefs to socio economic development is very pronounced. Chiefs remain the custodian of traditional land but do not have absolute control, there is government agency called the Administrator of Stool Lands, they register acquisitions and collect Royalties.

**Existing forms of Land Ownership**

Land use rights in Ghana can therefore be divided into two broad categories namely, customary and common law rights often co-existing in the same piece of land and in a hierarchical order with the allodial right at the apex within the customary set up. In the case of customary law, specific arrangements governing land ownership and use differ from community to community

**3.8.1 Discussion and Conclusion**

The survey sought to determine baseline socio-economic and health indicators in communities within the catchment communities surrounding PMGL which includes the Eastern Pits. Socio-economic baseline indicators found are typical of rural communities in Ghana is characterised by low income levels, large household sizes, low educational status and poor infrastructural development.

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With regard to health indicators, there is high communicable disease burden particularly malaria and other endemic diseases like STI's/HIV/AIDS, Schistosomiasis and Onchocerciasis. Prevalence of anaemia is high and nutritional status low among children.

Environmental sanitation is generally poor with most houses lacking toilet facilities. Underground water is the major source of drinking water. With regard to maternal health, safe motherhood indicators like antenatal coverage, supervised deliveries, and family planning acceptor rates recorded in the major health facilities show an increasing trend over the past three years.

With regard to heavy metal toxicity, arsenic and lead toxicity are the most common among both adults and children in both zones. There is also evidence of toxicity from mercury and cadmium. Knowledge about exposure to heavy metal is generally poor despite the serious potential health impacts.

In the light of the above findings, the following recommendations are being made:

- Inhabitants whose arable lands would be lost to mining activities should be well compensated financially and also enrolled in alternate livelihood training programs like training in fish-farming, bee-keeping, livestock etc in order not to worsen the already low income levels in the communities. In addition, efforts should be made to reclaim lands after they have been used for mining activities.
- Mining companies may consider as a corporate-social responsibility financial support in the form of scholarship packages to brilliant but needy students from the area in order to reduce illiteracy and unemployment among the youth both of which impact adversely on health.
- Mining companies may, in collaboration with the District Assemblies and the Ghana Health Service, support long-lasting insecticide net (LLIN) distribution and indoor residual spraying (IRS) in the communities as effective interventions necessary to reduce the burden of malaria in the communities. There should also be periodic screening of the communities to assess the effectiveness of these interventions and the impact of mining activities on malaria in general.
- The Ghana Health Service in collaboration with the various stakeholders should intensify nutritional programs in order to address the high level of malnutrition and anaemia among children in the area.
- HIV/TB screening and STI prevention programs should be strengthened to reduce prevalence of these endemic diseases that are notably associated with mining communities. Similar programs for other endemic diseases like onchocerciasis and schistosomiasis could also be supported with periodic mass chemotherapy,
- Mining companies may consider supporting health infrastructural development such as construction of CHPS compounds within demarcated CHPS zones so as to improve access to healthcare and empower communities to improve their own health.
- In collaboration with Ghana Health Service, the Health and Safety and Environment

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Departments of the company should intensify education on heavy metal exposure and their prevention.

Periodic assays should be undertaken to assess sources of exposure as well as trends in blood levels over time. Communities with naturally high concentrations of arsenic in the rocks and soil may benefit from treatment of their water sources for drinking through provision of pipe-borne water. Use of fertilizers that contain high levels of arsenic and cadmium should be discouraged in such communities. Furthermore intense education should be provided to communities on risks of indiscriminate handling of heavy metals like mercury and lead in view of their damaging effects particularly intelligence defects which may jeopardize the intellectual development of children for life. The detail socio-economic baseline report is provided in Appendix 3.10.

### **3.9 Archaeological and Cultural Heritage**

#### **3.9.1 Introduction**

This section of the social assessment of the Eastern Pits Project area presents the findings obtained from a field archaeological and cultural heritage resources survey in the concession area and the surrounding communities of the proposed project. The investigation was conducted in February 2014. The findings provide baseline data for assessing the archaeological and cultural heritage resources of the area investigated. The broader objective is to ensure that modern-day development projects do not succeed on the back of the destruction of valuable tangible and intangible heritage resources of communities in particular, and Ghana in general.

#### **3.9.2 Scope of Work**

A scope of work for archaeological and cultural heritage survey was provided by PMGL to include the following tasks:

- Investigate the oral traditions / settlement histories, linguistic identities, traditional practices, belief systems and structures of the communities in the project area;
- Undertake a physical ground survey of the Project area to identify and describe the cultural heritage resources and archaeological sites of the area;
- Describe and classify all significant cultural heritage and archaeological sites identified in communities whose location has implications for the construction and operation of the proposed project;
- Provide GPS positions for all sites identified; and
- Produce a map or maps showing the cultural heritage and archaeological sites of the project area.

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The baseline survey started with a gathering of useful information from personnel of PMGL, the conduct of a field cultural heritage and historical resource study as well as carrying out a detailed archaeological ground surface inspection in the project area to cover 5 areas designed for that purpose. The relevant community-based and private historical, social and cultural data collection (involving direct visits, interviews and specific observations) on the affected communities for broader purposes and immediate applications was undertaken.

From the examination of the project maps and interactions with the officials, the leadership and elders of four (4) communities were identified for the above research activity. The communities are: Ayanfuri, Odumkrom, Gyaaman and Wampem. An initial visit was made to the Chief/Heads and elders of Ayanfuri, Gyaaman, Odumkrom and Wampem to inform them of the study and seek their permission and support in its execution. Because Ayanfuri and Gyaaman were indigenous settlements, a bottle of Schnapps, an envelope (with some money) was presented to the Family Head of Ayanfuri, and Chief of Gyaaman.

All the interviews were done in the Akan language (Twi and Fante) without the use of an interpreter. All the questions posed to informants were short, clear and straightforward. The elders/informants were encouraged to give back the responses in shorter forms in line with the questions posed. The community Chief, elders and residents including a woman (at Wampem and Gyaaman) and youth (of both sexes) answered questions on brief aspects of their origin and settlement history, cultural profile (such as belief systems and practices and uses of land spaces for depositing of dead members). Other questions focused on the work activities of the community members for insight on their cultural and ritual indications and for understanding of behavior and decision making by individuals, households, and the community.

Four (4) communities (Ayanfuri, Odumkrom, Wampermu and Gyaaman) provided the human settlement contexts for cultural heritage interview, surveys and physical observations for the baseline studies and impact assessment of the Eastern Pits of the Edikan Gold Mining Project. These are the communities whose location, archaeological and cultural heritage attributes are of significance for impact assessment and mitigation regarding the infrastructural development and operation of the proposed project. The survey has helped our understanding of where archaeological and heritage resource sites are and what they consist of.

Specifically, it has improved the understanding of the surface attributes and assemblage content of the archaeological sites in the project area. Most of the archaeological sites have either been adversely affected or completely destroyed by the operations of a previous Corporate Mining Project. The survey identified the negative impact on archaeological sites especially on six (6) of the seven (7) Iron Slag/Smelting sites found from previous corporate mining development, and private infrastructure such as the Methodist Church and School buildings and associated grounds and also from cocoa farming activities

Seven (7) Archaeological sites (Ancient settlements) associated with the Later Iron Age through the Portuguese period (ca. AD 1000-1600) to the Colonial Period have been identified from survey and

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actual ground inspection for sites in the proposed Project area. Two (2) were found in the Esuajah South Mining Area where contemporary construction of houses has caused their total destruction. The remaining five (5) sites are found in the Ayanfuri Township where they fall on the boundary of the 500m buffer zone of the Esuajah North Mining Area or outside it. They manifest pieces of local pottery, fragments of imported alcoholic bottles, pieces of glass and smoking pipes. The old part of Ayanfuri (the palace area, the eastern slopes near the palace, and the Queen mother’s area are sitting on top of archaeological sites/ancient settlements.

Whether these ancient settlements are associated with the ancestors of Ayanfuri or not can only be answered with the findings of a systematic excavation and stratigraphic, material and temporal analysis. These sites should be left as they occur even after the resettlement of affected households. Similarly, a site associated with the ancient cemetery/settlement of Gyaaman and near the Old Pit and old Waste Dump should be left intact. No new mining development activities or material deposit should be undertaken without recourse to a systematic excavation of this site for analysis in relation to the Culture History and Archaeology of Gyaaman in particular and Ghana in general.

The design of the infrastructure (haul road, mine pit especially the expansion of existing ones and waste dump) in the three areas of direct development of the proposed project does not pose any danger to the destruction of archaeological sites. The site selected for the resettlement of the project affected persons (that is about 60% of the Ayanfuri town) carries no heritage and archaeological sites to be adversely affected by the housing project.

There are traditionally defined spaces of cultural and religious importance belonging to the local people in the four communities identified in project area, but none of these locations or features is exposed to damage from the project development. The Royal Cemetery of Ayanfuri falls in the inner boundary of the 500m buffer zone of Esuajah North. No danger of a physical destruction of the sacred grove is implied by the project design. The impact determined emanates from the effect of the noise and rocks ‘missiles’ from it. The mitigation of this impact has been provided.

Although Christianity and to a limited degree Islam have dominated the religious landscape and cultural environments in these communities, the fundamental framework of cultural life is to a good extent, influenced by indigenous religious and institutions. The several shrine compounds, shrine sites /sacred groves owned by Ayanfuri and Gyaaman are fundamental in the welfare and development of the people. They are critical in some community health matters, reversal of curses, protection of the community and source of assistance for people in these areas and from other parts of Ghana. The creation of a new community ritual/sacrificial site in January 2014, at Ayanfuri reinforces the point made above. It is also a reflection of the negative impact of previous corporate mining and contemporary galamsey on the local rivers that carry the local gods. The objective is that Ayanfuri has suffered from the impacts on the river gods and this had to be mitigated by the re-assembling of the various gods in a new sacred site/grove. Detailed results are provided in Appendix 3.11.

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### **3.10 Transport and Traffic Impact Assessment**

The Traffic Impact Assessment (TIA) survey aims to determine the transport and traffic implications of the development of the Eastern Pits including the Chirawewa, Esuajah North and Fetish. Undoubtedly, the implementation of the project will be crossing two major national highways transporting personnel and materials between the Eastern Pits and western side. This will necessitate the erection of two boom gates at the haul road intersection with the two major highways i.e. Ayanfuri –Tarkwa road (IR6 currently being rehabilitated with funds from the European Union and the Ayanfuri- Asawinso road (IR8) also being re-constructed with funds from the World Bank.

To assess the existing traffic condition on these highways, traffic studies were undertaken at a number of intersections in proximity to the mine site from 17th December 2013 - 25th January 2014. The traffic counts included turning movement, screenline counts, Origin-Destination (O-D) survey and pedestrian studies. Junction turning movements and screenline count data were collected on adjoining roads of the precinct of the mining site. Turning movement counts were carried out at selected locations of the road network in the vicinity of the proposed site for twelve (12) hours.

The major road leading to the mine site is a highway under the jurisdiction of the Ghana Highway Authority. It is a bi-directional single carriageway road with a graded surface, a width of about 15m and it is being upgraded to dual carriageway. The closest intersection to the site is Camp Junction on the Ayanfuri-Bogoso road. Since the major road leading to the project site is under construction, and therefore not yet complete, traffic flow along the road corridor is relatively free-flowing all day.

Traffic volumes for the existing conditions have been modelled for Analysis Methodology and Key Assumptions. The traffic operations analysis methodologies and key assumptions are described below. All intersection operations analyses were conducted using procedures and methodologies contained in the Highway Capacity Manual (HCM), Transportation Research Board, 2000. These methodologies were applied using the Sidra Intersection software package. The peak hour factors (PHF) for existing conditions were based on existing traffic counts. Traffic operations for each intersection have been evaluated based on their calculated level of service (LOS). LOS is a qualitative measure of traffic operating conditions whereby a letter grade, from A (least delay) to F (most delay), is assigned. These grades represent the perspective of drivers and are an indication of the comfort and convenience associated with driving.

The Bogoso-Prestea mine system is manual, where a pair of boom gates is opened out into the road to block through vehicular passage. A worker clad in a hard hat and reflective jacket waves a red flag for approaching vehicles to stop for mine vehicles to cross the road. Once the mine vehicles have crossed over the main road, the boom gates are returned to closed position and the vehicles on the main road are waved through with the green flag.

The consultant recommends that if a similar system is to be used at the Edikan mine sites, at crossings with the main roads, in addition to the presence of the manual boom gate system, an advance sign: ‘Mine trucks crossing’, as well as beacons with flashing amber lights should be installed immediately

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prior to the crossing on both approaches. This would alert the vehicle drivers that heavy trucks are crossing. In addition, the quality of the reflective material on the worker’s jacket and on the gates themselves should be maintained in order to be able to catch approaching vehicle drivers’ attention quickly. Detail report is provided in Appendix 3.12.

### **3.11 Hydrogeological Survey**

The Electrical Resistivity Imaging (ERI) survey has provided valuable information regarding subsurface resistivity variation in the Eastern Pits area. Four of the five 2-D sections of the ERI survey conducted around the Fetish Pit in general show higher resistivity rock on lower resistivity rock; suggesting that the rocks are different. This observation led to the interpretation that the relatively high resistivity rock is likely to be fresh granite which has intruded lower resistivity rocks suspected to be metasediments, most likely phyllite. The metasediments distinctly exhibit very low resistivity suggesting that they are porous and most probably represent an aquifer. Therefore, it may be inferred that groundwater is present in the study area and may be present within both weathered granite and weathered phyllite when they are near surface and in weathered phyllite below fresh granite.

It is also inferred from the drainage pattern exhibited by both streams that groundwater flow direction in these catchments is, in general, to the north.

The ERI survey conducted has thrown more light on the groundwater regime in the study area and probably in the wider environs. There are areas with regolith (weathered) aquifers with variable depth extent, which may be more than 60 m in some places. Some of these aquifers may be perched and restricted in areal extent in some places due to granitic intrusion. Bedrock aquifers are also expected in the study area where the rocks are fractured. However, it is envisaged that this type of aquifer will be restricted in areal extent. Additionally, the Piper diagram revealed that in general groundwater in the study area is Na- Ca-HCO<sub>3</sub> type. Five (5) water samples namely OPMGL, 021, 026, 045 and PMGL 019 and 023 appear to deviate from this water type especially due to their relatively low HCO<sub>3</sub> concentration and should be further investigated.

Some of the parameters analyzed at certain times posted concentrations above the EPA’s maximum allowable limits for general effluent quality standards for discharges into water bodies or water courses and World Health Organization (WHO, 2007) drinking water standards. Further study to find the cause(s) of such higher than expected concentrations is recommended.

The parameters which posted higher than acceptable concentrations are turbidity, colour, TSS, Cl, SO<sub>4</sub>, PO<sub>4</sub>, NO<sub>3</sub>, NO<sub>2</sub> in some Observation boreholes, Community wells and Stream sampling locations. Special mention is made for stream sampling locations PAS 13, 20, 21 and 61 in connection with Cl and SO<sub>4</sub> concentrations. In the case of PO<sub>4</sub>, locations PAS 11, 15, 19, 21, 35 and 61 as well as PAG 1, 6, 9 and 11 including OPAG 24 need study. The stream sampling point PAS 061 returned Cl, SO<sub>4</sub>, PO<sub>4</sub>, NO<sub>3</sub>, and NO<sub>2</sub> concentrations acceptable limits.

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## 4 IDENTIFICATION AND ASSESSMENT OF IMPACTS

All mining activity effects some changes in the natural environment. The extent and nature of the impact can vary widely depending on the method of mining, the characteristics of the mine site and its surroundings and the control and management of the mine operation.

This section presents an identification and assessment of the possible direct and indirect environmental impacts associated with the location, construction and operation of the Eastern Pits Project involving surface mining from four (4) different deposits.

Mitigation measures proposed by PMGL to minimise the environmental impacts associated with the construction and operation of the Project are presented in chapter 5.0. Also, a specific section outlining the intent and proposed form of the PMGL Environmental Management Plan (EMP) will be prepared. PMGL will operate the Project in accordance with Ghana legislation, regulations, guidelines and standards, other appropriate international environmental standards and PMGL's own internal standards and procedures to contain all chemicals/solutions and to minimise any adverse effects on the health and safety of the workers, the local population as well as the Project Area and regional environment.

### 4.1 Methodology of the Assessment

The methodology used to identify the potential impacts of the proposed mining Project and to predict their significance has been based on the following information:

- Evaluation of existing information describing the development, operational and closures phases of the Project:
- Comments and concerns raised by the relevant governmental agencies in Ghana, Community chiefs, other traditional authorities and local people to assess their perceptions and concerns about the proposed Project.
- Existing environmental regulations and procedures prevailing in Ghana as referred to in the introductory chapter of this document.
- An examination of the data obtained to characterise the existing environment of the Project Area.

Major decisions in term of mining type, mineral processing, water supply, tailings disposal, site accommodation, etc. have been made. Final design details and operation schedules will be refined should the Project be developed. The baseline study assessment focused on the following aspects:

- Climate;
- Air quality (Mainly dust deposition and noise values);

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- Hydrology;
- Hydrogeology;
- Surface and ground water quality;
- Streams Sediment;
- A synthesis of the ecological environment, which included fauna and flora surveys;
- Soil classification survey and soil suitability for agriculture;
- Radioactivity
- Traffic and pedestrian surveys
- Archaeological survey
- Land use survey including a detailed inventory of farms which may need to be compensated;
- Socio-economic characteristics of the Project Area and its environs including a detailed inventory of settlements, which will be affected by Project development.

All of this data was obtained following several site visits and field surveys undertaken by independent consultants and scientists who are very knowledgeable about the existing environment in Ghana and the Project Area in particular.

- Experience from similar gold mining operations developed in equivalent environmental conditions.

## **4.2 Summary of Potential Impacts**

A summary of the potential impacts arising from the development and operation of the Project is presented in Table 4.2. The nature and level of the potential impacts and the need for mitigation measures is then discussed.

The summary takes cognisance of the following:

- Potential impacts on the physical, chemical and biological aspects of the Project environment,
- Impacts on occupational health and safety,
- Location of Town relative to the Pit sites activities of the Project (Table 4.1).

The nearest facility to Nkonya is the haul road from the Fetish pit to the Plant site, a distance of 1.12 km. The impact of construction and operational activities from the Pits will be high on the Ayanfuri community. Impacts on Gyaman and Nkonya will virtually be very minimal.

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**Table 4.1- Distance between Communities and Pit**

Town	Measured Point to Point <sup>1</sup>	Distance (metres)
Ayanfuri	Pit site	<1000
Gyaman	Pit Site	>3000
Nkonya	Pit Site	>2000
Points measured in a direct line from nearest edge of town to the nearest edge of the facility Map) ignoring any topographical features along the line.		

Gyaman Community is also distant from mine facilities. The nearest facility is the FTSF (boundary at full development) at 1.8 km distant. The Plant site is 3 km distant. Consequently the impact of construction and operational activities will be virtually none. Social impacts on the Community arising from mine development are discussed in section 4.11 as are those for the other Communities. Farming activities in the operational area will be negatively be impacted.

### 4.3 Site Preparation and Construction Phase

#### 4.3.1 Introduction

The construction phase of the Project will involve site preparation activities, development and/or construction of Fetish, Chirawewa, Bokitiso and Esuajah North pits, four major waste rock dumps, settling pond and other support facilities.

The total area designated for the various Project facilities will cover a surface of approximately 1034.29 ha. The land take will correspond to 11.11 % of the two PMGL mining leases (93.1 km<sup>2</sup>). The distribution of the land areas by facility is detailed in Table 4.2 and a summarised version is presented below:

- The open pits development will cover an area of 132 ha,
- The waste rock dumps will cover approximately 306.8 ha,
- The new haul roads will cover approximately 12 ha,
- The contractor area (mine services, fuel) will cover 22 ha,
- The new access road from the highway to the existing Nkonya - Abenabena road will require approximately 11 ha,
- The power line right-of-way to the site will require approximately 9 ha.
- Delivery to site of components and erection.

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**Table 4.2- Summary of Potential Impacts of the Project**

Type of Impact	Activity Contributing to Impact	Potential Recipients
Visual intrusion	Surface developments for pits and other facilities	<ul style="list-style-type: none"> <li>Residents of Ayanfuri during construction and early operations</li> </ul>
<b>Air Quality Construction Phase</b>		
Airborne Particulate (dust)	Site clearance (starter pits, waste dumps, water storage facility, haul roads and access roads)	<ul style="list-style-type: none"> <li>Workers</li> <li>Adjacent fauna and flora</li> </ul>
	Vehicle movements on Project site	<ul style="list-style-type: none"> <li>Vehicle drivers</li> <li>Dwellers walking along roads</li> </ul>
	Hauling of construction material	<ul style="list-style-type: none"> <li>Travellers and vehicles along sections of the site access road</li> </ul>
<b>Air Quality Operation Phase</b>		
Airborne Particulate (dust)	Site clearance (ongoing development of pits and waste dumps)	<ul style="list-style-type: none"> <li>Workers</li> <li>Adjacent fauna and flora</li> </ul>
	Blasting at the pit (area evacuated)	<ul style="list-style-type: none"> <li>Atmospheric Environment<sup>(1)</sup></li> </ul>
	Excavation of the pits	<ul style="list-style-type: none"> <li>Workers</li> </ul>
	Haulage of waste and ore	<ul style="list-style-type: none"> <li>Vehicle drivers</li> </ul>
		<ul style="list-style-type: none"> <li>Workers</li> </ul>
	Vehicle movements on Project site	<ul style="list-style-type: none"> <li>Vehicle drivers</li> </ul>
PM10 from diesel engines	<ul style="list-style-type: none"> <li>Atmospheric Environment<sup>(1)</sup></li> </ul>	
Gaseous Emissions (CO <sub>2</sub> , SO <sub>x</sub> , NO <sub>x</sub> , CO)	Diesel engines (vehicles and generators)	<ul style="list-style-type: none"> <li>Atmospheric Environment<sup>(1)</sup></li> </ul>

- Compensation for mining areas before commencement of mining at Fetish, Chirawera, Bokitiso and Esuajah North Pits.
- Development of haul roads and mine infrastructure.
- Construction of offices, ChopHouse and infrastructure at the site.
- Commissioning and commencement of operations.

#### 4.3.2 Construction Phase

The construction phase or overall development period will take approximately 3 months. This phase will begin with site preparation activities of the main Project facilities areas listed below. This phase will impact on the air and water quality in terms of dust or airborne particular matter and silt loads in streams or drainage systems.

The construction phase will include the following sequential steps:

- Compensation of farms and negotiated access to the site.
- Preparation of the Eastern Haul road to the main Project site to link the Fetish Pit.

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- Clearing and earthworks for the infrastructure development at the Eastern pit sites.

**Table 4.2 Summary of Potential Impacts of the Project –Continuation**

Type of Impact	Activity Contributing to Impact	Potential Recipients
Noise	Increase in road traffic and heavy equipment used for construction of the various mine facilities	<ul style="list-style-type: none"> <li>• Workers</li> <li>• Travellers to Communities beyond the access roads e.g. Ayanfuri and Wampem</li> </ul>
<b>Physical Impacts Operation Phase</b>		
Noise and Vibrations	Blasting (This will be Intermittent and irregular)	<ul style="list-style-type: none"> <li>• Inhabitants of Ayanfuri (north) until waste dumps of sufficient height to provide some attenuation</li> <li>• Fauna</li> </ul>
Noise	Pit excavation	<ul style="list-style-type: none"> <li>• Workers</li> <li>• Fauna</li> </ul>
	Road traffic (including haulage of ore)	<ul style="list-style-type: none"> <li>• Workers Travellers/vehicles along section of the site access road and to/from Wampem</li> <li>• Haul roads crossing highways</li> </ul>
<b>Water Resources Construction Phase</b>		
Deterioration of water quality (streams in the Project Area are highly seasonal)	Increase in suspended solids from site clearance (only if activity is conducted in wet season)	<ul style="list-style-type: none"> <li>• Tributaries of the Subin and Danyami rivers</li> <li>• Farmers and inhabitants of Communities downstream of Project Area <sup>(2)</sup></li> <li>• Aquatic fauna (micro-organisms, insects, maybe some fish)</li> </ul>
	Accidental oil spillages from drums or heavy vehicles	
<b>Water Resources Operation Phase</b>		
Localised changes in surface water hydrology (flooding, drought)	Impoundment of raw water for Project supply requirements and permanent storage of tailings	<ul style="list-style-type: none"> <li>• Tributaries of the subri, danyami and Asanka streams (localised modification of flow regime)</li> </ul>
	Foot print of Project facilities resulting in local modification of the topography and hence catchment characteristics	<ul style="list-style-type: none"> <li>• Tributaries of the Subin river and the Offin as final receptor (localised modification of flow regime)</li> </ul>
	Discharge of mine water from pit dewatering.	<ul style="list-style-type: none"> <li>• Farmers and inhabitants of Communities in and downstream of Project Area <sup>(2)</sup></li> </ul>

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**Table 4.2 Summary of Potential Impacts of the Project –Continuation**

Type of Impact	Activity Contributing to Impact	Potential Recipients
Change in surface water quality (pH, suspended solids, cyanide, heavy metals and oil and grease)	Limited discharge of mine water.	<ul style="list-style-type: none"> <li>Subin, Danyami and Nsanka river</li> <li>Farmers and inhabitants of Communities in and downstream of Project Area<sup>(2)</sup></li> <li>Aquatic fauna<sup>(2)</sup></li> </ul>
	Runoff from the waste dumps and other Project facilities	<ul style="list-style-type: none"> <li>Tributaries of the Subin, Subin river. and</li> <li>Farmers and inhabitants of Communities in and downstream of Project Area<sup>(2)</sup></li> <li>Aquatic fauna<sup>(2)</sup></li> </ul>
	Leaching of waste and potential of acid mine drainage	
	Sewage Disposal	
	Accidental oil spillages from drums or heavy vehicles	
	Pit development and dewatering	
Modification of groundwater resources (quantity)	Potential seepages from waste dumps and stockpiles	<ul style="list-style-type: none"> <li>Localised lowering of water table</li> </ul>
Changes in the quality of groundwater resources	Potential seepages from waste dumps and stockpiles	<ul style="list-style-type: none"> <li>Localised pollution of aquifers</li> <li>Inhabitants using groundwater<sup>(2)</sup></li> </ul>
<b>Ecology Construction and Operation Phases Pit, and Waste dump development</b>		
Deforestation	Distribution of Project facilities and risk of fire outbreaks	<ul style="list-style-type: none"> <li>Flora</li> <li>Loss of timber resources<sup>(2)</sup></li> </ul>
Loss of immature or degraded secondary forest, thickets, etc.	Pits and waste dump development	<ul style="list-style-type: none"> <li>Flora and fauna</li> </ul>
Destruction and fragmentation of habitats	Operation of Project activities that generate nuisances (noise, dust, fumes)	<ul style="list-style-type: none"> <li>Fauna and flora</li> </ul>
Habitat avoidance	Operation of Project activities that generate nuisances (noise, dust, fumes)	<ul style="list-style-type: none"> <li>Fauna</li> </ul>
<b>Soil and Land Use Construction and Operation Phases</b>		
Loss of agricultural land	Clearing of large areas for Project development	<ul style="list-style-type: none"> <li>Farmers (Loss of farm-holding)</li> </ul>
Soil erosion resulting in sedimentation	Clearing of large areas for Project development	<ul style="list-style-type: none"> <li>Soil environment (loss of fertility)</li> <li>Tributaries of the Subin and Fobin rivers<sup>2)</sup></li> </ul>
<b>Socio-Economic Construction and Operation Phases</b>		
National and regional increase of employment	Operation of the Project, which will involve training with emphasis on local labour, purchase of goods manufactured in the country, payment of taxes, royalties and dividends Land take and loss of farm-holding for Project development	<ul style="list-style-type: none"> <li>Ghanaian economy</li> <li>Districts located in Project Area</li> <li>Local communities</li> </ul>
Improvement of local and national infrastructures		
Improvement of local skills		

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**Table 4.2 - Summary of Potential Impacts of the Project –Continuation**

Type of Impact	Activity Contributing to Impact	Potential Recipients
Loss of habitations and farm-holdings	Influx of peoples looking for employment	• Farmers in and around the Fetish, Esuajah North pit areas
Demographic changes	Competition for food resources and services. Workers with higher revenues	• Inhabitants of the Project Area
Increase in local cost of living	Increase in demography	
Increased pressure on utilities in particular water resources	Increase in demography	
<b>Waste Generated Construction and Operation Phases</b>		
Pollution/contamination of the local environment	Household waste, waste oils, hazardous waste, laboratory waste	• Soil and water resources
<b>Health and Safety Aspects of the Project</b>		
Illness, loss of life and injuries	Various operations of the Project	• Workers and inhabitants from the catchment communities
<b>Traffic Impact of the Project</b>		
Interference of vehicular movement	Blast operations, haulage of ore and construction materials,	• Inhabitants of catchment communities, workers and other road users

### 4.3.3 Description of Clearing Activities

#### General

This will involve activities such as felling of trees, clearing of vegetation, stockpiling of wood and branches, where possible segregation and stockpiling of topsoil and where necessary surface compaction. Stockpiled topsoil will also be used for early revegetation purposes required to stabilise certain structures such as embankments or earth mounds.

The activities of clearing, grubbing and topsoil segregation will be co-ordinated by the Health, Safety, Environment and Social Department (HSEC) to minimise the negative impacts on the environment and local community. Designated topsoil dumps have been mapped out for dumping stripped topsoil.

It must be pointed out that vegetation clearance of the various sites will be a gradual process and will not exceed the surface of the area required for each Project facility. For example, it will not be necessary to initially clear the entire surface of the waste dumps as waste rocks are produced and stored progressively from the beginning to the end of the life of the Project.

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## **4.4 Visual Impact**

### **4.4.1 General Description of the Project Site**

Topography in the Eastern Pits area is largely gently undulating, ranging from 120m to 240m Above Sea Level (ASL). Areas of lower relief are generally vegetated by open secondary forest of various ages and agricultural land. Agriculture in the area consists mainly of cocoa farms with lesser subsistence farming. There are no Communities within the boundary of the active Project area, however, a number of small settlements (cocoa farming hamlets) within areas designated for pits. It should be pointed out that the Project Area is not located within or near a location with significant tourism potential or within a forest reserve.

### **4.4.2 Methodology**

This visual impact survey is based on the concept of assessment of visual impacts from identified critical viewpoints which will be limited to the communities of Ayanfuri (Northern edge) identified.

### **4.4.3 Sources of Visual Impact**

The potential sources of undesirable visual intrusion associated with the development and operation of the Project were identified as the rock waste dumps, pits, haul and access roads, highway crossing and presence of equipment.

### **4.4.4 Assessment Results**

The development and implementation of the Project facilities will result in modification of the site configuration through the creation of artificial lines (holes for the pits, mounds of 25m to 70m (Fetish) height for the waste rock dumps, etc.). Because of the natural topography of the area and the proposed location of the various mine facilities, the Project will have very limited visual impact on communities around the Project area.

Ayanfuri has been identified as potential critical viewpoints. The footprint base of the final waste rock dump will be approximately 250 m from the Community boundary. The dump at the Fetish will have a maximum height of 25 m. This waste rock dump has been specifically designed to provide a degree of noise and light attenuation between the Communities and mining activity.

The southern edges of the waste rock dump east of Esuajah North pit will be visible from the northern limit of Ayanfuri. The waste rock dump height will be 35m high.

This impact category can be classified as very localised and will require implementation of specific mitigation measures.

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## **4.5 Evaluation of Impact on the Atmospheric Environment**

### **4.5.1 Airborne Particulate**

#### **Definitions**

The quality of the ambient air can be seriously affected by an increase in airborne particulate. This type of pollutant is generated from various sources generally classified in two categories:

- easily defined sources such as crushing, screening, conveyors, machinery etc.; and
- dispersed sources such as blasting, hauling, dust blow from working area and stockpiles, etc.

These are, respectively, point and non-point sources.

#### **Evaluation during the Construction Phase**

The potential sources of airborne dust associated with the construction phases of the Project are:

- Vehicle movement from delivery of construction equipment and materials to the main Project facilities area along the upgraded portion of public road that is part of the proposed new access road to the site;
- Site clearance of areas required for Project development as discussed under 4.4.2;
- Vehicles movement on the Project site roads.

Considering the prevailing wind conditions in this part of Ghana (less than 6 m/s), dust generated in the atmosphere is expected to settle rapidly and to travel only a few metres (20 to 50 m) from the source. Therefore, dust from clearing activities may affect the health of the workers and dust generated from vehicle movements on roads can reduce visibility for the road users, and affect nearby vegetation by reducing photosynthesis of leaves that become covered with dust.

Users of the road from Ayanfuri to Nkonya and also Ayanfuri to Gyaman are the most likely to be impacted by dust during construction activities. However, this will partly be alleviated considering the reasonable distances to the main Ayanfuri to Bogoso highway.

This impact category can be classified as short term, localised and reversible and will require mitigation measures.

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## Evaluation during the Operational Phase

### Potential Sources of Impact

The potential sources of airborne dust associated with the operational phase of the Project will involve the following activities:

- Open pit development blasting and grade-control drilling;
- Excavation, loading and haulage of ore and waste;
- Vehicle movement;
- Dust blow from excavated or cleared areas, *etc*; and
- Fine particles (PM10) generated from the combustion of diesel engines.

For the purpose of this assessment, source emissions have been classified into point sources and non-point sources of dust.

### Assessment of Impact

#### Point Sources of Dust

Concentration of fine particles generated by diesel fuelled engine exhausts at the mining pit area should be within acceptable limits as all equipment to be used by PMGL and Mining Contractor will be typical for this type of mining operation and comply with international standards (e.g.: The WHO/WB quote a maximum 24 hour average of 150 µg/m<sup>3</sup>). Mitigation measures will be required.

Ore mined from Fetish and Esuajah North will be transported to the main Plant site at Abenabena which is situated approximately 3.8 km away.

#### Non Point Sources of Dust

Fugitive dust from non-point sources is governed by two major climatic factors, wind speed and material moisture content. Based on the average number of rainy days per year recorded at Dunkwa-on-Offin it is estimated that site conditions will be wet between approximately 25 and 44 % of the year (number of rainy days per year range from 87 to 156). Such conditions will assist in damping down airborne particulate. At other times dust emissions could be significant, particularly during the driest months of the year from December to March where they will reach a maximum due to the contribution of Harmattan dust. The particle size distribution of this Harmattan dust has been reported by Orange and Al (1993) as 6.5% less than 2 µm, 91% between 2 and 50 µm and 2.5% more than 50 µm.

The principal non-point sources of airborne particulate will be:

- dust arising from blasting activities,
- fly rock generation,
- Movement of vehicles on Project roads and
- Fine particles (PM10) generated from diesel engines of haul trucks and other vehicles.

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Other potential sources such as dust blow from the waste dumps can be considered as negligible. Indeed, wind speeds expected in the region are generally very low except just before a storm event.

Dust from blasting is the source which so far appears to defy total control. Traditionally, the only practical control was to blast only when climatic conditions preclude the spread of dust to particularly sensitive locations.

Fly rock arising from blasting can have a major impact on local and plant areas unless careful blasting measures are in place. Mitigation measures will be required.

In the context of the Project, dust from blasting should not be a major problem as all settlements which have not been resettled are outside the 500 m blast zone. These distances must be treated with caution as they are measured from designated Community boundaries and do not necessarily mean that there are populated areas at those points. Similarly, low values for wind speed and the high topography of the site should all contribute to limit conditions in which dust can be dispersed in the environment.

On haul roads, dust could arise from spillage from trucks and abrasion by their wheels. The entire major mine haul roads and access roads will be located well away from human settlements. Minor nuisance dust generation may be expected where haul roads cross public roads – the haul road from Esuajah North pit and that from the Fetish pit as per existing level crossing around Ayanfuri used during previous mining activities.

Based on observations made within several mining operations in West Africa and Ghana, this impact can be classified as locally significant, intermittent and reversible. Appropriate mitigation measures will be required.

#### **4.5.2 Gaseous Emissions**

##### **Potential Sources of Impact**

No noxious gases will be generated from the operation of the mine in general. The ore is not refractory and, therefore, will not require any oxidation step such as roasting which can produce toxic fumes containing sulphur dioxide and/or arsenic when present in the mineralisation.

Potential sources of gaseous emissions resulting from the operation of the Project will be limited to diesel engine fumes from vehicles, carbon regeneration kiln, and the wet laboratory and stand-by generators when used during power supply failures.

It must be noted that, blasting fumes (containing low quantities of nitrous oxide and carbon monoxide) will be generated in quantities, which are generally neither detectable nor measurable at the pit limits.

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## Assessment of Impact

### Gaseous Emissions from Diesel Engines

Besides carbon dioxide (CO<sub>2</sub>), the main gaseous substances resulting from diesel engine combustion are sulphur oxides (SO<sub>x</sub>), nitrous oxides (NO<sub>x</sub>) and carbon monoxide (CO).

Concentration of fine particles generated by diesel fuelled engine exhausts should be within acceptable limits as all equipment used by PMGL is typical for this type of mining operation and comply with international standards. The volume of particles produced will be rapidly dispersed and any effect of deposition is considered negligible. Mitigation measure will, nevertheless, be required.

## 4.6 Noise and Vibrations

### 4.6.1 Definitions

Noise is normally defined as objectionable or unwanted sound which is produced by a source causing vibrations (air over pressure) in the medium surrounding it. It is usual to segregate noise problems into physical, physiological and psychological effects.

### 4.6.2 Potential Sources of Impact

Project operations will increase the general level of noise and vibration within the vicinity of its operations. Both mining and processing activities will generate noise and vibrations which can be classified as follows:

- Continuous or semi-continuous noise as a result of processing activities (mill, compressors, pumps, etc.) and vehicles (mainly heavy vehicles for mining activities and ore transportation). Vibration associated with these sources are generally low and localised; and
- Intermittent noise (air over pressure) and vibration resulting from blasting of the pits.

The recipient media will be mainly the Project workers, hamlets and nearby communities.

### 4.6.3 Assessment of Impact during the Construction Phase

During the construction phase, noise will be generated from an increase in road traffic along the proposed access road and the operation of heavy equipment used for the preparation of the various Project sites (starter pits, waste dumps, water storage facility and mine service area).

None of the communities will be affected by construction noise at the Fetish, Bokitiso and Esuajah North as Ayanfuri is 1.0km, respectively from the operations. The resettlement programme planned will ensure that there are no recipients within the immediate vicinity of major facilities construction.

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Users of the Ayanfuri – Bogoso Highway will be subject to intermittent noise from heavy traffic. This impact is considered low and irreversible.

Ayanfuri Community limit will be 320m from Esujah North pit at beginning of mining activities. Ayanfuri Community limit will be >380m from the Fetish pit at start-up of operations.

This impact category can be classified as short term, localised and reversible, but will require implementation of specific mitigation measures as part of the overall strategy to minimise the effect of noise.

#### **4.6.4 Assessment of Impact during the Operation Phase**

##### **Continuous or Semi-continuous Noise**

Semi-continuous noise will result from the operation of heavy vehicles for mining activities, transportation of the ore to the proposed treatment plant and processing activities at the plant site. Vibration associated with these sources is low and localised.

The relative remoteness of the haul roads and the plant site from communities that will remain in the Project Area after hamlets relocation and the existing vegetation cover indicates that noise and vibration will not be a significant issue. This impact can be considered as low and reversible.

Impact on fauna will also include species (particularly birds and small terrestrial mammals) which may leave temporarily, or permanently, the active Project area. In West Africa, there is no extensive data regarding animal behaviour in relation to noise level. However, investigations elsewhere have shown that response and adaptation is species dependent. Birds and small mammals can adapt to an increase in noise level providing their habitat is not destroyed, heavily fragmented or subject to high human intrusion.

### **4.7 Evaluation of Impact on the Aquatic Environment**

#### **4.7.1 Surface Water**

##### **Introduction**

The majority of streams in the Eastern Pits area eventually drain into the Offin River via the Subin. The Chirawewa pit complex area is drained by the Kyriawewa and Meretwe streams that form part of the Mansi River catchment of the Ankobra River. The main tributaries of the Subin River are the Aponapon, Bowodinawu, Asuaa, Danyami and the Nsanka streams.

The streams and rivers draining the Eastern Pits area receive flow contributions, which originate from an area where the deposits are located. Therefore, the main mining area is comprised of headwaters for these tributaries. The exception would be any drainage originating from the Fetish Main waste dump.

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Within the Project area, these water bodies have metal concentration within prescribed limits for potable water. Typically though, total suspended solids can be higher than acceptable limits: bacteriological limits are commonly above prescribed levels for drinking water. Some streams are used for drinking water and other purposes (Chapter 3) mainly during the rainy season. These streams are very seasonal, and dry completely except during exceptionally wet years. The five (5) main Communities, however, have boreholes to provide an alternative source of drinking water.

**Identification of Major Impact Categories**

Without adequate safeguards and management, the possible impacts of the Project on the surface water regime would include:

- Modification of stream hydrology through alteration, erosion and siltation giving rise to the more frequent occurrence of extreme events within the catchment area;
- Possible deterioration in surface water quality with particular respect to pH, suspended solids, cyanide, heavy metals and oil and grease.

Such modifications may have consequences for the ecological surface water environment and could affect downstream users, particularly those who are dependent upon streams for their source of drinking and domestic water because of distance from boreholes.

**Potential Sources of Impact**

Potential sources of impact on the surface water environment associated with the development and operation of the Project are:

**During the Construction Phase:**

- Site preparation and land clearance activities of the various Project sites, may result in an increase of suspended solids in the streams; and
- The potential deterioration of the quality of surface waters due to the accidental oil spillages from drums or heavy vehicle.

**During the Operational Phase:**

- Impoundment of raw water for Project supply requirements,
- Footprint of Project facilities resulting in local modification of the topography and hence catchment characteristics,

(It should be noted that water from pit dewatering will be returned to the FTSF thus avoiding any impact from suspended solids).

- Accidental discharge of process effluent,
- Runoff from the waste dumps and other Project facilities,
- Leaching of waste rock,

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- Sewage disposal,
- Accidental oil spillages from the various workshops or heavy vehicles,
- Effluent discharges from oil/water separators.

The recipient media will be the tributaries of the Subin, and Kyiriawewa and Meretwe streams of the Mansi sub-catchment ((Ankobra). All these sources of impact (generally related to a particular activity) may have an influence on either water hydrology and/or quality. This is discussed in detail in the following paragraph where each impact is related to a potential recipient.

For average climatic conditions, and based on FTSF performance the water balance will be positive for the first six years. Years 7-10 will have a water deficit. This water will be pumped from, Fetish, Esuajah North, Chirawewa, Bokitiso and from other surface sources on the leases.

**Assessment of Impact during Construction Phase**

**Impact on Stream Users**

Site preparation activities of the various Project sites (starter pits, waste dumps, , water storage facility, and mine service area) will involve land clearance which may induce erosion and potentially increase the level of suspended solids in some of the streams of the Project Area identified as follows:

- The Subin may be affected by clearing and development activities of the Fetish pit, with consequent impacts on Communities from Ayanfuri who use these streams for domestic purposes (but not usually) for drinking water as this is obtained from boreholes.
- The Subin, one of its tributaries, the Asuaa, and a small unnamed tributary may be affected by clearing activities for Esuajah North pit and waste dump.

Site starter preparation activities will be undertaken mainly during the dry season and therefore, major impact on the surface water environment is not expected in general. During the construction phase, some minor suspended solids pollution may not be totally avoidable. Mitigation measures will be required to ensure that these temporary and reversible impacts are kept to a minimum and mitigated.

**Impact on Hamlets**

Many of the cocoa farming hamlets located within the Eastern Pits Area rely on the Subin and the chirawewa and its small unnamed tributaries. Due to the seasonal character of most of these streams, the hamlets have to obtain water from more than one source. Those with a single stream water source still manage to obtain water through dugouts in the stream bed during the dry season or walk up to 1 km to have access to a well or borehole.

**Accidental hydrocarbon spillages**

Probability for accidental oil spillages to occur will be relatively low but should not be ignored. These spillages may result from drums stored in inappropriate conditions or from heavy vehicles during breakdowns.

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**Assessment of Impact on the Site Hydrology during Operational Phase**

**General**

Several activities, listed below, may have an influence on the site hydrology:

- Impoundment of raw water for Project supply requirements,
- Footprint of Project facilities resulting in local modification of the topography and hence catchment characteristics of the water bodies, and
- Discharge of mine water from pit dewatering.

**Impoundment of Raw Water**

The primary source of raw water will be the catchment area in which the FTSF is located. Its purpose is to provide a secure source of raw water supply required for processing operations during both the start-up period and subsequently to compensate for the shortfall in process water between recycled water (from tailings decant) and plant requirements.

**Impact on the Offin River Hydrology**

The total catchment area of the FTSF has been estimated at less than 500 ha (see catchment boundary within the Offin Catchment of 8,344 km<sup>2</sup>). Thus <0.1% of the Offin catchment area will be effected by the Project during operations.

**Changes in the Topography**

The development and operation of PMGL will result in the direct utilisation of a few small sub-catchment areas of the Offin River and the Ankobra River.. These are described as follows:

- The Project facilities will result in the direct utilisation of approximately 6.2% (or 8.4 km<sup>2</sup>) of the Subin.
- The utilisation of the Subin sub-catchment will represent 1% of the Offin River catchment area.
- The utilisation of Fetish waste dump area (if the fact that this will largely be the backfilling of an existing pit is ignored) will result in the direct utilisation of approximately 105 ha of the Mansi sub-basin of the Ankobra River and is therefore insignificant.

Changes in topography resulting from development of Project facilities would have an effect on the catchment characteristics of the sub-catchment areas listed above. Overland runoff could be faster as a result of removal of vegetation for land development. Consequently, the surface water flow regime in the area may be changed.

From a hydrological point of view, only the impact on the individual tributaries of the Subin could be locally appreciable as the upper parts of their catchment will be modified. This impact must be placed in the existing local context (seasonal flow, small size of sub-catchment, no commercial uses of the water, etc.) and it is unlikely that any changes will be measured on the Offin River or the Ankobra River downstream of the Project Area. Nevertheless, mitigation measures and monitoring will be required to

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minimise any adverse impact and to verify effectiveness of mitigation methods included as part of the design and management of the Project to preserve the water resources of the area.

**Mine Effluent**

Expected groundwater inflows to the pits will be generally less than 10% of the total dewatering requirements. The major contributor will be direct precipitation. Dewatering requirements to avoid flooding of the pits are considered to be relatively small. Perimeter drains will be established at each pit to prevent the inflow of rainwater. Pit rims will be bunded to protect against inflow in the event of high rainfall events.

**Assessment of Impact on Surface Water Quality during Operational Phase**

**General**

A certain number of activities listed (Potential Sources of Impact) may have some influence on the quality of the surface water environment mainly during the rainy season. Those changes could affect some parameters such as pH, turbidity, colour, suspended solids, cyanide, heavy metals and oil and grease. Only accidental spillages may be responsible for a pollution of the aquatic environment.

**Accidental Discharge of Process Effluent**

Two tailings streams will be discharged from the Process Plant – flotation tailings and CIL tailings. The former stream will not contain cyanide or elevated metals concentrations and are considered benign. Tailings from the CIL stream will be discharged at relatively high cyanide concentrations and consequently to minimise any seepage, will be HPDE lined. Discharges of water containing non-acceptable concentrations of cyanide will be prevented by operating all gold extraction and processing operations on 100% water/chemical solutions recycle system. It must be emphasized the operations of the two Tailings Storage Facilities are not located within the Eastern Pits Project.

**Runoff from the Waste Rock Dumps and Other Project Facilities**

Another consequence of overland runoff from the waste rock dumps and other Project facilities is the transport of earth particulate during heavy rains into water bodies, resulting in siltation and increase of suspended solids.

**Leaching of Waste Rock Dumps and Potential of Acid Mine Drainage**

Acid drainage arises from rapid oxidation of certain type of sulphide minerals, and often occurs where such minerals are exposed to air and water. This phenomenon is often accompanied with leaching of heavy metals contained in the rock material. The environmental consequences of acid drainage can be substantial, but prevention measures are available. Seventy-nine (79) rock samples representing granite and sediment hosted ore and waste from the Fetish, Bokitiso, Charawewa and Esuajah North were selected for ARD analysis by site geology staff.

Based on the review of the sulphur species concentrations, carbonate values, the AP, NP and net NP values and the NP/AP ratios only one sample (sediment hosted ore at AF- GAP) was classified as having a strong ARD potential; four samples were classified as medium ARD potential (three at AF-GAP, two ore

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and one waste and one at Fobinso, waste); and two samples as low AGP potential. All others samples were classified as “ uncertain/possible AGP or NP – 12 samples”, “low NP-18 samples”, “medium NP – samples 14” and “strong NP- 26 samples).

The main conclusions of the geochemical characterisation of the waste rock from the Project were summarised as follows:

- The greater majority of the ore and waste rock samples have been classified as Non-Acid Forming.
- Only one sample of ore was classified as strongly acid forming.
- All the waste rock samples had a low sulphide content ranging from 0 to < 0.5%, resulting in low Maximum Potential Acidity values.

**Sewage Disposal**

Sewage from the operation has the potential of polluting both surface and ground water which will greatly impact on the health of other stakeholders and the downstream users. Coliform loads might be increased and also might aid in the spread of diseases like cholera

**Oil and Grease Spillages**

Oil or grease can be accidentally introduced into the environment following a mechanical breakdown of mining equipment or from workshop areas. Oil and grease spillages in the field or on bare ground around workshops have the potential to contaminate soil. Rainfall can cause erosion and runoff into nearby streams with consequent impacts. Under normal circumstances, groundwater pollution is unlikely given the degree of compaction of lateritic soil that occurs in these working areas from previous construction and operational activities.

**4.7.2 Groundwater**

**Introduction**

In the Project area, due to the heterogeneity of the aquifers and their dependence on secondary permeability, such as fractures and quartz veins among others, flow of groundwater within aquifers occurs predominantly in the fractures and other discontinuities rather than as interstitial flow. There are many barriers to continuous groundwater flow laterally as well as with depth. The rock types are varied and as such, weather to different depths. The nature and degree of weathering also varies spatially. Similarly, unfractured rocks are very common giving credence to lateral barriers to groundwater flow.

**Potential Sources of Impact**

Potential sources of impact on groundwater resources are associated with the following Project activities:

- Exploitation of groundwater resources for Project supply requirements;

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- Dewatering of the open pits; and
- Seepages from Project facilities resulting in the introduction of pollutants into the aquifers.

**Exploitation of Groundwater Resources**

There will be limitation in the exploitation of groundwater resources. The water contained in the pits will be pumped to the Flotation Storage Tailings Facility (FTSF) Area 3E for storage which will then be pumped to the process water pond to be used at the process plant. The Senior Staff residential camp utilises boreholes for potable water abstraction and this has the potential or draw down effect on groundwater supply in the area.

**Pit Dewatering**

Dewatering of the open pits is likely to have some effect on groundwater recharge rates on lands close to the project areas. Localised lowering of the groundwater level can be expected within 200 m. The existing hydraulic relationship between recharge and discharge can be disturbed and could affect the quality of the groundwater as increased pumping induces rapid flow and thereby reduces the recharge time of groundwater.

These typical and localised impacts of open pit mining cannot be avoided.

**Potential Impact from Seepage**

Potential for acid mine drainage of both ore and waste rock material indicates the potential seepage from these facilities which will have a negative impact on groundwater resources of the Project area. Seepage of leachates into ground water system will affect the pH and dissolved metals.

**4.8 Impact on the Ecological Environment**

**4.8.1 Introduction**

The Project area lies within the tropical rain forest zone of the country and the vegetation has been classified by Hall and Swaine (1981) as a Moist Semi-Deciduous forest of the Northwest sub-type. The Eastern Pits area was an active mining site between 1994 and 2001, thus the current vegetation in the area has been severely disturbed and bears very little structural resemblance, if any, to the original primary forest classified by Taylor (1952) as belonging to the Celtis-Triplochiton Association.

Although commercial mining has been a destructive force of the forest vegetation, agriculture, particularly food and cash crop farming, has and continues to be another major land use system in the area. Food crops such as plantain and cassava and cash crops, mainly cocoa and oil palm are prevalent in the area. At present, there is no evidence of commercial logging activities but it may be assumed that parts of the Project area must have been logged sometime in the past. This assumption is based on the

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type of left-over primary forest tree species identified in the area. However, logging with chainsaws by the local people is still evident in the area.

#### **4.8.2 Potential Sources of Impact**

Mining projects, like many other industrial and agricultural developments will effect some changes on the ecological environment of an area which may result in modifications of the local species composition. Impact of the Project on the ecological environment can have the following origins:

- Localisation and distribution of Project facilities, which may result in the destruction of ecologically important areas and/or disrupt migratory movements of particular fauna species; and
- Development and operational activities, which generate nuisances (noise, dust, etc.) having a potential to effect certain species.

Past and current anthropogenic activities have resulted in the severe disturbance of local types of plant communities and no areas of conservation importance exist in the immediate Project area and its surrounds. Similarly, such activities have reduced or eliminated habitats suitable for large mammals and to a considerable extent for smaller mammals and reptiles. Only bird fauna has retained a semblance of species richness.

None of the Project facilities impact on closed forest. The greater majority of the major facilities are located in areas characterised by Isolated/Treeless, Mixed Bush and Isolated Trees and Moderately Open Forest (<60 %). Development and operational activities that generate nuisances are therefore considered to have only minor impact on flora and fauna in the Project area. Nevertheless, mitigation measures will be required to minimise noise and dust generation.

Activities contributing to the loss of fauna include:

- Site preparation activities such as surface earthworks and stripping of vegetation and topsoil for the creation of project infrastructure – extension of pits, waste dumps, and haul roads. Increase in noise, lights, traffic and general disturbance to area of influence
- Increase in demand for ‘bush meat’ as a result of influx of construction workers and increase in general development in area as a result of increased economic activity

#### **4.8.3 Assessment of Impact on Flora**

Development of mining and associated operational facilities will not result in the destruction of any ecologically important areas of vegetation or sensitive habitat. The vegetation generally, is very disturbed and modified. Indigenous vegetation is scrappy characterised by relic patches of degraded secondary forest, thicket re-growths and fallow farm bush with high preponderance of pioneer species. Weedy growth of ubiquitous herbs and grasses such as *Mimosa pudica*, *Sporobolus pyramidalis*, *Sida acuta*, *Imperata cylindrical*, *Stachytapheta cayenensis* and *Chromolaena odorata* are common feature of

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drill pads, borrowed soil excavations, haul roads and truck verges where the soil is stripped of its substrate.

Perennial *Raphia hookeri* swamps and Bamboo groves characteristic vegetation cover types noted in lowland areas

**4.8.4 Increased Demand on Flora Resources**

The development and operation of the Project will lead to an increase in local housing and small business construction activity as reflected by similar increases around other new large-scale mining projects in Ghana. There will be increased demand for building timber. There is also likely to be an increased demand for firewood due to the demands of an increased population.

The limited timber resources of the Project area and its area of influence will entail the importation of building timber from other localities near and far. The actual demand, and thus the level of impact on secondary forest areas, is almost impossible to quantify at this stage.

The increase in building construction activities will likely increase demand for bamboo poles for use as scaffolding and also on young timber for such use as well. An increased demand for firewood will increase pressure on an already limited woody plant resource

**4.8.5 Assessment of Impact on Fauna**

The terrestrial fauna survey of the Eastern Pt Area as a whole indicate that habitat disturbance resulting from earlier commercial and illegal mining activity, subsistence farming, logging and hunting pressures has all but destroyed good faunistic diversity, especially for the larger mammals one time found in the region.

Poor faunistic quality was emphasised by the fact that small terrestrial mammals were caught in only one site (Chirawewa pit). Although the presence of bats in the area was considered fairly good only two species of Ghana’s megachiropteran bats were caught. These were *Epomops* (*Epomops franqueti*) and *Epomorphorus* (*Epomorphorus gambianus*). They were caught at a rate of 1.4 mnn (mist net per night) for *Epomops franqueti* and 1.6 mnn for *Epomorphorus gambianus*. Concerning the few bats that were recorded in the concession it is interesting to note that they were caught in areas where there were native large trees. The presence, however, of *Afrixalus dorsalis* (Striped Spiny Reed Frog), a very sensitive species to pollution, in the concession is an indication that the study area did not face serious water pollution in the past but if not addressed in the proposed operation could lead to destruction of wildlife.

During the development phase, the proposed project poses impacts on terrestrial fauna within and close to the development footprint. Impacts on the fauna environment include a loss of habitat, an increase in general disturbance levels and hunting pressure.

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#### 4.8.6 Assessment of Impact of Dust on Flora

The effect that dust will have is determined by a number of variables, including:

- The concentration of dust particles in the ambient air and its associated deposition rates,
- Size distribution of dust particles,
- Vegetation characteristics such as the surface roughness and wetness of leaf surface can influence the rates of dust deposition, on vegetation, such as surface roughness and wetness,
- Meteorological and local microclimate conditions and degree of penetration of dust into vegetation,
- Dust chemistry - ranging from inert dust to highly alkaline dusts and acidic dusts.

Dust may have physical effects on plants such as blockage and damage to stomata, shading, abrasion of leaf surface or cuticle, and cumulative effects e.g. drought stress on already stressed species. The chemical effects of dust, either directly on the plant surface or on the soil, are likely to be more important than any physical effects.

The major source of dust that will have an impact on vegetation will be from traffic on Project haul roads, access roads and stockpile blow. Mitigation measures will be required.

### 4.9 Impact on Soils and Land use

#### 4.9.1 Introduction

##### General

The Project area is rural. Intensive farming activities for the production of both plantation and food crops and other human activities within this relatively well populated area have greatly influenced the nature of the soils resulting in nutrient depletion, soil erosion, iron pan formation and land degradation. The intensive farming activities for both plantation crops (mostly cocoa) and food crops (mostly plantain, cocoyam and maize) and forest degradation for slash and burn farming activities and other human activities have influenced the natural conditions of the soils and have resulted in nutrient depletion, soil erosion and land degradation in some parts of the Project area. The soils are acidic in reaction due to leaching of the bases as a result of intensive rainfall.

##### Soils

A detailed soil survey according to FAO 2006 guidelines for soil description was employed to identify and describe the soils of the project area at the series level. The soils belong to the Bekwai-Nzima/Oda compound association. On a typical topo-sequence, *Bekwai series* occupies the summit and upper slope sites followed by *zima series* on the upper to middle slopes, while *Kokofu series* follows on the middle to lower slope sites. The narrow valley bottoms are occupied by alluvial soils of *Oda*, *Kakum* and *Temang*

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*series*. Both *Bekwai* and *Nzima series* are developed in-situ whereas *Kokofu series* is a colluvial material from slope wash.

In general, the Project area has good agricultural soils that are suitable for a wide range of tree and arable crops. The well to moderately well drained soils of *Bekwai*, *Nzima* and *Kokofu series*, are extensively used for cocoa cultivation, even though, the results of the suitability evaluation showed that oil palm is highly suitable.

This shows the preference of farmers to cultivate cocoa rather than oil palm. The valley bottom soils were rated as suitable to moderately suitable for vegetables, rice and sugarcane.

The major agricultural land uses are cocoa farming, food crop farming, and bush fallow. The non-agricultural land uses include human settlements (towns, Communities and hamlets) and undeveloped inland valleys with swamp vegetation.

**Potential Sources of Impact on Soils**

The potential source of major impacts associated with the development and operation of the Project are:

- Land preparation and clearing during Project development and operation;  
Soil erosion from areas cleared but not subsequently revegetated; and
- Losses of soil forming material from embankments cut and fill areas on haul/access roads and topsoiled areas awaiting revegetation.

**Assessment of Impact**

Erosion occurs as a result of rapid water flow over a particular area. The loss of soil will be a function of the erosivity or intensity of the rainfall, the erodibility of the soil, the area of catchment, the length and gradient of the slope, the amount of vegetation cover and the erosion control measures undertaken. Soil erodibility depends on soil texture, structure and the degree to which soil particles disperse when in contact with water.

Land preparation associated with infrastructure development (mine offices and mine workshops) and operation of mining Projects will remove vegetation and topsoil. These operations will induce soil erosion, including subsoil erosion, and lead to degradation of soil structure, decreasing soil fertility and in the long term, agricultural production or the establishment of a vegetation cover. Another consequence of land clearing and erosion is the transport of soil during heavy rains into water bodies, resulting in siltation and increase of suspended solids.

In the absence of specific erosion control and management procedures Project development and operations will have a significant impact on loss of soils and soil-forming materials. Mitigation measures will be required during the construction and operational phases of the Project.

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**Land Use**

Both agricultural and non-agricultural land uses are found within the Project area. Agriculture is the predominant form of land use with the majority of people living in the area depending on farming for their livelihood and as the principal means of employment.

The major agricultural land uses can be divided as follows:

- Cocoa farming;
- Mixed food crops farming;
- Rice farming and fish pond in inland valleys;
- Bush fallows.

The non-agricultural land uses include:

- Human settlements (Communities and hamlets);
- Illegal mining activities;
- Undeveloped inland valleys;
- PMGL exploration areas; and
- Feeder roads and footpaths/tracks.

**4.9.2 Loss of Agricultural Land and Farm holdings**

**Potential Sources of Impact**

The potential source of major impacts associated with the development and operation of the Project is:

- Land take for Project facilities; and
- Resettlement of farmers and dwellers whose land is required for Project facilities.

**Quality of Agricultural Land**

The area of land required for Project development is approximately 1034.29 hectares including redevelopment land disturbed by earlier commercial mining operations. Though not all this land area is cultivated, agricultural land use largely dominates with majority of people depending on farming as the source of livelihood and the principal means of employment. The proliferation of hamlets in part of the Project Area is a clear indication of the economic importance of cocoa in the area. The importance of cocoa has attracted migrant farmers and motivated some indigenous farmers to establish cocoa farms. The soils in the greater PMGL Project area have been classified as from highly suitable to moderately suitable, depending upon the crop selected and the provision of inputs, particularly fertilizers.

Cocoa farming is by far the greatest farming activity as per the crop survey analysis shown in Table 4.3. The largest cocoa growing area occurs in the Fetish pit area

**Crop Survey Data**

PMGL has undertaken an intensive survey of farms and crops within and around the area potentially earmarked for Project facilities. The crop type and the percentage of cover are presented in Table 4.3

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**Table 4.3- Crop Survey Data**

Crop Type	% Cover
Cocoa	43.6%
Oil Palm (Agricultural)	18.0%
Plantain	9.0%
Pineapple	5.1%
Cassava	5.0%
Cocoyam	2.3%
Cedrella	1.7%
Rubber	1.3%
Coconut	1.2%
Orange	1.1%
Teak	0.9
Others	10.8%

#### Number of Residential houses

Surveys have identified 469 residential houses in the Project area. There will be a need to relocate these houses, providing relocation and crop compensation.

#### Impacts on Agricultural Land and Farms

The development of the PMGL Eastern Pits will have a high impact on agricultural land use and the hamlets, houses of farmers and individuals working in the areas that will include mostly the Ayanfuri communities. Not all hamlets and farmers would be directly affected but safety factors will necessitate their relocation and/or crop compensation.

Within the Project Area, approximately 1034.29 ha of agricultural land will be directly and indirectly affected. However, not all the land that will be required by project development is under cultivation or agricultural land. Within the context of the Districts of Wassa Amenfi East and Upper Denkyira West, the area of land that will be lost is considered to be significant.

#### 4.9.3 The Socio-Economic Environment

The present Project area falls with of two District administrative areas, Wassa Amenfi East and Upper Denkyira West. Both the Districts are almost entirely based on a “rural” cultural and economic way of life. The predominant economic activity in these areas is farming.

The main communities occurring within, or on the fringes of the Eastern Pits Project area are, Ayanfuri, Gyaaman and Nkonya. In addition to these Communities, there is a preponderance of scattered hamlets

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in the proposed active mining and operations area. A striking feature of the Project area is the paucity of modern socio-economic infrastructure (roads, health facilities, schools, water, etc).

The development and operation of the Project will, without doubt, have both positive and negative impacts on the socio-economic structure of the Project area and its environs, as well as impacts at district and national levels. It is considered, however, that the positive impacts will considerably outweigh the negative ones.

#### **4.9.4 Assessment of Positive Impacts**

##### **Introduction**

The positive impacts of the Project will relate mainly to the economic advantages which will have immediate and long term benefits on the sociological environment. This will be achieved in various ways at National, District and Local levels.

##### **National Considerations**

On a national basis, the Project will have positive impact through the direct payment of royalties and taxes related to gold production and Company profits respectively; indirectly through income taxes on the increase in direct and indirect employment; increased incomes and profits of local businesses and major suppliers, the purchase of goods and services manufactured and supplied in Ghana.

Based on the magnitude and far reaching implications, the impact of the Project on the national economy is considered positive.

##### **District and Local Considerations**

On a District and local basis the Project should have a positive impact. Some of the ways these impacts are envisaged are:

- Improvement of road structures within and around the project area.
- Establishment of new water sources and renovation of existing sources (boreholes and pipes).
- Assistance in improving health and sanitation facilities in Communities.
- Contribution to education facilities and teachers and students development.
- Training and employment of local youth for the Project.
- Training in specific skills and business assistance to women groups in the Communities.
- Assistance to handicapped or disadvantaged children.

The types of positive impacts to select as priority for development are based on the needs analysis of the communities. Selection would consider the wishes of the local Communities which will be expressed through their representatives on the Project Consultative Committee and the setup of the Community Development Fund by PMGL. Several public meetings have been held at each of the five communities (Abnabna, Ayanfuri, Fobinso, Gyaaman and Nkonya).

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**Based on the positive contribution to local infrastructure, the impact of the Project is considered positively significant.**

**PMGL Assistance to Local Communities**

During the exploration phase of the Project, PMGL has already actively assisted local communities in the Project area. Assistance in excess of USD 50,000 has been provided in the form of

- Renovation of existing water sources (Ayanfuri).
- Financial assistance to Ayanfuri Community for the development of its piped water scheme.
- Improvements to school buildings at Nkonya.
- Improved multi-user water borehole at Gyaaman

The Wassa Amenfie was consulted with respect to building requirements for new schools in the Project area. A suitable land has been acquired at Ayanfuri for construction of new educational facilities. The contribution of PMGL to the development of the Ayanfuri piped water supply has been recently acknowledged. PMGL is aware that it has a general responsibility to contribute to socio-economic infrastructure in the communities of the immediate area in which it will be operating. This responsibility will be undertaken in consultation with local communities and the two district administrations. PMGL may however not be able to meet all requests for assistance from the local communities. Assistance will have to be tailored and budgeted according to the economic realities of mine operations and revenue received.

Based on the positive contribution to local infrastructure, the impact of the Project is considered positively significant.

**Employment for Mining Operation**

The number of employees employed directly by PMGL stands at 342 and is expected to rise during the construction phase. Contractors will be employed for mining, drilling, security, vehicle and house maintenance, bus service and catering. Although the number of contractor employees has not been fully determined yet, it is expected that PMGL employees will exceed 50 persons. Construction activities will also have a positive effect on employment as more than 50 people will be employed to fulfil this task over a period of 12 months.

Construction contractors will be required to source employees locally to the maximum extent possible and provide training. The maximisation of local labour resources and skills will have long term benefits which will strengthen community relations and ultimately provide a stable work force and work environment.

There shall be indirect jobs created to service the new mine as well as to satisfy the needs of the various employees. The normal job creation multiplier for local service industries in the gold mining industry is in the range of 3 to 6 for each direct employee. Whether or not, this multiplier range will be achieved in the Project area will be assessed in due course. However, it should be noted that the area currently has very little support services industries, hence a high potential for new developments.

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### Training of Employees

Given the location of the Project, it is intended that the operations will be self-sufficient in as many areas as possible. To the maximum degree possible personnel will be sourced from within Ghana. Given that the area is a rural one and relatively isolated, there is a consequential shortage of industrial skilled workers in the area. The Company will undoubtedly have to source a number of workers with the required skills from other areas in Ghana. It also recognises, however, that bringing in such workers can be socially disruptive, both from an economic and cultural aspect.

PMGL proposes to continue to develop the local community and promote local employment through educational and career-based training programmes. These programmes have been adopted in other mining operations and have been found to provide various positive impacts listed as follows.

- Provides stable long term employees;
- Maximises local resource usage;
- Provides training and indirect communication with the local communities;
- Increases the skills in the local area;
- Reduces migration and thus disruption to the existing authority structure;
- Builds a base for trust within the local communities; and
- Minimises pressure on local housing, educational and medical services.

PMGL conducted a census survey of the three (3) main communities (Ayanfuri, Gyaaman and Nkonya) within or on the fringes of its Project area. These surveys have provided useful information on the nature and demographic status of the communities. This information will be used to assist in the continuing development of the PMGL Public Consultation and Economic Development Plan.

Based on the positive contribution to the development of employment skills the impact of the Project is considered positively significant.

#### 4.9.5 Assessment of Negative Impacts

The Project is not considered to have any negative impact at a National or District level. It is considered to have negative impacts at a Local level only. The general categories in which negative impacts will occur are:

- Project Impacted on highways (Ayanfuri-Bogoso and Ayanfuri-Diaso).
- Project Impacted Land.
- Project-Impacted Households.
- Project-Impacted Structures.
- Project-Impacted Public Facilities.
- Project-Impacted Businesses.
- Project Impact on Livelihood
- Project Impact (Indirectly) on social structure within communities.
- Project Impact on Water Resources

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**Project Impacted Land**

The Project Footprint includes open pits, waste rock dumps, contractor’s yard, haul roads, and other support facilities. The total land take of these facilities is approximately 1034.29 ha. The total includes land area disturbed by the previous mining, waste dump disposal activities of Cluff Resources and Ashanti Goldfields Corporation and all households, business within 500 radius of the three pits The total land take will be required for life-of-mine.

The development of the Fetish Pits, Bokitiso, Chirawewa and Esuajah North and its related waste dumps will variously impact on moderately open forest (<60 forest - > 30% tree crops), isolated treeless arable land, moderately open for tree crops land and mixed bush and thickets. Oil palm lands are also present at parts of the Project area.

**Project Impacted Households**

Sections of the Ayanfuri household will be physically affected by the Project development. The Project impacted households are those of the 469 residences located in the immediate Project area. In brief, these were observed to be in areas that falls within the 500m blast zone radius and which possess a potential safety hazard. These houses are generally owned by people who have developed a place of abode and also businesses in the area. Most of the inhabitants are the indigenous people.

Approximately 817 Residents Affected Households including tenant’s households are believed to be affected by the Project.

PMGL in consultation with the Resettlement Compensation Negotiation Committee (RCNC) have agreed to resettle all the impacted occupied households to a new site of 216.71 acres of land which has been acquired opposite Ayanfuri Senior High School. PMGL is yet to evaluate tenders submitted by various contractors for the construction of resettlement houses.

To ensure that the relocation and resettlement procedure is transparent and understood by all the stakeholders, PMGL has developed a detailed policy which outlines the established management procedures and practices for the resettlement process and will proceed through the Resettlement Compensation Negotiation Committee. The Committee will be chaired by an independent person and include representatives of all local stakeholders. It must be recognised that relocation/resettlement is a very complex issue as it is likely to affect the socio-cultural patterns, economic stability and the trajectory of local cultural life and history of the area and, therefore, must be planned with all these variables in mind.

The aspects of this resettlement, and relocation, process are discussed in Chapter 5.0: Mitigation Measures.

**Project Impacted Structures**

Total of 2,080 structures including houses which vary considerably in number of completed (occupied and not occupied), uncompleted and annexes (separate kitchen, bathrooms and toilets) structures are

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present. The total number of occupied structures is approximately 469, the number of uncompleted structures is 417 and the number of annexes is 1,194.

There is no identified shrine in the Project area that will require relocation.

There are no burial places in the Project area that require relocation due to Project activities.

### **Project Impacted Public Facilities**

Public facilities in the project area which will be impacted include schools, churches, market and public roads which include the Bogoso to Ayanfuri highway.

The impacted schools and the churches will be relocated. The open market and the lorry station will also be moved. Re alignment designs have been sent to the Ghana Highway Authority for consideration in a request has been made for temporary access during blasting along Begoso-Ayanfuri highway.

### **Project Impacted Businesses**

Businesses such as mechanical workshops, convenient stores, tailoring shops and hardware shops within the Project area that will be affected will also be moved for safety considerations if they lie in the 500m blast zone radius.

### **Project Impact (Indirectly) on Social Structure**

In Ghana, all people have total freedom of movement within the country. Consequently, there is no means to prevent or control the influx of people into towns and Communities of the Project area. This area, as previously noted has farming based rural economy. A significant influx of people into the area looking for employment in the Company or expanding local businesses and services would result in undesirable social and economic pressures. These could include inflation of local food and accommodation costs with a converse reduction of availability, a heavy additional burden on the community water resources, sanitation and garbage management, healthcare resources and policing along with unwelcome social problems like prostitution, crime and drunkenness.

PMGL is aware that it has a social obligation to assist government and traditional authorities in preventing too much disruption from the influx of people. It can assist by developing local training initiatives that enable local residents to be able to compete for, and acquire the skilled jobs available at start-up (see section 4.11.3.7).

Prior to, and during operations, PMGL will hold periodic information meetings with official and traditional authorities who will be the key to controlling the impacts of the influx of people. The main objective of these meetings will be to inform on the potential level of employment as a measure to control influx by reducing the level of expectation of those arriving in search of a job.

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**Project Impact on Livelihood**

**Employment**

Project impact on the livelihood of the area communities will take several forms. The employment opportunities offered during construction and then during operations will be financially beneficial to the communities. Employment opportunities will be greatest during the construction period, especially for the unskilled and semi-skilled males and females. Such employment offers i) wage earning opportunities for a period of time and ii) an opportunity to upgrade skills that could be required by PMGL, e.g. electricians, carpenters, mechanics and heavy equipment operators.

There shall also be employment opportunities with local and national service companies engaged on the Project by contractors and PMGL e.g. in the areas of camp services, cleaning and security. PMGL is committed to the employment of local people as much as possible. An employment procedure has been developed in the partnership agreement to ensure this.

**Loss of farms**

The loss of the farms in the Project area will affect two groups of farmers, the indigenous farmers and the settler farmers. The indigenous farmers will be able to approach the Chiefs of the Communities for alternate farmlands if that is their wish. The extent of available farmland is, however, not known. The farmers will also have opportunities for low skilled employment with the Construction contractor and later with PMGL. Those with aptitude for retraining will be given opportunities for such. It may well be thought that most opportunities will occur with the younger farmers and the older farmers may have to stay with relatively unskilled work e.g. such as security guards and gatekeepers.

PMGL has proposed a resettlement package that will include the building of a new sandcrete house to replace their existing dwelling and a rental allowance for 12 months or longer if the new house is not completed in that time. Several affected farmers in the Fetish pit area have been given the rental allowance of 12 months pending the final resettlement arrangement.

**Sustainable Livelihood Programmes**

The diversification of non-farm income generating activities as well as agriculture growth among other farmers in the area to meet the demands of an increased population are necessary to ensure food security, especially of the vulnerable relocated or resettled populations, and is critical to the enhancement of rural livelihoods and community security. Unless there are rapid improvements in agricultural productivity as well as alternative livelihood creation those farmers displaced by the Project could remain vulnerable and impoverished.

PMGL has already begun to organize women and youth groups in the affected area with the intent to diversify and increase their income. A number of income-generating activities, training to provide vocational and technical skills training (for example in masonry, carpentry, plumbing, electricals) training in small and medium-sized enterprise creation and expansion to encourage development of viable businesses are under consideration.

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Opportunities to work with local and international NGO’s in the development of local skills and services will be explored by the company

It must be recognised that the development of alternative livelihoods is not an instant process. It has to take into account the willingness of the local community, skill levels, and aptitude to develop new opportunities. Some will succeed, others will not. Nevertheless, the planned life-of-mine (10 years) offers a time frame within which some alternative livelihood can be developed to replace the livelihood opportunities for local people offered by Project development.

**Project Impact on Water Resources**

The existing drinking and domestic water supply resources of some settlements in the immediate vicinity of, or downstream, of the various facilities may be affected by development and subsequent operations. Some communities such as Ayanfuri may find that their current water supply resources will be inadequate to meet increases in demand resulting from the influx of new inhabitants. Table 4.4 presents the impact assessment on drinking and domestic water supplies of the main settlements in the active Project area.

The borehole water supply sources of Gyaaman, Nkonya and Nkotumso will not be affected by mining operation per se. They are too distant to be affected by any groundwater drawdown from mining. If there are to be impacts they are more likely to arise from increased demand from an increase in population due to the anticipated influx of workers and job seekers into the area. The borehole water supply sources of the Communities of Abnabna, Fobinso and Ayanfuri (includes Odumkrom) could be affected by increase in population for the same reasons. The PMGL project to facilitate water users in Gyaaman has found that a deepened or new well is required to provide a single point multi-user facility. Mitigation measures will be required to monitor borehole water supply status in this last group of Communities.

Surface water users in Gyaaman, Nkonya and Nkotumso will not be affected by mining operations. Some people of Ayanfuri community who use the Subin for domestic and construction purposes could be affected by mining activity (see section 4.8). In these cases alternative water supplies such as boreholes and hand dug wells are available but they may not be conveniently located for their domestic and construction activities. The number of boreholes and hand dug wells in each catchment community are provided in Table 4.4.

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**Table 4.4- Community Water Resources and Usage in the PMGL Project Area**

Community Name	No. of Boreholes and status	No. of Hand-dug wells with pump and status	Name of River water supply	Present uses of river water and surrounding environment
Nkonya	2 (1 non-functioning)	1 (has no hand pump)	-Asuafu -Amabri	-Wells in the river valleys - Drinking - House construction -Water management sacred grove.
Ayanfuri	6 (1 spoilt 8 years ago)	Several personal hand-dug wells	-Asua -Afuaworaa -Subin	-Block making -House construction
Gyaaman	3 (working)	Nil	-Beporso	-Drinking - Household chores -Bathing -House construction.

#### Impacts of Non-Mining Waste Generated

The development and operation of the Project will produce several types of solid waste such as household waste, waste oils, hazardous waste, etc.

The various type of waste identified are:

#### Household Waste:

This type of waste will be produced by administration and technical offices, the canteens and households living at the accommodation Community. The main items will be paper, office and domestic packaging and canteen waste. The impact of this waste is considered locally significant, low and short-term. Mitigation measures will be required.

#### Non-toxic Industrial Wastes:

This category of waste includes heavy and light equipment tyres, worn metallic parts and fittings and packaging material for non-toxic products (plastics containers, papers, wood, etc). Visual impact, sources of pest and disease infestation is the main impacts of this waste. The impact of this waste is considered locally significant, low and short-term. Mitigation measures will be required.

#### Waste oils:

Waste oils, oil filters and other small oil containers and grease will be produced at the plant and at the light and heavy vehicle workshop. Contamination of surface water and groundwater is possible. The impact of this waste is considered locally significant, high and could be long-term. Mitigation measures will be required.

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**Hazardous Industrial Wastes:**

All contaminated waste will be deposited in an HDPE lined landfill site at the Mine site. The cyanide packages and wooden cyanide boxes will be sent to the certified vendor for disposal. This category of waste will consist of hydrocarbon – plastic liners and wooden crates. Risks that cyanide containers or bags are reused by the local inhabitants are non-existent. The impact of this waste is considered locally significant, high and short-term. Mitigation measures will be required.

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## 5 MITIGATION MEASURES

This section of the EIS presents the mitigation measures proposed to minimise the environmental impacts associated with the mining operations of Edikan Gold (EGM). The impacts were identified and discussed in Chapter 4. Most of the impacts assessed can be mitigated by good planning and environmental management practices during the life of the mining operation.

The mitigation measures described herein are concerned with:

- General aspects of the mine,
- Operations over the currently estimated 10 year life.

### 5.1 Site Preparation

In order to minimise the potential negative impacts of clearing activities on both the environment and the local communities, the following mitigation measures are proposed:

Site preparation activities, which involve vegetation clearing, grubbing and topsoil stripping will be coordinated by the HSEC Department. This will be coordinated through a “Surface Disturbance” permitting system.

A plan that will address issues such as available quantities of topsoil per area, demarcation of vegetation and topsoil dumping sites, felling and use of timber species, allocation of responsibilities and monitoring of the process will be prepared. This plan will contain clear instructions and procedures for distribution and implementation by the various contractors involved with clearing activities. Topsoil required for rehabilitation of the exposed faces of the pits and the haul roads will be stockpiled at dedicated sites within active mine area

Stockpiled topsoil will be used for re-vegetation requirements to stabilise structures such as structural earth works. Additional site clearing during operation will also involve segregation and stockpiling of topsoil. Settling ponds will be built at appropriate locations downstream from some of the mine facilities such as the waste dumps and the services area.

### 5.2 Visual Impact

Mine development will result in alteration of the existing landscape and changes to the line, shape, form and colour of natural topography. Mine waste dumps, ore stockpiles and exposed high walls of different shades will contrast sharply with existing green hues of natural vegetation. Apart from elevated waste dumps and ore stockpiles, few areas of the mine are visible to neighbouring communities or members of the public travelling on public roads and the naturally hilly topography further restricts views of the

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mining activities from public roads in the vicinity of the mine. The Communities of Ayanfuri, Akyiase, Wampim and Gyaman were identified as potential critical view points from which the Eastern and Esuajah North mining activities will become visible.

The design of the Fetish and Esuajah North waste dump will take into consideration visual impact of the dump and the design with minimum impact will be adopted. Waste dump heights will not exceed landform patterns in the area. Accelerated re-vegetation program will be undertaken at the site and a screening barrier comprised of fast growing tree species (Acacia and Cassia species) will be planted along the section of the current access roads, elevated ridges and other locations that will be deemed necessary after assessments. The intent of this planting is to establish a “green zone” to assist in screening these mining areas from Ayanfuri, Akyiase, Wampim and Gyaman Communities. As the dump is developed, the dump faces will be planted with herbaceous plants (medicinal) and a mixture of native and exotic tree species of commercial importance which are found in the region.

### 5.3 Air Quality

#### 5.3.1 Airborne Particulate (Dust)

During access construction, fugitive dust will be generated from site clearance, vehicle movements and haulage of materials and blasting. Dust from these sources could have an impact on pedestrian users, natural vegetation and farm crops. To mitigate these impacts:

- Dust suppression will be carried out by water bowsers in such a manner and frequency that will ensure minimum dust generation. This measure should be sufficient to prevent the formation of high quantities of dust considered to be a nuisance to human health and vegetation.
- Specific measures will be taken to prevent over-speeding of vehicles when driving on site and through or near towns and Communities on the way to the site. To that effect, strict requirements will be sent to contractors and drivers, and speed limit sign boards and speed bumps will be posted at appropriate locations along the access road and in the mine area in general.

Mitigation measures to reduce the impact of blasting, including prevention of fly rock generation will be ensured; for instance fly rock will be managed through directional blasting, usage of controlled charge quantities of explosives, design of the stemming column, use of water proof explosives and well defined procedures

PMGL will initiate a dust monitoring programme based on gravimetric collection techniques, which accord to the Australian Standard: AS 3580.10.1-1991, "Methods for Sampling and Analysis of Ambient Air; Method 10.1: Determination of Particulate - Deposited Matter - Gravimetric Method.

Deposit gauges will be installed at the following locations across the Mine Area:

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- Ayanfuri Community in the vicinity of the Sungold residential area
- Wampim
- Gyaman
- Location between the Fetish pit and Akyiase Community

This will be complemented by volumetric sampling methods, which provide specific information appropriate to assess the degree of impact in relation to health and safety issue (e.g. PM10).

### **5.3.2 Gaseous Emissions**

Gaseous emissions for vehicles, carbon regeneration kiln and generators will be monitored. Planned maintenance and inspections programs will be implemented to ensure regular maintenance of all mobile equipment.

## **5.4 Noise and Ground Vibration**

Noise and vibration will be generated mainly from hauling equipment, movement of heavy machinery and blasting. Noise and ground vibration monitoring will be undertaken to ensure compliance with regulatory guidelines.

The minimum distance between the final toe of the east waste dump and the closest dwellings south-east of the dump is maintained at approximately 250m. The final toe of the north dump will be about 750m from the dwellings located at north the old Besem North pit.

### **5.4.1 Noise**

Planned maintenance and repair of heavy machinery and hauling equipment will be undertaken regularly and ensure that noise generated from these equipment are reduced. PMGL will ensure that in the design and construction of access roads, the location and the noise impact will be taken into consideration as much as practical. This will mitigate the impact of noise on the residents and commercial activities. Specific instructions will be issued to contractors to avoid as much as practicable transportation of material at night and over-speeding of vehicles when driving through or near towns and Communities. Employees who drive company vehicles will be trained and will require a valid Ghanaian driving licence as well as a PMGL driving permit. Signage indicating speed limits will be erected in the Project area. As part of the employee’s safety induction, speed limits will be explained as well as the consequences of not adhering to them.

Vibration induced by blasting, however, will be minimal because of controlled blasting technology to be used. Following the resettlement of various hamlets in immediate proximity to the Fetish and Esuajah North pits there will not be any inhabited areas within the designated blasting safety zone of 500m.

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However, noise arising from blasting operations can have a general psychological impact on some people even if such nuisance occurs once a day or only every few days. It is relatively common to have people confusing air over pressure with vibration level. It will therefore be the responsibility of the mine to mitigate this impact on the community by providing continuous information and education. Impact from blasting activities can be classified as locally significant, intermittent and reversible. Appropriate mitigation measures will be required.

The Health, Safety, Environmental and Community Department will prepare procedures for noise measurement, establish specific sample locations and undertake regular noise assessments in the mine area. Sample locations will be established within operational areas and locations outside these, such as Ayanfuri, Akyiase, Wampim and Gyaman Communities. Occupational noise monitoring during operations will be a routine procedure carried out by the HSEC Department

#### **5.4.2 Vibration**

Ground vibration levels up to and exceeding 1.0 mm per second may occur following blast detonations in active pits. A 500 meter exclusion zone is adopted for all blasting activities on the site and blast guards are posted at known access points to prevent inadvertent access to any blast zone. PMGL policy on drill and blast will address the number of blast holes fired per blast, time of blast and blast on special days such as public holiday. The mining contractor shall carry out its blasting operations in such a manner as to ensure that vibration does not result in valid public complaints. Blast patterns and powder factors shall be designed such that vibration is minimised. In the event of a complaint being received regarding blast vibrations the mining contractor shall investigate the complaint. The mining contractor shall provide PMGL mining manager with a detailed report within twenty-four (24) hours of the complaint. This report shall include, but not necessarily be limited to, the following information:

- full details of the nature of the complaint;
- an assessment of the validity of the complaint;
- a full description of the relevant blast pattern and powder factor used
- details of corrective action being taken or to be taken to eliminate future complaints.

#### **5.5 Fly Rocks**

Fly rock is generated by blasting operations with the associated impact based on the explosive charge, blast hole depth, fragmentation of the rock. A 500 metre exclusion zone around each blast point is established prior to blast operations in order to prevent injury from fly rock. Prior to a blast, notifications to the community and workers will be given through blast notice boards and public address systems within the communities. In addition, warning sirens will be used to alert people within the blast zone to department. Buildings and structures in nearby communities have been surveyed as baseline milestone for future reference. Structural survey for Ayanfuri community has been completed. Survey

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for (Gyaman and Nkonya) likely to be affected by blasting activities in the Eastern Pits will be surveyed prior to mining activities

Fly rock will be managed through directional blasting, usage of controlled charge quantities of explosives, design of the stemming column, use of water proof explosives (emulsions) and well defined procedures.

## 5.6 Flora

The species encountered were common and occur elsewhere in the region. There are only a few isolated timber trees of marketable size worth salvaging. No rare or endangered species were observed in the Project area as a whole.

No tree species of Black and Gold Star classification (i.e. of very high conservation concern) have been recorded in the Eastern Pit project area. Most of the left over trees can also be found in degraded moist semi-deciduous forests associated with other mining areas in the Western, Eastern and Ashanti regions. Typical examples of such species include *Alstonia boonei* and *Ceiba pentandra*.

The company has included all identified species in its rehabilitation programme and timber concessionaire operating in the project area will be assisted in afforestation programme.

## 5.7 Fauna

Overall, development in the Project area will not have any significant adverse impact on the existing and terrestrial fauna of the area. Hunting is very predominant in the area and a greater percentage of rare and endangered species are under extinction. PMGL will initiate an education programme to promote the preservation of rare and endangered species.

## 5.8 The Aquatic Environment

### 5.8.1 Surface Water

Mine activities including access construction, hauling of materials, pit development and/or expansion and waste dumps will involve land clearance which may potentially induce erosion and increase the level of suspended solids mainly in the Ankasa stream and some of its tributaries. Any settlements located downstream of the construction sites may have their main source of water affected. For preventive purposes, the following mitigation measures will be implemented by PMGL during access construction and operations:

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- Appropriate drainage control measures to minimise soil erosion will be put in place during preparation of each site. These measures will include construction of settling ponds at appropriate locations downstream of mine facilities such as the waste dumps, access and haul roads and the services area.
- Vertiver grass will be planted on the crests and slopes of waste rock dumps and on exposed surfaces to prevent sedimentation due to erosion.
- Land clearance will be progressive and will be carried out as and when required for the development of a particular area;
- Necessary earthworks will be undertaken to ensure effective drainage around the perimeter of the pits, haul roads and access roads;
- Early and progressive re-vegetation of disturbed areas will be undertaken as much as practicable using topsoil and/or subsoil segregated during the preparation phase;
- The vegetation and swamps along the various water courses (riparian flora) will be protected as much as possible
- Water from the Fetish pit will be discharged into the FTSF whereas mine effluent from the Esuajah North pit will be directed to the Subin stream (only after seeking and gaining EPA and WRC approval). Water released to the environment is considered to be negligible but will contribute to the base flow of the Subin River particularly during the dry period of the year. Mitigation measures will be required.

In order to further ensure a controlled situation over water quality measures will be adopted by PMGL. Management practices will be implemented to avoid or limit any occurrence of accidental spillages which may result in a deterioration of the aquatic environment.

- **Regular monitoring** of surface water bodies will be undertaken. Assessments will be undertaken along streams and sampling points locations identified. Sampling point will be located at vantage areas where potential contaminates can be captured during sampling; for instance locating points downstream of mine facilities and tributaries of the streams, the sub-catchment of the Ankobra River below the Fetish waste dump and backfill area, Nana Asanka at Esuajah North, runoff from mine facilities. The baseline water monitoring programme will be adapted to the conditions prevailing at the area
- **Acid drainage potential** will be monitored through analysis of waste by monitoring waste dump drainage and regular testing of waste rock samples during the life of the Mine. Should an acid drainage problem occur during the life of the Mine, appropriate prevention measures such as encapsulation of acid forming materials within a waste dump will be implemented. The results from ARD test work indicate that there should be none or very limited potential risk of acid mine drainage from the various waste dumps and it will be permissible to allow runoff and percolation from the waste dump directly into the local waterways without treatment. This will not, however, exempt the mine from continuously monitoring waste properties and waste dump drainage in general to ensure that such drainage is not having an environmental impact. In addition, blending of waste material at the various dumps will be implemented to encapsulate any potential sulphide material encountered. **Oil and grease contamination** from workshops will be controlled by all

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workshops being constructed with an appropriately graded concrete floor and perimeter drains that will direct any runoff into oil separators prior to discharge. Specific procedures will ensure that the workshop floors will be kept clean at all times

- **The mining contractor** will be contractually obliged to clean up and adequately dispose of any spillages of oil or grease on the open pit floors that may occur during the repair of mechanical breakdowns if the piece of equipment involved cannot be taken to the workshop. Accumulated waste will be regularly collected and appropriately disposed of by the fuel supplier.

PMGL will prevent impact of its operation on the water quality of the streams in the area by ensuring that discharges of effluent are appropriately managed and treated if necessary.

**Storm Water**

Storm water from run-off is controlled through the use of drainage control features such as settling ponds to minimize soil erosion. These are constructed at appropriate locations downstream of project facilities such as the waste dumps, and the mine services area. Other best management practices such as brush barriers, temporary sediment ponds, containments; small rock check dams and sediment fences to minimize erosion and minimizing exposure of mine process materials to storm water have been implemented.

At closure the runoff will be directed back into the Offin River.

**5.8.2 Community Water Sources**

- PMGL will assist the five main local communities to keep their current boreholes maintained in working condition.
- PMGL will sample, on a routine basis (quarterly) the boreholes in the Communities of Ayanfuri, Akyiase, Wampem and Gyaman for water quality testing by an independent laboratory. This monitoring will be undertaken to instil confidence in the communities that their water supplies are not being impacted by mine development and operations. Any water bore samples that show contaminants in excess of World Health Organisation (WHO) drinking water standards shall result in that bore being decommissioned for human consumption until such time as the reason for the contaminant has been investigated and the bore has been pumped until the sample analysis is within WHO guidelines.
- Observation bores drilled in the catchment Communities. The purpose of these bores is twofold. Firstly to determine the impact of dewatering activities on the water table. Secondly, if this is impacting on water levels in the community boreholes.
- PMGL will ensure that proper requirements to protect the environment and prevent oil contamination of surface and groundwater are included in all contractor agreements. Example of typical requirements are: the use of well-maintained vehicles, storage of oil drums within bunded areas, provision of spill kits for each vehicle or decontamination of a site after being accidentally polluted by such products.

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### **5.8.3 Groundwater**

Impact of the Mine on the groundwater resources of the area is expected to be localised. The very low potential for acid drainage of both ore and waste rock material and inclusion of environmental safeguards in the design and operation of these facilities should adequately prevent groundwater quality from contamination.

Nevertheless, PMGL will assess and locate monitoring boreholes at strategic areas that will enable the capturing of potential or possible ground water contaminants. PMGL will establish a ground water monitoring program and will sample on a routine basis (quarterly), including water level readings and the taking of water samples for water quality testing purposes.

## **5.9 The Ecological Environment**

The development and operation of the Eastern Pits will not have any major pollution effects or cause loss of rare or endangered flora and fauna species. The baseline flora and fauna studies conducted did not find any flora and fauna species of conservation importance. Nevertheless, PMGL will endeavour to preserve, or avoid any serious impact on the ecological environment and adopt several measures promoting conservation of certain areas.

Land clearing will be progressive and as required for the development of a particular area. Any timber and wood resulting from clearing activities will be properly managed in collaboration with the District Forestry Department and the concessionaire of the area for harvesting of economic trees. PMGL will implement a land reclamation programme as part of its overall environmental management strategy including erosion control measures. PMGL will ensure that areas required for development have been assessed to help identify species of ecological interest and/or advice alternative areas if practicable. It will also ensure minimum disturbance and that appropriate permit conditions have been met.

## **5.10 Soil and Land Use**

### **5.10.1 Soil Erosion and Sedimentation**

Vegetation clearing, topsoil removal and land preparation for development and operation potentially induces soil erosion. PMGL will adopt measures to limit these impacts and to promote soil conservation, particularly during design and construction of the mine facilities. Erosion control practices are proposed as follows:

- Deforestation and land clearance will be limited to the strict minimum;
- Measures to protect the soil from water erosion will be carried out on a catchment basis;
- Drainage from external catchment will be controlled by diversion channels or appropriate holding structures;

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- Side drains and road camber will be constructed to ensure adequate drainage;  
Whenever possible, early re-vegetation of waste dump slopes and disturbed areas will be undertaken as part of the land reclamation programme;  
Visual assessment of erosion and analysis of run-off water quality as a preventative measure carried out on a routine basis, which will provide rapid evidence of where control measures need repair or implementation.

**5.10.2 Loss of Agricultural Land and Farm Holdings**

The area of land required for Mine development is approximately 1034ha including redevelopment land disturbed by earlier commercial mining operations. Though not all this land area is cultivated, agricultural land use largely dominates with majority of people depending on farming as the source of livelihood and the principal means of employment. The number of farm land in parts of the mine area is a clear indication of the economic importance of cocoa in the area. The importance of cocoa has attracted migrant farmers and motivated some indigenous farmers to establish cocoa farms. The soils in the mine area have been classified as from highly suitable to moderately suitable, depending upon the crop selected and the provision of inputs, particularly fertilizers.

PMGL is committed to pay compensation for crops grown on land required for mine development. Following a series of meetings a Compensation Agreement has been reached with the Compensation Negotiation Committee (CNC). This group was represented by their elected representatives from Ayanfuri, Nkonya, Wampim, Gyaaman, Akyiase, in the Upper Denkyira West and Wassa Amenfi East Districts.

Farmers living in the mine area whose farms are not directly affected by mine activities will be encouraged to continue their farming activities as long as safety conditions allow. PMGL will also encourage compensated farmers to participate in various company sponsored alternative livelihood programs that will be implemented by the company in collaboration with NGO’s, under the auspices of its Community Development Fund.

**5.11 Mitigation of Traffic Impact**

PMGL is cognizant of the impact of its operations on the two public highways and will therefore ensure that effective measures are put in place. This will include the following:

- Re-alignment of access road from Ayanfuri to Chirawewa which is used by settler farmers and other cottages beyond the Chirawewa pit
- Construction of boom gate and traffic light at the interception along the Ayanfuri Gyaman road. This access will be used for haulage of ore from the Esuajah North pit to the process plant.
- Temporal provision of boom gate and traffic light at the Camp gate access road junction. This is along the Bogoso Ayanfuri highway. To be upgraded to an independent underpass interception upon Ghana Highway Authority (GHA) approval.

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## **5.12 The Socio-Economic Environment**

PMGL is obligated to compensate people who, because of the proximity of their farms and/or buildings to areas needed for mine development, or because of public safety concerns, are required to be relocated or resettled.

### **5.12.1 Compensation for Project Affected Persons**

PMGL has developed Resettlement Action Plan (RAP) which specifies the procedure and actions to mitigate adverse effect, compensate for losses and provide development benefits to affected people and communities. The RAP is in conformity with the following Ghanaian regulations

- Minerals and Mining (Compensation and Resettlement) (2012) L.I.2175;
- Minerals and Mining Act 703 (2006);
- Building Regulation Act 1630 (1996), the Local Government Act 462 (1993);
- Town and Country Ordinance Ca, 84, 86 (1951); and
- National Environment and Sanitation Policy,

The RAP outlines the Compensation Framework for the Project which was developed through extensive consultation and negotiation with the Resettlement Compensation Negotiation Committee (RCNC) and Compensation Negotiation Committee (CNC) for immovable structures and crops respectively. These committees were the main conduit and representative bodies for communities in negotiating on all aspects of the lands access and resettlement.

The negotiating bodies consist of community representatives, relevant Government Department representatives and PMGL. The negotiations were overseen by independent moderators. The negotiations were supplemented by necessary consultation and discussion with other key stakeholders, including local, regional and national authorities, traditional leaders and communities.

Project-affected Persons are eligible for compensation and other assistance if they have a “legitimate interest” in respect of “immoveable assets” in the Project Area that are in place (i.e. established, in the case of crops, or constructed, in the case of buildings) at the time of the Entitlement Cut-Off Date. For more information on the compensation process, kindly refer to the Resettlement Action Plan.

PMGL’s resettlement policy indicates that, in the case of residential structures which are deemed to be primary or principal residences, compensation must include the provision of a replacement residential structure. Therefore, Eligible owners and their spouses are entitled to receive a replacement plot within

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the resettlement community( *opposite Ayanfuri Senior High School*) on which their resettlement houses will be constructed as compensation for the loss of occupied residential structures that were in place as of the Entitlement Cut-off Date.

All structures in place at the time of the Entitlement Cut-Off Date, which are not deemed for resettlement, will be entitled for cash compensation at the agreed valuation rate determined by the RCNC. Figures 5.1, 5.2 and 5.3 are examples of designed structures for the proposed resettlement structures for residency, school and church.



**Figure 5.1 Proposed 2 Bedroom Design**

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Figure 5.2 Proposed Junior High School Design



Figure 5.3 Proposed Methodist Church Design

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In consultation with stakeholders, including local communities, the documentation of compensation works will follow established procedures to ensure transparency, fairness and honesty towards all involved stakeholders. The Resettlement Project schedule will reflect the timing of the associated infrastructure development. Figure 5.4 is the infrastructural plan for the resettlement site at Ayanfuri.

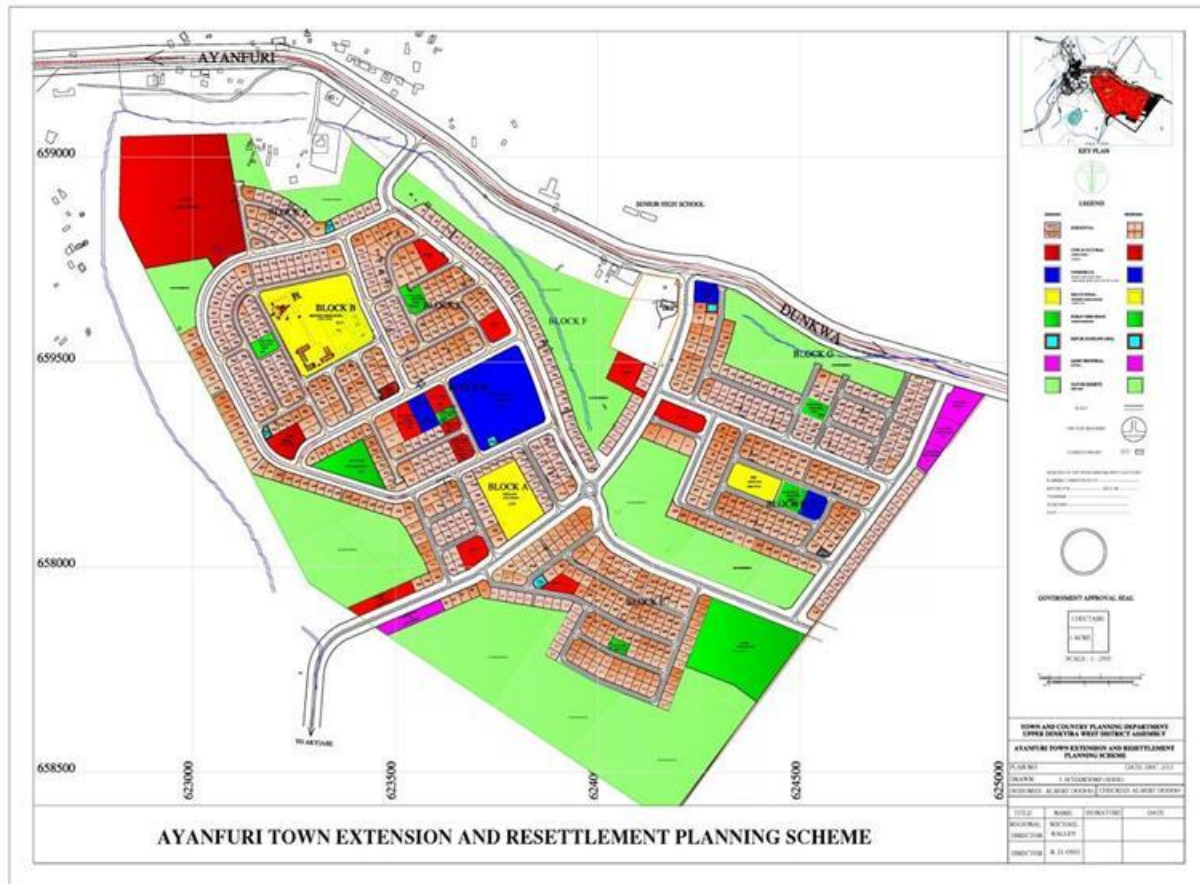


Figure 5.4 Proposed Ayanfuri Town Extension and Resettlement Plan

### 5.12.2 The Issue of Influx of People into the Mine Area

In Ghana, all people have total freedom of movement within the country. Consequently, the influx of people into towns and Communities of the Mine area is expected. These may be people seeking employment directly with PMGL or any of the contractor companies or conducting their own businesses in the communities.

The mitigation measures proposed to deal with impacts associated with influx of people to the mine area include:

- PMGL assisting in developing local training initiatives that will enable local residents to be able to compete for, and acquire the skilled jobs available at start-up. Also company

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policy requires all unskilled labour to be sourced as much as possible from within the “zone of impact”. Construction and mining contractors will also be required to source locally.

- Prior to, and during operations, PMGL will hold periodic information meetings with official and traditional authorities who will be the key to controlling the impacts of the influx of people. The main objective of these meetings will be to give information and the level of potential for employment as a measure to control influx by reducing the level of expectation of those arriving in search of a job.

### 5.13 Waste Management

PMGL has identified the various types and their potential mode of disposal. Any waste, such as oil filters, waste paper and wood packing will be disposed of in accordance with best practice applicable in Ghana. PMGL will ensure that all employees and contractors are made fully aware of their environmental responsibility toward waste management.

The following principles relating to waste management has been adopted by PMGL:

- Identification of materials and preparation of waste inventories;
- Preparation of a waste management plan;
- Minimise generation of waste;
- Sorting of waste by type and seeking alternative to disposal such as reuse and recycling;
- Appropriate storage of waste prior to disposal;
- Appropriate disposal of waste at a cost economically acceptable;
- Seeking collaboration with other industrial partners;
- Waste tracking of certain hazardous wastes (eg. waste oils).

#### 5.13.1 Classification and Management of Waste

The various type of waste identified and associated method of disposal are:

##### Non-Hazardous Waste (Domestic)

Non-hazardous waste is usually generated by administration and technical offices, the canteen/mess and households living at the camp. Waste paper is used as a raw material alongside sludge from the sewage treatment plant for compost generation.

A landfill planned for non-hazardous solid waste disposal will be constructed on a well-drained and accessible site such as a waste dump. Exact site selection and construction methods will minimise both the rate of infiltration and the quantity of run-off available for infiltration. Operating procedures will ensure that materials having undesirable, potentially leachable constituents (e.g. batteries from flashlights and electronic equipment) are not placed in the landfill. Disposal of materials will be considered only after all other options of reduction, reuse and recycling have been eliminated. Material

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in the landfill will be covered with earth as required to avoid wind-blowing garbage and to reduce scavenging by animals and birds. A programme will be rolled out to promote further segregation of non-hazardous waste. Plastics, empty sachet water rubber and canned mineral tins will be segregated for recycling or reuse

**Sewage Effluent**

Sewage generated from ablution facilities at the mining facilities will be is treated in a package treatment plant. Mobile toilet facilities will be placed at vantage areas for employees and contractors to access. These will be inspected on a regular basis by the HSEC Department to ensure efficiency. The sewage effluent will be dislodged and taken to the plant package sewage treatment facility. The treatment plant will use aerobic methods and the treated discharge directed to the FTSF. The selected packaged plant will conform to one of more standards such as Australian/New Zealand Standard AS 1547:2000 Onsite Domestic Waste Water Management, Australian/New Zealand Standard AS 1546:3 2001 Onsite Domestic Wastewater Treatment Units – Aerated wastewater treatment systems, the USA National Sanitation Foundation (NSF) International Standard NSF 40 - 1996, or European Union Standard - EN12566-3 2005. Licensed contractors are used to regularly evacuate sewerage tanks for subsequent treatment at the sewage treatment plant

**Hazardous Waste**

Hazardous wastes generated at the Eastern pits with potential for release to the environment include cyanide packaging, plastic liners, waste hydrocarbon, used batteries etc. PMGL will ensure that the principle of waste reduction, reuse and recycle is implemented. Waste from explosive packaging will be sent back to contractor (Barbex and AEL) for incineration. Other hazardous waste will be disposed of in a well-constructed landfill which is lined with HPDE liner for disposal and encapsulation of other hazardous waste that cannot be recycled or incinerated.

**Clinical Waste**

Any medical waste produced from first aid applications will be segregated, collected in a bin marked with biohazard symbol and such waste will be incinerated using the turbo burner on a scheduled basis in a purpose built incinerator located close to the environmental nursery. A water tight receptor has been constructed for the deposition of incinerated ash.

**Waste Oil and Oil Filters**

Used waste oils and grease may be produced as a result of on-site servicing and repairs of machinery, and mining and drilling equipment. Used waste oils will be stored in appropriate containers for collection by EPA certified vendor and sent to a recycling facility available in Ghana. Oil filters will be crushed to drain the oil from it and the crushed metal part treated as scrap metal. Oil contaminated rags or material will be treated as hazardous waste.

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## **5.14 Health and Safety Aspects**

Safety will be an integral part of the operations as it contributes to maximisation of productivity and lowered costs. Good safety practices are reflected in having a clean work environment and attention to procedures and routines: which if improperly managed can lead to environmental incidents. Employee training, preparation of health and safety procedures, provision of suitable personal protective gear equipment, protection against fire potential and monitoring of employee health will be the very important aspects of the safety programme.

### **5.14.1 Training**

Operators will be trained not only in detailed aspects of their work station but also in such matters as hazard recognition, chemical handling procedures, first aid, personal hygiene, electrical safety, rigging and lifting, vehicle safety, pond safety, fire safety, safety practices for working around machinery with moving parts, among other topics. A major effort will be focused on personal protection gear and equipment training. Only qualified operators shall be permitted to operate equipment.

Foremen and supervisors will receive more detailed training on these topics through regular safety meetings. Assistance will be provided by the Emergency Response Technicians in the form of instructions, inspections and safety training. Safe work practices are encouraged and reinforced by various safety-based incentive schemes, bonuses and awards to be operated by the Company.

### **5.14.2 Documentation**

Work plans will be generated in terms of appropriate documentation. These standards, manuals and procedures will be drafted as required and will cover, inter alia, topics such as transportation, handling and storage of hazardous materials, use of specific equipment; material safety data sheets for all the chemicals/products used, emergency procedures, etc.

### **5.14.3 Personal Protection Equipment**

Personal protective gear will be mandatory under Company policy for all activities in all departments. At a minimum, all employees will be required to wear hard-hats high-visibility clothing, safety glasses, hard-toes boots in operational areas. Rubber gloves, rubber arm protectors, full protection rubber (rain suit) coveralls, face shield, splash goggles, safety belts and lanyards, life vests and flotation rings, dust respirators hearing protectors, welding hoods and goggles, thermal protection suits and high voltage insulated gloves and sticks will be available and used where appropriate. Safety showers will be provided at strategic locations within the processing plant, work shop, warehouse, etc.

### **5.14.4 Fire Potential**

Several types of fire extinguishers will be positioned at numerous locations throughout the processing area, explosive magazine and on mobile equipment. Water for fire fighting will be sourced from the raw

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water dam. Electrically driven pumps will deliver water to the plant area, service area and staff Community

#### **5.14.5 Medical Facilities**

First aid equipment will be stationed at all main work locations and clinic staff with a physician, Paramedic and supporting ambulance will be located at the Edikan site. For serious cases, injured persons will be stabilised and transported to either Dunkwa-On-Offin or Kumasi Government hospitals via ambulance.

#### **5.14.6 Working Environment**

All building or work places will be constructed and equipped on ergonomic principles.

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## **6 ENVIRONMENTAL MONITORING PROGRAMME**

### **6.1 Background**

This chapter presents a generic summary of the proposed Environmental and Social Monitoring Programme to be implemented under the Eastern Pits Project. The social aspects of the programme shall be done in conjunction with Social Development Committee to ensure that it has input from all appropriate stakeholders. Continuous Environmental and Social monitoring will be an integral part of the operations to ensure sustainability of the Project.

Environmental and Social Monitoring will have the following objectives:

- Continued gathering of baseline data within the Project Area,
- Evaluation of impacts resulting from the development of the Project,
- Evaluating of success of mitigation measures implemented by the company,
- Identifying situations requiring corrective measures and additional mitigation measures,
- Provide management with information regarding the effectiveness of environmental management,
- To detect changes in the receiving environment and enable analysis for their causes,
- To enhance effective liaison with communities, including address any complaints that may arise from communities,
- In accordance with EPA standards and guidelines.

As part of the SEIS, once-off baseline surveys on the Flora and Fauna, Soil and Land Use, Hydrology, Hydrogeology, Transport and Traffic Impact, Archaeological and Cultural environment of the Project Area was conducted by various consultants in 2013 and 2014. Perseus conducted in-house monthly monitoring of surface water and groundwater and conducted baseline measurements for air and noise in the Project area. PMGL proposes to continue the monthly monitoring until production starts after which the frequencies of monitoring and sampling locations will be re-assessed.

### **6.2 Monitoring Assessment Criteria**

#### **6.2.1 General**

In developing a monitoring program, there is a need to establish appropriate levels of environmental protection, identify applicable water, air quality and other criteria and establish appropriate monitoring compliance points.

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This proposed monitoring program will therefore be assessed against the Ghana EPA guidelines (January 2001) and international best practice guidelines for the mining industry, including:

- IFC Environmental, Health and Safety Guidelines – Mining (December 2007),
- IFC Performance Standards on Social and Environmental Sustainability (July 2006),
- "Equator Principles" 2006,
- "The Community Development Toolkit" ESMAP Formal Report Series, Report No. 310/05, 2005.
- The Government of Ghana and EPA's Environmental Rating Methodology for Mining Companies (AKOBEN Program). PMGL will be aiming to achieve Gold status under this program.

### **6.3 Categories of Monitoring**

Environmental Monitoring may be classified into a number of categories as follows:

- **Discharge or compliance monitoring:** The monitoring of potential contaminants being discharged or emitted from the project to the environment. Such monitoring is usually undertaken either at the point of discharge or at the license boundary. Discharge monitoring provides direct information concerning the concentrations and loads of potential contaminants being discharged from the operation, and also serves as a link between ambient monitoring results and the operational monitoring. Discharge monitoring would typically occur where site runoff or pit waters are discharged to downstream drainage lines, or where sediment traps overflow. It could also be used as nominated compliance monitoring points for meeting local and international guidelines for effluent discharge etc.
- **Ambient or baseline monitoring:** The monitoring of the receiving environment beyond the project boundary. While operational and discharge monitoring should determine if environmentally significant releases have occurred, effects on the ultimate receptors within the receiving environment can be determined only by ambient monitoring. Ambient monitoring typically includes the monitoring of upstream and downstream water quality, potentially affected community water sources, and air and noise quality at nearby habitation.
- **Investigation or opportunistic monitoring:** Monitoring undertaken as part of a specific investigation, typically to determine the occurrence, nature and extent of possible impacts following a major environmental incident or to verify/refute third-party claims of environmental impact.
- **Operations or surveillance monitoring:** The comprehensive routine monitoring that is undertaken for process control, cost control, technical efficiency and safety reasons, as well as for environmental purposes. Operations monitoring typically includes monitoring of process reagent consumption, process water quality, tailing cyanide concentration etc. Often, but not

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exclusively, such monitoring is the responsibility of a mine Process Department, not the Environmental Department but with the results provided to the latter.

## **6.4 Proposed Monitoring Programmes**

The proposed environmental parameters that will be included in the monitoring programme at the Eastern Pits are as following:

- Meteorological Data
- Surface Water Quality
- Ground Water Quality
- Sediment
- Dust
- Noise
- Vibration
- Ecological Environment
- Socio-economic Environment

## **6.5 Meteorological Data**

### **Data Collection**

Rainfall and temperature data was obtained from the nearest national climatologically station operated by the Ghana Meteorological Agency (GMA) at Dunkwa-on-Offin located about 15km east of Ayanfuri. Three weather stations have been installed at the project area to monitor weather conditions such as temperature, evaporation and wind direction. A total of five rain gauges installed at the Eastern Pits area.

### **6.5.1 Frequency**

Daily rainfall readings will be taken from rain gauges installed at the old Cluff Administration Building, Esuajah North area and the Mine Community stations. Information acquired will be kept by the Company to maintain historic data and establish a trend in the climatic data. Annual data will be collected from the Dunkwa weather station for historical and comparative data.

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## 6.6 Surface Water Quality

### 6.6.1 Baseline Sampling

A comprehensive surface water quality monitoring programme was put in place in October 2013 to collate data and establish a trend in the quality of water around the project area prior to construction. A table of existing surface water monitoring locations used during the baseline data collection phase is provided in Table 6.1.

### 6.6.2 Construction, Operations and Closure Monitoring

The Eastern Pits Project may impact significantly on the surface water quality, especially where downstream water users utilise water for drinking and domestic purposes. Surface water monitoring points that will be required during construction, operation and closure include downstream of pit discharge points, waste rock dumps and other stockpiles, as well as locations around any other activity such as workshops and fuel bays. It is proposed that sampling downstream of pits and waste dumps is phased to align with mining development, operation and closure. Monitoring will continue for up to three (3) years post closure.

**Table 6.1- Surface Water Sampling Locations in the Eastern Pit Project Area**

SAMPL ID	DESCRIPTION	CATEGORY	GPS COORDINATES		FREQUENCY
			Eastern	Northern	
PAS1	Along Ayanfuri-Nkonya main road	Surveillance	621204	657559	Monthly
PAS2	Ansankaa stream along access to wampem commun	Surveillance	624096	660295	Monthly
PAS3	Danyami stream near PMGL camp site	Compliance	621285	656993	Monthly
PAS7	Bekwai road; down stream of Odumkrom	Control	621987	659975	Monthly
PAS8	Wampem upstream	Control	624964	662222	Monthly
PAS11	Culvert; along Ayanfuri-Nkonya rd.	Surveillance	619343	656236	Monthly
PAS18	Chirawewa Pit downstream	Surveillance	622920	656619	Monthly
PAS19	Odumkrom downstream	Control	622346	660137	Monthly
PAS22	Chirawewa Pit Area; downstream of PAS18	Surveillance	623080	655733	Monthly
PAS35	Last culvert on the access to Dabiasem	Surveillance	621328	654304	Monthly
PAS37	Ayanfuri close to the Pentecost church	Control	622075	659559	Monthly

### 6.6.3 Frequency

It is proposed that surface water samples be sent for laboratory analysis from all identified sites on a monthly basis until the start of the project construction phase. Once construction starts, it is proposed that the frequency of sampling may be changed between weekly and fortnightly, monthly and quarterly. Those sites with increased risk of exposure to adverse impacts from operations will be sampled more frequently than those with a low risk of exposure (Table 6.2).

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Field analyses will be undertaken for pH, conductivity, turbidity, TDS and dissolved oxygen on a weekly and monthly basis by PMGL environmental staff. Quarterly suite parameters will be sent to an independent laboratory. The prime purpose of weekly sampling will be to determine if unknown changes are occurring that would need to be quickly rectified.

**Table 6.2- Frequency of Sampling**

Type of Site	Sampling frequency
<b>Waste Rock Dumps</b>	Weekly suite of field parameters Monthly suite of detailed parameters
<b>Pit Water Discharge Points</b>	Weekly suite of field parameters
<b>Community Boreholes</b>	Weekly suite of field parameters
<b>Disturbed Areas</b>	Monthly suite of detailed parameters

#### 6.6.4 Parameters

The following parameters are recommended for analysis at the laboratory:

- Physico-Chemical: pH, Dissolved Oxygen (DO), Conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Apparent Colour, True Colour, Turbidity, Alkalinity and Hardness (CaCO<sub>3</sub>)
- Nutrients and Other Chemical analysis: Sodium (Na), Potassium (K), Sulphate (S), Chloride (Cl), Nitrate (NO<sub>3</sub>-), Nitrite (NO<sub>2</sub>-), Phosphate (PO<sub>4</sub>), Calcium (Ca) and Magnesium (Mg)
- Metals (Total or Dissolved): Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Lead (Pb), Mercury (Hg), Chrome (Cr), Nickel (Ni), Arsenic (As), Cadmium (Cd) and Aluminium (Al).

### 6.7 Groundwater Quality

The observation and community boreholes within the three (3) communities are monitored on monthly and weekly basis respectively. This monitoring schedule will continue until such time as construction begins. Thereafter, it is proposed that the boreholes will be monitored on weekly basis during construction and operational stages of the mine.

The sample ID and GPS coordinates of the monitoring boreholes that are monitored are provided in Table 6.3.

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**Table 6.3- Monitoring boreholes with ID and GPS Coordinates**

SAMPL ID	DESCRIPTION	CATEGORY	GPS COORDINATES		FREQUENCY
			Eastern	Northern	
PAG1	Gyaman (by the road side)	Surveillance	620519	660972	Weekly
PAG2	Gyaman behind the Chief's palace	Surveillance	620392	661127	Weekly
PAG3	Fobinso (market/station)	Surveillance	617330	661332	Weekly
PAG4	Fobinso (football park)	Surveillance	617358	661424	Weekly
PAG5	Abenabena (station)	Surveillance	616230	659021	Weekly
PAG6	Nkoya (after the market)	Surveillance	619282	655590	Weekly
PAG7	Nkoya (before the market)	Surveillance	619058	655665	Weekly
PAG8	Abenabena close to the football park	Surveillance	616282	658958	Weekly
PAG9	Nkotumso (by the road side)	Surveillance	619479	663296	Weekly
PAG10	Nkotumso (within the village)	Surveillance	619649	663400	Weekly
PAG11	PMGL Camp Site	Surveillance	621036	656455	Weekly
PAG13	Ayanfuri, in front of the Chief's Palace	Surveillance	622429	659434	Weekly
PAG14	Ayanfuri, near the Pentecost Church	Surveillance	622201	659494	Weekly
OPAG15	Ayanfuri behind the Methodist Church	Surveillance	622463	659717	Monthly
OPAG16	Gyaman beside the road	Surveillance	620542	660965	Monthly
OPAG17	Gyaman behind the Chief's Palace	Surveillance	620375	661137	Monthly
OPAG21	Nkonya close to PAG6	Surveillance	619286	655578	Monthly
OPAG22	Nkonya behind the chopbar	Surveillance	619017	655692	Monthly
OPAG54	Fobinso community	Surveillance	617513	661229	Monthly
OPAG55	Wampem Village close to railway line	Surveillance	624771	660393	Monthly
OPAG64	Ayanfuri in front of Pentecost Church	Surveillance	622216	659546	Monthly
OPAG65	AMS residential camp	Surveillance	621376	656608	Monthly

## 6.8 Stream Bottom Sediment

### 6.8.1 Baseline Sampling

Sediment samples were taken in 2013 from the old Chirawewa, Fetish, Wampem (Asankaa Stream) and Ayanfuri (Subin River). These are streams that are likely to be impacted upon by operations of the Eastern Pits Projects. Samples were collected from a total of 15 locations for the purposes of the baseline survey.

### 6.8.2 Development, Operational and Closure Sampling

Sediment sampling will continue at the 15 sampling locations until the construction commences. Thereafter, a review of the sampling points will be conducted to assess and include new sampling locations and eliminate locations that are not representative.

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### 6.8.3 Frequency and Parameters

It is proposed that sediment is sampled on a biannual basis in the Asankaa and Subin rivers as the other three of the sample point locations are used in the aquatic ecology baseline survey.

Stream bottom sediment parameters to be analyzed as follows:

- Physico - Chemical: pH and Conductivity; and
- Metals: Iron (Fe-Total), Manganese (Mn-Total), Copper (Cu-Total), Zinc (Zn-Total), Lead (Pb-Total), Mercury (Hg-Total), Chrome (Cr-Total), Nickel (Ni-Total), Arsenic (As-Total), Cadmium (Cd-Total), Aluminium (Al-Total) and Selenium (Se-Total).

## 6.9 Dust Monitoring

### 6.9.1 Baseline Sampling

As part of the baseline sampling, total suspended particulate (TSP) and Particulate Matter (PM<sub>10</sub>) were measured for 24 hrs at two locations, in two Communities namely Esuajah North and Esuajah South.

### 6.9.2 Development, Operational and Closure Monitoring

Dust generated along the haul roads, and from pits, waste dumps and stockpiles may impact traffic and residents of nearby Communities.

### 6.9.3 Location and Frequency

The company will continue to monitor TSP and PM<sub>10</sub> concentrations on daily basis within the catchment communities.

## 6.10 Noise

### 6.10.1 Baseline Sampling

In order to characterize background noise levels of the Project area, maximum noise levels were recorded during 24-hours periods at three sensitive locations that surround the area designated for the proposed project facilities.

### 6.10.2 Location and Frequency

Noise monitoring will be undertaken during the development and operational phases. It is proposed that noise monitoring is conducted in Ayanfuri community and other area where deemed appropriate on daily basis.

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## 6.11 Vibration

### 6.11.1 Location and Frequency

Vibration and air blast monitoring will be required for each pit as it is developed and worked which along with the seismograph, blast design and charge records (e.g. hole depth, hole angles, rock type, stemming depth and type) shall be analysed by the blast foreman and a report issued for each blast conducted. This will assist in assessing how well the blast went and what improvement measures can be implemented.

Routine blast monitoring will be required at Ayanfuri, Nkonya and Gyaman communities when blasting is undertaken at the Eastern Pits based on the location of the pit.

## 6.12 Ecological Environment

### 6.12.1 Baseline Sampling

Once off surveys were undertaken of the terrestrial fauna and flora and the freshwater environment during the baseline surveys.

### 6.12.2 Development, Operational and Closure Monitoring

No surveys of terrestrial fauna and flora are to be undertaken during the development or operation phases.

Although post mining land uses are likely to be agriculturally oriented, a terrestrial fauna survey could be considered during the closure phase to assess habitat regeneration.

It is however proposed that the fresh water environment is sampled on a biannual basis for the first two (2) years of operations. The freshwater environment provides a highly sensitive biological receptor for water quality and is considered to be a very useful monitoring tool.

### 6.12.3 Location and Frequency

Sampling points for the freshwater sampling have been selected downstream of significant infrastructure and are proposed in Table 6.4.

**Table 6.4- Sampling of selected Downstream Infrastructure**

Basin	Frequency	Parameters
Asankaa River sub-catchment	Biannual	Qualitative and quantitative analysis of Phytoplankton, Macro-invertebrates and aquatic insects
Subin River sub-catchment	Biannual	

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### **6.13 Erosion and Sediment control**

Erosion and sediment loss will be monitored during the development, operational and closure phases. Several accepted informal methods are as follows:

- Regular inspection of pit and waste dump operations and of surface run-off control structures
- Visual assessment of erosion as a preventative measure carried out on a routine basis, which will provide rapid evidence of where control measures need repair or implementation
- Sampling and analysis of run-off water quality and existing surface water for key parameters.

This programme will be integrated with the PMGL site-wide surface water quality monitoring.

#### **6.13.1 Installation of Monitoring Boreholes**

Groundwater monitoring boreholes will be installed, upstream and downstream of the facility to assess the impact of groundwater drawdown of the Eastern Pits on Ayanfuri community.

### **6.14 Reclamation Monitoring**

The success of rehabilitation will need to be monitored to demonstrate PMGL’s commitment in this area to the government, community and other stakeholders, and to enable rehabilitation techniques to be continuously refined and improved.

Parameters that could be monitored include:

- Percentage ground cover and species composition of re-vegetated areas.
- Chemical/elemental analysis of vegetation on reclaimed areas.

### **6.15 Post Closure Monitoring**

Post closure monitoring of areas managed by PMGL would be to best practice standards, and rehabilitation success would be measured by the development of a self-sustaining state of rehabilitated areas compared with undisturbed communities

#### **6.15.1 Socio-Economic Monitoring and Indicators**

The Company has initiated the implementation of a Social Development Consultative Committee. The Committee includes representatives of all stakeholders in the three (3) major communities within the Project Area including minority groups.

It will be the responsibility of the Committee to determine the community needs and how the Community Development Fund shall be fairly allocated to the three (3) participating communities and

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on what projects funds will be allocated to within each community. As stated in the PMGL Community Relations Policy the process of ‘Participatory Rural Appraisals’ shall be used to ensure the Community has full involvement and ownership of all projects that the Company partners in. The Company’s considered areas of involvement will include but not necessarily be limited to health, education, and women’s groups, the disabled and agricultural projects.

It is not the Company’s role to dictate to the community what they need and as such, from this participatory process, the Company shall be able to develop its Community Development Plan. The Company shall develop the Plan, in conjunction with the stakeholders, prior to commencement of production.

The Company proposes the following methodology for monitoring and indicators of the outcomes of social development initiatives:

- Define project in consultation with the community;
- Seek formal acceptance of project and activity from the Social Development Committee (SDC);
- Describe the goal (s) the activity/ project is being designed to deliver as accepted by SDC and the relevant interest groups/stakeholders;
- Determine the time frame for the activity/project/goal;
- State and describe the important assumptions of external factors that may likely affect the achievement of objectives;
- Periodic checking and reporting of inputs: - such as money/time contributed, number of meetings held or number of scholarships awarded;
- Regular assessment and reporting on the direct results of the activity/ community development – this includes direct communication and feedback with the benefactor(s); and
- Periodic assessment and reporting on the overall desired returns on investment for a particular activity/project (that is improvement in the community’s quality of life, health or economic wellbeing).

Some examples of indicators for social project are:

- Increase in student enrollments in schools the Company works with;
- Increase in the standard of education in the school the Company work with, measured by an improvement in the students exam results;
- The increase in employment of women through income generating projects; and
- General increase in health through the provision of clean potable water bores and malaria prevention workshops in the community, measured by a decrease in attendances at local medical clinics.

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Once the Social Development Committee and the Company has finalized the Social Development Plan, a thorough list of measures and indicators can be applied to it.

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## **7 PROVISIONAL ENVIRONMENTAL MANAGEMENT PLAN**

### **7.1 Introduction**

This chapter of the SEIS outlines a summary of the proposed Environmental and Social Management Programme to be implemented by PMGL.

A detailed and specific programme shall be written prior to commencement of the project. The social aspect of the programme shall be done in conjunction the Social Development Consultative Committee to obtain input from appropriate stakeholders.

In line with Best Practice, it is PMGL’s aim to manage its operations so that negative environmental impacts of the Project during operations and closure are mitigated (e.g. impacts on water and air quality) whilst positive impacts are maximized (e.g. employment and training opportunities for the locally available workforce and the development of sustainable programmes for the Project area).

### **7.2 Components of the Provisional Environmental Management Plan (PEMP)**

Typically, the PEMP will give consideration to the following subjects:

- Corporate Commitment and HSE Policies
- Environmental Management Structure
- Financial Allocations
- Project Overview
- Existing Natural Environment
- Existing Socio-Economic Environment
- Environmental Impacts and Mitigation Measures
- Environmental Action Plans
- Monitoring Programme
- Reclamation and Decommissioning
- Emergency Response Plan
- Auditing and Review
- Community Relations and Resettlement

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## **7.3 Perseus Mining Limited Corporate Policies**

### **7.3.1 Environment**

PMGL regards environmental care as an integral part of its business and is committed to excellence in the management of environmental matters. The Company aims to minimize environmental impacts at every stage of work from planning, through exploration, development, mining, processing and decommissioning. PMGL, through its personnel will:

- Maintain a comprehensive Environmental Management System;
- Undertake consultation to ensure that community interests are considered;
- Comply with applicable laws, regulations and standards;
- Provide safeguards and contingency plans to mitigate potential impacts;
- Monitor all activities and strive to continually improve performance; and
- Promote environmental awareness amongst the workforce to increase understanding of environmental responsibilities.

All employees and contractors will be responsible for upholding PMGL's standard of environmental management.

### **7.3.2 Community**

PMGL recognizes that a cordial relation between the communities is crucial to the success its operations. For this reason, the company maintains a policy of employment from local community of the individual projects. Most of the company's skilled labours are from Ghana with all unskilled from the communities.

### **7.3.3 Health and Safety**

The company firmly believes that the health and safety of its employees and affected third parties is of prime importance in the successful pursuit of its business activities.

The company has a basic commitment to conduct its operations in a manner that will prevent injuries to its employees and not put anybody's health at risk. In doing so it embraces the principle that a zero lost time injury frequency rate is achievable.

The company has established high standards of Occupational Health and Safety for the western pits. This will be adopted and maintained at all levels for the proposed Eastern Pits project.

## **7.4 Health, Safety and Environmental Management System**

PMGL has an already established Environmental Management System that follows the principles contained in ISO14001 and OHSAS 18001 for its operations. This covers the proposed Eastern Pits

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projects. The major elements of the Environmental Management System will be:

- Accountability of all staff for minimizing environmental risk and assuring compliance with regulatory requirements as well as corporate environmental objectives.
- Implementation of monitoring programs to provide early warning of any deficiency or unanticipated performance in environmental safeguards
- Training and orientation of employees in order to perform their jobs in compliance with sound environmental practices.
- Consideration of environmental factors to be included in all new or modified facilities and in the purchase of equipment and materials.
- An environmental incident reporting system will be established and reports prepared in a timely manner.
- Environmental response planning will be completed to provide the basis for response to environmental incidents, including spill prevention and counter measures plans, monitoring plans and mitigation plans.
- Periodic reviews will be conducted to verify environmental performance and to continuously strive towards improvement.
- Procedures are implemented to assure ongoing dialogue with government entities in connection with regulatory changes which may affect the operation.

## 7.5 Resource

To facilitate environmental and social management practices PMGL has established a Health, Safety, Environment, Social and Community (HSEC) Department (refer to Figure 8.1) for the proposed Eastern Pits projects. The HSEC Manager reports to the PMGL Executive General Manager thereby ensuring that sustainability issues for the proposed project are assigned the appropriate priority and level of attention.

## 7.6 Departmental Responsibilities

The HSEC Department staff will manage Safety and Health, Environment and Community Relations functions and will be controlled by a senior management team member. This department will be responsible for the following:

- Environmental monitoring,
- Rehabilitation,
- Forestry/Livelihood Support/Land Access
- Community relations and services, and
- Health and Safety

The Department will be responsible for directing and maintaining all environmental monitoring and

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reclamation programmes/activities in the Project area and engaging regulators and stakeholders on related issues. This ensures specific environmental management responsibilities are allocated as appropriate and ensure the commitments stated in the environmental policy are achieved.

The community relations and community services will manage community management planning leading to the sustainable development of the proposed project within the community through joint initiatives that will see benefit and enrichment to the social fabric through understanding and open dialogue with the mine.

Specifically the mine will assist with joint programs that will focus on improved health, education, hygiene, and infrastructure. The forestry/livelihood support function will manage the growth of re-vegetation plant; establish a seedling farm and a market garden for mine staff food requirement. The livelihood support team will work hand in glove with the rehabilitation functions ensuring the clean sustainable return of the active mining areas to socially responsible land usage as jointly agreed with the long term land users. The total workforce of the HSEC has been estimated at 50 people.

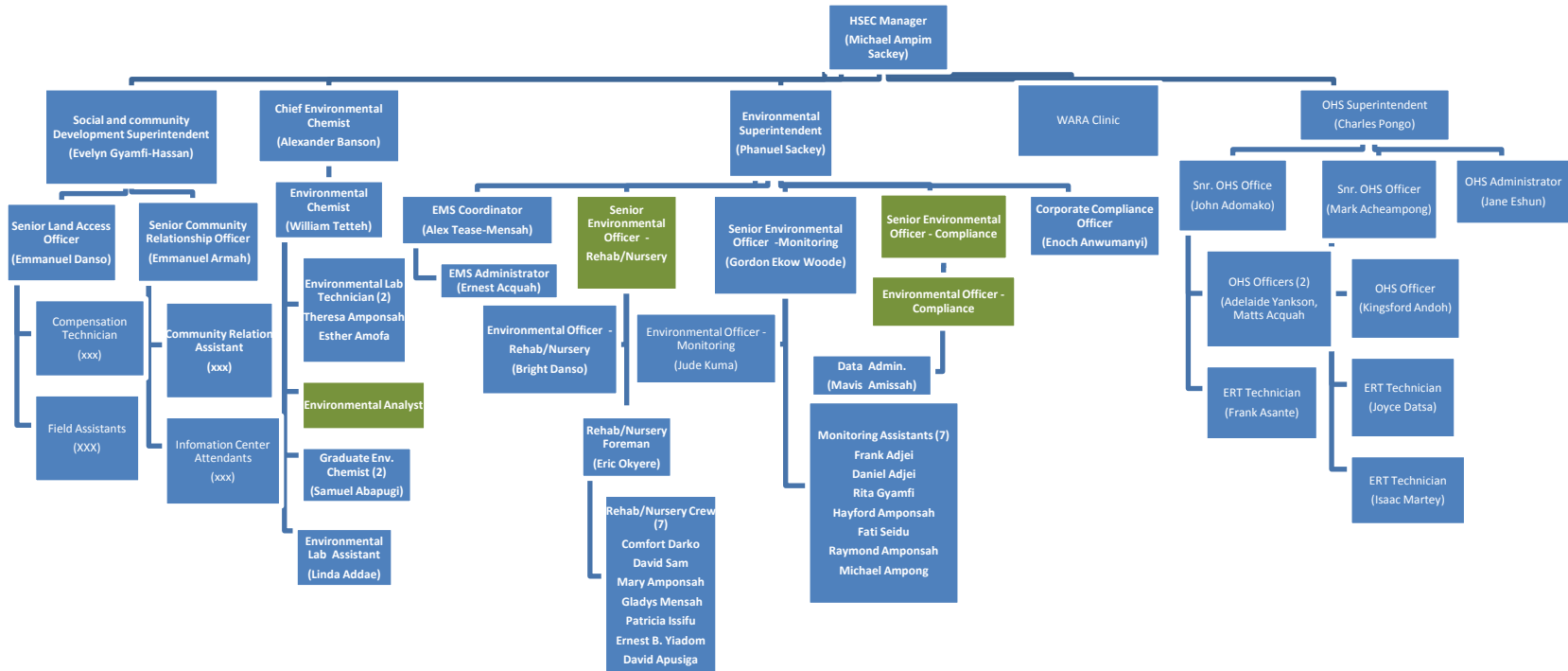
## **7.7 Project Components**

A complete project description is presented in Chapter 2 of this report will consist of operation and decommissioning (including reclamation) phases of the following elements:

- Pits Development – Chirawewa, Fetish, Esuajah North, and Bokitiso.
- Rock Waste Dumps – Chirawewa, Fetish, Esuajah North and Bokitiso.
- Blasting of Rocks
- Construction of haulage roads.
- Haulage of gold bearing material.
- Sediment Control (Inc drains).

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**HSEC Organogram**



**Figure 7.1: Edikan Gold Mine HSEC Organogram**

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## 7.8 Project Components

A complete project description is presented in Chapter 2 of this report will consist of operation and decommissioning (including reclamation) phases of the following elements:

- Pits Development – Chirawewa, Fetish, Esujah North, and Bokitiso.
- Rock Waste Dumps – Chirawewa, Fetish, Esujah North and Bokitiso.
- Blasting of Rocks
- Construction of haulage roads.
- Haulage of gold bearing material.
- Sediment Control ( drains).

## 7.9 Waste, Discharges and Emissions

A register of the waste, discharges and emissions that will arise from the proposed Project is provided in Tables 7.1 to 7.3. This lists both the routine discharges and emissions and those that may occur as a result of accidental occurrences. For ease of description and for completeness, the Project has been divided into specific locations where considered necessary.

**Table 7.1- Potential Air Emissions During Operations**

Location / Source	Description
Mining, including blasting	Dust, gaseous emissions, noise and vibration.
Waste Rock Dump	Dust raised by haulage and unloading, and from erosion of exposed surfaces. Noise and engine emissions from heavy equipment.
Haulage / transport	Noise and dust raised by mine surface vehicles on unsealed roads; emission from surface vehicle exhausts

**Table 7.2- Potential Solid Wastes and Residues During Operations**

Source / Location	Description
Mining	Waste rock transported to the waste rock dumps and/or rehandling when partially backfilling mined out pit
Mine and infrastructure facilities	All solid wastes, e.g. used tyres, oil filters, batteries, scrap metal and wood packaging, used metal containers (e.g. paints and solvents) to be properly stored.
Hydrocarbon wastes	Waste hydrocarbons will be moved to the fuel storage facility and removed from site by the facility operator.
General refuse	Office and chop kitchen waste will be taken to the managed landfill site.

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**Table 7.3- Potential Liquid Discharges During Operations**

Source / Location		Description
Mining Operations	Haulage and waste rock disposal	Run-off from surface mine roads and dumps Leachate from dumps drains to the local environment
	Pit water	Water accumulating in the pits will be actively removed by pumping to settling ponds before being utilised for dust suppression. Excess water will be discharged to the environment provided laboratory analysis shows it meet EPA effluent discharge quality.
Heavy Vehicle Workshop	Waste oils/fuels	Waste will be stored on site in a tank and removed and disposed of by fuel supply contractor.
	Fuel delivery and storage	Run-off containing hydrocarbons will drain through oil/silt traps before reporting to the natural environment provided effluent quality is good for discharge.
Container office block, First aid station, Contractors yard, Ablution block	Surface drainage	Run-off containing suspended solids or oils drains through oil/silt traps will drain into sediment pond and then to watercourses.
	Sewage	Sewage disposed to septic tanks.
Transport of personnel, fuels, general supplies		Spillage of fuel and oil. Accidental spillage; rupture of storage tanks; potential release to local environment.

## 7.10 Register of Environmental Impacts

The purpose of this PEMP is to ensure that appropriate control and monitoring measures are in place to deal with all significant potential environmental impacts of a project. An impacts register therefore provides a focus for environmental management. The potential impacts of the proposed operations are summarised in Table 7.4.

## 7.11 Environmental Standards and Quality Objectives

In accordance with the PMGL's Environmental Policy, the company will manage its operations so as to minimise potential effects on the environment and to comply with all relevant legislation regarding the protection of the environment. This section sets out the environmental standards that PMGL is committed to achieving. These standards have been set in accordance with the following:

- All statutory requirements which are specific to PMGL
- Relevant Environmental Acts and Regulations (including LI 1652 *Environmental Assessment Regulations* 1999)
- Relevant Regulatory Agencies' environmental guidelines (including Ghana's Mining and Environmental Guidelines and Environmental Protection Agency guidelines for the quality of discharges into natural watercourses, environmental quality guidelines for ambient air and noise)

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- Industry best practice.

## **7.12 Mitigation and Environmental Controls**

PMGL is committed to limiting the impacts of the emissions/discharges identified in the SEIS to ensure compliance with the standards and quality objectives. In order to achieve this aim, PMGL will implement mitigation and control measures as described in Chapter 5 of this document. Specific operational control procedures will be developed to ensure on-going application of the EMP principles throughout the life of the proposed project.

## **7.13 Monitoring**

The current environmental monitoring programme will be modified to encompass all potential new or changed impacts as outlined in Chapter 6 of this document. This will include:

- Continuation of surface and groundwater monitoring at locations established during baseline data collection,
- Establishment of surface and groundwater quality monitoring stations at settling ponds, regular monitoring of water accumulating in the pit and ensure levels meet the EPA criteria before discharge to the environment,
- Selective monitoring of trace elements within ore deposit,
- Maintenance of noise and dust monitoring programme during operations,
- Establishment of an operational blast monitoring regime,
- The community consultative monitoring program, which comprises informal and formal meetings of the community, will be maintained during the PMGL Project.

In accordance with EPA requirements, monthly monitoring returns will be submitted to the EPA.

## **7.14 Occupational Health and Safety**

The principal aspects of the Health and Safety programme that PMGL will be implementing are:

- Training and education of all new employees and contractors at the site prior to commencing work, including use of personal protective Equipment (PPE).
- An internal health and safety report prepared on a monthly basis, which reviews the data available for the previous month and provides recommendations for improvements;
- Application of appropriate occupational health and safety standards, such as World Bank Environment, Health and Safety Guidelines and WHO drinking water standards;

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- PMGL will prepare a comprehensive Emergency Response Management Plan (ERMP), which will provide for emergencies such as fuel spill or fires. A Medical Evacuation Plan, which will be implemented in the event of an accident or medical emergency, will form part of the ERMP.

## 7.15 Audit and Review

Following implementation of the provisional EMP, the HSEC Manager will undertake internal reviews (Table 7.4). The purpose of the reviews is to:

- Ensure that the EMP is being implemented appropriately.
- Identify corrective actions where appropriate.
- Assess the effectiveness of previous corrective measures.

**Table 7.4 - Summary Matrix of Potential Impacts During Operations**

Nature of Impact	Environmental issues							
	Surface water	Ground - water	Air Quality	Soil and Land use	Flora and Fauna	Local Community	Land- scape	Cultural Heritage
<b>Air emissions</b>								
Noise and dust from mining and blasting			√	√	√	√		
Dust from ore stockpile and waste rock dump			√	√	√	√		
Dust from haul roads, un-vegetated ground and vehicular movements			√	√	√	√		
Noise from haulage					√	√		
Emissions from vehicles			√			√		
<b>Liquid effluents</b>								
Pit de-watering	√				√	√		
Potential seepage of water from the opens pit to groundwater and consequent implications for abstraction by local communities		√				√		
Run-off from waste dumps and stockpiles	√				√	√		
Leakage/spillage of oils/fuels	√	√			√	√		
Run-off from site/haul roads	√				√	√		
Sewage storage (septic tank) and disposal		√				√		
Accidental spillage of fuel, oil or chemicals during transport to and from CAGP	√	√			□	√		
<b>Solid wastes</b>								
Waste rock to dump	√	√	√	√	√	√	√	√
Disposal of used storage containers	√	√				√		

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**Table 7.5 - Summary Matrix of Potential Impacts during Operations -Continuation**

	Surface water	Ground - water	Air Quality	Soil and Land use	Flora and Fauna	Local Community	Land- scape	Cultural Heritage
Disposal of scrap, workshop wastes, used tyres, batteries etc.	√	√				√		
<b>Community</b>								
Employment – direct and indirect				√		√		
Loss of income to farmers						√		
Influx of population into area communities due to employment opportunities and potential infrastructure development				√	√	√	√	√
Increase in speculative farming				√	√	√	√	√
Increase in galamsey activity	√	√		√	√	√	√	√
Training opportunities						√		
<b>Others</b>								
Change in topography (open pit, waste storage)	√			√	√	√	√	
Visual						√		
Land take for mining development				√	√	√	√	√
Key: √ Potential impacts								

## 7.16 Environmental Action Plan

PMGL will regularly review its environmental performance against its stated objectives, to determine whether the objectives are being met or whether improvements can be identified. Where a need for improvement is identified, the Environmental Action Plan (EAP) will be scheduled to implement the improvement. Implementation of the Eastern Pits Project will require the following specific actions to follow up on potential impacts and mitigation measures identified, including:

- Implementation of mitigation measures, stipulated in Chapter 5 of this document.
- Implementation of a monitoring programme, stipulated in Chapter 6 of this document.
- Development of detailed EMP as specified in this chapter.

The implementation of the monitoring programme will be the responsibility of the HSEC Manager.

## 7.17 Reclamation/Decommissioning

PMGL is required by legislation to implement a land rehabilitation programme and prepare a decommissioning plan as part of its overall environmental management strategy. In addition, when acquiring the Ayanfuri mining property, Perseus Mining Limited also acquired the rehabilitation liabilities

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of Stratsys Investments Ltd, which in turn had acquired such liabilities from AngloGold Ashanti (Ghana) Limited. Consequently, the Closure Rehabilitation Plan (CRP) will have to address the existing liabilities and those that would newly arise from the development and operation of the Project. Provisional reclamation and decommissioning plans are presented in detail in Chapters 7 and 9 of the SEIS. Rehabilitation will be concurrent with operations to the extent practicable.

## **7.18 Emergency Response Plan**

PMGL will develop an Emergency Response Plan containing procedures to provide the basis for the prevention of and response to environmental incidents. These will cover:

- Identification of the potential for uncontrolled or unintentional release situations;
- Understanding the environmental risk presented by these situations;
- Establishing preventative measures; and
- Preparation and implementation of effective notification and response systems.

Preparedness for accidents and emergencies is implemented in order to reduce risk of occurrence and to control/mitigate the environmental impacts associated with them if they should occur. The requirements will provide for regular reviews and for practice drills. The Emergency Response Plan also requires the Company to notify Governmental Departments and Agencies of any non-compliance to statutory requirements.

## **7.19 Community Relations**

### **7.19.1 Community Consultative Committee**

PMGL understands and is committed to proactive community relations as a key principle in its day-to-day operations as well as for future development planning, as demonstrated in its Community Relations Policy (see introduction note). Many of these community relations will be managed through the proposed Community Consultative Committee (CCC). Some of the issues the Committee will discuss when they meet include but are not limited to:

- Current activities and mining progress
- Planned changes in mining operations
- Proposed exploration activities
- Development of partnerships with stakeholders for community development
- Proposals for company sponsored sustainable livelihood programmes; and
- Plans for company/community development projects and other assistance.

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The Committee will continue to be the forum for discussion and decisions to be made by community leaders and the company on a range of community issues from addressing complaints to community assistance projects.

### **7.19.2 Resettlement Handing Over and Maintenance**

As part of the project development process, an implementing committee to be known as the Handover Technical Committee (HOTC) will be constituted. The HOTC will have a representation from the communities, key government partners, and PMGL. The role of HOTC is to monitor and oversee the construction of the resettlement houses and infrastructure projects at the resettlement site. The committee will also develop the modalities to handover the infrastructure at the resettlement site to the respective statutory bodies.

The HOTC will develop a Commitments Register to assist them in the participatory monitoring of resettlement activities. As part of the HOTC's work, Agreements will be prepared with the respective statutory authorities and the District Assembly to facilitate formal handover of infrastructure and the resettlement community.

Resettlers will be provided with a Handover Document, which will include title to their individual resettlement plot, and guidance on responsibilities in terms of maintenance of private and public infrastructure.

Resettlers will be responsible for maintenance of their individual houses and plots. In terms of public infrastructure, roads, drainage and solid waste disposal will be adopted and managed by the District Administration. Water and electrical infrastructure will be adopted by the respective statutory authorities.

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## 7.20 Financial Allocations

**Table 7.5- Estimated Monitoring Cost for the Eastern Pits Project**

No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
			mE	mN	DRY	WET			
1	PAS1	Along Ayanfuri-Nkonya main road	621204	657559	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
2	PAS7	Bekwai road; downstream of Odumkrom	621987	659975	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
3	PAS8	Wampem upstream	624964	662222	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
4	PAS11	Culvert; along Ayanfuri-Nkonya road.	619343	656236	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16

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No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
5	PAS18	Chirawewa Pit downstream	622920	656619	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
6	PAS19	Odumkrom downstream	622346	660137	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
7	PAS22	Chirawewa Pit Area; downstream of PAS18	623080	655733	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
8	PAS23	Waste pond; Chirawewa Pit area	622905	656723	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
9	PAS37	Ayanfuri close to the Pentecost church	622075	659559	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
10	PAS60	Fetish Pit	621927	657664	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16

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**Table 7.5 Estimated Monitoring Cost for the Eastern Pits Project - Continuation**

No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
11	PAS67	Esujah South Pit	621743	659392	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
12	PAS68	Chirawewa Pit	622526	656638	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
13	PAG24	Wampem community borehole close to railway	624574	660429	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
14	PAG32	Wampem community close to the church	624683	660376	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
15	OPAG15	Ayanfuri behind the Methodist Church	622463	659717	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
16	OPAG41	Along access to camp site	620922	656538	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16

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**Table 7.5 Estimated Monitoring Cost for the Eastern Pits Project – Continuation**

No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
17	OPAG51	Ayanfuri near Hannah's school	622613	659186	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
18	OPAG55	Wampem Village close to railway line	624771	660393	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
19	OPAG56	Military camp	621564	659582	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
20	OPAG57	Wampem Village close to the church	624690	660393	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
21	OPAG59	Nkonya community	619279	655933	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16
22	OPAG64	Ayanfuri in front of Pentecost Church	622216	659546	Once month	Once month	Environmental Monitoring Officer	pH, EC, TDS, TSS, App. Col, True Col, Turb, Alk, Hard, Cl, SO <sub>4</sub> , Na, K, PO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , DO, COD, BOD, Free CN, Total CN, As, Hg, Fe, Mn, Cu, Zn, Al, Cd, Cr, Co, Pb, Mo, Ni, Ca, Mg,	4,367.16

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No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
	Administrative Cost - SGS								423.00
	<b>Sub-Total (SGS)</b>								<b>96,500.52</b>
	VAT+NHIL (17.5% of sub-total)								16,887.59
	Administrative Cost - PMGL								5,000.00
	<b>TOTAL</b>								<b>118,388.11</b>

**NB: The cost is based on the current quotation from SGS. It is assumed that samples will be analyzed once per month.**

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**Table 7.5 Estimated Monitoring Cost for the Eastern Pits Project – Continuation**

No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
			mE	mN					
1	AYC	Ayanfuri Community	YTD	YTD	Weekly	Weekly	Environmental Monitoring Officer	Total Suspended Particulate (TSP), Particulate Matter (PM10) & Noise	7,105.00
2	AYI	Ayanfuri Interface	YTD	YTD	Weekly	Weekly	Environmental Monitoring Officer	Total Suspended Particulate (TSP), Particulate Matter (PM10) & Noise	7,105.00
3	WPC	Wampem Community	YTD	YTD	Weekly	Weekly	Environmental Monitoring Officer	Total Suspended Particulate (TSP), Particulate Matter (PM10) & Noise	7,105.00
4	NKC	Nkonya Community	YTD	YTD	Weekly	Weekly	Environmental Monitoring Officer	Total Suspended Particulate (TSP), Particulate Matter (PM10) & Noise	7,105.00

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**Table 7.5 Estimated Monitoring Cost for the Eastern Pits Project – Continuation**

No.	ID	Description	GPS Coordinates		Frequency of Sampling by Seasons		Sampled By	Analysis	Cost Per Year (USD)
			YTD	YTD	Weekly	Weekly			
5	AKC	Akyease Community	YTD	YTD	Weekly	Weekly	Environmental Monitoring Officer	Total Suspended Particulate (TSP), Particulate Matter (PM10) & Noise	7,105.00
	Equipment Cost	Noise - Casella CEL 633C							33,000.00
	Equipment Cost	Dust - Minivol Tactical Air Sampler							26,820.00
	Administrative Cost	Filters, Calibration and other cost							12,000.00
	<b>TOTAL</b>								<b>107,345.00</b>

## 8 REHABILITATION AND DECOMMISSIONING PLAN

### 8.1 Introduction

The rehabilitation of the Eastern Pits area will be part of the overall closure and decommissioning plan as outlined in the Environmental Management Plan submitted in December 2012 and as per the final decommissioning and closure plan for the Edikan Gold Mine. At mine closure, the active mining or operational areas will have to be restored to a usable state that will be beneficial to all stake holders with special emphasis on the catchment communities. The rehabilitation and decommissioning activities which will be undertaken will conform to Environmental Assessment Regulations, 1999 (LI 1652), Mineral and Mining Act, 2006 (Act 703) as per the reclamation schedule, The Minerals and Mining (Health, Safety and Technical) Regulations, (LI 2182), the EPA permit conditions (EPA/EIA/306), international standards like World Bank Policies and IFC Guidelines and comply with national legislation.

This section provides a description of activities that will be implemented to meet the objectives for rehabilitation and decommissioning at closure. The section also provides an estimation of costs associated with these activities as well as a conceptual schedule for their implementation. It will be subject to ongoing review as part of the environmental management activities in the three year environmental permit review. PMGL is not required to submit a formal closure and decommissioning plan (CDP) until two years before the closure of the Project. In practice, the earlier development of a CDP assists both the Company and the EPA in understanding what will be required, technically and financially, and that the environmental management practices during life-of-mine are consistent with the plans for mine closure and decommissioning.

It is intended that over the life of the mine (6 years), the rehabilitation plan will be subject to regular and detailed review (every three years). The reviews will enable the plan to be developed in more detail and to incorporate changes in design criteria or in the physical conditions on site. In particular, as trials and studies are undertaken, a more detailed plan for closure will be developed.

### 8.2 Reclamation Objectives

PMGL will implement a concurrent progressive rehabilitation and a specific mine site reclamation plan at closure. The plan will focus on the reclamation of the process plant facilities, open pits, haul and access roads, waste rock dumps, ROM Pad, ore stockpile areas, and workshop. The main objectives of the plan will be to:-

- Ensure human health and the safety of humans and property;
- Implement and stimulate sustainable and alternative economic activities in the area at closure;

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- Return the land to conditions capable of supporting the former land use (woodland and agriculture), or where this is not practical, or feasible, an alternative sustainable land use; and
- Minimise potential significant adverse environmental effects on adjacent natural resources, being groundwater and surface water, air quality, fauna and flora.

The requirement and criteria for reclamation and decommissioning are provided in Table 8.1 and 8.2 respectively. Following international environmental guidelines as well as best practice, PMGL will establish a basic Rehabilitation Procedure which sets out general planning and development objectives for progressive reclamation and mine closure.

These objectives are:

- Provide a final land-use that considers the needs of the stakeholders;
- Provide landforms that blend with the natural topography;
- Provide a site both chemically and physically stable;
- Leave disturbed areas in a safe and stable condition;
- Ensure that potential long-term environmental liabilities associated with the closure of the site are minimized;
- Restore as much as possible the mining area to a sustainable land-use capability as practicable; and
- Provide rehabilitated areas that contribute to the long-term sustainability of the local economy.

**Table 8.1- Reclamation and Decommissioning Requirements**

Legal Compliance	Meets current Ghanaian legislation and anticipates changes to Ghanaian legislative and community expectations over the project life of 6 years
Corporate Policy	Complies with policy
Risk of future non-compliance	Low
Final land use	Restoration of disturbed areas and agricultural on non-forest areas after consultations with all stakeholders including the Community Consultative Committee.

### 8.3 Reclamation Principles

The basic principles of reclamation (also stated in the Rehabilitation Procedure) that will be followed by PMGL are:

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**Table 8.2- Closure criteria**

Community Involvement	<ul style="list-style-type: none"> <li>Stakeholders including the Community Consultative Committee will be team members and will be involved at all stages of the planning process by means of periodic formal meetings</li> <li>Entrepreneurial local people or businesses will be encouraged to participate in the execution of work programmes</li> </ul>
Socio Economic Impacts	<ul style="list-style-type: none"> <li>The quality of life of all stakeholders, as measured by quality of living conditions, health services, general infrastructure and per capita income will be measurably higher than what existed before commencement of operations, with the improvements that will be self-funding and sustainable at the completion of operations</li> </ul>
Water Resources	<ul style="list-style-type: none"> <li>If an impact is identified a remediation programme will be implemented such that the impact shows a diminishing trend.</li> <li>Should any long term management be required it will be achieved by passive and self-sustaining systems</li> </ul>
Soil Erosion	<ul style="list-style-type: none"> <li>The suspended solids loading of run-off from site will be no higher than as is measured at control sites established up slope of operations</li> </ul>
Revegetation	<ul style="list-style-type: none"> <li>Establishment of agricultural crops or livestock feed</li> </ul>
Visual Amenity	<ul style="list-style-type: none"> <li>Consideration will be given during the design stage</li> </ul>
Physical safety	<ul style="list-style-type: none"> <li>Drill holes plugged, trenches backfilled, open pits bunded or fenced as required</li> </ul>
Waste Rock Dumps	<ul style="list-style-type: none"> <li>Demonstrate that the final landform has been designed to maintain integrity for a 100 year timeframe</li> </ul>
Residual Contamination	<ul style="list-style-type: none"> <li>Allows establishment of agricultural crops and does not restrict public access to site</li> </ul>

- Progressively rehabilitate the site wherever possible;
- To the greatest extent possible, reshape the land so that it is stable, adequately and sensibly drained, and suitable for the end-land use and for re-vegetation;
- Recover, characterize, store, and reuse as much topsoil as possible;
- If topsoil is not adequate or if unsuitable, test alternative substrates such as overburden or oxide materials, and/or utilize agricultural soil amendment techniques;

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- Identify and manage reactive waste rock so as to minimize long-term effects on the environment;
- Re-vegetate with local species as much as possible, or use species that have been proven to adapt to local environmental conditions; and
- Monitor and manage rehabilitated areas until the vegetation is self-sustaining and reclamation objectives have been met.

## **8.4 Progressive Rehabilitation and Decommissioning Activities**

Progressive rehabilitation encompasses those activities that will be undertaken during the operational phase of a facility in order to prepare or which are part of the facility and/or site for final closure. Progressive rehabilitation activities will be undertaken without hindering regular mining operations, and will be generally carried out in areas which are no longer expected to be affected by mining operations. Such activities may include the progressive re-vegetation of inactive mining areas, the erection of warning signs in areas of subsidence, the installation of erosion control structures or the construction of final surface spillways for tailings impoundments.

The objectives for undertaking these activities are defined in the Environmental Action Plans. The period of time required for these activities varies depending on the extent and nature of rehabilitation required and the anticipated duration of operations of the facility.

Decommissioning activities will be undertaken at closure to achieve the required closure objectives, namely, public health and safety, environmental protection and the restoration of land capability to pre-mining levels as in Table 6.1. For the purpose of scheduling, periods of three (3) years have been assumed for the completion of decommissioning activities towards final closure of the mining facilities.

Following closure of each mine component, provision has been made for a three (3) year monitoring period and maintenance. Closure will be considered complete when the site or facility can be shown to be physically and chemically stable, and the land has been restored to its pre-mining capability (i.e., when closure objectives have been met). A summary cost and schedule of progressive rehabilitation, decommissioning and closure, and post-closure monitoring for each mine component is provided in Table 8.3 with breakdown of cost components in Table 8.4. The estimated reclamation cost is \$2,900,256 with operational cost of backfilling two pits at \$10,558,643.

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**Table 8.3- Rehabilitation and Closure Cost Estimat**

	Comments	Footprint Area (m <sup>2</sup> )	Footprint Area (ha)	Reshaping of Slopes (\$1132/ha)	Storm Water Channels & Safety Windrows (\$110/ha)	Topsoil Placement & Spreading (\$1400/ha)	Erosion Control & Groundcover Vegetation (\$1300/ha)	Establish vegetation (\$2600/ha)	Ongoing Soil Analysis (\$300/ha)	Ongoing Care & Maintenance (\$800/ha)	Drainage (\$300/ha)	
<b>HISTORICAL</b>	Besem North Pit	41557	4.2	\$4,704	\$457	\$5,818	\$5,402	\$10,805	\$1,247	\$3,325	\$	
	Besim Pit	21833	2.2	\$2,472	\$240	\$3,057	\$2,838	\$5,677	\$655	\$1,747	\$	
	Besim South	17933	1.8	\$2,030	\$197	\$2,511	\$2,331	\$4,662	\$538	\$1,435	\$	
	Nkonya Pit	26912	2.7	\$3,046	\$296	\$3,768	\$3,499	\$6,997	\$807	\$2,153	\$	
	Besim North Waste Dump	31225	3.1	\$3,535	\$343	\$4,372	\$4,059	\$8,119	\$937	\$2,498	\$	
	Nkonya Waste Dump	26266	2.6	\$2,973	\$289	\$3,677	\$3,415	\$6,829	\$788	\$2,101	\$	
	Bokitsi Waste Dump	129503	13.0	\$14,660	\$1,425	\$18,130	\$16,835	\$33,671	\$3,885	\$10,360	\$	
	Fetish Waste Dump	132737	13.3	\$15,026	\$1,460	\$18,583	\$17,256	\$34,512	\$3,982	\$10,619	\$	
	<b>Totals</b>		<b>427966</b>	<b>42.8</b>	<b>\$48,446</b>	<b>\$4,708</b>	<b>\$59,915</b>	<b>\$55,636</b>	<b>\$111,271</b>	<b>\$12,839</b>	<b>\$34,237</b>	<b>\$1</b>
	<b>EASTERN PITS OPERATION</b>	Fetish Waste Rock Dump	Newly created	384724	38.5	\$43,551	\$4,232	\$53,861	\$50,014	\$100,028	\$11,542	\$30,778
Chirawewa North Waste Rock Dump		Covers Chirawewa North Backfilled pit	93197	9.3	\$10,550	\$1,025	\$13,048	\$12,116	\$24,231	\$2,796	\$7,456	\$
Bokitiso South Waste Rock Dump			72737	7.3	\$8,234	\$800	\$10,183	\$9,456	\$18,912	\$2,182	\$5,819	\$
Chirawewa South Waste Rock Dump		Covers existing waste rock dump and bakfilled Chirawewa South pit	87509	8.8	\$9,906	\$963	\$12,251	\$11,376	\$22,752	\$2,625	\$7,001	\$
Esujah North Rock Waste Dump		Covers historical Festish Waste Rock Dump	323900	32.4	\$36,665	\$3,563	\$45,346	\$42,107	\$84,214	\$9,717	\$25,912	\$1
Haul Roads		Include haul road from Fetish and Esujah North pits to Highway	66000	6.6	\$7,471	\$726	\$9,240	\$8,580	\$17,160	\$1,980	\$5,280	\$
Access Roads			23000	2.3	\$2,604	\$253	\$3,220	\$2,990	\$5,980	\$690	\$1,840	\$
Office Area			8000	0.8	\$906	\$88	\$1,120	\$1,040	\$2,080	\$240	\$640	\$
Fuel Storage Area			8000	0.8	\$906	\$88	\$1,120	\$1,040	\$2,080	\$240	\$640	\$
ROM pad			34256	3.4	\$3,878	\$377	\$4,796	\$4,453	\$8,907	\$1,028	\$2,740	\$
Pit Area Non-restorable			247891	24.8	\$28,061	\$2,727	\$34,705	\$32,226	\$64,452	\$7,437	\$19,831	\$
Misc			28340	2.8	\$3,208	\$312	\$3,968	\$3,684	\$7,368	\$850	\$2,267	\$
			314500	31.5	\$35,601	\$3,460	\$44,030	\$40,885	\$81,770	\$9,435	\$25,160	\$1
			135000	13.5	\$15,282	\$1,485	\$18,900	\$17,550	\$35,100	\$4,050	\$10,800	\$

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Comments	Footprint Area (m <sup>2</sup> )	Footprint Area (ha)	Reshaping of Slopes (\$1132/ha)	Storm Water Channels & Safety Windrows (\$110/ha)	Topsoil Placement & Spreading (\$1400/ha)	Erosion Control & Groundcover Vegetation (\$1300/ha)	Establish vegetation (\$2600/ha)	Ongoing Soil Analysis (\$300/ha)	Ongoing Care & Maintenance (\$800/ha)	Drainage (\$300/ha)
	228631	22.9	\$25,881	\$2,515	\$32,008	\$29,722	\$59,444	\$6,859	\$18,290	\$18,290
	35419	3.5	\$4,009	\$390	\$4,959	\$4,605	\$9,209	\$1,063	\$2,834	\$2,834
<b>TOTAL</b>	<b>2091104</b>	<b>209</b>	<b>\$236,713</b>	<b>\$23,002</b>	<b>\$292,755</b>	<b>\$271,844</b>	<b>\$543,687</b>	<b>\$62,733</b>	<b>\$167,288</b>	<b>\$167,288</b>

Infrastructure  
**Backfilling of Bokitiso South and Chirawewa Pits**      **Backfilling part of operational budget**

3016755      3.5

Sustainable Livelihood

**TOTAL AMOUNT**

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**Table 8.4 Breakdown of Unit Costs for Task, Operations and Items in Table 8.3**

Task, Operations, Item	Unit Costs/ year USD	No. Of Units/ year	Total Costs/ year		
<b>Establish erosion control vegetation (Vetiver)</b>					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials part of annual opex)	1250	1	1,250		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	3	5,100		
Vetiver grass grown in owners nursery, costs included in the operating costs					
<b>Total</b>			124,916		
<b>Annual Coverage (based on other operations performance)</b>	100	Ha/yr	<b>1,249</b>		per Ha
<b>Establish initial nitrogen fixing vegetation</b>					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials )	1250	1	1,250		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	6	10,200		
Seedlings (2m x 2.5m seeding space for good coverage) USD each	2.5	2000	5,000		
<b>Total</b>			135,016		
<b>Annual Coverage (based on other operations performance)</b>	75	Ha/yr	<b>1,800</b>		per Ha
<b>Establish final land use vegetation</b>					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials )	1250	8	10,000		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	6	10,200		
Seedlings (2m x 2.5m seeding space for good coverage) USD each	4.00	2000	8,000		

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**Table 8.4: Breakdown of Unit Costs for Task, Operations and Items in Table 8.3 – Continuation**

Task, Operations, Item	Unit Costs/ year USD	No. Of Units/ year	Total Costs/ year	Task, Operations , Item	
Total			146,766		
<b>Annual Coverage (based on other operations performance)</b>	60	Ha/yr	<b>2,446</b>		per Ha
<b>Establish vegetation on pit benches</b>					
Unskilled (unit costs for gardeners)	7030	10	70,300		
Supervision & management (annual cost for supervisor)	21333	2	42,666		
Vehicle (operating costs only assumed fully owned)	2800	2	5,600		
Mobile equipment (owned equipment used to move materials )	1250	8	10,000		
Watering 3 months (as per indicated costs from Mining Contractor)	1700	6	10,200		
Seedlings (2m x 2.5m seeding space for good coverage) USD each	4.50	2000	9,000		
Dozer works	1200	20	24,000		
<b>Total</b>			<b>171,766</b>		
<b>Annual Coverage (based on other operations performance)</b>	60	Ha/yr	<b>2,863</b>		per Ha

## 8.5 General Land Reclamation Methods

The following land reclamation and re-vegetation methods, soils management and conservation technologies will be under consideration for the restoration of reclamation units disturbed by mining operations.

### 8.5.1 Topsoil and overburden cover

The use of topsoil (and oxide or overburden cover as necessary) is a principal means of preparing reshaped land forms for vegetation establishment on disturbed areas. PMGL has a Topsoil Management Procedure in place, to recover as much topsoil as practicably possible from any area prior to its disturbance. Significant depths and quantities of recoverable topsoil materials exist on relatively flat lying upland areas. Any recoverable topsoil will be stockpiled and protected in accordance with company guidelines and best practice for future re-handling and reuse.

The spreading of layers of local recovered topsoil (0.5m), containing natural seeds and growth medium, on to oxide or laterite materials to establish vegetation is a recognised reclamation technique. This technique has been shown to be successful in establishing sown seeds on disturbed areas and waste dumps. The Project reclamation programme will continue to utilize this technique as a valuable

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revegetation method. Its potential value will largely depend on the amount and quality of topsoil that can be conserved during development of the project.

### **8.5.2 Agricultural Soil Amendment Methods**

If sufficient quantities of topsoil are unavailable, the use of agricultural soil amendment methods will be considered. These methods generally consist of adding suitable quantities of a substance (chemical or natural such as manure, compost, sludge, etc.), or topsoil substitutes (subsoil, overburden, mine oxide waste material) to increase fertility of the surface to be rehabilitated though the latter is limited in its effect. Saw dust from numerous timber mills in the catchment communities will be utilised for this programme.

### **8.5.3 Direct Establishment of Vegetation**

The establishment of vegetation directly on reclamation units is the most effective and economical method of achieving the objectives of a reclamation programme. This technique is often not expensive and has been proved successful particularly in tropical areas. It also provides for greater long-term stability of the vegetative cover. Prior to establishment of any vegetation, reclamation units will be adequately reshaped and scarified if compacted during operations. The operational area is endowed with indigenous nitrogen fixing and commercial tree species.

### **8.5.4 EPA Species Planting Recommendations**

The inclusion of a given percentage of at least 40% of the indigenous species in non-agricultural revegetation programmes is a stated objective of the EPA. PMGL is currently planting 80% indigenous and 20% semi-exotic species.

### **8.5.5 Production of Plant Material**

PMGL has established a tree species nursery with an average stock of 80,000. The designed capacity of the nursery is 100,000 species comprising of both nitrogen fixing and commercial species. Adequate provision has been made to sufficiently produce seedlings to meet the reclamation plan. Table 8.5 represents the current stock levels at the PMGL nursery.

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**Table 8.5- Plant species at the PMGL Nursery**

PMGL NURSERY TREES FOR REHABILITATION		
SCIENTIFIC NAME	COMMON NAME	TOTAL
<b>LOCAL</b>		
<i>Albizia zygia</i>	Okoro	2180
<i>Entandrophragma angolense</i>	Edinam	17855
<i>Antiaris toxicaria</i>	Kyenkyen	595
<i>Ceiba pentandra</i>	Onyina	759
<i>Terminalia ivorensis</i>	Emire	3386
<i>Khaya spp.</i>	Mahogany	11050
<i>Heritiera utilis</i>	Nyankom	1410
<i>Terminalia superba</i>	Ofram	1695
<i>Pycnanthus angolensis</i>	Otie	994
<i>Nuclea diderichii</i>	kusia	888
<i>Triplochiton scleroxylon</i>	Wawa	3780
<i>Albizia ferruginea</i>	Awiefo samena	2160
<i>Militia milita</i>	Militia	2830
<b>EXOTIC</b>		
<i>Samania samea</i>	Samania	990
<i>Cedrela odorata</i>	Cedrela	298
<i>Cassia siamea</i>	Cassia	645
<b>OTHERS</b>		
<i>Anacardium occidentale</i>	Cashew	2045
<i>Piper nigrum</i>	Hwintea	420
<i>Mangifera indica</i>	Mango	308
<i>Cocos nucifera</i>	Equitorial dwarf coconut	1000
		<b>55288</b>

### 8.5.6 Establishment of Plant Material

Establishment of plant material on surfaces that have been adequately prepared for reclamation will be manually planted with nursery-raised seedlings or dispersion of seeds and cuttings.

### 8.5.7 Testing of Reclamation Techniques

The various reclamation species and manual techniques presented above are currently being utilised at various mine operations in southern Ghana. The programme will be under the supervision of the HSEC Department.

### 8.5.8 Control of Erosion

Control of erosion is important during the life of mine. It is a key factor to achieve sustainable reclamation. A number of practices to ensure control of erosion are proposed as follows:

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- Deforestation and land clearance will be limited to the strict minimum;
- Whenever possible, early revegetation of disturbed areas will be undertaken;
- Drainage from external catchments will be controlled by diversion channels or appropriate holding structures;
- The length and gradient of structure slopes will be managed to be at a minimum. Long slopes will be provided with erosion control and water management structures (such as interception ditches, drop structures or other energy dissipation structures, sculpted areas and sediment control features);
- Use of erosion control materials on structures such as embankments and steep drainage channels, as necessary;
- Drainage structures designed for a 1:100 year storm event;
- Use of Vetiver and other grasses to control sheet and rill erosion;
- On roads, use of side drains, road camber, and drainage controls to ensure adequate drainage; and
- Visual assessment of erosion and analysis of run-off water will be a preventative measure carried out on a routine basis, which will provide rapid evidence of where control measures need repair or implementation.

## **8.6 Post-Reclamation Monitoring and Maintenance**

Post-reclamation monitoring and maintenance will begin after completion of the reclamation work and will extend through the period of physical stabilisation. It is expected that such monitoring will be for a minimum of three years.

The reclamation programme will be concurrent with the mining operation wherever feasible and practical, although for this relatively short-lived mining operation, the opportunities for concurrent reclamation will be limited. Information from current operations, in conjunction with the overall environmental monitoring programme during the same period, will enable the prospective length of the post-monitoring programme to be more accurately determined towards the end-of-mine life.

Surface and ground water sampling will continue on a quarterly basis through the post-reclamation period or more frequently if water test results prove it necessary. These results will be compared with baseline data collected at the beginning of the project to ascertain current status and identify problem areas. Periodic qualitative and quantitative monitoring of the revegetated areas and notation of observations will identify actual and potential problems that can be corrected with the maintenance programme. Qualified and experienced personnel will conduct the monitoring.

Monitoring techniques will be selected from one or more of the following:

- Qualitative and quantitative analysis of vegetation cover and revegetation successes;
- Tissue analysis of selected plant species; and
- Analysis of re-vegetated soils and wastes.

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## 8.7 Decommissioning and Closure

### 8.7.1 Waste Rock Dumps

All rock waste dumps will be reshaped at an overall angle of repose between 20 - 30 degrees followed by placement of 250 cm thickness of growth medium and subsequent 250 cm of topsoil prior to revegetation. Rehabilitation monitoring will be carried out on annual basis over a three years period to establish metals and nutrient levels for a particular area. Seepage from waste dumps will be monitored on a monthly basis to establish acid generating potentials. Waste rock dumps will be converted to woodlots, afforested with commercial tree species, plantation or trial plots for cash crops.

### 8.7.2 Workshops and Offices

All ore on the ROM Pad and transient ore stockpiles will be processed at the existing plant. The area will be re-profiled to establish the natural drainage pattern.

The following plant and equipment dismantling and disposal practices will be applied to the crusher plant, mill, process plant and workshops, provided there are no demands on them from the local businesses or people :-

- Removal of all prefabs and brick buildings;
- Breaking out and removal of all concrete foundations;
- Removal of steel frames;
- Demolish reinforced concrete structures and dispose of on-site;
- Remove HDPE liners and backfill all process ponds;
- Remove electrical equipment, cables, pumps, motors, and other fixed equipment;
- Remove all above and below fuel storage tanks;
- Cut up and remove all steel tanks;
- Remove all pipelines;
- Dig up and remove all below ground electricity cables;
- Remove conveyor belting;
- Remove all mechanical equipment;
- Materials handling areas will be cleared of all raw materials and concentrates;
- General site clean up
- Site levelling and profiling to re-establish the natural drainage pattern across the site; and redistribution of stockpiled soils and re-vegetation of the site with indigenous grasses and trees. A soil cover of 500mm should be spread over the site before revegetation as per EPA requirements.
- Scrap metals and equipment will be sorted and sold to the local community, businesses and scrap metal merchants. The company will remove all equipment and materials that cannot be re-used, recycled or sold, to an approved non-hazardous disposal site.

PMGL will negotiate with private, governmental and non-governmental organisations to identify whether the water treatment facility can be sold for use by a private, governmental or NGO water provider. The negotiation will be concluded three (3) years before closure.

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### 8.7.3 Reclamation of Open Pits

Reclamation and decommissioning of open pits are classified into two main streams; non-restorable and restorable pits.

#### Non-Restorable

The Abenabena/AF Gap pits, Fetish and Esuajah North pits will remain as open pits and considering their final geometry and the pre-mining ground water conditions and the surface water drainage network, it is anticipated a pit lake will develop in each in the post-closure mine condition. The perimeter drains established upstream of each pit to prevent inflow of rainwater into the pits during operation will be modified to enable upstream runoff to flow into the pit. Using this method the pits can be filled during wet season. The possibility of converting them into sources of domestic and/or irrigation water for agriculture and/or fisheries development will be investigated.

Rehabilitation work will include:

- Reshaping of pit perimeters to accord with the document
- To ensure public safety is achieved the pits will be double bunded after the reshaping has been completed. Live vegetation fences (madrass thorn) in front of the bunds will be planted as an additional safety barrier on reshaped perimeters.
- Installation of an emergency spillway.

The perimeters of pits that will not be backfilled will be reshaped prior to closure according to the guidelines of the Revised Akoben Methodology. The final production wall will be graded back from the base of complete oxidation within the pit into the surrounding natural contour. The reshaped perimeter would have benches 10m wide and 8m in height. Pits that will not be backfilled will be converted into aquacultures or as source of water for irrigation farming as per what will be agreed on through the Community Consultative Meetings.

The reshaped perimeter berms and walls will be revegetated with a mixture of native and introduced species according to EPA requirements on such mixtures. The pit ramp will be double bunded and made safe from vehicle access, further the ramp will be scarified dressed with topsoil and seeded with stabilization vegetation.

#### Restorable Pits

The backfilled Chirawewa and Bokitiso South pits will be rehabilitated in the same manner as all waste dumps.

## 8.8 Other Infrastructure and Facilities

### 8.8.1 Transport Infrastructure

Transport infrastructure such as site access roads, bridges and drainage channels will be re-vegetated based on the end user to be established in consultation with all stakeholders. This will be evaluated at the appropriate time pre-closure through the company's ongoing public consultation programme. Road

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infrastructure to be retained will be identified and those not needed will be cleared and re-profiled to suit natural drainage and re-vegetated.

### **8.8.2 Settlement Pond and Mine Site Drainage Systems**

After cessation of mine operations all settlement pond silt will be tested for contamination. The results of this test work will indicate the measures needed to stabilise the silt to avoid additional contamination of the surface and groundwater. The settlement ponds will be re-profiled with the addition of waste or previously stripped topsoil and organic matter and re-vegetated.

### **8.8.3 Re-vegetation of Disturbed Areas**

For the purposes of re-vegetation, stripped soil and organic material will be stockpiled for future use during site preparation. A tree species nursery will be stocked for the concurrent and progressive re-vegetation of closed stable areas. The nursery will consist of 80 percent indigenous tree species. In general the stages of re-vegetation will be:-

- Site stabilisation and profiling;
- Site contamination assessment in order to evaluate conditions needed for re-vegetation;
- Addition of stripped soil, fertiliser and organic material;
- Planting or transfer of trees from the nursery (under the supervision of a competent forester);
- Post planning care (replacement and fertilising); and
- Final site inspection to clarify if the re-vegetation is successful.

The areas that will be re-vegetated at post closure include:

- Waste rock dump;
- Tailings dam;
- Ore stockpiles;
- Settlement ponds;
- Drainage channels;
- Closed areas of the plant; and
- Roads, and areas underlying removed infrastructure.

The time table for successful re-vegetation of all relevant areas of the project area is three (3) years post closure. However where possible progressive rehabilitation will be undertaken for such identified areas. This will ensure validation of measures and cost effectiveness.

### **8.8.4 Management of Contaminated Soil**

A soil survey will be conducted at closure to identify any areas of inorganic and/or organic soil contamination. The soil survey will involve a programme of test pitting to a depth of 500mm, soil sampling and analysis. The number and location of test pits will be based on a site walkover/inspection at closure to identify potentially contaminated soils.

A deeper soil inspection may be necessary at specific locations (pollution sources) depending on the findings of the near surface soil survey. Inorganic soil contamination including nickel, copper, cobalt and sulphate will be treated on-site using neutralisation methods to reduce the concentration of

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contaminants in the soil solution. Localised soil contamination resulting from the accidental spill of diesel and oil will be treated by the removal of contaminated soil from affected areas to an appropriate disposal facility or to the bio-remediation site.

Soil contaminated with chemicals, reagents or oils will be removed to an approved hazardous waste disposal site. Soil heavily contaminated with ore and concentrate materials will be treated in the concentrator before dismantling. The ROM pad, ore stockpiles and process plant site will be re-vegetated following the removal of any remaining ore, process plant dismantling, removal from site of all equipment and materials, treatment or removal of contaminated soil (if any) and re-profiling of the area to re-establish natural drainage patterns. A soil improvement programme will be carried out using stockpiled organic matter and topsoil, prepared organic mulches and fertilizer. Indigenous plants, shrubs and trees will be transplanted from a nursery area. The dismantling and removal from site of all buildings, sewage systems, workshops, fuel storage facilities, electrical and mechanical equipment and materials will be carried out, unless they can be put towards a sustainable use. The mine drainage sedimentation ponds will be cleaned (if necessary) and backfilled.

### 8.8.5 Management of Waste Disposal Sites

#### Non-Hazardous Waste

The non-hazardous waste disposal site which will mainly be on the rock waste dumps will be encapsulated with clay material and top soil layer of 250mm and re-shaped to suit the natural drainage and re-vegetated.

#### *Hazardous Waste Disposal Site*

A hazardous waste disposal area will be re-shaped and topsoil spread over the area for revegetation. Concurrent rehabilitation of decommissioned trenches will be carried out to reduce cost and expenditure at closure. A monitoring borehole sited 200 meters North-west of the hazardous waste disposal site will be monitored on a monthly basis for early detection of contamination of ground water

### 8.8.6 Historical Facilities

The Eastern Pits area was the core center of historical mining in the area and the following facilities have been ear marked for reclamation;

- Besem North Pit
- Chirawewa South Pit
- Nkonya Pit
- Besem North Waste Dump
- Nkonya Waste Dump

## 8.9 Post Closure Mine Site Inspection, Monitoring and Reporting

The Company will implement a programme of post closure environmental inspection and monitoring to assess the success of mine reclamation and verify that the various components of the closed mine are not adversely impacting adjacent watercourses and groundwater, and do not pose a potential health

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risk and/or danger to the public. The Company proposes a bi-annual closure environmental inspection and monitoring for the first 3 years to establish seasonal variations. Bi-annual site visits will be made in September (before the minor rain season) and in April (at the start of the major rain). Final inspection and monitoring will be conducted 4 years after mine closure. The findings of this inspection will determine whether or not any further post closure site inspection is necessary.

### **8.9.1 Post Closure Environmental Inspection**

Post closure environmental inspections will focus on:-

- Erosion on the waste rock dump sidewalls and upper surfaces;
- Erosion at the CTSF and FTSF;
- Success of establishing an indigenous vegetation cover on the CTSF, FTSF, process plant site, ROM pad, mine waste rock and ore stockpile areas;
- Any activity by the general public or persons unknown that may adversely affect the stability of disused mine structures, pose a danger to the community or possibly result in environmental degradation; and
- The condition of site access roads, bridges and culverts.

Consultations will be held with local community leaders to listen to and record any issues of concern pertaining to the closed mine site.

### **8.9.2 Post-closure Environmental Monitoring**

Post-closure reclamation monitoring and maintenance will begin after completion of the reclamation work and will extend through the period of physical stabilisation. It is estimated that such monitoring will be for a minimum of three years or such time as necessary.

Surface and ground water sampling will continue on a quarterly basis through the post-reclamation period or more frequently if water test results prove it necessary. These results will be compared with baseline data collected during the Project's exploration phase and throughout the operational phase to ascertain current status and identify problem areas.

Periodic qualitative and quantitative monitoring of the re-vegetated areas and notation of observations will identify actual and potential problems that can be corrected with the maintenance program

Post-closure environmental monitoring will include the following tasks:-

Surface water samples will be taken at the following sites: -

- Drainage from the former process plant area;
- Drainage from the former ROM Pad;
- Drainage from the waste rock dump;
- Drainage from the CTSF and FTSF;
- Drainage from the workshop and former ore stockpile area; and
- Local Streams
- Groundwater sampling at the plant area, TSF and workshop and boreholes

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- Dust sampling from the TSF, and process plant area
- Soil sampling and testing for rehabilitated areas like the waste rock dump, plant area and TSF
- Fauna Survey of rehabilitated areas
- Aquatic biological monitoring of major streams in the area

### **8.9.3 Post-closure Environmental Reporting**

The HSEC manager will produce an annual post-closure environmental monitoring report at the end of years 1 and 2 and a final post closure environmental report at the end of year three. These post closure environmental reports will be submitted to the EPA and made available to all stakeholders. The reports will present the findings of the mine site inspections/walkovers and the results of the environmental monitoring programme.

Additional reclamation works will be undertaken where earlier works carried out has not met the desired criteria for closure. The reports will include a post closure photographic record of mine reclamation. No significant post closure environmental issues are anticipated. Environmental inspections and monitoring should cease in year 4, subject to approval from the EPA.

## **8.10 Mine Site Rehabilitation, Decommissioning and Closure Costs**

The costs shown in Table 9.3 are estimated values and actual values will be established during the first environment certificate period following consultation with relevant stakeholders. Actual estimates will be established to carry out mine site decommissioning and reclamation works and conduct post closure inspections and environmental monitoring for the Eastern Pits Project.

### **8.10.1 Mine Decommissioning and Rehabilitation Costs**

The project will have impacted on agriculture and land use activities. The current reclamation and decommissioning cost and schedule is for the six (6) years mine life. Decommissioning and rehabilitation plan assumes that mining and mineral processing operations at EGM will not continue after the end of the project life. The estimated cost of decommissioning and rehabilitating all mine components is provided in Table 8.3.

PMGL will finance of the rehabilitation and closure aspects of the project from its annual budget and operating costs. A detailed cash flow analysis of annual funds required was provided by PMGL in the reclamation bond. Periodical reviews of reclamation costs developed through trials on the Project areas during operations will be utilised.

### **8.10.2 Calculation of Unit Costs in Southern Ghana**

Unit Cost for Soil Movement (Load, Haul, Dump and Spread)

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**Equipment Hiring Cost**

The minimum equipment combination for reclamation work has been assumed to be: Bulldozer, (1 D9 or D8); Excavator (1); 5 Dump Trucks (20m<sup>3</sup>).

The commercial hiring rate of earth moving equipment is presented in Table 8.6. The variation in rates is attributed to the state of the equipment. The preferred equipment to be used is as presented.

**Table 8.6- Equipment Basic Rate Scenarios**

<u>Equipment</u>	<u>Rate (US\$/hr)</u>		<u>Rate (US\$/day) of 10hrs</u>
A. Bulldozer	1	115	1150.00
	2	95	950.00
	3	75	750.00
B. Excavator	1	120	1200.00
	2	100	1000.00
	3	80	800.00
C. Dump truck - (20m <sup>3</sup> )	1	80	800.00
	2	45	450.00
	3	40	400.00

*Source: African Mining Services*

Using rates in Tables 9.5 and 9.6 for topsoil and waste rock handling;

Trips per hour (5 trucks)      10

Volume of trucks                      20m<sup>3</sup>

Volume per hour:                      10 x 20 m<sup>3</sup> = 200m<sup>3</sup>

Therefore cost/m<sup>3</sup>:                      US\$(A'(1) + B'(1) + 5C'(1))/200

US\$(155+155+400)/200 = US\$710/200

**US\$3.55/m<sup>3</sup>**

Similarly, cost for **scenario 2:**      US\$(135+135+280)/200

**US\$2.75 /m<sup>3</sup>**

Also, cost for **scenario 3:**              US\$260/200

**US\$2.26/m<sup>3</sup>**

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The selected unit cost is **US\$3.55/m<sup>3</sup>** calculated from scenario 1 equipment hiring cost (Table 8.7). The present prevailing contractors' rate for material transport at other mine sites (e.g. Obuasi and Tarkwa) averages **US\$3.53/m<sup>3</sup>**, which compares well with the unit rate selected.

**Unit Cost for Battering and Re-contouring of Facilities**

From experience a dozer working, covers an average ground of 800m<sup>2</sup>/hr

Using this work rate (i.e. 800m<sup>2</sup> /hr), a dozer will cover 0.08hr/ha.

But unit cost of dozer/hr= US\$155 (see Table 9.5 above)

Therefore the cost for re-contouring a hectare of land = US\$155/0.08ha

**= US\$1,937.5/ha**

Table 8.7- Equipment Unit Rate Scenarios (includes fuel and lubricants)

Therefore **unit cost** applied to re-contouring: **US\$1,938/ha. (Component A)**

**Re-vegetation Cost**

All the areas reclaimed will have to be re-vegetated to return biodiversity to the area.

**Items Required**

The items required include:

- Topsoil
- Manure/Fertilizer
- Seedlings
- Planting implements
- Transportation

Activities to be undertaken include:

- Spreading of topsoil on re-contoured land
- Planting of seedling
- Fertilizer or manure spreading
- Weeding
- Biodiversity restoration

**Cost of Material**

The material required per hectare, their unit cost and the cost per hectare are presented in Table 8.8.

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**Table 8.7- Equipment Basic Rate Scenarios**

Equipment	Rate (US\$/hr)		Rate (US\$/day) of 10hrs
	1	2	3
A'. Bulldozer D8	1	155	1550
	2	135	1350
	3	115	1150
B'. Excavator(cat 330)	1	155	1550
	2	135	1350
	3	115	1150
C' Dump truck (20m <sup>3</sup> )	1	80	800
	2	70	600
	3	65	550
Totals	1	390	3900
	2	330	3300
	3	285	2850

**Table 8.8- Items Required Per Hectare and Cost**

Item	Quantity/Ha	Unit Cost (US\$)	Cost/Hectare (US\$)
Seedling	4,800	0.4	1,920.00
Topsoil (20m <sup>3</sup> )	6 trips	90	540.00
Fertilizer (bags)	4 (25 kg)	30	120.00
Farm implements	lot		10.00
Pest control	Lot	120	120.00
Transportation (days)	20	100	2,000.00
<b>Total (Component B)</b>			<b>4710.00</b>

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### Cost of Activities

The activities to be carried out in order to re-vegetate a hectare of reclaimed land and the cost per hectare are presented in Table 8.9.

The cost of re-vegetation required has been estimated from material and activity (Tables 9.7 and 9.8) as **(x) and (y)**.

Therefore unit cost for vegetating 1 hectare of reclaimed land = **Component A + Component B + Component C**  
 = 1,938 + 4710 + 3,150  
 = **US\$9,798**

**Table 8.9- Cost of activities per hectare of re-vegetation**

Activity	Man-days	Unit Cost (US\$)	Amount (US\$)
Topsoil spreading	40	5	200.00
Seedling planting	80	5	400.00
Fertilizer broadcasting	30	5	150.00
Maintenance weeding	480	5	2,400
Total (Component C)			3,150.00

Therefore, the unit cost of vegetating a hectare is **US\$9, 9798**.

### Estimating the Environmental Restoration Cost

The environmental restoration mitigation required for which cost must be estimated include:

- Backfilling of pit void;
- Construction of safety bunds around mined out pits;
- Creation of pit lake;
- Re-contouring or battering of rock waste dump slopes;
- Construction of drainage/storm water channel; and
- Re-vegetation of all reclaimed lands

The unit costs for reclamation and re-vegetation are presented in Table 8.10.

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**Table 8.10- Unit Cost for Reclamation and Re-vegetation**

Activity	Rate (US\$)
Material /Topsoil handling	3,500/ha
Battering and re-contouring	1,938/ha
Re-vegetation of reclaimed land	9,380/ha
Eco-conservation (10% of Revegetation Cost)	938/ha
Decommissioning of structures	*Lot

**Pits Reclamation**

The company proposes to turn Esujah North and Fetish mined out pits to aquaculture. Other activities to be undertaking as part of the reclamation include placement of environmental bunds, back shaping of the pits perimeter, vegetation of the area between the pits and the environmental bunds and finally progressive vegetation of the pits berm and height wall.

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## **9 STAKEHOLDER CONSULTATION**

### **9.1 Introduction**

This section describes public and stakeholder participation in the Project planning process.

Perseus Mining (Ghana) Limited endorses the concept that communication with project stakeholders is an essential component of any Project Development process.

PMGL is committed to open communication with all agencies, organizations, and individuals with an interest in the development of the Project. The Company has undertaken consultation, disclosure activities, and stakeholder engagement exercises since acquiring the concessions in 2009. Project stakeholders including individuals, groups, and organizations with an interest in the Project are engaged on regular bases in the consultation process.

### **9.2 Public Consultation and Disclosure Plan (PCDP)**

A Public Consultation and Disclosure Plan (PCDP) will be developed to showcase how PMGL involves the public in Edikan Project at various stages thus:

- During the resettlement planning and implementation stage.
- During development of the Project.
- Continuing throughout the life of the Project.

The purpose of the PCDP is to ensure adequate information is provided to PAPs and other stakeholders in a clear and timely manner, and that these groups have sufficient opportunity to voice their concerns and opinions so that they can influence project decisions.

In addition, Progress Reports will be developed on a quarterly basis for disclosure to key stakeholders and communities. These Reports will contain details of specific activities undertaken and planned for the coming months.

### **9.3 Key Public Consultation and Disclosure Objectives**

The main purpose of the PCDP is to improve and facilitate decision-making and create an atmosphere of understanding involving individuals, groups, and organizations that can impact on the development of the Project.

The importance of the PCDP is to allow implementation of a formal program of communication in an objective, simple manner, to focus efforts on improving communications between PMGL and interested parties.

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Monitoring and evaluation of program results and behaviour of the respected parties will enable constant development and improvements to the program over time.

Key objectives of the PCDP are to:

- Keep stakeholders informed of PMGL activities.
- Consult and educate stakeholders on key aspects of the project.
- Develop community inputs to project development and design.
- Generate and document broad community support for the Project.
- Improve communications between interested parties.
- Describe formal complaint submittal and resolution mechanisms.

## **9.4 Identification of Stakeholders for the Eastern Pits Project**

The Eastern Pits Project has a wide range of stakeholders and organisations that may be directly or indirectly impacted by the Project (positively or negatively). It is vital to identify the various stakeholder groups to develop an effective stakeholder program.

Stakeholders for Edikan Eastern pits Project were identified in 2012, through a variety of methodologies. These include::

- Reference to the PMGL Database (PACE).
- Formal discussions with traditional leaders and government agencies
- Community meetings and forums
- Focus groups with key groups such as traditional leaders, farmers, religious leaders, and market operators

Stakeholders in the local communities have been identified through comprehensive surveys undertaken at the commencement of the Project. The stakeholders' contact information is incorporated in the PMGL Stakeholder Database.

At the inception of the Project, PMGL permitted stakeholder groups to elect individuals as their representatives to assure stakeholders of collaborative approach to conflict resolution free from coercion and based on informed consent.

Representatives to various stakeholder committees, in particular the CNC and RCNC, were elected by voting or acclamation during community gatherings and group meetings. PMGL observed these meetings to ensure that the election of representatives was fair and transparent, and that the election process had widespread community support. After election, PMGL asked groups to confirm that their representatives were genuine advocates of the views of their members. To do so, it posted pictures and information of the elected representatives on PMGL notice boards placed at vantage areas in the affected communities.

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## 9.5 Formal Stakeholder Consultation and Information Disclosure

Formal Consultation and Information Disclosure on the Project issues occur through a variety of processes and activities.

### 9.5.1 Community Durbars / Public Meetings

A series of initial public meetings were held periodically, open to all members of the community, traditional authorities, assemblymen and local opinion leaders. The purposes of the initial public meetings (Figure 9.1) were to: Introduce the resettlement project, explain the land access and control process, gain trust and support for the process and to declare Moratorium over the Mining Area.



**Figure 9.1 A section of the Ayanfuri Community During Community Durbar in 2012**

Additional meetings are organised on regular bases to:

- Provide project updates.
- Confirm any agreements and consensus reached.
- Assist CNC and RCNC representatives in providing feedbacks on negotiation to the community.

### 9.5.2 Community Consultative Committee (CCC)

Community Consultative Committee (CCC) is a representative of all stakeholders including traditional authorities, government agencies, youth groups, affected farmers etc. The Committee was established in 2010 and meet quarterly. However, in 2011 and 2012, during the formation of the Edikan Trust Fund, the committee met frequently. Thirty-two (32) meetings (Figure 9.2) have been organized since its inception (Appendix 9.1). Some of the issues discuss at the CCC meetings includes:

- Project development and updates
- Identifying issues of concerns regarding the Project

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- Edikan Trust Fund and other Community Development Project.



**Figure 9.2 Community Consultative Committee Meeting At Ayanfuri – Pentecost Church**

### 9.5.3 Crop Negotiation Committee

The Crop Negotiation Committee (CNC) was formally established in February 2012 as a negotiating body for crops. Prior to this establishment, there was a consultative team in place negotiating annually on crop compensation rate for the Western Side Project. The Committee was extended to include representatives from the Eastern Pits Project and this constituted the CNC (Figure 9.3). The CNC comprised of representatives from all the 5 EGM Project-affected areas including Abenabena, Nkonya, Gyaman, Fobinso and Ayanfuri. Government Agencies; Ministry of Food and Agriculture (MoFA) and District Assembly representatives are present to witness and offer technical advice. The CNC has organised 52 meetings from 2012 to 2014 (Appendix 9.2).



**Figure 9.3 Crop Negotiation Committee Meeting At Nkonya – Peace Baptist Church**

### 9.5.4 Resettlement Compensation Negotiation Committee

The Resettlement Compensation Negotiation Committee (RCNC) was established in April 2013 and concluded negotiations in September 2014. The Committee comprised community representatives from

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all the affected areas, PMGL, relevant Government Agencies, and independent valuers. The RCNC was the principal conduit for negotiating on all aspects of The Eastern Pits Resettlement Project and the meetings were overseen by an independent moderator (Figure 9.4). The Committee met 32 (Appendix 9.3) times to negotiate and agreed on the following:

- Incomplete Structure Rates
- Resettlement Eligibility Criteria
- Residential Plot Rate
- Resettlement Package.



**Figure 9.4 Resettlement Compensation Negotiation Committee Meeting Dunkwa**

### 9.5.5 Consultations with Government Agencies

Government Departments and Agencies such as EPA and Mineral Commission influence the Project through a regulatory process of monitoring for compliance, issuing licenses and permits. The Central Region Administration and the Upper Denkyira West District Administration provide regulation and services to local residents and are responsible for future planning of the area. These agencies are consulted on regular bases to inform them of the Project updates and they in turn provide the technical advice and support required for the Project development (Appendix 9.4 is the approved Upper RAP by the Denkyira West District Assembly). Figure 9.5 shows a meeting section at Diaso.

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**Figure 9.4 A Section of WDWDA during The RAP Workshop Held At Diaso**

### **9.5.6 Traditional Authorities**

The Company consults the traditional leaders within the catchment area quarterly to discuss development and cultural issues. They are also informed about the Project updates and solicit their advice to improve the Project activities. Most of the chiefs and other opinion leaders are used to resolve grievances and disputes regarding compensation payment and ownership of properties.

### **9.5.7 Women Consultation Meetings**

This Women Consultative Committee (WCC) was established in 2011, made up of Women Groups' representatives from the communities including religious women, Market women, Female Teachers and Officials from the MMDAs. The Committee has met 4 times since its inception. It provides a platform for women to freely express their views about PMGL operations.

### **9.5.8 Community Employment Committee**

The committee was established purposely to ensure that local communities are given first priority to any vacant position with PMGL or its contractor organisation. It is the policy of the Company to employ all unskilled labour from the catchment communities. The role of the Employment Committee is to ensure that the unskilled labour is allotted to the local community. The Committee meets quarterly to discuss the procedure and approaches to enhance the employment process.

### **9.5.9 Interviews with Key Informants**

Key influential people identified in the Project catchment area are interviewed on a regular basis in order to ascertain the support for the Project, and any concerns that may not have been openly raised in other forums.

### **9.5.10 Information Centres and Noticeboards**

PMGL has established Information Centres within the catchment communities as focal points for community communication with the EGM. The centres make it easy for PAPs to access Community

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Liaison Officers (CLOs) for Project and Company information thereby facilitating an open-door approach for information disclosure and consultation.

The Information Centres are also used for receiving and logging of complaints or concerns regarding the Project in accordance with the PMGL Grievance Procedure. Public records of EIA and EPA correspondence and reports, and posters informing the community on aspects of the Project are available at the Information Centres.

Another key point of information dissemination is the Company notice boards. These notice boards are located at vantage points in the within the Company and are used to advertise job openings and disseminate project information. PMGL employees also receive regular project information through Company notice boards located at the mine site.

### **9.5.11 Media Broadcasts**

Announcements are broadcast on local radio stations and community public address systems to inform Project-affected persons (PAPs) and key stakeholders of planned community meetings and outline key project activities such as blasting time, Moratorium declaration, surveys, etc., as well as educating and informing PAPs on compensation and resettlement plans. Media briefing on Project activities and updates are organised on regular bases for the local mass media as well as at the District and the Regional level.

## **9.6 Informal Stakeholder Consultations**

Informal Stakeholder interaction occurs when PMGL representatives undertake their daily tasks. These consultations take place with Community Relation team, Resettlement team and also other members of the Community and Social Development Unit, such as surveyors and technical personnel.

PMGL employees and contractors are regularly briefed on the project, to ensure consistent messaging and dissemination of information. All technical personnel working directly on the Project are informed on community relations.

## **9.7 Formal Stakeholder Consultation and Disclosure Schedule**

Table 9.1 outlines the schedule for Project consultations. This schedule is periodically reviewed for effectiveness, and adapted according to project needs and stages of development.

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**Table 9.1- Stakeholder Consultation and Disclosure Schedule**

<b>Edikan Eastern Side Project: Ongoing Consultation and Disclosure</b>	
<b>Topic</b>	<b>Frequency</b>
<b>Formal Consultations</b>	
Briefing for Regional Minister and Staff	Ad-hoc
Briefing for Local MP	Ad-hoc
Briefing for District Chief Executive	Quarterly
Briefing for Regional Ministries, Departments and Agencies	Ad-hoc
Briefing for District Ministries, Departments and Agencies	Monthly
Briefing for Paramount chiefs and Stool Land Owners (local Chiefs)	Quarterly
Briefing for Youth, Women and other Groups	Monthly or as needed
Briefing for Religious Leaders	Monthly or as needed
<b>Informal Consultation</b>	
Informal sessions with all traditional authorities and opinion leaders in the Mining Area	As needed, Sometimes daily
<b>Dissemination of Information</b>	
Updates to public notice boards	Weekly or as needed
Scheduled visits by Community Relations/ Resettlement teams to the community	Weekly or as needed
Community Information Officers	Daily
Public Consultation and Disclosure Plan	Yet to be documented
Project Progress Reports	Quarterly from date of moratorium, for dissemination to key stakeholders and Perseus Internal Stakeholders

**Table 9.2- Stakeholder Consultation and Disclosure Schedule - Continuation**

Edikan Eastern Side Project: Ongoing Consultation and Disclosure	
Topic	Frequency
<b>Committees</b>	
CNC, RCNC	Bi-weekly (or as advised)
CCC, Employment Committee	Quarterly
<b>Complaint Process</b>	
Grievance and Complaints (Information Centres)	Daily, Mon to Fri, 8am to 5pm
Audit of complaint log to ensure effectiveness of process, screen for outstanding issues, monitor reoccurring issues.	Weekly

## 9.8 Reporting and Evaluation

PMGL maintains a file regarding all public consultation and disclosure documentation collected throughout the Project, which is available for public review upon request.

### 9.8.1 Record Keeping

Record keeping takes the following form:

- Maintaining an electronic and hard copy filing system for all external relations activities
- Recording issues raised at meetings and distributing the report to attendees for verification at regular intervals.
- Attendance registers completed at all meetings, and as far as possible taking tape recordings at some meetings.
- Keeping a comprehensive record for reporting purposes of:
  - All meetings (dates, venues, attendees, objectives, etc.).
  - All events such as launches, open days etc (dates, venues, attendees, objectives, outcomes).
  - All comments, compliments, grievances and all responses to these.

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## 9.9 Future Consultation Activities

This shall include documentation of the Public Consultation and Disclosure Plan (PCDP) which outlines PMGL’s consultation and disclosure practices being implemented, and planning of additional consultation programmes.

Community consultation is an ongoing process which will continue throughout operations, and the closure phases of the project.

Current and future consultation will include information and consultation on:

- Mine planning and development.
- Resettlement construction and moves.
- Livelihood Restoration Programs.

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## 10 CONCLUSION

PMGL is submitting a Supplementary Environmental Impact Statement for its Eastern Pits Project for the Edikan Gold Mine. The project was permitted and approved in June 2010 which formed part of the Central Ashanti Gold Project. This became necessary due to the developmental activities around historical pits in the Eastern section of the Mining Lease.

Baseline surveys were carried out in order to update existing data acquired in 2009. Risk assessments of significant impacts have been analysed and mitigation measures outlined to make the Project a sustainable one. Monitoring of performance indicators have been outlined in the proposed monitoring programme and addressed in the Provisional Environmental Management Plan. PMGL will run a concurrent rehabilitation and reclamation programme for the proposed operation with the objective of returning the impacted areas back to bio-physically stable conditions to sustain economic activities after closure.

PMGL wishes to operate the Eastern Pits under the Ghanaian legal framework, best practice and responsible manner.

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